

MYANMAR
NATIONAL
BUILDING
CODE
2016

PART 1 & PART 2

**MYANMAR
NATIONAL
BUILDING
CODE
2016**

PART 1

**PLANNING, ENVIRONMENT,
ADMINISTRATION AND LEGISLATION**

MYANMAR NATIONAL BUILDING CODE 2016
PART 1 PLANNING, ENVIRONMENT, ADMINISTRATION
AND LEGISLATION

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PART 1. PLANNING, ENVIRONMENT, ADMINISTRATION AND LEGISLATION

1.1 GENERAL

1.1.1 Title and Scope

1.1.1.1 Title

These regulations shall be known as **the Myanmar National Building Code**, hereinafter referred to as “this code”, consist of 7 Sections as follow:

1. Planning, Environment, Administration and Legislation
2. Architecture and Urban Design
3. Structural Design
4. Soil and Foundation
5. Building Services
6. Building Materials
7. Construction Practices and Safety

1.1.1.2 Scope

The provisions of this code shall apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures.

1.1.2 Definitions

The terminology given hereunder concerns only with the Section 1.

Accessory Use — Any use of the premises subordinate to the principal use and customarily incidental to the principal use.

Alteration — A change from one type of occupancy to another, or a structural change, such as an addition to the area or height, or the removal of part of a building, or any change to the structure, such as the construction of, cutting into or removal of any wall, partition, column, beam, joist, floor or other support, or a change to or closing of any required means of ingress or egress or a change to the fixtures or equipment.

Approved — Approved by the Authority having jurisdiction.

Authority Having Jurisdiction — The Authority which has been created by a statute and which, for the purpose of administering the Code/Part, may authorize a committee or an official or an agency to act on its behalf hereinafter called the ‘Authority’.

BDS or Back Drain Service — *is a space for drain which locates at the back of the building (see details in Part 5)*

Building — Any structure for whatsoever purpose and of whatsoever materials constructed and every part thereof whether used as human habitation or not and includes foundation, plinth, walls, floors, roofs, chimneys, plumbing and building services, fixed platforms, verandah, balcony, cornice or projection, part of a building or anything affixed thereto or any wall enclosing or intended to enclose any land or space and signs and outdoor display structures. Tents, tarpaulin

shelters etc, erected for temporary and ceremonial occasions with the permission of the Authority shall not be considered as building.

Building Height — The vertical distance measured, in the case of flat roofs from the average level of the ground around, *or from any reference point as determined by the authority* and contiguous to the building or as decided by the Authority to the terrace of last liveable floor of the building adjacent to the external walls; and in the case of pitched roofs, up to the point where the external surface of the outer wall intersects the finished surface of the sloping roof, and in the case of gables facing the road, the midpoint between the eaves level and the ridge. Architectural features serving no other function except that of decoration shall be excluded for the purpose of measuring heights. (Height of building will be measured to the most extreme height in case of heritage conservation areas.)

Building Line — the line up to which the plinth of a building adjoining a street or an extension of a street or on a future street may lawfully extend. It includes the lines prescribed, if any, in any scheme. The building line may change from time-to-time as decided by the Authority.

Conversion — the change of occupancy or premises to any occupancy or use shall be requiring additional occupancy permit.

Development — ‘Development’ means the carrying out of building, engineering, mining or other operations in, or over, or under land or water, or in the use *or change of use* of any building or land, and includes redevelopment and layout and subdivision of any land; and ‘to develop’ shall be construed accordingly.

Drainage — The removal of any liquid by a system constructed for the purpose.

Lanes for bicycles and slow moving vehicles — *like buggies, push carts* *see Part2*

Occupancy or Use Group — *see Part 2.*

Occupier — Occupier includes any person for the time being, paying or liable to pay rent or any portion of rent of the building in respect of which the ward is used, or compensation or premium on account of the occupation of such building and also a rent-free tenant. An owner living in or otherwise using his own building shall be deemed to be the occupier thereof.

Operational Construction/Installation — A construction/ installation put up *for public services* by *authorised agencies* for operational purposes. (see Part 5)

Owner — Person or body having a legal *title* in land and/or building thereon. This includes free holders, leaseholders or those holding a sub-lease which both bestows a legal right to occupation and gives rise to liabilities in respect of safety or building condition. In case of lease or sub-leaseholders, as far as ownership with respect to the structure is concerned.

Pathway — Any way meant covered or uncovered for pedestrian. *see Part2*

Permit — A permission or authorization in writing by the Authority to carry out work regulated by the Code.

Plot — A piece of land enclosed by definite boundaries.

Registered Architect, Engineer, Structural Engineer, Supervisor, Urban Planner, Landscape Architect, Urban Designer — A qualified architect, engineer, structural engineer, supervisor, urban planner, landscape architect or urban designer who has been registered by the Authority or by the body governing such profession and constituted under a statute, as may be applicable. The registration requirements of these professionals shall be as given in *Annex A*.

NOTES:

The word ‘licensing/ licensed, etc’ if used by the Authority in the above context shall be deemed to mean ‘registration/ registered’, etc.

Right of Way (ROW) — See Part 2

Road — Roads are classified as follows:

Union Highways, District Connectors, Urban Roads etc. in reference to Department of Highways.

Collectors, Feeders, Residential, Service road etc.

SDS or Side Drain Service — is a space for access to the roadside drain.

Set-back Line — A line usually parallel to the **plot boundaries** and laid down in each case by the Authority, beyond which nothing can be constructed towards the **site boundaries**.

Street — Any means of access, namely, highway, street, lane, pathway, alley, stairway, passageway, carriageway, footway, square, place or bridge, whether a thoroughfare or not, over which the public have a right of passage or access or have passed and had access uninterruptedly for a specified period, whether existing or proposed in any scheme and includes all bunds, channels, ditches, storm-water drains, culverts, sidewalks, traffic islands, roadside trees and hedges, retaining walls, fences, barriers and railings within the street lines.

Street Level or Grade — The officially established elevation or grade of the centre line of the street upon which a plot fronts and if there is no officially established grade, the existing grade of the street at its mid-point.

To Erect — To erect a building means:

- a) to erect a new building on any site whether previously built upon or not
- b) to re-erect any building of which portions above the plinth level have been pulled down, burnt or destroyed.

Unsafe Building — Buildings which are structurally and constructionally unsafe or unsanitary or not provided with adequate means of egress or which constitute a fire hazard or are otherwise dangerous to human life or which in relation to existing use constitute a hazard to safety or health or public welfare, by reason of inadequate maintenance, dilapidation, where the building requires either improvement or total removal.

1.1.3 Applicability of the Code

1.1.3.1 All Parts of the Code and their sections shall apply to all buildings described in 3.2 to 3.8, as may be applicable.

1.1.3.2 Where a building is erected, the Code applies to the design and construction of the building.

1.1.3.3 Where the whole or any part of the building is removed, the Code applies to all parts of the building whether removed or not.

1.1.3.4 Where the whole or any part of the building is demolished, the Code applies to any remaining part and to the work involved in demolition.

1.1.3.5 Where a building is altered (see 12.4 and 12.4.1), the Code applies to the whole building whether existing or new except that the Code applies only to part if that part is completely self-contained with respect to facilities and safety measures required by the Code.

1.1.3.6 Where the occupancy of a building is changed, the Code applies to all parts of the building affected by the change.

1.1.3.7 Where development of land is undertaken the Code applies to the entire development of land.

1.1.3.8 Existing Buildings The Code shall require the removal, alteration or abandonment, and prevent continuance of the use or occupancy of an existing building, by the opinion of the Authority, and if such building constitutes a hazard to the safety of the adjacent property or the occupants of the building itself.

1.1.4 Alternative Materials, Design and Methods of Construction and Equipment

The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

1.1.4.1 Research reports Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from approved sources.

1.1.4.2 Tests Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the official shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the official for the period required for retention of public records.

1.2. ORGANIZATION AND ENFORCEMENT

1.2.1. Development Planning and Building Authority

1.2.1.1 The Authority shall be created by the relevant **Government Body** and that authority shall carry out the development planning and building control.

1.2.1.2 Appointment of Team of Officials The team of officials shall be appointed by the Authority. The team shall comprise officials drawn from concerned disciplines such as engineers, architects, town planners, landscape architects and urban designers as may be decided by the Authority. For scrutiny of buildings and development areas shall be the responsibility of people with relevant expertise who will be appointed by the authority.

1.2.1.3 Organization In the Organization of the Authority, such number of officers, technical assistants, inspectors and other employees shall be appointed to assist the team of building officials as shall be necessary for the administration of the Code.

1.2.1.4 Delegation of Powers The Authority may designate one or a group of persons, or agencies who shall exercise all the powers in the name of the authority. The work of the team of building officials may be outsourced to competent professional/ agency group as may be deemed necessary.

1.2.1.5 Qualification of The Officials The qualification of building officials scrutinizing the plans and carrying out inspection of buildings shall not in any case be less than those prescribed in Annex A. (qualifications and -----) 

1.2.1.6 Restriction on Employees No official or employee connected with the building authority shall be engaged directly or indirectly in works connected with furnishing of labour, materials or appliances for the construction, alteration, maintenance of a building.

1.2.1.7 Records Proper records of all applications received, permits and orders issued, inspections made shall be kept properly for future retrieval. The administration of its duties shall be retained and all such records shall be open to public inspection at all appropriate times.

1.2.2 Power and Duties of the Officials

The team of the officials shall enforce all the provisions of the Code and shall act on any question related to the mode or manner of construction and the materials to be used in the erection, addition, alteration, repair, removal, demolition, installation of service equipment and the location, use, occupancy and maintenance of all buildings except as may otherwise be specifically provided.

1.2.2.1 Application and Permits The team of the officials shall receive all applications and issue permits (see in Permit section 12.10) for the erection and alteration of buildings and examine the premises for which such permits have been issued and enforce compliance with the Code.

1.2.2.2 Building Notices and Orders The team of building officials shall issue all necessary notices or orders to remove or change illegal or unsafe conditions, to require the necessity safeguards during construction, to require adequate exit facilities in existing buildings and to ensure compliance with all the requirements of safety, health and general welfare of the public as included in the Code.

1.2.2.3 Right of Entry Where it is necessary to make an inspection to enforce provision of this Code, or where the building officials have reasonable cause to believe that there exists in a structure or upon a premises a condition which is contrary to all in violation of this Code which makes the structure or premise unsafe, the building official is authorized to enter the structure or premises at reasonable times to inspect or perform the duties imposed by this Code, provided that if such structure or premises can be occupied that credential be presented to the occupants at entry requested. If such structure or premises unoccupied the building officials shall first make a reasonable effort to locate the owner or other person having charge or control of the structure or premises and request entry. If entry is refused, the building officials shall have recourse to the remedies provided by law to secure entry.

In case of dangerous or hazardous building the building official is authorized to enter immediately to inspect without prior notice.

1.2.2.4 Inspection The team of the officials shall make all the required inspections or it may accept reports of inspections of authoritative and recognized services or individuals; and all reports of inspections shall be in writing and certified by a responsible officer of such authoritative service, as he may deem necessity to report upon unusual technical issues that may arise.

1.2.2.5 Construction not According to Plan Should the team of officials determine at any stage that the construction is not proceeding according to the approved plan or is in violation of any of the provisions of the Code, or any other applicable Code Regulation, Act or Bylaw, **it shall notify the owner and the qualified person and all further construction shall be withheld until correction has been effected and approved.**

Should the owner fail to comply with the requirements at any stage of construction, the Authority shall issue a notice to the owner asking explanation for non-compliance. If the owner fails to comply within 14 days from the date of receiving the notice, the Authority shall be empowered to cancel the building permit issued and shall cause notice of such cancellation to be securely pasted upon the said construction.

1.2.2.6 Modification Wherever practical difficulties are involved in carrying out any provision of the Code, the team of the officials may vary or modify such provisions upon application of the owner or his representative provided, the Code shall be observed and public welfare and safety be assured.

1.2.2.7 Occupancy Violations Wherever any building is being used contrary to provisions of the Code, the team of officials may order such use discontinued and the building or portion thereof, vacated by the notice served on any person, causing such use to be discontinued. Such person shall discontinue the use within 10 days after receipt of such notice or make the building or portion thereof, comply with the requirements of the Code.

1.2.2.8 Liability The official, member of the authority of appeals or employee charged with the enforcement of this code, while acting for the jurisdiction in good faith and without malice in the discharge of the duties required by this code or other pertinent law or ordinance, shall not thereby be rendered liable personally and is hereby relieved from personal liability for any damage accruing to persons or property as a result of any act or by reason of an act or omission in the discharge of official duties. Any suit instituted against an officer or employee because of an act performed by that officer or employee in the lawful discharge of duties and under the provisions of this code shall be defended by legal representative of the jurisdiction until the final termination of the proceedings. The official or any subordinate shall not be liable for cost in any action, suit or proceeding that is instituted in pursuance of the provisions of this code.

1.2.3. Appealing Authority

In order to determine the suitability of alternative materials or methods of design or construction and to provide for reasonable interpretation of the provisions of the Code or in the matter of dispute relating to an ongoing construction vis-à-vis the sanctioned plan, a Authority of Appeals consisting of members who are qualified by experience and training and to pass judgment upon matters pertaining to building construction, shall be appointed by the Authority. A representative of the team of officials shall be an ex-officio member and shall act as secretary to **the Appealing Authority**. The **authority** shall adopt reasonable rules and regulations for conducting its investigations and shall render all decisions and findings in writing to the team of building officials with a duplicate copy to the appellant and may recommend such modifications as are necessary.

1.2.3.1 General In order to hear and decide appeals of orders, decisions or determinations made by the official related to the application and interpretation of this code, there shall be and is hereby created **the appealing authority**. **The appealing authority** shall be appointed by the governing body and shall hold office at its decision. **The authority** shall adopt rules of procedure for conducting its duties.

1.2.3.2 Limitations on authority An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted there under have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The authority shall have no authority to waive requirements of this code.

1.2.4 Violations and Penalties

1.2.4.1 Unlawful acts It shall be unlawful for any person, firm or corporation to erect, construct, alter, extend, repair, move, remove, demolish or occupy any building, structure or equipment regulated by this code, or cause same to be done, in conflict with or in violation of any of the provisions of this code.

1.2.4.2 Notice of violation The official is authorized to serve a notice of violation or order on the person responsible for the erection, construction, alteration, extension, repair, moving, removal, demolition or occupancy of a building or structure in violation of the provisions of this code, or in violation of a permit or certificate issued under the provisions of this code. Such order shall direct the discontinuance of the illegal action or condition and the abatement of the violation.

1.2.4.3 Prosecution of violation If the notice of violation is not complied, the official is authorized to request the legal counsel of the jurisdiction to institute the appropriate proceeding at law.

1.2.4.4 Violation penalties Any person who violates a provision of this code or fails to comply with any of the requirements thereof or who erects, constructs, alters or repairs a building or structure in violation of the approved construction documents or directive of the building official, or of a permit or certificate issued under the provisions of this code, shall be subject to penalties as prescribed by the law.

1.2.5 Stop Work Order

1.2.5.1 Authority

Whenever the building official finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or dangerous or unsafe, the building official is authorized to issue a stop work-order.

1.2.5.2 Issuance

The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order, and the conditions under which the cited work will be permitted to resume.

1.2.5.3 Unlawful Continuance

Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to penalties as prescribed by law.

1.2.6. Miscellaneous

1.2.6.1 Power to Make Rules

The Authority may make rules for carrying out the provisions and intentions of the Code provided that any rule shall not be in direct/ indirect conflict or nullify/ dilute any of the provisions of the Code.

1.2.6.2 Power to Prescribe Procedures & Set Standards

The officials may, from time to time, issue or amend codes or other documents setting out such standards, designs, requirements, procedures or other details pertaining to the matters under the Act and these Regulations, not inconsistent with the provisions of the Act and these Regulations.

The Authority may make rules for carrying out the provisions and intentions of the Code provided that any rule shall not be in direct/indirect conflict or nullify/dilute any of the provisions of the Code .

1.3 PERMIT AND INSPECTION

1.3.1 Development Planning Permit

1.3.1.1. Planning Permit Required

All major land use developments, which include new construction, extension, retrofitting, increase of floor area, and changes in usage of buildings/land, shall require “Planning Permit”. Planning permit shall be granted by “The Development Planning and Building Authority”, as in accordance with Section 1.B.1 of this Code. 

1.3.1.2 Zoning Requirements

All major land use developments, which include new construction, extension, retrofitting, increase of floor area, and changes in usage of buildings/land, shall be in conformity with zoning classification. *(Refer to Development Control Chapter)* 

1.3.1.3 Urban Aesthetics Control

Compliance with the provisions of the Code is adequate for normal buildings. But for major public building complexes or buildings coming up in an important area near historic/monumental buildings and areas of urban conservation, the aesthetics of the whole scheme may also have to be examined, vice-visa existing structures. In addition, any development which may *detract* the general characteristics and environment of historical, architectural or other monuments should also be subject to the provisions of this clause. This clause is intended to cover very few structures to come up in the vicinity of other declared/historically important structures.

 **An Urban Arts Committee** shall be established at the city/state level on issues related to urban aesthetics, through a statute. **This Committee** shall accord approval to all major buildings/important development projects having bearing on the urban aesthetics, depending upon the importance of the area with respect to natural or built heritage or projects. **The Urban Arts Committee** shall act as guardian of urban architecture; mainly with regard to building form and envelope, the relationship between the building, and the ambient environment vice-versa other dependant factors. *The Committee* shall be formed with specialists in urban aesthetics, heritage conservation etc.

The Urban Arts Commission should also be charged with advising the city government, on schemes which will beautify the city and add to its cultural vitality.

1.3.1.4 Environment Control and Land Law

It is necessary for the developers and the qualified persons to abide by the Myanmar Environmental Conservation Law of 2012 and to be in conformity with other land bylaws of the regional authorities.

1.3.1.5 Application for Planning Permission

 Everyone who intends to do major land use developments, which include new construction, extension, retrofitting, increase of floor area, and changes in usage of buildings/land shall give notice in writing to the Authority of his said intention in the prescribed form and such notice shall be accompanied by plans and documents as required (soft/hard copy).

Works exempt

Notwithstanding above clause, no planning permission shall be necessary:

(a) for the carrying out of such works as are necessary for the maintenance, improvement, or other alteration of a building, being works that affect only the interior of the building and do not_

involve any change in the use of the building or the land to which it is attached;

materially affect the external appearance of the building;

involve any increase in the height or floor area of the building;

involve any addition to or alteration of a building that affects or is likely to affect its drainage, sanitary arrangements, or its soundness; or

contravene or involve or result in inconsistency with any provision in the local plan;

(b) for the carrying out by any authority established by law to provide utilities of any works for the purposes of laying, inspecting, repairing, or renewing any drains, sewers, mains, pipes, cables, or other apparatus, or for the purpose of maintaining or repairing roads, including the breaking open of any road or ground for those purposes;

(c) for any excavation, including excavation of or for wells, made in the ordinary course of agricultural operations in areas zoned for agriculture;

(d) for the use of any land or building for a period not exceeding one month or such further period as the local planning authority may allow for purpose of_

a temporary or mobile cinema, theatre, or show;

a temporary amusement park, fair, or exhibition; or

a temporary ceremony or festivity of a religious, social, or other character,

and for any development necessary to give effect to such use;

(e) for the construction or erection on any land of temporary buildings for the accommodation of workers involved in the construction or erection of a building on the land, for which planning permission has been granted;

(f) for the use of any land or building within the area of a dwelling-house for any purpose incidental to the enjoyment of the dwelling-house as such; or

(g) for the making of such material change in the use of land or buildings as the State/Regional Authority may prescribe to be a material change for which no planning permission is necessary.

1.3.1.6 Submission Requirements

Where the development involves the erection of a building, the planning authority may give written directions to the applicant in respect of any of the following matters:

the level of the site of the building;
the line of frontage with neighbouring buildings;
the elevations of the building;
the class, design, and appearance of the building;
the setting back of the building to a building line;
access to the land on which the building is to be erected; and
any other matter that the planning authority considers necessary for purposes of planning.

In addition to the documents and plans required to be submitted above, the applicant shall submit a development proposal report which shall contain the following:

the development concept and justification;
a location map and a site plan;
particulars of land ownership and restrictions, if any;
 (i) a description of the land including its physical environment, topography, landscape, geology, contours, drainage, water bodies and catchments and natural feature thereon;
 (ii) a survey of the trees and all forms of vegetation; and
 (iii) particulars of a building, which may be affected by the development;
a land use analysis and its effect on the adjoining land;
layout plans, the details of which are specified in *layout plan requirement*; and
such other matters as may be prescribed by the planning authority.

The authority may specify that the development proposal report submitted in respect of certain categories of development shall include an analysis of the social implications of the development for the area which is the subject of the application for planning permission.

The layout plan requirement shall show the proposed development and in particular:

where the development is in respect of any land _
measures for the protection and improvement of its physical environment;
measures for the preservation of its natural topography;
measures for the improvement of its landscape;
measures for the preservation and planting of trees thereon;
the location and species of trees and other vegetation thereon;
the making up of open spaces;
the proposed earthworks, if any; and
description of the works to be carried out; and
where the development is in respect of a building with special architecture of historical interest, particulars to identify the building including its use and condition, and its special character, appearance, make and feature and measures for its protection, preservation and enhancement; and
where the development involves a building operation, particulars of the character and appearance of buildings in the surrounding areas.

Any other matter that the planning authority considers necessary for purposes of planning means other requirements such as:

The application of the Planning Permit shall conform to the “zoning requirements of the respective area” as described in 1.C.1.2 of this Code.

The application of the Planning Permit shall be attached with changes or new requirements of infrastructure.

The requirements in infrastructure, after and during the construction period shall be accompanied by the new concept of infrastructure provision.

The application of the Planning Permit shall be attached with the conceptual design of the planned activities, which shall include:

Plot area ratio/index

Built-up area ratios

Plans of all levels

The building heights

Parking facilities

Three-dimensional presentation in relation with surrounding environment within 300 feet radius.

The application of the Planning Permit shall conform to the requirements of existing heritage conservation bylaws of respective towns / settlements and areas.

The application of the Planning Permit shall conform to corresponding portions of this code.

1.3.1.7 Fees

Processing Fees: The current fees payable for the processing of planning applications are prescribed. The fees must be paid at the time of application. Government departments and statutory boards are not exempted from payment. Application fees are payable in respect of the following:

for written permission to develop or subdivided land or buildings;

for written permission with regard to works within conservation area;

for determination of development charge;

for approval on car park plans or proposals;

for inquiry about encumbrances on property;

for search of the record plan or development register;

for plans and certification of notice, order, etc; and

for usage and installation of infrastructure as required by the respective authorities.

Development Charges:

Where a local plan or an alteration of a local plan effects a change of use, density, or floor area in respect of any land so as to enhance the value of the land, a development charge shall be levied in respect of any development of the land commenced, undertaken, or carried out in accordance with the change.

The rate of the development charge or the method of calculating the amount of development charge payable shall be as prescribed by the rules (*under Urban and Regional Planning Act*).

The State/Regional Authorities may, by above rules, exempt any person or class of persons or any development or class, type, or category of development from liability to the development charge, subject to such conditions as the State/Regional Authority may specify in the rules.

NOTE— The fees may be charged as a consolidated fee. In the event of a building/ development permit is not issued, the fees so paid shall not be returned to the owner, but he shall be allowed to re-submit it without any fees after complying with all the objections raised by the Authority within a period of one year from the date of rejection after which fresh fees shall have to be paid.

1.3.1.8 Decision for Approval and Revision

The Authority shall examine the applications for permits and amendments there to within a reasonable time after filing. If the Authority is satisfied that the proposed work conforms to the requirements of this code, the Authority shall issue a permit within reasonable period. If the applications do not conform to the requirements of the Authority, the Authority shall reject such applications in writing, stating the reasons. The applicant has a right to revise and reapply based on the reason given by the authority.

1.3.1.9 Issuance

The application, plans, specifications, computations and other data filed by an applicant for a permit shall be reviewed by the planning authority. Such plans may be reviewed by other departments of this jurisdiction to verify compliance with any applicable laws under their jurisdiction. If the planning authority finds that the work described in an application for a permit and the plans, specifications and other data filed therewith conform to the requirements of this code and other pertinent laws and ordinances, and that the fees specified in C.1.7 have been paid, the planning authority shall issue a permit therefor to the applicant. 

When the planning authority issues the permit where plans are required, the planning authority shall endorse in writing or stamp the plans and specifications APPROVED. Such approved plans and specifications shall not be changed, modified or altered without authorizations from the planning authority, and all work regulated by this code shall be done in accordance with the approved plans.

1.3.1.10 Suspension and Revocation

The Authority has the right to keep the application in the suspension or to revoke the permit wherever the permit is issued in error or on the basis of incorrect, inaccurate or incomplete information, or in violation of any ordinance or regulation or any of the provisions of this code and in case the activity falls within the area of other planning process. However, the Authority shall give the applicant in writing of the reason for suspension and revocation.

1.3.1.11 Responsibilities of the Owners/Developers

Requirements and Duties:

Neither the granting of the permit nor the approval of the drawings and specifications, nor inspections made by the Authority during erection of the building shall in any way relieve the owner of such building from full responsibility for carrying out the work in accordance with the requirements of the Code (see Violation and Penalties).

Every Owner shall-

- a) permit the Authority to enter the building or premises for which the permit has been granted at any reasonable time for the purpose of enforcing the Code;
- b) submit required documents of approved planning permit of the site;
- c) obtain, where applicable, from the Authority, permits relating to building, zoning, grades, sewers, water mains, plumbing, signs, blasting, street occupancy, electricity, highways, and all other permits required in connection with the proposed work;
- d) give notice to the Authority of the intention to start work on the site (see *Form for notice for commencement*);
- e) give written notice to the Authority in case of termination of services of a professional engaged by him; and

f) obtain an occupancy permit (see *Form for Occupancy Permit*) from the Authority prior to any:

1) occupancy of the building or part thereof after construction or alteration of that building or part, or

2) change in the class of occupancy of any building or part thereof.

Upon the request of the holder of the permit, the Authority may issue a temporary certificate of occupancy for a building or part thereof, before the entire work covered by permit shall have been completed, provided such portion or portions may be occupied safely prior to full completion of building without endangering life or public welfare.

1.3.1.12 Responsibilities of the Qualified Persons

1.12.1 Architects, engineers, structural engineers, landscape architect, urban designer, supervisors, town planners and Licensed contractors wherever referred in the Code, shall be registered by the respective Authorities, as competent to do the work for which they are employed. A guide for the equivalent technical qualifications and professional experience required for such registration with the Authority is given in (**Annex Guide for the Qualifications and Competence of Professionals**).

1.12.2 The Registered town planner shall be competent to carry out the work related to the development permit as given below:

a) preparation of plans for land subdivisions/ layout and related information connected with development permit for all areas,

b) issuing of certificate of supervision for development of land of all areas.

1.12.3 In case the registered professional associated with the preparation and signing of plans or for supervision, is being changed during any stage of building/land development process, the professional shall inform the Authority in writing about the further non-association with the project.

1.3.1.13 Validity of Permit

The issuance or granting of a permit shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of this code or of any other ordinance of the jurisdiction. **Permits presuming to give authority to violate or cancel the provisions of this code or other ordinances of the jurisdiction shall not be valid.** The issuance of a permit based on construction documents and other data shall not prevent the building official from requiring the correction of errors in the construction documents and other data. The building official is also authorized to prevent occupancy or use of a structure where in violation of this code or of any other ordinances of this jurisdiction.

1.3.1.14 Expiration

Every permit issued shall become invalid unless the work on the site authorized by such permit is commenced within one year after its issuance, or if the work authorized on the site by such permit is suspended or abandoned for a period of one year after the time the work is commenced. The building official is authorized to grant, in writing, one or more extensions of time, for periods not more than one year each. The extension shall be requested in writing and justifiable cause demonstrated.

1.3.2 Building Permit

1.3.2.1 Building Permit Required

Any owner or authorized agent who intends to construct, enlarge, alter, repair, move, demolish, or change the occupancy of a building or structure, or to erect, install, enlarge, alter, repair, remove, convert or replace any electrical, gas, mechanical or plumbing system, the installation of which is regulated by this code, or to cause any such work to be done, shall first make application to the building official and obtain the required permit.

1.3.2.2 Application for Permit

Application. To obtain a permit, the applicant shall first file an application there for in writing on a form furnished by the building authority safety for that purpose. Such application shall:

1. Identify and describe the work to be covered by the permit for which application is made.
2. Describe the land on which the proposed work is to be done by legal description, street address or similar description that will readily identify and definitely locate the proposed building or work.
3. Indicate the use and occupancy for which the proposed work is intended.
4. Be accompanied by construction documents and other information as required in *Submission Requirements Section*.
5. Be signed by the applicant, or the applicant's authorized agent.
6. Give such other data and information as required by the building official.

Action on application. The building official shall examine or cause to be examined applications for permits and amendments thereto within a reasonable time after filing. If the application or the construction documents do not conform to the requirements of pertinent laws, the building official shall reject such application in writing, stating the reasons there for. If the building official is satisfied that the proposed work conforms to the requirements of this code and laws and ordinances applicable thereto, the building official shall issue a permit therefor as soon as practicable.

Time limitation of application. An application for a permit for any proposed work shall be deemed to have been abandoned 180 days after the date of filing, unless such application has been pursued in good faith or a permit has been issued; except that the building official is authorized to grant one or more extensions of time for additional periods not exceeding 90 days each. The extension shall be requested in writing and justifiable cause demonstrated.

Work exempt from permit. Exemptions from permit requirements of this code shall not be deemed to grant authorization for any work to be done in any manner in violation of the provisions of this code or any other laws or ordinances of this jurisdiction. Permits shall not be required for the following:

Building:

One-story detached accessory structures used as tool and storage sheds, playhouses and similar uses, provided the floor area does not exceed 120 square feet (11 m²).

Oil derricks.

Sidewalks and driveways not more than 3 feet above adjacent grade, and not over any basement story below and are not part of an accessible route.

Painting, papering, carpeting, cabinets, counter tops and similar finish works of interior spaces.

Temporary structures as defined in PART-2 of this Code.

Prefabricated swimming pools accessory to a Group R-3 (see Zoning Specification) occupancy that are less than 24 inches deep, do not exceed 5,000 gallons and are installed entirely above ground.

Shade cloth structures constructed for nursery or agricultural purposes, not including service systems.

Swings and other playground equipment accessory to detached one- and two-family dwellings.

Non-fixed and movable fixtures, cases, racks, counters and partitions not over 5 feet 9 inches in height.

Electrical Repairs and maintenance:

Minor repair work, including the replacement of lamps or the connection of approved portable electrical equipment to approved permanently installed receptacles.

Radio and television transmitting stations:

The activities concerning this sector shall be coordinated with **concerned telecommunication authorities**.

Temporary testing systems:

A permit shall not be required for the installation of any temporary system required for the testing or servicing of electrical equipment or apparatus.

Gas:

1. Portable heating appliance.
2. Replacement of any minor part that does not alter approval of equipment or make such equipment unsafe.

Mechanical:

1. Portable heating appliance.
2. Portable ventilation equipment
3. Portable cooling unit.
4. Steam, hot or chilled water piping within any heating or cooling equipment regulated by this code.
5. Replacement of any part that does not alter its approval or make it unsafe.
6. Portable evaporative cooler.
7. Self-contained refrigeration system containing 10 pounds (5 kg) or less of refrigerant and actuated by motors of 1horsepower (746 W) or less.

Plumbing:

1. The stopping of leaks in drains, water, soil, waste or vent pipe, provided, however, that if any concealed trap, drain pipe, water, soil, waste or vent pipe becomes defective and it becomes necessary to remove and replace the same with new material, such work shall be considered as new work and a permit shall be obtained and inspection made as provided in this code.

2. The clearing of stoppages or the repairing of leaks in pipes, valves or fixtures and the removal and reinstallation of water closets, provided such repairs do not involve or require the replacement or rearrangement of valves, pipes or fixtures.

Emergency repairs. Where equipment replacements and repairs must be performed in an emergency situation, the permit application shall be submitted within the next working business day to the building official.

Repairs. Application or notice to the building official is not required for ordinary repairs to structures, replacement of lamps or the connection of approved portable electrical equipment to approved permanently installed receptacles. Such repairs shall not include the cutting away of any wall, partition or portion thereof, the removal or cutting of any wall, partition or portion thereof, the removal or cutting of any structural beam or load-bearing support, or the removal or change of any required means of egress, or rearrangement of parts of a structure affecting the egress requirements; nor shall ordinary repairs include addition to, alteration of, replacement or relocation of any standpipe, water supply, sewer, drainage, drain leader, gas, soil, waste, vent or similar piping, electric wiring or mechanical or other work affecting public health or general safety.

Public service agencies. A permit shall not be required for the installation, alteration or repair of generation, transmission, distribution or metering or other related equipment that is under the ownership and control of public service agencies by established right.

1.3.2.3 Submission Requirements

Submittal documents. Construction documents, statement of special inspections and other data shall be submitted in one or more sets with each permit application. The construction documents shall be prepared by a registered design professional, according to respective council laws, required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the building official is authorized to require additional construction documents to be prepared by a registered design professional.

Exceptions: The building official is authorized to waive the submission of construction documents and other data not required to be prepared by a registered design professional if it is found that the nature of the work applied for is such that review of construction documents is not necessary to obtain compliance with this code.

Information on construction documents: Construction documents shall be dimensioned and drawn upon suitable materials. Electronic media documents may be required by the building official. Construction documents shall indicate clearly the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code and relevant laws, rules and regulations, as determined by the building official.

Fire protection system: The requirements concerning fire protection and other safety systems shall apply the concerned portions of this Code (see Fire Code).

Means of egress: The construction documents shall show in sufficient detail the location, construction, size and character of the means of egress in compliance with the respective portions of this Code (see Part 2&5).

Exterior wall envelope and boundary line: Construction documents for all buildings shall describe clearly the exterior wall envelope, the set-back and boundary line in sufficient detail to determine compliance with this code.

Site plan

The construction documents submitted with the application for permit shall be accompanied by the demarcation map and site plan showing to scale the size and location of new construction and

existing structures on the site, distances from lot lines, the established street grades and the proposed finished grades as applicable, flood prone areas, flow directions, and design flood elevations shall be drawn in accordance with an accurate boundary line survey. In the case of demolition, the site plan shall show portions to be demolished and the location and size of existing structures and construction that are to remain on the site or plot. The building official is authorized to waive or modify the requirement for a site plan when the application for permit is for alteration or repair or when otherwise warranted.

Examination of documents: The building official shall examine or cause to be examined the accompanying construction documents and shall ascertain by such examinations whether the construction indicated and described is in accordance with the requirements of this code and other existing laws.

Approval of construction documents: When the building official issues a permit, the construction documents shall be approved, in writing or by stamp, as “Reviewed for Code Compliance.” Required number of set of construction documents so reviewed shall be retained by the building official. The other set shall be returned to the applicant, shall be kept at the site of work and shall be open to inspection by the building official or a duly authorized representative.

Previous approvals: This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been issued previously or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.

Phased approval: The building official is authorized to issue a permit for the construction of foundations or any other part of a building or structure before the construction documents for the whole building or structure have been submitted, provided that adequate information and detailed statements have been filed complying with the requirements of this code. The holder of such permit for the foundation or other parts of a building or structure shall proceed at the holder’s own risk with the building operation and without assurance that a permit for the entire structure will be granted.

1.3.2.4 Fees

Payment of fees. A permit shall not be valid until the fees prescribed by law have been paid, nor shall an amendment paid.

Schedule of permit fees. On buildings, structures, electrical, gas, mechanical, and plumbing systems or alterations requiring a permit, a fee for each permit shall be paid as required, in accordance with the schedule as established by the concerned authority.

Building permits valuations. The applicant for a permit shall provide the permit value at time of application. If, in the opinion of the building official, the valuation is underestimated on the application, the permit shall be denied, unless the applicant can show detailed estimates to meet the approval of the building official. Final building permit valuation shall be set by the building official.

Work commencing before permit issuance. Any person who commences any work on a building, structure, electrical, gas, mechanical or plumbing system before obtaining the necessary permits shall be subject to a fee established by the building official that shall be in addition to the required permit fees.

Related fees. The payment of the fee for the construction, alteration, removal or demolition for work done in connection to or concurrently with the work authorized by a building permit shall

not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

Refunds. The building official is authorized to establish a refund policy.

1.3.2.5 Relevant Laws

The building permit shall be processed in the framework of this Code and Urban & Regional Planning Law to be promulgated by the Government of the Republic of the Union of Myanmar and other relevant laws such as respective City Development Committee Laws, etc.

The provisions of this code shall not be deemed to nullify any provisions of local, state/region or union law.

1.3.2.6 Decision for Approval and Revision

The Authority shall examine the applications for permits and amendments there to within a reasonable time after filing. If the Authority is satisfied that the proposed work conforms to the requirements of this code, complying also the structural, safety of buildings, requirements in public utility services, etc. the Authority shall issue a permit within reasonable period. If the applications do not conform to the requirements of the Authority, the Authority shall reject such applications in writing, stating the reasons. The applicant has a right to revise and reapply based on the reason given by the authority.

1.3.2.7 Suspension and Revocation

The Authority has the right to keep the application in the suspension or to revoke the permit wherever the permit is issued in error or on the basis of incorrect, inaccurate or incomplete information, or in violation of any ordinance or regulation or any of the provisions of this code and in case the activity falls within the area of other planning process. However, the Authority shall give the applicant in writing of the reason for suspension and revocation. However, the Authority shall give the applicant in writing of the reason for suspension and revocation.

1.3.2.8 Placement of Permit & Signage

The building permit or copy shall be kept on the site of the work until the completion of the project, together with the following documents:

The plans, elevations, sections, structural drawings and other details as required for the construction

The mechanical and electrical drawings and utilities design drawings

The signage shall be of the same format as described by the Authority and shall indicate the consultants and companies in the following order:

Owner/Developer and the name of the project

The Architect or the Architectural firm

The Structural Engineer or Structural Engineering firm

The consultants for building services

The contracting firm or firms

Alteration/revision Notice. When the notice is only for an alteration of the building, only such plans and statements, as may be necessary, shall accompany the notice.

No notice and building permit is necessary for the following alterations, and the like which do not otherwise violate any provisions regarding general building requirements, structural stability and fire and health safety requirements of the Code:

- (a) Opening and closing of a window or door or ventilator;
- (b) Providing intercommunication doors;
- (c) Providing partitions;
- (d) Providing false ceiling;
- (e) Gardening;
- (f) White washing;
- (g) Painting of interior spaces;
- (h) Re-tiling and reproofing;
- (j) Plastering and patch work;
- (k) Re-flooring; and
- (m) Construction of sunshades on one's own land.

1.3.2.9 Deviations during Construction

If during the construction of a building any departure (excepting for items as given in 2.8.2) from the sanctioned plan is intended to be made (see also B.2.5 *Construction not according to plan*), sanction of the Authority shall be obtained before the change is made. The revised plan showing the deviations shall be submitted and the procedure laid down for the original plan heretofore shall apply to all such amended plans except that the time limit shall be **30 days** in such cases.

1.3.2.10 Grant of Permit or Refusal

The Authority shall inform the applicant in written form whether the permit has been sanctioned or refused, by giving full reasons in case of refusal.

1.3.2.11 Responsibilities and Duties Of Owners/Developers

Neither the granting of the permit nor the approval of the drawings and specifications nor inspections made by the Authority during erection of the building shall in any way relieve the owner of such building from full responsibility for carrying out the work in accordance with the requirements of the Code.

Every owner shall:

- (a) permit the Authority to enter the building or premises for which the permit has been granted at any reasonable time (referred to *Right of Entry*) for the purpose of enforcing the Code;
- (b) submit a document of ownership of the site;
- (c) obtain, where applicable, from the Authority, permits relating to building, zoning, grades, sewers, water mains, plumbing, signs, blasting, street occupancy, electricity, highways, and all other permits required in connection with the proposed work;
- (d) submit the certificate for execution of work as per structural safety requirements (see Form for certificate for execution of work as per structural safety requirements); and give written notice to the Authority regarding completion of work described in the permit (see Form for building completion application)

(e) give written notice to the Authority in case of termination of services of the professionals engaged ;

Documents at Site

a) Where tests of any materials are made to ensure conformity with the requirements of the Code, records of the test data shall be kept available for inspection during the construction of the building and for such a period thereafter as required by the Authority.

b) The person to whom a permit is issued shall during construction keep pasted in a conspicuous place on the property in respect of which the permit was issued:

(a) a copy of the building permit; and

(b) a copy of the approved drawings and specifications .

1.3.2.12 Responsibilities and Duties of Qualified Persons

Architects, engineers, structural engineers, landscape architects, urban designers and town planners wherever referred in the Code, shall be registered by the concerned council/ Authority. A guide for the equivalent technical qualifications and professional experience required for such registration with the Authority is given in *Guide for the qualifications and competence of the professionals*.

In case the registered professional associated with the preparation and signing of plans or for supervision, is being changed during any stage of building/land development process, the professional shall inform the Authority in writing about the further non-association with the project.

1.3.2.13 Validity of Permit

The issuance or granting of a permit shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of this code or of any other ordinance of the jurisdiction. Permits presuming to give authority to violate or cancel the provisions of this code or other ordinances of the jurisdiction shall not be valid. The issuance of a permit based on construction documents and other data shall not prevent the building official from requiring the correction of errors in the construction documents and other data. The building official is also authorized to prevent occupancy or use of a structure where in violation of this code or of any other ordinances of this jurisdiction.

1.3.2.14 Expiration

Every permit issued shall become invalid unless the work on the site authorized by such permit is commenced within one year after its issuance, or if the work authorized on the site by such permit is suspended or abandoned for a period of one year after the time the work is commenced. The building official is authorized to grant, in writing, one or more extensions of time, for periods not more than one year each. The extension shall be requested in writing and justifiable cause demonstrated.

1.3.2.15 Building Demolition

Before a building is demolished, the owner shall notify all utilities having service connections within the building, such as water, electric, gas, sewer and other connections. A permit to demolish a building shall not be issued until a release is obtained from the utilities stating that their respective service connections and appurtenant equipment, such as, meters and regulators have been removed or sealed and plugged in a safe manner.

1.3.3 Inspections

1.3.3.1 General

Construction or work for which a permit is required shall be subject to inspection by the team of officials (appointed according to 1.2.1.2) and such construction or work shall remain accessible and exposed for inspection purposes until approved. Approval as a result of an inspection shall not be construed to be an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction. Inspections presuming to give authority to violate or cancel the provisions of this code or of other ordinances of the jurisdiction shall not be valid. It shall be the duty of the permit applicant to cause the work to remain accessible and exposed for inspection purposes. Neither the building official nor the jurisdiction shall be liable for expense entailed in the removal or replacement of any material required to allow inspection.

1.3.3.2 Preliminary Inspection

Before issuing a permit, the building official is authorized to examine or cause to be examined buildings, structures and sites for which an application has been filed.

1.3.3.3 Required Inspections

The official, upon notification, shall make the inspections set forth in the construction process when and where necessary, i.e., Planning/Development inspection, phase by phase inspections up to final inspection.

1.3.3.4 Inspection Agencies

The official is authorized to accept reports of approved inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability.

1.3.3.5 Inspection Requests

It shall be the duty of the holder of the permit or their duly authorized agent to notify the official when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such works that are required by this Code.

1.3.3.6 Approval Required

Work shall not be done beyond the point indicated in each successive inspection without first obtaining the approval of the official. The official, upon notification, shall make the requested inspections and shall either indicate the portion of the construction that is satisfactory as completed, or notify the permit holder or his or her agent wherein the same fails to comply with this code. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the official.

1.3.3.7 Building Completion Certificate (B.C.C)

Use and occupancy. No building or structure shall be used or occupied, and no change in the existing occupancy classification of a building or structure or portion thereof shall be made until the building official has issued a certificate of *Building Completion* there for as provided herein. Issuance of a certificate of *Building Completion* shall not be construed as an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction.

Certificate issued. After the building official inspects the building or structure and finds no violations of the provisions of this code or other laws that are enforced by the department of building safety, the building official shall issue a certificate of *occupancy* that contains the following:

1. The building permit number
2. The address of the structure
3. The name and address of the owner
4. A description of the portion of the structure for which the certificate is issued
5. The edition of the code under which the permit was issued
6. The use and occupancy, in accordance with the provisions of 'Use and Occupancy Classification Chapter' (PART2).
7. The type of construction as defined in 'Types of Construction Chapter' (PART 7).
8. Any special stipulations and conditions of the building permit.

Revocation. The building official is authorized to, in writing, suspend or revoke a certificate of building completion issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure or portion thereof is in violation of any regulation or any of the provisions of this code.

1.3.4. Service Utilities

1.3.4.1 Connection of Service Utilities

No person shall make connections from utilities, such as source of water, source of energy, fuel or power, etc. to any building or system that is regulated by this code for which a permit is required, until released by the building official.

1.3.4.2 Temporary Connection

The concerned authorities shall authorize the temporary connection of the building or system to the utility sources.

1.3.4.3 Authority to Disconnect Service Utilities

The concerned authorities shall authorize disconnection of utility service to the building, structure or system regulated by this code and the codes referenced in case of emergency where necessary to eliminate an immediate hazard to life or property. The building official shall notify the serving utility, and wherever possible the owner and occupant of the building, structure or service system of the decision to disconnect prior to taking such action. If not notified prior to disconnecting, the owner or occupant of the building, structure or service system shall be notified in writing, as soon as practical thereafter.

1.3.5 Unsafe Building

All unsafe building shall be considered to constitute danger to public safety and shall be restored by repairs or demolished or dealt with as otherwise directed by the Authority.

1.3.5.1 Examination Of Unsafe Building

The Authority shall examine or cause to be examined every building reported to be unsafe or damaged, and shall make a written record of such examination.

1.3.5.2 Special Cases

The Buildings defined as heritage structures can be exempted from immediate demolishing if the concerned authority would take the responsibility for further maintenance and protection from public safety.

1.3.5.3 Notice to Owner/Occupier

Whenever the Authority finds any building or portion thereof to be unsafe, it shall, in accordance with established procedure for legal notice, give to the owner/occupier of such building written notices stating the defects thereof. This notice shall require the owner or the occupier within a stated time either to complete specified repairs or improvements or to demolish and remove the building or portion thereof. The Authority may direct in writing that the building which in his opinion is dangerous, or has no provision for exit if caught fire, shall be vacated immediately or within the period specified for the purpose; provided that the Authority concerned shall keep a record of the reasons for such action with him. If any person does not comply with the orders of vacating a building, the Authority shall take legal actions to comply with the orders.

1.3.5.4 Disregard of Notice

In case the owner or occupier fails, neglects, or refuses to comply with the notice to repair or to demolish the said building or portion thereof, the Authority shall cause the danger to be removed whether by demolition or repair of the building or portion thereof or otherwise.

1.3.5.5 Cases of Emergency

In case of emergency, which, in the opinion of the Authority involves imminent danger to human life or health, the decision of the Authority shall be final. The Authority shall forthwith or with such notice as may be possible promptly cause such building or portion thereof to be rendered safe by retrofitting/strengthening to the same degree of safety or removed. For this purpose, the Authority may at once enter such structure or land on which it stands, or abutting land or structure, with such assistance and at such cost as may be deemed necessary. The Authority may also get the adjacent structures vacated and protect the public by an appropriate fence or such other means as may be necessary.

1.3.5.6 Costs

Costs incurred under 'Disregard of Notice' and 'Cases of Emergency' shall be charged to the owner of the premises involved. Such costs shall be charged on the premises in respect of which.

APPENDIX

Provision in Part-1 and Part-2 of Myanmar National Building Code , rules and regulations under Urban and Regional Planning Law to be promulgated and respective City Development Committee Laws shall be applied as Development Control Guideline of this Code.

ZONING CLASSIFICATION

The followings are classified zones. The requirements in the zoning plans shall be described in Urban and Regional Planning Act to be promulgated.

I Residential Use Zone:

Primarily Residential Use Zone

Mixed Residential Use Zone

Use Zone I(a) Primarily Residential Use Zone

All residential building including single and multifamily dwellings, apartment dwellings and tenements together with appurtenances pertaining there to;

Professional consulting offices of the residents and other relevant uses therefore;

Petty shops dealing with daily essentials including retail provisions, soft drinks, cigarettes, newspapers milk Kiosks, cycle repair shops and single person tailoring shops;

Use Zones I(b) Mixed Residential Use Zone

Uses Permitted

All uses permitted under Use Zone (a) i.e. Primarily Residential Use Zone

All buildings belonging to R-6 of (PART2)

Community Halls, and Religious buildings, welfare centres and Gymnasium

Recreation clubs, Libraries and Reading rooms

Clinics (PART-2), Dispensaries and Nursing homes

Government, Municipal and other institutional Sub-Offices

Police Stations, Post & Telegraph Offices, Fire Stations and Electric Sub-station

Banks and Safe Deposit Vaults;

Educational institutions

Restaurants, Hotels and other Boarding and Lodging Houses

Petrol filling and Service station

Departmental stores or super market or wet market, shops for the conduct of retail business

Use Zones 1(c) Informal Residential Use Zone

Uses Permitted

Informal residential zones are the areas that exist in some cities, however, these are to be identified in the development plan as for future improvement and upgrading.

II Commercial Use Zone – Use Zone II

Use permitted

1. All uses permitted in use zone I(a) and I(b) i.e residential use zone.

All commercial and business uses including all shops, stores, markets, and uses connected with the display of merchandise, either wholesale or retail rent excluding exposures, obnoxious products and other materials likely cause health hazards and hazardous to the environment (see PART-2).

2. Business Offices and other commercial and financial institutions.

3. Warehouses, repositories and other uses connected with storage or wholesale trade, but excluding storage of explosives or products which are either obnoxious or likely to cause health hazards.

Cinemas, the theatres and other commercial entertainment centres;

Research experimental and testing laboratories not involving danger of fire, explosions or health hazards;

Transportation terminals including bus stands, railway stations and urbanized parking lots;

Automobiles repair shops and garages;

III. Industrial Use Zone – Use Zone III.

Controlled Industrial use zone

a. Hazardous free

General Industrial use zone

b. Low hazardous

Special Industrial and Hazardous use zone

c. Medium hazardous

d. Hazardous

Use Zone III (a) Controlled Industrial Use Zone

Uses Permitted.

All commercial uses listed under use zone I(a), I(b) and II i.e. residential and commercial use zones;

Industries using electric power not exceeding 130 H.P. (L.T. maximum load) but excluding industries of obnoxious and hazardous nature by reason of odour, liquid effluent, dust, smoke, gas vibration etc. Or otherwise likely to cause danger or nuisance to public health or amenity;

Hotels, Restaurants and Clubs, places for social intercourse, recreation and worship and dispensaries and clinics, and

Residential buildings for caretakers, watchman and other essential staff required to be maintained in the premises.

Use Zone III (b) General Industrial Use Zone

Uses Permitted.

All commercial uses listed under use zone I(a), I(b) and I i.e. residential and commercial use zones;

All industries without restrictions on the horse power installed or type of motive power used excluding those of obnoxious or hazardous nature by reason of odour,

liquid effluent, dust, smoke, gas vibration etc. Or otherwise likely to cause danger or nuisance to public health or amenity;

Hotels, Restaurants and Clubs, places for social intercourse, recreation and worship and dispensaries and clinics, and

Residential buildings for caretakers, watchman and other essential staff required to be maintained in the premises.

Use Zone III (c) Special Industrial and Hazardous Use Zone

Use Permitted.

All commercial uses listed under Use Zones I and II i.e. residential and commercial use zones,

All industries permissible in the Use Zones III (a) and III (b) i.e. the controlled and general industrial use Zones.

All uses involving storage, handling, manufacture or processing of highly combustible or explosive materials or products which are liable to burn with extreme rapidity and / or which may produce poisonous fumes or explosion.

All uses involving storage, handling, manufacture or processing which involve highly corrosive, toxic or noxious alkalis acids or other liquids or chemicals producing flames, fumes and explosive, poisonous, irritant or corrosive gases.

All uses involving storage, handling or processing of any material producing explosive mixtures of dust, or which result in the division of matter into fine particles subject to a spontaneous ignition.

Processing or manufacturing anything from which offensive or unwholesome smells arise.

Melting or processing tallow or sulphur.

Storing, handling or processing of manure, offal, bones, rags, hides, fish, horns or skin;

Washing or drying wool or hair;

Making fish oil;

Making soap, boiling or pressing oil, burning bricks, tiles, pottery, or lime;

Manufacturing of distilling sugar and artificial manure;

Brewery beer, manufacturing by distillation barrack or spirit containing alcohol

In general, any industrial process which is likely to be dangerous to human life or health or amenity and not permissible in the Use Zone III(a) and III (b) i.e. controlled industrial and the general industrial use zones;

Hotels, restaurants and clubs, or places for social intercourse, recreation and worship or dispensaries and clinics, and

Residential buildings for caretakers, watchman and other essential staff required to be maintained in the premises.

IV. Public, Educational and Social Use Zone

Government/Semi-Government/Public Offices (PS- 1)

Government Land (use determined) (PS-2)

Educational and Research (PS-3)

Medical and Health Care Services (PS-4)

Social, Cultural and Religious (PS-5) (*library, museum, galleries*)

Utilities and Services (PS-6) (*Garage/Parking, Gasoline Station*)

Cremation and Burial Grounds (PS-7)

Exhibition Hall, Convention Facilities

Bus, railway and harbour Terminals,

Schools, Colleges and other higher education and Training institutions and the uses connected therewith;

All uses permitted in Use Zone I (a) i.e. primary residential use zone

Hotels and single person apartments

Recreation clubs Libraries and Reading rooms and

Restaurants.

Government and Quasi Government Offices;

Art Galleries, Museums, Aquarium and Public Libraries;

Hospitals, Sanitary and other medical and public health institutions;

Harbour, Airport and Flying Club;

V. Agricultural Use Zone – Use Zone V

Uses permitted.

All agricultural uses;

Farm houses and buildings for agricultural activities;

Rural settlements with allied uses;

Public and Private parks, playfield, gardens, caravan and camping sites and other recreational uses;

Dairy, Poultry, Fishery Farms, etc.

Water tanks bodies and reservoirs;

Sewage farms, Compost and garbage dump yards;

Airports and broadcasting installations;

Forestry;

Cemeteries, Crematoria and Burning and Burial grounds;

Storing and drying of fertilizers;

Fish curing;

Salt manufacturing;

Brick, tile or pottery manufacture;

Stone crushing and quarrying; and
Sand, clay and Gravel quarrying.

VI Special Area Old Built-up (Core) Area (City Centre) (S-1)

Heritage and Conservation Areas (S-2)

Scenic Value Areas (S-3)

Cantonments (S-4)

Village Settlement (S-5)

Other Uses (S-6)

Airport

Quarry

REQUIREMENTS FOR PERMIT APPLICATION

Submittal Documents

Where the development involves the erection of a building, the local planning authority may give written directions to the applicant in respect of any of the following matters, that is to say:

the level of the site of the building;
the line of frontage with neighbouring buildings;
the elevations of the building;
the class, design, and appearance of the building;
the setting back of the building to a building line;
access to the land on which the building is to be erected; and
any other matter that the local planning authority considers necessary for purposes of planning.

In addition to the documents and plans required to be submitted, the applicant shall submit a development proposal report which shall contain the following:

the development concept and justification;
a location map and a site plan;
particulars of land ownership and restrictions, if any;
(i) a description of the land including its physical environment, topography, landscape, geology, contours, drainage, water bodies and catchments and natural feature thereon;
(ii) a survey of the trees and all forms of vegetation; and
(iii) particulars of a building,
which may be affected by the development;
a land use analysis and its effect on the adjoining land;
layout plans, the details of which are specified; and
such other matters as may be prescribed by the local planning authority.

The Authority may specify that the development proposal report submitted in respect of certain categories of development shall include an analysis of the social implications of the development for the area which is the subject of the application for planning permission.

Layout Plans

The layout plans under paragraph shall show the proposed development and in particular:

where the development is in respect of any land _
measures for the protection and improvement of its physical environment;
measures for the preservation of its natural topography;
measures for the improvement of its landscape;
measures for the preservation and planting of trees thereon;
the location and species of trees with a girth exceeding 0.8m and other vegetation thereon;
the making up of open spaces;
the proposed earthworks, if any; and
description of the works to be carried out.

Table(1.1) Control of Building Use By Land Use Zones (MNBC)

[illegible]

Group	No.	Sub. No.	Building Categories	Residential Use Zone			Commercial Use Zone	Industrial Use Zone			Public, Educational & Social Use Zone	Agricultural Use Zone	Special Use Zone
				Primary Residential Use Zone	Mixed Residential Use Zone	Informal Residential Use Zone		Controlled Industrial Use Zone	General Industrial Use Zone	Special Industrial and Hazardous Use Zone			
			Airport traffic control towers										
			Ambulatory health care facilities		with spec:								
			Veterinary		with spec:								
			Banks		Mini Bank								
			Barber and beauty shops										
			Car wash		with spec:								
			Clinic-outpatient										
			Dry cleaning and laundries: pick-up and delivery stations and self-service	with spec:	with spec:		with spec:						
			Electronic data processing: public internet access centre	with spec:	with spec:								
			Laboratories: testing and research				with spec:						
			Motor vehicle showrooms										
			Post offices										
			Print shops	with spec:	with spec:								
			Professional services (architects, attorneys, dentists, physicians, engineers, etc.)										
			Radio and television stations										
			Telephone exchanges	with spec:	with spec:								
			Training and skill develop- ment not within a school or academic program, etc.		with spec:								
E			Educational										
			Basic Education Schools	with spec:									
			Day care	with spec:									
			Universities and Colleges				with spec:						
			Vocational Training Centres, etc.				with spec:						
			Factory and Industrial (Group F)										
			F-1										
			Aircraft (manufacturing, not to include repair)										
			Appliances						with spec:				
			Athletic equipment										
			Automobiles and other motor vehicles										
			Bakeries						with spec:				
			Beverages: over 16-percent alcohol content										
			Bicycles										
			Boats										
			Brooms or brushes										
			Business machines										
			Cameras and photo equipment										
			Canvas or similar fabric						with spec:				

Group	No.	Sub. No.	Building Categories	Residential Use Zone			Commercial Use Zone	Industrial Use Zone			Public, Educational & Social Use Zone	Agricultural Use Zone	Special Use Zone
				Primary Residential Use Zone	Mixed Residential Use Zone	Informal Residential Use Zone		Controlled Industrial Use Zone	General Industrial Use Zone	Special Industrial and Hazardous Use Zone			
			Carpets and rugs (includes cleaning)						with spec:				
			Clothing						with spec:				
			Construction and agricultural machinery										
			Disinfectants										
			Dry cleaning and dyeing										
			Electric generation plants										
			Electronics										
			Engines (including rebuilding)										
			Food processing										
			Furniture						with spec:				
			Fibrous products										
			Jute products						with spec:				
			Laundries										
			Leather products										
			Machinery										
			Metals										
			Millwork (sash and door)										
			Motion pictures and television filming (without spectators)										
			Musical instruments										
			Optical goods										
			Paper mills or products										
			Photographic film										
			Plastic products										
			Printing or publishing						with spec:				
			Recreational vehicles										
			Refuse incineration										
			Shoes										
			Soaps and detergents										
			Textiles										
			Tobacco										
			Trailers										
			Upholstering										
			Woodworking (cabinet, etc.)						with spec:				
			Wood; distillation, etc.						with spec:				
			F-2										
			Beverages: up to and including 16-percent alcohol content						with spec:				
			Brick and masonry										
			Ceramic products										
			Cottage industries		with spec:				with spec:				
			Foundries						with spec:				
			Glass products						with spec:				
			Gypsum										
			Ice						with spec:				

[illegible]

[illegible]

[illegible]

Classification of Roads

All roads outside the urban areas are classified as follows:

a) Expressway:

An expressway is a highway or arterial road for high-speed traffic which has many or most characteristics of a controlled-access highway(freeway or motorway), including limited or no access to adjacent property, some degree of separation of opposing traffic flow, use of grade separated interchanges to some extent, prohibition of some modes of transport such as bicycles or horses and very few or no intersecting cross-streets.

b) Special Ring Roads:

Special Ring Roads is outer ring road of city and town for special case: military, security, etc which has many or most characteristics of a controlled-access highway(freeway or motorway).

c) Asia and ASEAN High Way Roads:

Asia and ASEAN High Way Roads connecting to Asia and ASEAN Regions for delivering of goods and services.

d) Union highway roads or Inter-Region roads:

These roads are planned to connecting from one region to others and are free of all vehicles which are not motorized .

e)Township roads:

Township roads, which may be Asia and ASEAN High Way Roads and pass through within township as a major road of town, are the roads connecting between the rural settlements or between the rural settlements or connecting between small urban centres.

f) Rural roads:

Rural roads are the roads connecting between the rural settlements or between the rural settlements and their urban centres.

g) Urban roads:

All urban roads have the following classifications:

1) Urban Avenues/ Boulevard: Urban Avenues are the roads connecting zones in the urban areas and are longer than 5 miles.

2) Urban Main Road: Urban main roads are the roads connecting one the zone in the urban areas and which are not longer than 5 miles.

3) Feeder Roads: Feeder roads are the roads connecting collector roads and urban avenues or the urban main roads where several collector roads are connected.

4) Collector Roads: Collector roads are the roads connecting between the feeder roads and residential areas. is a low-to-moderate-capacity road which serves to move traffic from local streets to arterial roads. Unlike arterials, collector roads are designed to provide access to residential properties.

5) Local roads: These roads have the lowest speed limit, and carry low volumes of traffic. In some areas, these roads may be unpaved.

6) Residential roads: Residential roads are the roads in the residential areas

7) Short residential roads: Residential roads serving less than 4 units can be of one lane unless the roads do not exceed 300 feet in length, and these roads must be consist of two lanes if these served more than 4 units and longer than 300 feet.

8) Cul-de-sacs: All cul-de-sacs longer than 300 feet in length must have the minimum width of 20 feet, such cul-de-sacs must be provided turning circle.

9) One Way roads: One way roads can be planned in the residential areas meant only for one direction.

10) Service roads: Service roads are the roads where the usage is limited only to delivery vehicles.

Table 1.2a ROAD HIERARCHY CLASSIFICATION AND FUNCTIONS OUTSIDE THE URBAN AREA

No.	Type of facility	Functions and Design Features	R.O.W (ft)	Pavement	Max. Speed (mph)	Other Features & Spacing
1.	Expressways	Provide metropolitan and city continuity and unity. Limited access; Some channelized grade crossing and signal at major inter - section. Parking prohibited. (Fully Access Control)	400	Min. 4-6 lanes 12' per lane; 8'-10' shoulders; 8'-24' median strip.	60	Require service roads or adequate rear lot building setback lines. Spacing- Variable; radial or circumferential
2.	Special Ring Roads	Outer Ring Roads of Major cities Limited access	300	Min. 4-6 lanes 12' per lane	80	Required detached sidewalks in urban areas, planting strips and adequate building setback line. Spacing – 1500'-6000'
3.	Asia and ASEAN High Way Roads	Registered Highway in the region of Asia and ASEAN connecting city to city. Limited access	230	Min. 4-6 lanes 12' per lane	80	Required detached sidewalks in urban areas, planting strips and adequate building setback line. Spacing – 1500'-6000'
4.	Union Highway/ Inter-Region Roads	All highway connecting region to region, township to township Limited access	150	Min-4 lanes 12' per lane;	80	Required detached sidewalks in urban areas, planting strips and adequate building setback line. Spacing – 1500'-6000'

Table 1.2b **ROAD HIERARCHY CLASSIFICATION AND FUNCTIONS WITHIN THE URBAN AREA**

No.	Type of facility	Functions and Design Features	R.O.W (ft)	Pavement	Max.Speed (mph)	Other Features & Spacing
1.	Major Roads/Urban Avenues/ Boulevard	Provide unity through contiguous urban areas. Usually from boundaries for neighborhoods. Minor access control; parking generally prohibited.	100-200	Min- 4 lanes; 6'-14' median strip	45	Required detached sidewalks in urban areas, planting strips and adequate building setback line. Spacing – 1500'-6000'
2.	Secondary Roads/ Feeder Roads	Main feeder streets. Signals where needed; stop signs on side streets. Occasionally from boundaries from neighborhoods.	80 -120	2-12' or 4-12' Traffic lanes; 2-10' parking lanes	30	Required detached sidewalks in urban areas, planting strips and adequate building setback line. Spacing – 1000'-3000'
3.	Collector Streets	Main interior streets. Stop sign on side streets.	60-80	2-12' traffic lanes; 2-10' parking lane	30	Required at lease 4ft detached sidewalks, vertical curbs, planting trips are desirable, building setback line. Spacing – 600'-1500'

4.	Local Streets	Local service streets. Non conductive to through traffic.	30 -60	Min- 2 lanes; 9' to 11' traffic lanes	20	Sidewalks, vertical curbs, planting strips are desirable, building setback line. Spacing – at blocks
	Residential Streets	In residential area	30 -60	Min- 2 lanes Min-10'		Platform width- min 4'
	Short Residential Streets	More than 4 units Road length longer than 300'	Min-28	Min- 2 lanes Min-10'		
		Less than 4 units, Road length not exceed 300'	Min-28	Min-1 lane Min-20'		
	One Way Streets					
	Service Streets					
5	Cul-de-sac	Street open at only one end, with provision for a practical turnaround at the other.	30 (90 dia. Turn- around)	Min-20'	20	Should not have length greater then 500 ft.

Table (1.3) Land Use and Building Regulation attached to each Zones

No.	Category of Land Use Zones	Max: Floor Area Ratios (FAR) (%)	Max: Building Coverage Ratios (BCR) (%)
1	Exclusive Low-storey Residential Area	50, 60, 80, 100, 120	30, 40
2	Low-storey Residential Area	50, 60, 80, 100, 120, 150	30, 40, 50
3	Mid-storey Residential Area	50, 60, 80, 100, 120, 150, 200, 300, 400, 450	30, 40, 50, 60
4	Medium-High Rise Residential Area	100, 200, 300, 400, 450	30, 40, 50, 60
5	Informal Residential Area		
6	Mixed Use Area (Residential & Commercial)	100, 200, 300, 400, 500, 600, 700, 800	30, 40, 50, 60
7	Neighbourhood Commercial Zone	100, 200, 300, 400, 500, 600	40,50,60
8	Commercial Zone	100, 200, 300, 400, 500, 600, 700, 800, 1000, 1200	40,50,60,80
9	Controlled Industrial Zone	100, 150, 200, 300, 400, 500	50, 60
10	Industrial Zone/ General Industrial Zone	100, 150, 200, 300, 400	50, 60
11	Exclusive Industrial Zone/ Special Industrial Zone	100, 150, 200, 300, 400	30, 40, 50, 60

FAR = Total Building Floor Area / Plot Area

BCR = Building Footprint Area / Plot Area

MYANMAR

NATIONAL

BUILDING

CODE

2016

PART 2

ARCHITECTURE AND URBAN DESIGN

MYANMAR NATIONAL BUILDING CODE 2016
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2.1 USE AND OCCUPANCY CLASSIFICATION

2.1.1 General

2.1.1.1 Scope

The provisions of this chapter shall control the classification of all buildings and structures as to use and occupancy. In addition that this chapter contains the requirements to cooperate with allied disciplines in architectural design.

2.1.1.2 Cooperation and Coordination with other Disciplines

2.1.1.2.1 General Architectural Design Process

All design must consider the requirements of building services, structural engineering, building safety, etc. already in the designing process and to coordinate with various concerned disciplines during the conceptual design stage.

2.1.1.2.2 Design of Multi-storeyed Buildings

The architectural design must provide spaces for mechanical and electrical components such as, transformer stations, electrical meter boxes, underground tanks, waste disposal systems, vertical and horizontal shaft etc., which should be coordinated and allocated with the respected specialists already in the process of conceptual planning stage. All these provision must conform to the respective chapter of this building code. For example: the required provision should be complied with Part 5 Building Services.

2.1.2 Classification of all Buildings by Use or Occupancy

2.1.2.1 General

This section defines the scope of this chapter as the provisions to control the classification of all buildings, structures, and spaces as to use and occupancy. Structures or portions of structures shall be classified with respect to occupancy in one or more of the groups listed below. A room or space that is intended to be occupied at different times for different purposes shall comply with all of the requirements that are applicable to each of the purposes for which the room or space will be occupied. Structures with multiple occupancies or uses shall comply with *Chapter 3, General Building Heights and Areas*. Where a structure is proposed for a purpose that is not specifically provided for in this code, such structure shall be classified in the group that the occupancy most nearly resembles, according to the fire safety and relative hazard involved. It defines ten groups in which structures or portions of structures shall be classified.

- a) Group A: Assembly (A1 to A5)
- b) Group B: Business
- c) Group E: Educational
- d) Group F: Factory and Industrial (F1 & F2)
- e) Group H: Hazardous
- f) Group I: Institutional (I1 to I5)
- g) Group M: Mercantile
- h) Group R: Residential (R1 to R6)
- i) Group S: Storage (S1 & S2)
- j) Group U: Utility and Miscellaneous (U1 to U3)

2.1.3 Assembly (Group A)

2.1.3.1 General

Assembly occupancy includes, among others, the use of building or portions of building or structure for people gathering for civic, social or religious functions, recreation, entertainment, education or instruction, food or drink consumption or waiting for transportation. Assembly occupancies shall include a building or portions of building or tenant space used for assembly purposes with an occupant load of more than 50 persons and/or more than 500 square feet. Otherwise, it shall be classified as Group B occupancy or as part of other occupancy.

Exceptions:

- a) Assembly areas that are accessory to Group E occupancies are not considered separate occupancies except when applying the assembly occupancy requirements of *Chapter 7, Accessibility*.
- b) Accessory religious educational rooms and religious auditoriums with occupant loads of less than 50 and/or less than 500 square feet are not considered separate occupancies.

Assembly occupancies shall include the following:

A-1 Assembly uses, usually with fixed seating, intended for the production and viewing of the performing arts or motion pictures including, but not limited to:

Motion picture theatres

Symphony and concert halls

Television and radio studios admitting an audience

Theatres, etc.

A-2 Assembly uses intended for food and/or drink consumption including, but not limited to:

Banquet halls

Clubs

Restaurants

Food courts

Bars

A-3 Assembly uses intended for worship, recreation or amusement and other assembly uses not classified elsewhere in Group A including, but not limited to:

Amusement arcades

Art galleries

Bowling alleys

Community halls

Courtrooms

Dharma Halls

Dance halls

Exhibition halls

Funeral parlours

Gymnasiums

Indoor swimming pools

Indoor tennis courts

Lecture halls

Libraries

Museums

Places of religious worship: Pagodas, Temples, Churches, Mosques, etc.

Pool and billiard parlours

Waiting areas in transportation terminals, etc.

A-4 Assembly uses intended for viewing of indoor sporting events and activities with spectator seating including, but not limited to:

Arenas

Skating rinks

Swimming pools

Tennis courts, etc.

A-5 Assembly uses intended for participation in or viewing outdoor activities including, but not limited to:

Amusement park structures

Grandstands

Stadiums

2.1.4 Business (Group B)

2.1.4.1 General

Business occupancy includes, among others, the use of a building or structure, or a portion thereof, for office, professional or service-type transactions, including storage of records and accounts. Business occupancies shall include, but not limited to:

Airport traffic control towers

Ambulatory health care facilities

Veterinary

Banks

Barber and beauty shops

Car wash

Clinic-outpatient

Dry cleaning and laundries: pick-up and delivery stations and self-service

Electronic data processing: public internet access centre

Laboratories: testing and research

Motor vehicle showrooms

Post offices

Print shops

Professional services (architects, attorneys, dentists, physicians, engineers, etc.)

Radio and television stations

Telephone exchanges

Training and skill development not within a school or academic program, etc.

2.1.4.1 Definitions

The following words and terms shall, for the purposes of this section and as used elsewhere in this code, have the meanings shown herein.

CLINIC, OUTPATIENT. Buildings or portions thereof used to provide medical care on less than a 24-hour basis to individuals who are not rendered incapable of self-preservation by the services provided.

2.1.5 Educational (Group E)

Educational occupancy includes, among others, the use of a building or structure, or a portion thereof, by six or more persons at any time for educational purposes of the basic education (Group E1) and higher education (Group E2). Assembly areas of Group E occupancy having more than 50 occupant loads are considered as Group A-3 occupancy. Religious educational rooms and religious auditoriums, which are accessory to places of religious worship in accordance with assembly portion and have occupant loads of more than 50, shall be classified as A-3 occupancies.

Educational occupancies shall include, but not limited to:

Group E1

Basic Education Schools

Day care

Vocational Training Centres, etc.

Group E2

Educational occupancies for students above High School

2.1.5.1 Definitions

The following words and terms shall, for the purposes of this section and as used elsewhere in this code, have the meanings shown herein.

DAY CARE: The use of a building or structure, or portion thereof, for educational, supervision or personal care services for more than five children older than 2 1/2 years of age shall be classified as Group E occupancy.

2.1.6 Factory and Industrial (Group F)

2.1.6.1 General

Factory and Industrial occupancy includes, among others, the use of a building or structure, or a

portion thereof, for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operations that are not classified as a Group H hazardous or Group S storage occupancy.

2.1.6.2 Factory and industrial F-1 low-hazard occupancy

Factory industrial uses that involve the fabrication or manufacturing of non combustible materials which during finishing, packing or processing do not involve a significant fire hazard shall be classified as F-1 occupancies (which can be small, medium or large industries according to the 1990 Private Industrial Enterprises Law) including, but not limited to:

Beverages: up to and including 16-percent alcohol content

Brick and masonry

Ceramic products

Cottage industries

Foundries

Glass products

Gypsum

Ice

Metal products (fabrication and assembly),etc.

2.1.6.3 Factory and industrial F-2 moderate-hazard occupancy

Factory industrial uses which are not classified as Factory Industrial F-1 Low Hazard (which can be small, medium or large industries according to the 1990 Private Industrial Enterprises Law) shall be classified as F-2 Moderate Hazard including, but not limited to:

Aircraft (manufacturing, not to include repair)

Appliances

Athletic equipment

Automobiles and other motor vehicles

Bakeries

Beverages: over 16-percent alcohol content

Bicycles

Boats

Brooms or brushes

Business machines

Cameras and photo equipment

Canvas or similar fabric

Carpets and rugs (includes cleaning)

Clothing

Construction and agricultural machinery

Disinfectants

Dry cleaning and dyeing

Electric generation plants

Electronics

Engines (including rebuilding)

Food processing

Furniture

Fibrous products

Incineration Plant

Jute products

Laundries

Leather products

Land Fill Gas Plant

Machinery

Metals

Millwork (sash and door)

Motion pictures and television filming (without spectators)

Musical instruments

Optical goods

Paper mills or products

Photographic film

Plastic products

Printing or publishing

Recreational vehicles

Refuse incineration

Shoes

Soaps and detergents

Textiles

Tobacco

Trailers

Upholstering

Woodworking (cabinet, etc.)

Wood; distillation, etc.

2.1.7 High Hazardous (Group H)

H1 Storage and handling of hazardous and highly flammable material,

H2 Storage and handling of flammable material, dry cleaning plants using flammable liquids, paint stores with bulk handling, paint shops and spray painting rooms.

H3 Wood working establishments, painting mills and box factories, shops, factories where loose combustible fibers or dust are manufactured, processed or generated, warehouses where high combustible material is stored

H4 Repair garages

H5 Aircraft repair hangars.

2.1.8 Institutional (Group I)

2.1.8.1 General

Institutional Group I occupancy includes, among others, the use of a building or structure, or a portion thereof, in which people are provided for public service facilities and cared for or live in a supervised environment, having physical limitations because of health or age are harboured for medical treatment or other care or treatment, or in which people are detained for penal or correctional purposes or in which the liberty of the occupants is restricted. Institutional occupancies shall be classified as Group I-1, I-2, I-3 or I-4.

2.1.8.2 Group I-1

This occupancy shall include buildings, structures or parts thereof housing more than 16 persons, on a 24-hour basis, who because of age, mental disability or other reasons, live in a supervised residential environment that provides personal care services. The occupants are capable of responding to an emergency situation without physical assistance from staff. This group shall include, but not limited to:

Alcohol and drug centres

Home for Handicapped

Old aged Centres

Residential board and care facilities

Social rehabilitation facilities

Old Aged Centres, etc.

2.1.8.3 Group I-2

This occupancy shall include buildings and structures used for medical, surgical, psychiatric, nursing or custodial care for persons who are not capable of self-preservation. This group shall include, but not limited to:

Child care facilities

Detoxification facilities

Hospitals

Mental hospitals

Nursing homes (both intermediate care facilities and skilled training), etc.

2.1.8.3.1 Definitions

The following words and terms shall, for the purposes of this section and as used elsewhere in this code, have the meanings shown herein.

CHILD CARE FACILITIES. Facilities that provide care on a 24-hour basis to more than five children, 2 1/2 years of age or less.

DETOXIFICATION FACILITIES. Facilities that serve patients who are provided treatment for substance abuse on a 24-hour basis and who are incapable of self-preservation or who are harmful to themselves or others.

HOSPITALS AND MENTAL HOSPITALS. Buildings or portions thereof used on a 24-hour basis for the medical, psychiatric, obstetrical or surgical treatment of inpatients who are incapable of self-preservation.

NURSING HOMES. Nursing homes are long-term care facilities on a 24-hour basis, including both intermediate care facilities and skilled nursing facilities, serving more than five persons and where any of the persons are incapable of self-preservation.

2.1.8.4 Group I-3

This occupancy shall include buildings and structures that are inhabited by more than five persons who are under restraint or security. Facility of An I-3 is occupied by persons who are generally incapable of self-preservation due to security measures not under the occupants' control. This group shall include the following:

Correctional Centres

Detention Centres

Jails

Prisons,etc.

Buildings of Group I-3 shall be classified as one of the occupancy conditions indicated as following:

2.1.8.4.1 Condition 1

This occupancy condition shall include buildings in which free movement is allowed from sleeping areas, and other spaces where access or occupancy is permitted, to the exterior via means of egress without restraint. A Condition 1 facility is permitted to be constructed as Group R.

2.1.8.4.2 Condition 2

This occupancy condition shall include buildings in which free movement is allowed from sleeping areas and any other occupied smoke compartment to one or more other smoke compartments. Egress to the exterior is impeded by locked exits.

2.1.8.4.3 Condition 3

This occupancy condition shall include buildings in which free movement is allowed within individual smoke compartments, such as within a residential unit comprised of individual sleeping units and group activity spaces, where egress is impeded by remote-controlled release of means of egress from such a smoke compartment to another smoke compartment.

2.1.8.4.4 Condition 4

This occupancy condition shall include buildings in which free movement is restricted from an occupied space. Remote-controlled release is provided to permit movement from sleeping units, activity spaces and other occupied areas within the smoke compartment to other smoke compartments.

2.1.8.4.5 Condition 5

This occupancy condition shall include buildings in which free movement is restricted from an occupied space. Staff-controlled manual release is provided to permit movement from sleeping units, activity spaces and other occupied areas within the smoke compartment to other smoke compartments.

2.1.8.5 Group I-4 day care facilities

This group shall include buildings and structures occupied by persons of any age who receive custodial care for less than 24 hours by individuals other than parents or guardians, relatives by blood, marriage or adoption and in a place other than the home of the person cared for.

2.1.8.5.1 Adult care facility

A facility that provides accommodations for less than 24 hours for more than five unrelated adults and provides supervision and personal care services shall be classified as Group I-4.

Exception: A facility where occupants are capable of responding to an emergency situation without physical assistance from the staff shall be classified as *Group R-3*.

2.1.8.5.2 Child care facility

A facility that provides supervision and personal care on less than a 24-hour basis for more than five children 2-1/2 years of age or less shall be classified as Group I-4.

Exception: A child day care facility that provides care for more than five but no more than 100 children 2-1/2 years of age or less, where the rooms in which the children are cared for are located on a level of exit discharge serving such rooms and each of these child care rooms has an exit door directly to the exterior, shall be classified as Group E.

2.1.8.6 Group I-5

This occupancy shall include buildings, structures or parts thereof in which people are provided for public service facilities. This group shall include the following:

Civic administration

Fire Station

Police Station, etc.

2.1.9. Mercantile (Group M)

2.1.9.1 General

Mercantile Group M occupancy includes, among others, the use of a building or structure or a portion thereof, for the display and sale of merchandise and involves stocks of goods, wares or merchandise incidental to such purposes and accessible to the public. Mercantile occupancies shall include, but not limited to:

Department Stores

Mini Stores

Drug Stores

Fuel Stations

Markets

Motor fuel-dispensing facilities

Retail or wholesale stores

Sales rooms

2.1.10 Residential (Group R)

R-1 Residential occupancies where the occupants are primarily permanent in nature, including: Buildings that do not contain more than two dwelling units, eg. Detached and Duplex houses, Congregate living facilities with 16 or fewer persons.

R-2 Residential occupancies where the occupants are primarily permanent in nature, containing more than two dwelling units, including:

Apartment houses

Condominiums

Executive Residences

R-3 Residential occupancies containing sleeping units where the occupants are primarily permanent in nature, including:

Convents

Dormitories

Hostels

Monasteries

R-4 Residential occupancies shall include buildings arranged for occupancy as residential care/assisted living facilities not more than 16 occupants, excluding staff.

R-5 Residential occupancies containing sleeping units or more than two dwelling units or care/assisted living facilities where the occupants are primarily permanent in nature, including:

Home for the aged

Nursing home

Retirement home

Orphanage

R-6 Residential occupancies containing sleeping units where the occupants are primarily transient in nature, including:

Inns, guest houses

Hotels

Motels

Service Apartments (transient)

2.1.10.6 Definitions

The following words and terms shall, for the purposes of this section and as used elsewhere in this

code, have the meanings shown herein.

APARTMENT. An apartment is a self-contained housing unit (a type of residential real estate) that occupies only part of a building.

BOARDING HOUSE. A building arranged or used for lodging, with or without meals, and not occupied as a single-family unit.

CONDOMINIUM . A condominium, is the form of housing tenure and other real property where a specified part of a piece of real estate (usually of an apartment house) is individually owned, while use of and access to common facilities in the piece such as hallways, heating system, elevators, exterior areas is executed under legal rights associated with the individual ownership and controlled by the association of owners that jointly represent ownership of the whole piece.

CONGREGATE LIVING FACILITIES. A building or part thereof that contains sleeping units where residents share bathroom and/or kitchen facilities.

DORMITORY. A space in a building where group sleeping accommodations are provided in one room, or in a series of closely associated rooms, for persons not members of the same family group, under joint occupancy and single management, as in college dormitories or fraternity houses.

EXECUTIVE RESIDENCE. An executive residence is a type of furnished apartment available for long-term stays, which provides amenities for daily use.

PERSONAL CARE SERVICE. The care of residents who do not require chronic or convalescent medical or nursing care. Personal care involves responsibility for the safety of the resident while inside the building.

RESIDENTIAL CARE/ ASSISTED LIVING FACILITIES. A building or part thereof housing persons, on a 24-hour basis, who because of age, mental disability or other reasons, live in a supervised residential environment which provides personal care services. The occupants are capable of responding to an emergency situation without physical assistance from staff. This classification shall include, but not be limited to, the following: residential board and care facilities, assisted living facilities, halfway houses, group homes, congregate care facilities, social rehabilitation facilities, alcohol and drug abuse centres and convalescent facilities.

SERVICED APARTMENT. A serviced apartment is a type of furnished apartment available for short-term or long-term stays, which provides amenities for daily use.

TRANSIENT. Occupancy of a dwelling unit or sleeping unit for not more than 30 days.

2.1.11 Storage (Group S)

2.1.11.1 General

Storage Group S occupancy includes, among others, the use of a building or structure, or a portion thereof, for storage that is not classified as a hazardous occupancy.

2.1.11.2 Low-Hazard storage (Group S-1)

Group S-1 includes, among others, buildings used for the storage of non-combustible materials such as products on wood pallets or in paper cartons with or without single thickness divisions; or in paper wrappings. Such products are permitted to have a negligible amount of plastic trim, such as knobs, handles or film wrapping. Group S-1 storage uses shall include, but not limited to:

Asbestos

Beverages up to and including 16-percent alcohol in metal, glass or ceramic containers

Cement in bags
Chalk and crayons
Dairy products in non waxed coated paper containers
Dry cell batteries
Electrical coils
Electrical motors
Empty cans
Food products
Foods in non-combustible containers
Fresh fruits and vegetables in non plastic trays or containers
Frozen foods
Glass
Glass bottles, empty or filled with non-combustible liquids
Gypsum board
Inert pigments
Ivory
Meats
Metal cabinets
Metal desks with plastic tops and trim
Metal parts
Metals
Mirrors
Oil-filled and other types of distribution transformers
Parking garages open or enclosed
Porcelain and pottery
Stoves
Talc and soap
Washers and dryers, etc.

2.1.11.3 Moderate-hazard storage (Group S-2)

Buildings occupied for storage uses that are not classified as Group S-1, but not limited to:

Aerosols, Levels 2 and 3
Aircraft hangar (storage and repair) I
Bags: cloth, burlap and paper
Bamboos and rattan
Baskets

Belting: canvas and leather
Books and paper in rolls or packs
Boots and shoes
Buttons, including cloth covered, pearl or bone
Cardboard and cardboard boxes
Clothing, woollen wearing apparel
Cordage
Dry boat storage (indoor)
Furniture
Furs
Glues, mucilage, pastes and size
Grains
Horns and combs, other than celluloid
Leather
Linoleum
Lumber
Motor vehicle repair garages
Photo engravings
Resilient flooring
Silks
Soaps
Sugar
Tires, bulk storage of
Tobacco, cigars, cigarettes and snuff
Upholstery and mattresses
Wax candles

2.1.12 Utility and Miscellaneous (Group U)

2.1.12.1 General

Buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to the requirements of this code commensurate with the fire and life hazard incidental to their occupancy. Group U shall include, but not limited to:

2.1.12.2 Agricultural Buildings (Group U-1)

Group U-1, Agricultural uses, including, but not limited to:

Livestock Shelters or Buildings, including Shade Structures & Milking barns

Poultry Buildings or Shelters

Barns

Storage of equipment & machinery used exclusively in agriculture

Horticultural Structures including Crop Protection Shelters

Sheds

Grain Silos

Stables

Greenhouse

2.1.12.3 Group U-2

Group U-2 shall include, but not limited to:

Fences over 6 feet (1829 mm) high

Retaining Walls

2.1.12.4 Group U-3

Group U-3 shall include, but not limited to:

Aircraft Hangars

Carports

Private Garages, Generator Houses

Sheds, Telephone Booth, Kiosk, Media Corner

Stables

Tanks, Towers

Public Bath

Garbage Yards

PART 2 ARCHITECTURE AND URBAN DESIGN

**SECTION 2.2 ARCHITECTURAL REQUIREMENTS AND SPECIAL DETAILED
REQUIREMENTS BASED ON USE AND OCCUPANCY**

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2.2 ARCHITECTURAL REQUIREMENTS AND SPECIAL DETAILED REQUIREMENTS BASED ON USE AND OCCUPANCY

This section is intended for applying to buildings or structures along with the architecture, occupancy and construction requirements. It contains the Architectural and special detailed requirements for Health Care buildings, Education, Covered Mall Building, High-rise buildings to cooperate with allied disciplines in architectural design.

This should comply with the related rules, regulations, guidelines and standards issued by concerned Authorities such as Development Committee in respective cities and regions, Committee for Quality Control of High-Rise Building Projects (CQHP), Fire Services Department, Health, Education, Hotel, Culture, etc.

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2.2.1 Health Care Buildings

2.2.1.1 General

Generally all health care buildings are divided into hospital and clinics.

The buildings belonging to “hospital category” are defined as those where the patients’ care require longer than 24 hours and clinics are all where health-care personnel provision time less than 24 hours.

All health care buildings shall have proper garbage disposal system or shall have hygienic arrangements for garbage disposal.

All health care buildings shall be provided with accessibility systems in accordance with Chapter 7 of this code.

2.2.1.2 General requirement of hospitals

All hospitals, whether these are rehabilitation hospitals or healing hospitals, the followings rules shall be observed:

- a) The maximum height for all hospital buildings shall be according to the functions of the hospitals and the permission of Regional Governments and concerned Municipal Authorities and Health..
- b) The maximum number of beds in one patient-room in any hospital is 10.
- c) Whether the patients’ rooms are provided with air-conditioning systems or not, all patients’ rooms are to have windows leading to outside space and with the following rules:
 - (1) The window areas shall be minimum of 10% of floor area.
 - (2) The minimum distance of building near that window in any case shall be minimum 5 ft.
- d) The floor area of any patient-room shall be minimum 60 sq.ft. per bed.
- e) The egress and the escape routes must be in conformity with Chapters 6 of this code.
- f) There shall be minimum of one toilet for 8 beds and one shower facility for 16 beds.
- g) In cases of patients’ rooms with more than 2 beds, separate room for the patient’s attendants, individual or the nurse, shall be provided separate space. The attendants, living in the patients’ rooms is not permissible.

- h) All hospitals with more than 20 beds shall have mortuary with proper cooling system.

2.2.1.3 General requirement of clinics

All clinics, whether these are out-patient clinics or clinics combined with operational and other kinds of treatments, the followings rules shall be observed:

- a) There shall be not more than 10 doctors in one joined consultation room.
- b) There shall be physical separation between the paediatric clinics and the general clinics.
- c) There shall be physical separation between the gynecological clinics and the general clinics, however paediatric clinics and the gynecological clinics can be combined.
- d) The floor area of waiting room in a consultation unit shall be calculated based on the number of consultants. This shall be minimum of 200 sq.ft. per consultant.
- e) The egress and the escape routes must be in conformity with Chapters 6 of this code.
- f) There shall be minimum of one toilet for 15 waiting chairs.

2.2.2 Ambulatory Health Care Facilities

2.2.2.1 General

Occupancies classified as Group B ambulatory health care facilities shall comply with the provisions of Sections 2.2.15.1 through 2.2.15.6 and other applicable provisions of this code.

2.2.2.2 Smoke barriers

Smoke barriers shall be provided to subdivide every ambulatory care facility greater than 10,000 square feet (929 m²) into a minimum of two smoke compartments per storey. The travel distance from any point in a smoke compartment to a smoke barrier door shall not exceed 200 feet (60 960 mm). The smoke barrier shall be installed in accordance with [Myanmar Fire Safety Code of Practice](#).

2.2.2.3 Refuge area

At least 30 net square feet (2.8 m²) per no ambulatory patient shall be provided within the aggregate area of corridors, patient rooms, treatment rooms, lounge or dining areas and other low-hazard areas on each side of each smoke barrier.

2.2.2.4 Independent egress

A means of egress shall be provided from each smoke compartment created by smoke barriers without having to return through the smoke compartment from which means of egress originated.

2.2.2.5 Automatic sprinkler systems

Automatic sprinkler systems shall be provided for ambulatory care facilities in accordance with [Myanmar Fire Safety Code of Practice](#).

2.2.2.6 Fire alarm systems

A fire alarm system shall be provided in accordance with **Myanmar Fire Safety Code of Practice**.

2.2.3 Educational Buildings

2.2.3.1 Groupings and class rooms

The number of children in each group for respective ages and levels and required minimum floor areas must conform to the following norms, unless otherwise define in the concerned educational authorities.

Table 2.2.3 Groupings and Floor Area Requirements in the Class Rooms for Respective Levels

Levels	No. of children per room	Class room Area (sq-ft per child)
Nursery children below four years	10 children	30 sq-ft per child
Kindergarten children below six years	15 children	30 sq-ft per child
Primary classes, first grade to 4 th grade	25 children	25 sq-ft per child
Middle classes, fifth grade to eight grade	40 children	20 sq-ft per child
High school classes	40 children	20 sq-ft per child

All class rooms must have additional storage space for common properties of the class. For nurseries and kindergartens: there should be separate space for play areas and rest/sleeping areas. For all classes: The maximum width of all class rooms should not exceed 35 feet. Class rooms must have window areas which are not less than 15% of the floor areas and window sill heights must be not less than 3ft. And the railing height must be in conformity with section 2.5.6.3. Class rooms' heights must be minimum 9 ft. All class rooms must be connected with covered corridors or passages.

2.2.3.2 General requirements

All education building must have assembly areas which should hold at least 50% of all children with minimum floor areas of 7 sq.ft per child. For urban schools, ample parking space and delivery of children must be considered. There should be rooms for teachers with maximum eight teachers in one room and at least 80 sq-ft per teacher. There should be separate toilet facilities for teachers and children and the toilets for the students must be able to check the misuse of drugs and other illicit activities. All schools must have schools library and computer facilities. All schools must have space for facilities of physical education, handicraft and domestic science education for the children. In addition to the open space requirements of this chapter there should be play ground around 20,000 sq-ft for all schools with more than 500 children.

2.2.3.3 Open space requirements

The requirements for open spaces of respective norms are as the following table 2.2.2.

Table 2.2.3 Open Space Requirements for Respective Levels

Levels	Covered open space (minimum)	Open spaces (minimum)	Open shed (minimum)

Nursery children below four years	10 sq-ft per child	10 sq-ft per child	
Kindergarten children below six years	10 sq-ft per child	10 sq-ft per child	
Primary classes, first grade to 4 th grade		15 sq-ft per child	10 sq-ft per child
Middle classes, fifth grade to eight grade		20 sq-ft per child	10 sq-ft per child
High school classes		20 sq-ft per child	10 sq-ft per child

2.2.3.4 General requirements for higher educational institution

The requirements for higher educational institution are as follow:

- a) The higher educational institution shall have separate compound with ample land area to provide academic and recreational facilities.
- b) The higher educational institution shall provide auxiliary functions and facility such as libraries, multimedia places etc.
- c) The higher educational institution shall have sport facility for students.
- d) The higher educational institution shall have medical care facility for students and staffs.

2.2.3.5 Requirements for New School design

The following requirements shall be considered:

- a) The building should provide for health, safety, and security.
- b) The learning environment should enhance teaching and learning and accommodate the needs of all learners.
- c) The learning environment should serve as a center for the community.
- d) The learning environment should result from a planning/design process that involves all stakeholders.
- e) The learning environment should allow for flexibility and adaptability to changing needs.
- f) The learning environment should make effective use of all available resources.

2.2.3.6 Current design principles,

1. Current design principles including:
2. Design for protection against natural hazards
3. Design with increased attention to occupant security
4. Design with increased use of day lighting and comfort control

5. Design for durability

2.2.4 Covered Mall and Open Mall Buildings

2.2.4.1 Scope

The provisions of this section shall apply to buildings or structures defined herein as covered mall buildings not exceeding three floor levels at any point nor more than three stories above grade plane. Except as specifically required by this section, covered mall buildings shall meet applicable provisions of this code.

Exceptions:

- a) Foyers and lobbies of Business Groups B, and Residential Groups R are not required to comply with this section.
- b) Buildings need not comply with the provisions of this section when they totally comply with other applicable provisions of this code.

2.2.4.2 Definitions

The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

ANCHOR BUILDING. An exterior perimeter building of a group other than H having direct access to a covered mall building but having required means of egress independent of the mall.

COVERED MALL BUILDING. A single building enclosing a number of tenants and occupants, such as retail stores, drinking and dining establishments, entertainment and amusement facilities, passenger transportation terminals, offices and other similar uses wherein two or more tenants have a main entrance into one or more malls. For the purpose of this chapter, anchor buildings shall not be considered as a part of the covered mall building. The term "covered mall building" shall include open mall buildings as defined below.

Mall. A roofed or covered common pedestrian area within a covered mall building that serves as access for two or more tenants and not to exceed three levels that are open to each other. The term "mall" shall include open malls as defined below.

Open mall. An unroofed common pedestrian way serving a number of tenants not exceeding three levels. Circulation at levels above grade shall be permitted to include open exterior balconies leading to exits discharging at grade.

Open mall building. Several structures housing a number of tenants, such as retail stores, drinking and dining establishment, entertainment and amusement facilities, offices, and other similar uses, wherein two or more tenants have a main entrance into one or more open malls. For the purpose of Chapter 4 of the International Building Code, anchor buildings are not considered as a part of the open mall building.

FOOD COURT. A public seating area located in the mall that serves adjacent food preparation tenant spaces.

GROSS LEASABLE AREA. The total floor area designed for tenant occupancy and exclusive use. The area of tenant occupancy is measured from the center lines of joint

partitions to the outside of the tenant walls. All tenant areas, including areas used for storage, shall be included in calculating gross leasable area.

2.2.4.4 Lease plan

Each covered mall building owner shall provide both the building and fire departments with a lease plan showing the location of each occupancy and its exits after the certificate of occupancy has been issued. No modifications or changes in occupancy or use shall be made from that shown on the lease plan without prior approval of the building official.

2.2.4.4 Means of egress

Each tenant space and the covered mall building shall be provided with means of egress as required by *Chapter 6, Means of Egress*.

2.2.4.5 Mall width

For the purpose of providing required egress, malls are permitted to be considered as corridors but need not comply with the requirements of *Chapter 6, Means of Egress* of this code where the width of the mall is as specified in this section.

2.2.4.5.1 Minimum width

The minimum width of the mall shall be 20 feet (6096 mm). The mall width shall be sufficient to accommodate the occupant load served. There shall be a minimum of 10 feet (3048 mm) clear exit width to a height of 8 feet (2438 mm) between any projection of a tenant space bordering the mall and the nearest kiosk, vending machine, bench, display opening, food court or other obstruction to means of egress travel.

2.2.4.5.2 Minimum width open mall

The minimum floor and roof opening width above grade shall be 20 feet (9096 mm) in open malls.

2.2.4.7 Fire-resistance-rated separation

Fire-resistance-rated separation is not required between tenant spaces and the mall. Fire-resistance-rated separation is not required between a food court and adjacent tenant spaces or the mall.

2.2.4.7.1 Attached garage

An attached garage for the storage of passenger vehicles having a capacity of not more than nine persons and open parking garages shall be considered as a separate building where it is separated from the covered mall building by not less than 2-hour fire barriers constructed in accordance with **Myanmar Fire Safety Code of Practice**.

Exception: Where an open parking garage or enclosed parking garage is separated from the covered mall building or anchor building a distance greater than 10 feet (3048 mm), the provisions of *fire-resistance rating requirements* shall apply.

Pedestrian walkways and tunnels that attach the open parking garage or enclosed parking garage to the covered mall building or anchor building shall be constructed in accordance with *Pedestrian Walkways and Tunnels, Chapter 4, Special Building and Construction*.

2.2.4.7.2 Tenant separations

Each tenant space shall be separated from other tenant spaces by a fire partition complying with **Myanmar Fire Safety Code of Practice**.

A tenant separation wall is not required between any tenant space and the mall.

2.2.4.7.3 Anchor building separation

An anchor building shall be separated from the covered mall building by fire walls complying with **Myanmar Fire Safety Code of Practice**.

Exception: Anchor buildings of not more than three stories above grade plane that have an occupancy classification the same as that permitted for tenants of the covered mall building shall be separated by 2-hour fire-resistive fire barriers complying with **Myanmar Fire Safety Code of Practice**.

2.2.4.8 Interior finish

Interior wall and ceiling finishes within the mall and exits shall have non-flammable materials and all floors must be of non-slip finishes.

2.2.4.9 Automatic sprinkler system

The covered mall building and buildings connected shall be equipped throughout with an automatic sprinkler system in accordance with **Myanmar Fire Safety Code of Practice**, which shall comply with the followings:

- a) The automatic sprinkler system shall be complete and operative throughout occupied space in the covered mall building prior to occupancy of any of the tenant spaces. Unoccupied tenant spaces shall be similarly protected unless provided with approved alternative protection.
- b) Sprinkler protection for the mall shall be independent from that provided for tenant spaces or anchors. Where tenant spaces are supplied by the same system, they shall be independently controlled.

2.2.4.9.1 Standpipe system

The covered mall building shall be equipped throughout with a standpipe system as required by **Myanmar Fire Safety Code of Practice**.

2.2.4.10 Smoke control

Where a covered mall building contains an atrium, a smoke control system shall be provided.

Exception: A smoke control system is not required in covered mall buildings when an atrium connects only two stories.

2.2.4.11 Kiosks

Kiosks and similar structures (temporary or permanent) shall meet the following requirements:

- a) Combustible kiosks or other structures shall not be located within the mall unless permitted by the **Myanmar Fire Safety Code of Practice**.

- b) Kiosks or similar structures located within the mall shall be provided with approved fire suppression detection devices.
- c) The minimum horizontal separation between kiosks or groupings thereof and other structures within the mall shall be 20 feet (6096 mm).
- d) Each kiosk or similar structure or groupings thereof shall have a maximum area of 300 square feet (28 m²).
- e) There shall be no function in the kiosks with open flame.

2.2.4.12 Children's playground structures

Structures intended as children's playgrounds that exceed 10 feet (3048 mm) in height and 150 square feet (14 m²) in area shall comply with Covered mall and Open mall Buildings Sections.

2.2.4.12.1 Materials

Children's playground structures shall be constructed of non-combustible materials.

2.2.4.12.2 Fire protection

Children's playground structures located within the mall shall be provided with the same level of approved fire suppression and detection devices required for kiosks and similar structures.

2.2.4.12.3 Separation

Children's playground structures shall have a minimum horizontal separation from other structures within the mall of 20 feet (6090 mm).

2.2.4.12.4 Area limits

Children's playground structures shall not exceed 300 square feet (28 m²) in area, unless a special investigation has demonstrated adequate fire safety.

2.2.4.13 Security grilles and doors

Horizontal sliding or vertical security grilles or doors that are a part of a required means of egress shall conform to the following:

- a) They shall remain in the full open position during the period of occupancy by the general public.
- b) Doors or grilles shall not be brought to the closed position when there are 10 or more persons occupying spaces served by a single exit or 50 or more persons occupying spaces served by more than one exit.
- c) The doors or grilles shall be openable from within without the use of any special knowledge or effort where the space is occupied.
- d) Where two or more exits are required, not more than one-half of the exits shall be permitted to include either a horizontal sliding or vertical rolling grille or door.

2.2.4.14 Standby power

Covered mall buildings exceeding 50,000 square feet (4645 m²) shall be provided with standby power systems that are capable of operating the emergency voice/ alarm communication system and lighting.

2.2.4.15 Emergency voice/ alarm communication system

Covered mall buildings exceeding 50,000 square feet (4645 m²) in total floor area shall be provided with an emergency voice/ alarm communication system. Emergency voice/ alarm communication systems serving a mall required or otherwise, shall be accessible to the concerned authority.

2.2.4.16.2 Height and width of Signs

Plastic signs shall not exceed a height of 36 inches (914 mm), except that if the sign is vertical, the height shall not exceed 96 inches (2438 mm) and the width shall not exceed 36 inches (914 mm).

2.2.4.17 Fire department access to equipment

Rooms or areas containing controls for air-conditioning systems, automatic fire-extinguishing systems or other detection, suppression or control elements shall be identified for use by the fire services department.

2.2.4.18 Daylight provision for Mall

For the purpose of providing daylight, meant for the time of power failure, there should be minimum of 10% of the floor area of day-light provisions such as windows, etc. The furthest distance of such openings shall be less 80 feet from any point in that mall area.

2.2.5 High-Rise Buildings

2.2.5.1 Applicability

High-rise buildings shall comply with Sections 2.2.5.2 through 2.2.5.6.

Exception: The provisions of *Sections 2.2.5.2 through 2.2.5.6* shall not apply to the following buildings and structures:

- a) Concerning the location of high-rise buildings shall be designed to build in the vicinity of historical structures, according to the local Zoning Plan and regulations or, **as specified by Regional Governments and concerned Municipal Authority of the respected towns and regions.**
- b) Airport traffic control towers in accordance with *Section 2.2.11*.
- c) Open parking garages in accordance with *Section 2.2.7.3*.
- d) Buildings with a Group A-5 occupancy in accordance with *Assembly Group A, Chapter 1, Use and Occupancy Classification*.
- e) Special industrial occupancies in accordance with *Chapter 3, General Building Height and Area*.

2.2.5.2 Automatic sprinkler system

Buildings and structures shall be equipped throughout with an automatic sprinkler system and a secondary water supply in accordance with **Myanmar Fire Safety Code of Practice**.

Exception: An automatic sprinkler system shall not be required in spaces or areas of:

- a) Open parking garages in accordance with *Section 2.2.7.3*.
- b) Telecommunications equipment buildings used exclusively for telecommunications equipment, associated electrical power distribution equipment, batteries and

standby engines, provided that those spaces or areas are equipped throughout with an automatic fire detection system.

2.2.5.2.1 Number of sprinkler risers and system design

Each sprinkler system zone in buildings that are more than 420 feet (128 m) in building height shall be supplied by a minimum of two risers. Each riser shall supply sprinklers on alternate floors. If more than two risers are provided for a zone, sprinklers on adjacent floors shall not be supplied from the same riser.

2.2.5.2.1.1 Riser location

Sprinkler risers shall be placed in exit enclosures that are remotely located in accordance with *Exit and Exit Access Doorways* Section, Chapter 6, *Means of Egress*.

2.2.5.2.2 Water supply to required fire pumps

Required fire pumps shall be supplied by connections to a minimum of two water mains located in different streets.

Separate supply piping shall be provided between each connection to the water main and the pumps. Each connection and the supply piping between the connection and the pumps shall be sized to supply the flow and pressure required for the pumps to operate.

Exception: Two connections to the same main shall be permitted provided the main is valued such that an interruption can be isolated so that the water supply will continue without interruption through at least one of the connections.

2.2.5.3 Emergency systems

The detection, alarm and emergency systems of high-rise buildings shall comply with *Myanmar Fire Safety Code of Practice*.

2.2.5.3.1 Standby power

A standby power system complying with *Part 5, Building Services*.

2.2.5.4 Means of egress and evacuation

The means of egress in high-rise buildings shall comply with *Chapter 6, Means of egress*.

2.2.5.5 Elevators

Elevator installation and operation in high-rise buildings shall comply with *Part 5, Building Services*.

2.2.6 Atriums

2.2.6.1 General

The provisions of this section shall apply to buildings or structures containing vertical openings defined herein as "Atriums."

2.2.6.1.1 Definition

The following word and term shall, for the purposes of this chapter and as used elsewhere in this code, have the meaning shown herein.

ATRIUM. An opening connecting two or more stories other than enclosed stairways, elevators, hoist ways, escalators, plumbing, electrical, air-conditioning or other

equipment, which is closed at the top and not defined as a mall. Stories, as used in this definition, do not include balconies within assembly groups or mezzanines that comply with *Mezzanines Section, Chapter 3, General Building Heights and Areas*.

2.2.6.2 Use

The floor of the atrium shall not be used for other than low fire hazard uses and only approved materials and decorations in accordance with *P Myanmar Fire Safety Code of Practice* shall be used in the atrium space.

Exception: The atrium floor area is permitted to be used for any approved use where the individual space is provided with an automatic sprinkler system in accordance with *Automatic Sprinkler Systems, Myanmar Fire Safety Code of Practice*.

2.2.6.3 Automatic sprinkler protection

An approved automatic sprinkler system shall be installed throughout the entire building.

2.2.6.4 Fire alarm system

A fire alarm system shall be provided in accordance with *Myanmar Fire Safety Code of Practice*.

2.2.6.5 Smoke control

A smoke control system shall be installed in accordance with *Myanmar Fire Safety Code of Practice*.

Exception: Smoke control is not required for atriums that connect only two stories.

2.2.6.6 Enclosure of atriums

Atrium spaces shall be separated from adjacent spaces by a 1-hour fire barrier constructed in accordance with *Myanmar Fire Safety Code of Practice*.

2.2.6.7 Standby power

Equipment required to provide smoke control shall be connected to a standby power system in accordance with *Myanmar Fire Safety Code of Practice*.

2.2.7 Special Amusement Buildings

2.2.7.1 General

Special amusement buildings having an occupant load of 50 or more shall comply with the requirements for the appropriate Group A occupancy and *Sections 2.2.10.1 through 2.2.10.8*. Amusement buildings having an occupant load of less than 50 shall comply with the requirements for a Group B occupancy and *Sections 2.2.10.1 through 2.2.10.8*.

Exception: Amusement buildings or portions thereof those are without walls or a roof and constructed to prevent the accumulation of smoke.

2.2.7.2 Definition

The following word and term shall, for the purpose of this section and as used elsewhere in this code, have the meaning shown herein.

SPECIAL AMUSEMENT BUILDING. A special amusement building is any temporary or permanent building or portion thereof that is occupied for amusement, entertainment or educational purposes and that contains a device or system that conveys passengers or provides a walkway along, around or over a course in any direction so arranged that the

means of egress path is not readily apparent due to visual or audio distractions or is intentionally confounded or is not readily available because of the nature of the attraction or mode of conveyance through the building or structure.

2.2.7.3 Automatic fire detection

Special amusement buildings shall be equipped with an automatic fire detection system in accordance with *Fire Alarm and Detection Systems Section*, **Myanmar Fire Safety Code of Practice**.

2.2.7.4 Automatic sprinkler system

Special amusement buildings shall be equipped throughout with an automatic sprinkler system in accordance with **Myanmar Fire Safety Code of Practice**.

Where the special amusement building is temporary, the sprinkler water supply shall be of an approved temporary means.

2.2.7.5 Alarm

Actuation of a single smoke detector, the automatic sprinkler system or other automatic fire detection device shall immediately sound an alarm at the building at a constantly attended location from which emergency action can be initiated including the capability of manual initiation of requirements in **Myanmar Fire Safety Code of Practice**.

PART 2 ARCHITECTURE AND URBAN DESIGN
SECTION 2.3 GENERAL BUILDING HEIGHTS AND AREAS
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2.3 GENERAL BUILDING HEIGHTS AND AREAS

2.3.1 Definitions

The following words and definitions applied to this chapter and used in other places in this code have the meanings as described below:

AREA, building: The area included within surrounding exterior walls (or exterior walls and fire walls) exclusive of vent shafts and courts. Areas of the building not provided with surrounding walls must be included in the building area if these areas are included within the horizontal projection of the roof or floor above.

BASEMENT: The portions of buildings that are partly below grade plane. A basement must be considered as a story above grade plane where the finished surface of the floor above the basement is more than 6 feet above grade plane or more than 12 feet above the finished ground level at any point. A basement is a story that is not a story above the grade plane.

EQUIPMENT PLATFORM: An unoccupied, elevated platform used exclusively for mechanical systems or industrial process equipment, including the associated elevated walkways, stairs, and ladders necessary to access the platform.

GRADE PLANE: A reference plane representing the average of finished ground level adjoining the building at exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane must be established by the lowest points within the area between the building and the lot line or, where the lot line is more than 6 feet from the building, between the building and a point 6 feet from the building.

HEIGHT, building: The vertical distance from grade plane to the average height of the highest roof surface.

HEIGHT, STORY: The vertical distance from top to top of two successive finished floor surfaces; and, at the topmost story, from the top of the floor finish to the top of the ceiling joists or, where there is not a ceiling, to the top of the roof rafters.

MEZZANINE: An intermediate level or levels between the floor and ceiling of any story and in accordance with this chapter.

2.3.2 General height and area limitations

The height and area for buildings of different construction types will be ruled by the intended use of the building and cannot go over the limits except as modified from the date of this code coming into force. In Protection and Preserved Zone, Cultural Heritage Regions and Conservation Zones, building heights and locations of new buildings are restricted by the relevant laws concerning the preservation and management of historic views (1998 Law, Chapter IV) and the wider setting of listed buildings, conservation zones and other historic areas and landscapes. Where a new building will affect any of these heritage assets, the developer must set out clearly the potential impact of the new development on those assets. Where there is demonstrable harm to the assets, the development will be refused permission. Each part of a building included within the inside and outside walls and fire walls, where present, will be allowed to be a separate building. Buildings and structures that are designed to accommodate special industrial processes that require large areas and unusual heights to contain cranes or special machinery and equipment are exempt from the height restrictions, such as:

- Rolling mills
- Structural metal fabrication shops and foundries
- The production and distribution of electricity

- The production and distribution of gas or steam power.

There are situations when two or more buildings are on the same building lot. When this happens, they are to be regulated as separate buildings or they will be considered as parts of one building if the height of each building and the total area of the buildings are within the limits of Tables as shown in this code. The requirements of this code that are valid to the total building will be appropriate to each building. Buildings that are Type I construction are allowed to be unlimited level heights and areas are not required to stick to the special requirements that allow unlimited area buildings, unlimited height, or increased height and areas for other types of construction in this chapter.

2.3.2.1 The limitation of area and height of buildings of different occupancy classes

Different occupancy classes (Part 2) and types of construction (Part 3,7) shall be achieved by specifying it in terms of Floor area ratio FAR, which shall take into account the various aspects that govern in specifying FAR by Concerned Zoning Plan and Municipal Authority.

2.3.2.1.1 Height

The height that is allowed by code will be increased in agreement with this section with the exception that the height of one-story aircraft hangars, aircraft paint hangars, and buildings used for the manufacturing of aircraft will not be limited if the building is provided with an automatic fire-extinguishing system and is entirely surrounded by public ways or yards no less in width than one and one-half times the height of the building.

2.3.2.1.2 Mezzanines

Mezzanines that conform to this section can be considered a portion of the story.

The total area of a mezzanine is not allowed to be over 60% of the gross floor area that they are in and also cannot include the enclosed part of the room to determine the floor area where the mezzanine is located, and the total area of mezzanines in buildings and structures that are Type IV or V, provided that the clear floor height of the mezzanine cannot be less than 8 feet.

The total area of a mezzanine within a room is not allowed to be over 50% of the floor area of the room or the space that they are in and also cannot include the enclosed part of the room to determine the floor area where the mezzanine is located. The area of the mezzanine must be included in determining the fire area, The clear floor height of the mezzanine cannot be less than 7 feet. When determining the allowable mezzanine area, the area of the mezzanine cannot be included in the floor area except for the following:

- a) The total area of mezzanines in buildings and structures that are Type I or II for special industrial occupancies in accordance with this chapter cannot be more than two-thirds of the area in the room.
- b) The total area of mezzanines in buildings and structures that are Type I or II cannot be more than one-half of the area of the room in buildings and structures that have an approved sprinkler system throughout. The sprinkler system has to be in accordance with code requirements and an approved emergency voice/alarm communication system.
- c) Mezzanines are no different when talking about exits and exit routes. Each occupant of a mezzanine must have access to at least two exits where the common path of exit travel is over the limits of Chapter (6). If the exit from your mezzanine is a stairway, the maximum travel distance must include the distance traveled on the stairway measured in the plane of the tread nosing.

d) Accessible means of exits must be provided, as well as a single means of exit. If a building or structure has a mezzanine it has to be open and no obstructions are allowed in the room where the mezzanine is located, except for walls that are not more than 42 inches high, columns, and posts.

There are five exceptions to this code, and they are as follows:

- a) Mezzanines or portions that are of concern are not required to be open, provided that the occupant load does not go over 10 persons.
- b) Mezzanines or portions that are of concern are not required to be open to the room if at least one of the exits provides direct access to an exit from the mezzanine level.
- c) Mezzanines are not required to be open to the room, provided that the total floor area of the enclosed space does not go over 10 percent of the area.
- d) In industrial facilities, mezzanines used for control equipment are allowed to be glazed on all sides.
- e) In Groups H and I occupancies that are no more than two stories in height above grade plane and equipped with an automatic sprinkler, a mezzanine having two or more exits is not required to be open to the room in which the mezzanine is located. And required to be complied with travel distance in Chapter 2.6 of this code.

2.3.3 Allowable Floor Areas

The Allowable Floor Area of any proposed building/structure shall only be as allowed based on the Allowed Percentage of Plot Area Ratio (PAR) and floor area ratio (FAR) as specified by concerned Zoning Plan and Municipal Authority.

2.3.3.1 Allowable Floor Area Increases

The floor areas hereinabove provided may be increased in certain specific instances and under appropriate conditions, based on the existence of public space, streets or yards extending along and adjoining two or more sides of the building or structure subject to the approval of the Building Official.

2.3.4 Maximum Height of Buildings

The maximum height and number of storeys of proposed building shall be dependent upon the character of use or occupancy and the type of construction (see notes), considering end-user population density, light and ventilation, width of streets particularly of its roadway/carriageway component, off-street cum off-site parking requirements, etc. and in relation to local land use plan and zoning regulations as well as other environmental considerations. The height shall be measured from the highest adjoining side walk or ground surface, Provided that the height measured the lowest adjoining surface shall not exceed such maximum height by more than 3.00 meters or 9.84 feet; Except that towers, spires, and steeples, erected as part of a building and not used for habitation or storage are limited as to height only by structural design of combustible materials or may extend not to exceed 6.00 meters or 10.7 feet above the height limits for each occupancy group if of combustible materials.

Determination of Building Height

Building Height Limit (BHL) the maximum height to be allowed for building/structures based on their proposed use or occupancy; the BHL is generally determined after the application of other development controls (DC) and certain other parameters, i.e., considerations of site conditions, view, etc. (Table 2.3.4.1). The BHL shall be generally measured from the established grade line to

the topmost portion of the proposed building/structure. If applicable, the BHL may be subject to clearance requirements of the Air Transportation Office (ATO) or of the concerned military/security authorities, BHL excludes the height of permitted/allowed projections above the roof of the building/structure, e.g., signage, mast, antenna, telecom tower, beacons and the like. The Building Height Limit (BHL) of any proposed building/structure shall only be as allowed under this Rule (as shown in table below) or under the duly approved city/municipal (local) zoning ordinance, whichever is more restrictive.

Table 2.3.4.1 Building Height Limit (BHL) by Type of Use or Occupancy

Table 2.3.4.1 Building Height Limit (BHL) by Type of Use or Occupancy

Character of Use or Occupancy	Type of Building/ Structure	Building Height Limit (BHL)	
		Number of allowable Storeys/floors above Established grade	Feet / Meters above highest Grade
Residential	Residential R1 Detached and Duplex houses	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	Residential R2 Apartment houses Condominiums Executive Residences	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	Residential R3 Convents Dormitories Hostels Monasteries	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	Residential R4 Home for the aged Nursing home Retirement home Orphanage	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	Residential R5 Home for the aged Nursing home Retirement home Orphanage	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	Residential R6 Inns, guest houses Hotels Motels Service Apartments (transient)	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
Commercial	Business (B)	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority

	Mercantile (M)	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
Educational	Schools(E-1)	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	Schools(E-2)	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
Industrial	Industrial. 1 (F-1)	Concerned Zoning Plan and Municipal Authority	
	Industrial. 2 (F-2)	Concerned Zoning Plan and Municipal Authority	
	Industrial. 3 (F-3)	Concerned Zoning Plan and Municipal Authority	
Institutional	Institutional (I-1 to 5)	Concerned Zoning Plan and Municipal Authority	
Parks and Open Recreational and Entertainment Spaces		Concerned Zoning Plan and Municipal Authority	
Agricultural/Agro-Industrial/Tourism		Concerned Zoning Plan and Municipal Authority	
Planned Unit Development (PUD)	PUD at a reclamation area close to an operating airport	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	PUD at a reclamation area	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	PUD at a coastal area	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	PUD at a reclamation area close to an operating airport	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority
	PUD at an inland area	Concerned Zoning Plan and Municipal Authority	Concerned Zoning Plan and Municipal Authority

Proposed Type of Construction:

For purposes of the Code, all buildings proposed for construction shall be classified according to the following types; and should also link with Part 3, Structure.

Type I - shall be of wood construction. The structural elements may be any of the materials permitted by (AHJ) Authority having Jurisdiction.

Type II - shall be of wood construction with protective fire-resistant materials and one-hour fire-resistive throughout, except, that permanent non-load bearing partitions may use fire- retardant treated wood within the framing assembly with one-hour resistivity.

Type III - shall be of masonry and wood construction. Structural elements may be any of the materials permitted by (AHJ) Authority having Jurisdiction, provided, that the building shall be one-hour fire-resistive throughout. Exterior walls shall be of incombustible fire-resistive construction.

Type IV - shall be steel, iron, concrete, or masonry construction and walls, ceiling and permanent partitions, shall be of Incombustible fire- resistive construction, except, that permanent non-

bearing partitions of one-hour fire-resistive construction may use fire-retardant treated wood within the framing assembly.

Type V - shall be fire-resistive. The structural elements shall be of steel, iron, concrete, or masonry construction. Walls, ceilings and permanent partitions shall be of incombustible fire-resistive construction.

Note 2:

Establishing Grade

a) In case of sloping grade where the building footprint running perpendicular to the Road right of way (RROW) has a difference in elevation of less than 3.00 meters, the highest adjoining natural grade (ground surface) or finished grade (sidewalk surface) shall be considered the established grade elevation;

b) In case of sloping grade where the edges of the building footprint turning perpendicular to the RROW has a difference in elevation of more than 3.00 meters, the average grade level of the building footprint shall be considered the established grade elevation .

2.3.5 Mixed use and occupancy

Buildings or parts of buildings that contain two or more occupancies or uses are classified as mixed use. This section applies to mixed use occupancy and the buildings that they occupy. An incidental use area must be classified in accordance with the occupancy of that portion of the building in which it is located or the building must be classified as a mixed occupancy and will comply with this section.

Where the code allows an automatic fire-extinguishing system without a fire barrier, the incidental use area must be separated from the rest of the building by construction that is capable of resisting smoke from passing through the building. The partitions must extend from the floor to the underneath of the fire-resistance-rated floor/ceiling assembly or fire-resistance-rated roof/ceiling assembly above or to the bottom of the floor or roof sheathing or sub deck above. Doors must be self-closing or automatic closing when the detection of smoke is made. Doors also must not have any air transfer openings and cannot be undercut in excess of the clearance that is permitted in *Fire Services Department*. With some exceptions, no separation is required between ancillary occupancies and the main occupancy. Where an automatic fire-extinguishing system or automatic sprinkler system is provided, only the incidental use areas need to be equipped with this system.

2.3.6 Equipment platforms

Equipment platforms in buildings cannot be considered as a portion of the floor below and must not contribute to either the building area or the number of stories as regulated by this chapter, and may also not use the area of the equipment platform to determine the fire area. Equipment platforms cannot be part of any mezzanine and these platforms and walkways, stairs, and ladders that provide access to an equipment platform cannot be used as an exit from the building either. There are some area limitations that you must be aware of.

The total area of all equipment platforms within a room cannot be larger than two-thirds of the area of the room which they are in. If the equipment platform is located in the same room as a mezzanine, the area of the mezzanine must be determined by this chapter and the combined total area of the room that they are in. If a mezzanine is in a building that is required to have an automatic sprinkler system, equipment platforms must be fully protected by these sprinklers above and below the platform.

Width must be at least 20 feet.

- a) The automatic sprinkler system increase cannot apply to buildings with an occupancy in Group H-1.
- b) The automatic sprinkler system increase must not apply to the floor area of occupancy in Group H-2 or H-3. For mixed-use buildings containing these occupancies, the allowable area must be calculated in accordance with this book, with the sprinkler increase applying only to the portions of the buildings not classified as Group H-2 or H-3.

2.3.7 Height determination for sky terrace floors

For developments with sky terrace floors, the overall height control will be relaxed, based on the proposed storey height of the development. The additional allowable height over and above the overall aggregate height for the development is tabulated:

Propose story height of development	Additional height allowable over the overall aggregate height for developments with sky terrace levels
7- 20	10.0m or 32.8 ft
21- 30	15.0m or 49.2 ft
31- 40	20.0m or 65.6 ft
41- 50	25.0m or 82 ft
50 above	30m or 98.4 ft

NOTE:

- a) A sky terrace floor refers to a floor where the sky terrace areas within the 45-degree line occupy at least 60% of the floor plate, and is used for sky terrace and other communal purposes.
- b) This additional height can only be distributed to sky terrace floors within the development.
- c) Spaces for M&E services located directly beneath the sky terrace floor can also be included under the additional height. Drop-panels are not allowed at the soffit along the perimeter of sky terrace floors, as the intention is to encourage the provision of high volume open communal spaces.

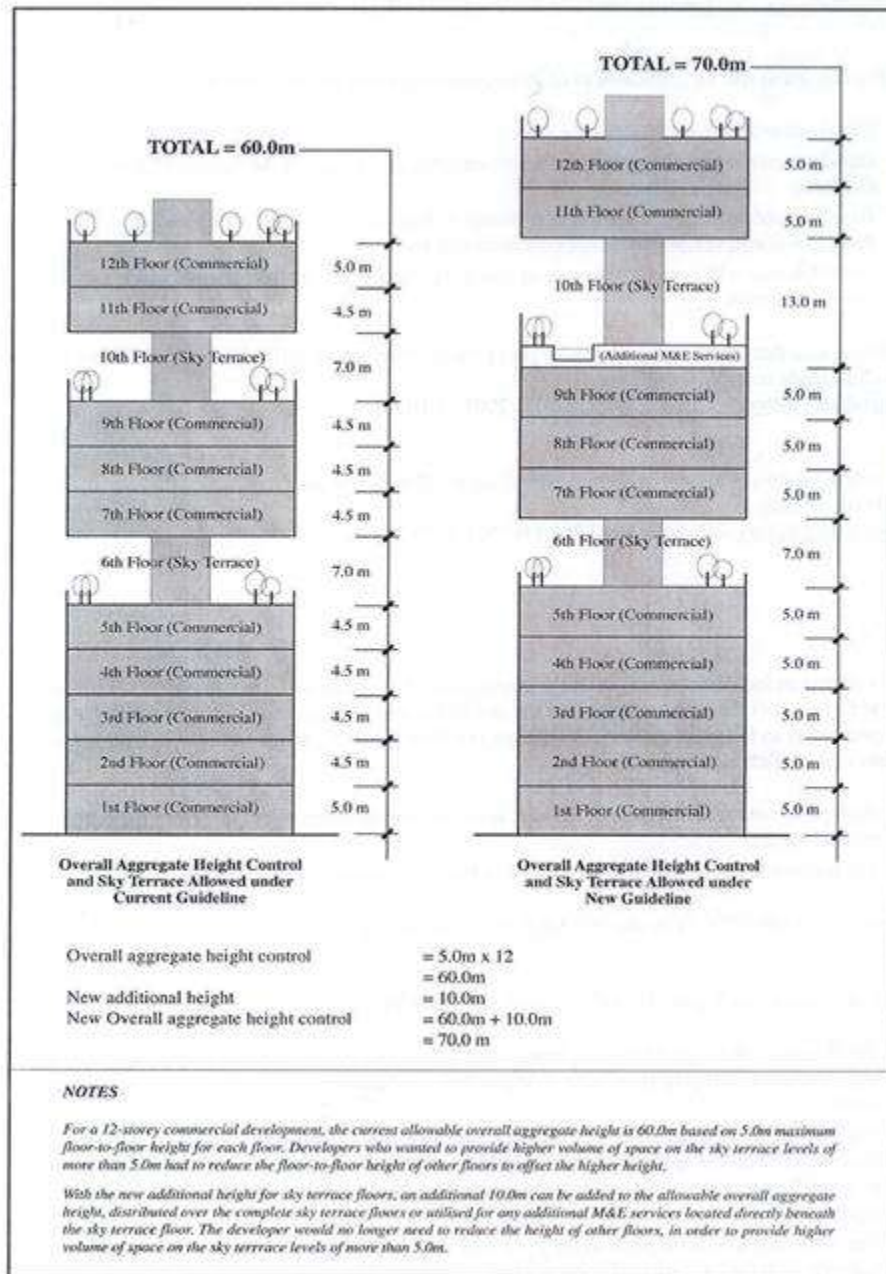


Figure 2.3.7.1 : Illustration On The Relaxation Of The Overall Aggregate Heights For Developments With Sky Terrace Floors

The illustration is shown as a guideline of a typical 12-storey commercial development that has an overall aggregate height of 60.0m based on 5.0m maximum floor-to-floor height for each floor, can enjoy an additional height of 10m, if the development includes at least one sky terrace floor.

PART 2 ARCHITECTURE AND URBAN DESIGN
SECTION 2.4 SPECIAL BUILDINGS AND CONSTRUCTION
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2.4 SPECIAL BUILDING AND CONSTRUCTION

2.4.1 General

2.4.1.1 Scope

The provisions of this chapter shall manage special building construction including membrane structures, temporary structures, pedestrian walkways and tunnels, automatic vehicular gates, awnings and canopies, marquees, signs, and towers and antennas.

2.4.2 Membrane Structures

2.4.2.1 General

The provisions of this section shall apply to air-supported, air-inflated, membrane-covered cable and membrane-covered frame structures, collectively known as membrane structures, erected for a period of 180 days or longer. Those erected for a shorter period of time shall comply with the *Part 5, Building Services (Fire)* and *Myanmar Fire Services Law*. Membrane structures covering water storage facilities, water clarifiers, water treatment plants, sewage treatment plants, greenhouses and similar facilities not used for human occupancy are required to meet only the requirements of *Part 3, Structural Design*. Membrane structures erected on a building, balcony, deck or other structure for any period of time shall comply with this section.

2.4.2.2 Definitions

The following words and terms shall, for the purposes of this section and as used elsewhere in this code, have the meanings shown herein.

AIR-INFLATED STRUCTURE. A structure that uses air-pressurized membrane beams, arches or other elements to enclose space. Occupants of such a structure do not occupy the pressurized area used to support the structure.

AIR-SUPPORTED STRUCTURE. A building wherein the shape of the structure is attained by air pressure and occupants of the structure are within the elevated pressure area. Air-supported structures are of two basic types:

Double skin. Similar to a single skin, but with an attached liner that is separated from the outer skin and provides an airspace which serves for insulation, acoustic, aesthetic or similar purposes.

Single skin. Where there is only the single outer skin and the air pressure is directly against that skin.

CABLE-RESTRAINED, AIR-SUPPORTED STRUCTURE. A structure in which the uplift is resisted by cables or webbings which are anchored to either foundations or deadmen. Reinforcing cable or webbing is attached by various methods to the membrane or is an integral part of the membrane. This is not a cable-supported structure.

MEMBRANE-COVERED CABLE STRUCTURE. A nonpressurized structure in which a mast and cable system provides support and tension to the membrane weather barrier and the membrane imparts stability to the structure.

MEMBRANE-COVERED FRAME STRUCTURE. A nonpressurized building wherein the structure is composed of a rigid framework to support a tensioned membrane which provides the weather barrier.

NONCOMBUSTIBLE MEMBRANE STRUCTURE. A membrane structure in which the membrane and all component parts of the structure are noncombustible.

2.4.2.3 Allowable floor areas

The area of a membrane structure shall not exceed the limitations set forth in *Chapter 3, General Building Heights and Areas*.

2.4.2.4 Maximum height

Membrane structures shall not exceed one story nor shall such structures exceed the height limitations in ft set forth in *Chapter 3, General Building Heights and Areas*.

Exception: Non-combustible membrane structures serving as roofs only.

2.4.2.5 Engineering design

The structure shall be designed and constructed to sustain dead loads, live loads including wind, rain or flood and seismic loads and in accordance with *Part 3, Structural Design*.

2.4.2.6 Inflation systems

Air-supported and air-inflated structures shall be provided with primary and auxiliary inflation systems to meet the minimum requirements of the following.

2.4.2.6.1 Equipment requirements

This inflation system shall consist of one or more blowers and shall include provisions for automatic control to maintain the required inflation pressures. The system shall be so designed as to prevent overpressurization of the system.

2.4.2.6.1.1 Auxiliary inflation system

In addition to the primary inflation system, in buildings exceeding 1,500 sq-ft (140 sq-m) in area, an auxiliary inflation system shall be provided with sufficient capacity to maintain the inflation of the structure in case of primary system failure. The auxiliary inflation system shall operate automatically when there is a loss of internal pressure and when the primary blower system becomes inoperative.

2.4.2.6.1.2 Blower equipment

Blower equipment shall meet all of the following requirements:

- a) Blowers shall be powered by continuous-rated motors at the maximum power required for any flow condition as required by the structural design.
- b) Blowers shall be provided with inlet screens, belt guards and other protective devices as required by the concerned Authority to provide protection from injury.
- c) Blowers shall be housed within a weather-protecting structure.
- d) Blowers shall be equipped with backdraft check dampers to minimize air loss when inoperative.
- e) Blower inlets shall be located to provide protection from air contamination. The location of inlets shall be approved.

2.4.2.6.2 Standby power

Wherever an auxiliary inflation system is required, an approved standby power-generating system shall be provided. The system shall be equipped with a suitable means for automatically starting the generator set upon failure of the normal electrical service and for automatic transfer and operation of all of the required electrical functions at full power within 60 seconds of such service failure. Standby power shall be capable of operating independently for a minimum of 4 hours.

2.4.2.6.3 Support provisions

A system capable of supporting the membrane in the event of deflation shall be provided for in air-supported and air-inflated structures having an occupant load of 50 or more or where covering a swimming pool regardless of occupant load. The support system shall be capable of maintaining membrane structures used as a roof not less than 20 ft (6096mm) above floor or seating areas. The support system shall be capable of maintaining other membranes at least 7 ft (2134 mm) above the floor, seating area or surface of the water.

2.4.3 Temporary Structures

2.4.3.1 General

The provisions of this section shall apply to structures erected for a period of less than 180 days. Tents and other membrane structures erected for a period of less than 180 days shall comply with the *Part 5, Building Services (Fire)* and *Myanmar Fire Services Law*. Those erected for a longer period of time shall comply with applicable sections of this code.

2.4.3.1.1 Permit required

Temporary structures that cover an area in excess of 120 sq-ft (11.16 sq-m), including connecting areas or spaces with a common means of egress or entrance which are used or intended to be used for the gathering together of 10 or more persons, shall not be erected, operated or maintained for any purpose without obtaining a permit from the concerned Authority.

2.4.3.2 Construction documents

A permit application and construction documents shall be submitted for each installation of a temporary structure. The construction documents shall include a site plan indicating the location of the temporary structure and information delineating the means of egress and the occupant load.

2.4.3.3 Means of egress

Temporary structures shall conform to the means of egress requirements of *Chapter 6, Means of Egress* and shall have a maximum exit access travel distance of 100 ft (30 480mm).

2.4.3.4 Design and construction

The structure shall be designed and constructed to sustain dead loads, live loads including wind, rain or flood and seismic loads and in accordance with *Part 3, Structural Design*. Those erected for a shorter period of time shall comply with the *Part 5, Building Services (Fire)* and *Myanmar Fire Services Law*.

2.4.4 Pedestrian Walkways or Tunnels

2.4.4.1 General

This section shall apply to connections between buildings such as pedestrian walkways and/or tunnels, located at, above or below grade level, that are used as a means of travel by persons. The pedestrian walkway shall not contribute to the building area or the number of stories or height of connected buildings.

2.4.4.2 Separate structures

Connected buildings shall be considered to be separate structures.

Exceptions:

a) Buildings on the same lot. Two or more buildings on the same lot shall be regulated as separate buildings or shall be considered as portions of one building if the building height of each building and the aggregate building area of the buildings are within the limitations of *Chapter 3, General Building Heights and Areas*. The provisions of this code applicable to the aggregate building shall be applicable to each building.

b) Structurally connected buildings and buildings with multiple wings shall be considered one structure.

2.4.4.3 Construction

The pedestrian walkway shall be of noncombustible construction.

Exceptions:

Combustible construction shall be permitted where connected buildings are of combustible construction.

2.4.4.4 Contents

Only materials and decorations approved by the concerned Authority shall be located in the pedestrian walkway.

2.4.4.5 Fire Barriers between pedestrian walkways and buildings

Walkways shall be separated from the interior of the building by not less than 2 hour fire barriers constructed. This protection shall extend vertically from a point 10 ft (3048 mm) above the walkway roof surface or the connected building roofline, whichever is lower, down to a point 10 ft (3048 mm) below the walkway and horizontally 10 ft (3048 mm) from each side of the pedestrian walkway. Openings within the 10 ft (3048 mm) horizontal extension of the protected walls beyond the walkway shall be equipped with devices providing a 3/4-hour fire protection rating.

Exception: The walls separating the pedestrian walkway from a connected building and the openings within the 10 ft (3048 mm) horizontal extension of the protected walls beyond the walkway are not required to have a fire-resistance rating by this section where any of the following conditions exist:

a) The distance between the connected buildings is more than 10 ft (3048 mm). The pedestrian walkway and connected buildings, except for open parking garages, are equipped throughout with an automatic sprinkler system. The wall is capable of resisting the passage of smoke or is constructed of a tempered, wired or laminated glass wall and doors subject to the following:

1) The wall or glass separating the interior of the building from the pedestrian walkway shall be protected by an automatic sprinkler system and the sprinkler system shall completely wet the entire surface of interior sides of the wall or glass when actuated;

2) The glass shall be in a gasketed frame and installed in such a manner that the framing system will deflect without breaking (loading) the glass before the sprinkler operates; and

3) Obstructions shall not be installed between the sprinkler heads and the wall or glass.

b) The distance between the connected buildings is more than 10 ft (3048 mm) and both side walls of the pedestrian walkway are at least 50 percent open with the open area uniformly distributed to prevent the accumulation of smoke and toxic gases.

c) Buildings are on the same lot.

d) Where exterior walls of connected buildings are required to have a fire-resistance rating greater than 2 hours, the walkway shall be equipped throughout with an automatic sprinkler system installed.

e) The previous exception shall apply to pedestrian walkways having a maximum height above grade of three stories or 40 ft (12 192 mm), or five stories or 55 ft (16 764 mm) where sprinklered.

2.4.4.6 Public way

The installation of a pedestrian walkway over a public right-of-way shall be subject to the approval of the applicable concerned Authority. The vertical clearance from the public right-of-way to the lowest part of a pedestrian walkway shall be 15 ft (4572 mm) minimum.

2.4.4.7 Egress

Access shall be provided at all times to a pedestrian walkway that serves as a required exit.

2.4.4.8 Width

The unobstructed width of pedestrian walkways shall not be less than 36 inches (914 mm). The total width shall not exceed 30 ft (9144 mm).

2.4.4.9 Tunneled walkway

Separation between the tunneled walkway and the building to which it is connected shall not be less than 2 hour fire-resistant construction and openings therein shall be protected.

2.4.5 Awnings and Canopies

2.4.5.1 General

Awnings or canopies shall comply with the requirements of this section and other applicable sections of this code.

2.4.5.2 Definitions

The following term shall, for the purposes of this section and as used elsewhere in this code, have the meaning shown herein.

AWNING. An architectural projection that provides weather protection, identity or decoration and is wholly supported by the building to which it is attached. An awning is comprised of a lightweight frame structure over which a covering is attached.

CANOPY. A permanent structure or architectural projection of rigid construction over which a covering is attached that provides weather protection, identity or decoration, and shall be structurally independent or supported by attachment to a building on one end and by not less than one stanchion on the outer end.

RETRACTABLE AWNING. A retractable awning is a cover with a frame that retracts against a building or other structure to which it is entirely supported.

2.4.5.3 Design and construction

Awnings and canopies shall be designed and constructed to withstand wind or other lateral loads and live loads as required by *Part 3, Structural Design* with due allowance for shape, open construction and similar features that relieve the pressures or loads. Structural members shall be protected to prevent deterioration. Awnings shall have frames of noncombustible material, fire-retardant-treated wood or noncombustible covers and shall be fixed, retractable, folding or collapsible.

2.4.5.4 Public way

There should be temporary awnings which project to the public right-of-way. If it is allowed by the concerned authority, the vertical clearance from the public right-of-way to the lowest part of awning, including valances, shall be 7 ft (2134 mm) minimum and the projection to the public way shall not be more than 3 ft.

2.4.6 Marquees

2.4.6.1 General

Marquees shall comply with this section and other applicable sections of this code.

2.4.6.2 Definitions

The following term shall, for the purposes of this section and as used elsewhere in this code, have the meaning shown herein.

MARQUEE. A permanent roofed structure attached to and supported by the building.

2.4.6.3 Thickness

The maximum height or thickness of marquee measured vertically from its lowest to its highest point shall not exceed 3 ft (914 mm) where the marquee projects more than two-thirds of the distance from the property line to the curb line, and shall not exceed 9 ft (2743 mm) where the marquee is less than two-thirds of the distance from the property line to the curb line.

2.4.6.4 Roof construction

Where the roof or any part thereof is a skylight, the skylight shall comply with the requirements of *Part 3, Structural Design*. Every roof and skylight of a marquee shall be sloped to downspouts that shall conduct any drainage from the marquee in such a manner so as not to spill over the sidewalk.

2.4.6.5 Location prohibited

Every marquee shall be so located as not to interfere with the operation of any exterior standpipe, and such that the marquee does not obstruct the clear passage of stairways or exit discharge from the building or the installation or maintenance of street lighting.

2.4.6.6 Construction

A marquee shall be supported entirely from the building and constructed of noncombustible materials. Marquees shall be designed as required in *Part 3, Structural Design*. Structural members shall be protected to prevent deterioration.

2.4.6.7 Public way

If it is allowed to construct in the public right-of-way by the concerned authority, marquees with less than 15 ft (4572 mm) clearance above the sidewalk shall not extend into or occupy more than two-thirds the width of the sidewalk measured from the building. Stanchions or columns that support awnings, canopies, marquees and signs shall be located not less than 2 ft (610 mm) in from the curb line.

2.4.7 Signs

2.4.7.1 General

A sign shall not be erected in a manner that would confuse or obstruct the view of or interfere with exit signs required by means of egress or with official traffic signs, signals or devices. Within Conservation Zones and designated historic areas, signage and materials must comply with the local planning guidance intended to conserve and enhance the built environment. Commercial, advertising billboards will not be permitted in Conservation Zones, designated historic areas and landscape or sites affecting their broader setting. Signs shall not be erected, constructed or maintained so as to obstruct any fire escape or any window or door or opening used as a means of egress or so as to prevent free passage from one part of a roof to any other part thereof. A sign shall not be attached in any form, shape or manner to a fire escape, nor be placed in such manner as to interfere with any opening required for ventilation. Signs and sign support structures, together with their supports, braces, guys and anchors, shall be kept in repair and in proper state of preservation. The display surfaces of signs shall be kept neatly painted or posted at all times.

Signs which are written in any foreign language shall have a corresponding translation in English or in Myanmar. No sign or signboard shall be constructed as to unduly obstruct the natural view of the landscape, distract or obstruct the view of the public as to constitute a traffic hazard, or otherwise defile, debase or offend aesthetic and cultural values and traditions. The installation of all kinds of signs shall be such that a harmonious and aesthetic relationship of all units therein is presented.

2.4.7.2 Definitions

For the purpose of this Section, the following definitions shall apply.

ADVERTISING SIGN. Any surface or structure with characters, letters or illustrations applied thereto and displayed in any manner whatsoever out of doors for purposes of advertising or to give information regarding or to attract the public to any place, person, public performance, article or merchandise whatsoever, and which surface or structure is attached to, forms part of or is connected with any building, or is fixed to a tree or to the ground or to any pole, screen, fence or hoarding or displayed in space.

BANNER SIGN. A sign utilizing a banner as its display surface.

CANOPY SIGN. A sign affixed to the visible surface(s) of an attached or freestanding canopy.

CLOSED SIGN. An advertising sign in which at least more than fifty percent of the area is solid or tightly enclosed or covered.

COMBINATION SIGN. A sign that is supported partly by a pole and partly by a building structure.

DIRECTION SIGN. Usually included with an arrow and used for indicating a change in route or confirmation to a correct direction.

ELECTRIC SIGN. An advertising sign in which electric fittings, which are an integral part of the signs, are used

FREESTANDING SIGN. A sign principally supported by a structure affixed to the ground, and not supported by a building, including signs supported by one or more columns, poles or braces placed in or upon the ground.

GROUND SIGN. An advertising sign detached from a building, and erected or painted on the ground or on any pole, screen, fence or hoarding and visible to the public.

IDENTIFICATION SIGN. A sign that gives specific location information, identifies specific items, for example, Parking Lot B, Building No. 5, First Aid, etc.

ILLUMINATED SIGN. An advertising sign, permanent or otherwise, the functioning of which depends upon its being illuminated by direct or indirect light, and other than an electric sign.

INFORMATIONAL SIGN. Used for overall information for general organization of a series of elements that is, campus plan, bus route, building layout, shopping mall plan, etc.

MARQUEE SIGN. An advertising sign attached to or hung from a marquee canopy or other covered structure projecting from and supported by the building and extending beyond the building wall, building line.

OPEN SIGN. An advertising sign in which at least fifty percent of the enclosed area is uncovered or open to the transmission of wind.

PORTABLE SIGN. Any sign not permanently attached to the ground or to a building or building surface.

PROJECTING SIGN. An advertising sign affixed to any building element and projecting more than 300 mm therefrom.

REGULATORY SIGN. Sign that gives operational requirements, restrictions or gives warnings, usually used for traffic delineation or control, for example 'stop', 'No parking', 'one Way', etc.

ROOF SIGN. An advertising sign erected or placed on or above the parapet or any portion of a roof of a building including signs painted on the roof of a building.

SKY SIGN. An advertising sign displayed in space like:

- a) a gas filled balloon anchored to a point on the ground and afloat in the air with or without a streamer of cloth, etc; or
- b) sky-writing, that is, a sign or word traced in the atmosphere by smoke discharged from an aeroplane.

SIGN. Any device visible from a public place that displays either commercial or non-commercial messages by means of graphic presentation of alphabetic or pictorial symbols or representations. Noncommercial flags or any flags displayed from flagpoles or staffs shall not be considered as signs

TEMPORARY SIGN. An advertising sign, banner or other advertising device constructed of cloth, canvas, fabric or any other light material, with or without a structural frame, intended for a limited period of display; including decorative displays for holidays or public demonstrations.

VERANDAH SIGN. An advertising sign attached to, posted on or hung from a VERANDAH.

WALL SIGN. An advertising sign, other than a projecting sign, which is directly attached to or painted or pasted on the exterior surface of or structural element of any building.

WINDOW SIGN. A sign affixed to the surface of a window with its message intended to be visible to and readable from the public way or from adjacent property.

2.4.7.3 Permits

No sign shall be erected, altered or maintained without first obtaining a permit for the same from the concerned Authority.

2.4.7.4 Maintenance and inspection

All signs for which a permit is required, together with all their supports, braces, guys and anchors shall be kept in good repair, both structurally and aesthetically, and when not galvanized or constructed of approved corrosion-resistive non-combustible materials, shall be painted when necessary to prevent corrosion. It shall be the duty and responsibility of the owner of every sign to maintain the immediate premises occupied by the sign, in a clean, sanitary and healthy condition. Every sign for which a permit has been issued and every existing sign for which a permit is required shall be inspected by the concerned Authority at least once in every calendar year.

2.4.7.5 General requirements for all signs**2.4.7.5.1 Load**

Every advertising sign shall be designed so as to withstand safely the wind, dead, seismic and other loads as set out in *Part 3, Structural Design*.

2.4.7.5.2 Illumination

No sign shall be illuminated by other than electrical means and electrical devices and wiring shall be installed in accordance with the requirements of *Part 5, Building Services (Electrical and Allied Installations)*. In no case, shall any open spark or flame be used for display purposes unless specifically approved by the Authority.

2.4.7.5.3 Design and location of advertising signs

- a) Sign should not obstruct any pedestrian movement, fire escape, door or window, opening used as a means for egress or fire fighting purposes.
- b) No sign shall in any form or manner interfere with openings required for light and ventilation.
- c) When possible signs should be gathered together into unified systems. Sign clutter should be avoided in the landscape.
- d) Signs should be combined with lighting fixture to reduce unnecessary posts and for ease of illuminating the signs.
- e) Information signs should be placed at natural gathering spots and included in the design of sight furniture.
- f) Placement of sign should be avoided where they may conflict with pedestrian traffic.
- g) Sign should be placed to allow safe pedestrian clearance vertically and laterally.
- h) Braille strips may be placed along sign edges or raised letters may be used for readability for the blind and partially sighted.
- i) No sign shall be attached in anyway to a tree or shrub.
- j) The signs other than pertaining to building shall not be permitted to come in front of buildings such as hospitals, educational institutions, public offices, museums, buildings devoted to religious worship and buildings of national importance.

2.4.7.5.4 Materials

Materials for construction of signs or sign structures shall be of the quality and grade as specified in *Part 6, Building Materials*. Exceptions will be made in respect of sign in conservation zones, where they will conform to the planning guidance for each zone.

2.4.7.5.4.1 Use of combustibles

Wood or plastic or other 'materials of combustible characteristics similar to wood may be used for mouldings, cap pings, nailing blocks, letters and latticing where permitted and for other purely ornamental features of signs. Sign facings may be made of approved combustible materials provided the area of each face is not more than 108 sq-ft (10 sq-m) and the wiring for electric lighting is entirely enclosed in metal conduit and installed with a clearance of not less than 2 in (5 cm) from the facing material.

2.4.7.5.4.2 Glass in signs

All glass used in advertising signs, other than glass tubing used in gas discharge or similar signs, shall be of safety glass conforming to accepted standards at least 3 mm thick. Glass panels in advertising signs shall not exceed 64.58 sq-ft (6 sq-m) in area, each panel being securely fixed in the body of the sign independently of all other panels. Glass signs shall be properly protected from the possibility of damage by falling objects by the provisions of suitable protecting metal canopies, or by other approved means. Use of glass may be discouraged or avoided wherever possible for signs placed overhead.

2.4.7.5.5 Traffic control interference

No advertising sign shall be erected or maintained which interferes with or is likely to interfere with any sign or signal for the control of traffic. No advertising sign shall be placed particularly in bends and curves so as to obstruct the view of traffic at intersecting streets.

2.4.7.5.6 Draining of signs

Adequate provision for drainage shall be made in every advertising sign, where the possibility of collection of moisture exists.

2.4.7.5.7 Animated devices

Signs which contain moving section or ornaments shall have fail-safe provisions to prevent the section or ornaments from releasing and falling or shifting its centre of gravity more than 18 in (450 mm). The fail-safe device shall be in addition to the mechanism and its housing which operate the movable section or ornament. The fail-safe device shall be capable of supporting the full dead weight of the section or ornament when moving mechanism releases.

2.4.7.6 Electric signs and illuminated signs**2.4.7.6.1 Material for electric signs**

Every electric sign shall be constructed of non-combustible material except where the sign is purely a flood-lit sign.

2.4.7.6.2 Installation of electric signs and illuminated signs

Every electric sign and illuminated sign shall be installed in accordance with *Part 5, Building Services (Electrical and Allied Installations)*.

2.4.7.6.3 Colour

No illuminated sign in red, amber or green colour shall be erected or maintained within a horizontal distance of 32.8 ft (10 m) of any illuminated traffic sign.

2.4.7.6.4 Height

All advertising signs illuminated by light other than a white light at height of less than two storeys or 20 ft (6 m) above the fpath, whichever be the greater height, shall be suitably screened so as to satisfactorily prevent any interference with any sign or signal for the control of traffic.

2.4.7.6.5 Intense illumination

No person shall erect any sign which is of such intense illumination as to disturb the residents in adjacent or nearby residential buildings. Notwithstanding any permission given for such erection, any such sign which after erection is, in the opinion of the Authority, of such intense illumination as to disturb the occupants of adjacent or nearby buildings shall, on the order of the Authority, be suitably altered or removed by the owner of the site concerned within such reasonable period as the Authority may specify.

2.4.7.6.6 Hours of operation

No electric sign, other than those necessary in the opinion of the Authority in the interest of public amenity, health and safety, shall be operated between midnight and sunrise.

2.4.7.6.7 Flashing, Occulting and Animated

No flashing, occulting or animated advertising signs, the periodicity of which exceeds 30 flashes to the minute, shall be erected so that the lowest point of such signs is less than 30 ft (9 m) above the ground level.

2.4.7.7 Ground signs**2.4.7.7.1 Material**

Every ground sign exceeding 20 ft (6 m) in height together with frames, supports and braces shall be constructed of non-combustible material except as in 2.4.7.5.4.1.

2.4.7.7.2 Dimensions

No ground sign shall be erected to a height exceeding 30 ft above the ground. Lighting reflectors may extend beyond the top or face of the sign.

2.4.7.7.3 Supports and anchorage

Every ground sign shall be firmly supported and anchored to the ground. Supports and anchors shall be of treated timber in accordance with good practice, or metal treated for corrosion resistance or masonry or concrete.

2.4.7.7.4 Site cleaning

The owner of any site on which a ground sign is erected shall be responsible for keeping such part of the site as is visible from the street, clean, sanitary, un-offensive and free of all obnoxious substances and unsightly conditions to the approval of the Authority.

2.4.7.7.5 Obstruction to traffic

No ground sign shall be erected so as to obstruct free access to or egress from any building.

2.4.7.7.6 Set Back

No ground sign shall be set nearer to the street line than the established building line.

2.4.7.7.7 Bottom clearance

The bottom line of all ground signs shall be at least 2 ft above the ground, but the intervening space may be filled with open lattice work or platform decorative trim.

2.4.7.8 Roof signs

2.4.7.8.1 Material

Every roof sign together with its frames, supports and braces, shall be constructed of non-combustible material, except as in 2.4.7.5.4.1. Provision shall be made for electric grounding of all metallic parts; and where combustible materials are permitted in letters or other ornamental features, all wiring and tubing shall be kept free and insulated there from.

2.4.7.8.2 Dimensions

No roof sign shall exceed the following heights on buildings of heights:

Table 2.4.1 Dimensions for Roof Signs

No.	Height of Building	Height of Sign (Max)
1.	Not exceeding four storeys or 59 ft (18m)	6.56 ft (2 m)
2.	Five to eight storeys or exceeding 59 ft (18m) but not exceeding 118 ft (36m)	9.84 ft (3 m)
3.	Exceeding eight storeys or 118 ft (36m), provided that in calculating the height of such signs, signs placed one above the other, or on planes at different levels of the same building shall be deemed to be one sign, whether or not such signs belong to different owners	16.4 ft (5 m)

2.4.7.8.3 Location

- a) No roof sign shall be so placed on the roof of any building as to prevent free passage from one part of the roof to another.
- b) No roof sign shall be placed on or over the roof of any building unless the entire roof construction is of non-combustible material.

2.4.7.8.4 Projection

No roof sign shall project beyond the existing building line of the building of which it is erected or shall extend beyond the roof in any direction.

2.4.7.8.5 Supports and anchorage

Every roof sign shall be thoroughly secured and anchored to the building on or over which it is erected. All loads shall be safely distributed to the structural members of the building.

2.4.7.8.6 Clearance

Roof signs shall be so constructed as to leave a clear space of not less than 6 ft (1829 mm) between the roof level and the lowest part of the sign and shall have at least 5 ft (1524 mm) clearance between the vertical supports thereof.

2.4.7.9 Verandah signs

2.4.7.9.1 Material

Every verandah sign shall be constructed entirely of non-combustible material except as in 2.4.7.5.4.1.

2.4.7.9.2 Dimensions

No verandah sign exceed 3.28 ft (1 m) in height. No verandah sign hanging from a verandah shall exceed 8.2 ft (2.5 m) in length and 50 mm in thickness, except that verandah box signs measuring not more than 200 mm in thickness, measured between the principal faces of the sign and constructed entirely of metal wired glass may be erected.

2.4.7.9.3 Alignment

Every verandah sign shall be set parallel to the building line, except that any such sign hanging from a verandah shall be set at right angles to the building line.

2.4.7.9.4 Location

Verandah signs, other than hanging signs only, shall be placed in the following locations:

- a) Immediately above the eaves of the VERANDAH roof in such a manner as not to project beyond the rear of the roof gutter;
- b) Against but not above or below the VERANDAH parapet or balustrade provided such parapet or balustrade is solid and the sign does not project more than 20 cm from the outside face of such parapet or balustrade; or
- c) On the VERANDAH beams or parapets in the case of painted signs.

2.4.7.9.5 Height of hanging VERANDAH signs

Every VERANDAH sign hanging from a VERANDAH shall be fixed in such a manner that the lowest point of such sign is not less than 8.2 ft (2.5 m) above the pavement.

2.4.7.9.6 Projection

Except as provided for in 2.4.7.9.4, no VERANDAH sign shall extend outside the line of the VERANDAH to which it is attached.

2.4.7.10 Wall signs

2.4.7.10.1 Material

Every wall sign exceeding 43 sq.-t (4 sq-m) in area shall be constructed of non-combustible material except as in 2.4.7.5.4.1.

2.4.7.10.2 Dimensions

- a) The total area of any wall sign shall not exceed 215 sq.ft (20 sq.m) for every 49 ft (15 m) of building frontage to the street to which such sign faces; except that in the case of a wall sign, consisting only of the name of a theatre or cinema, the total area of such sign shall not exceed 2153 sq.ft (200 sq.m).
- b) No wall sign which exceeds 323 sq.ft (30 sq.m) in area shall be located on any wall not directly facing the road; provided that any such sign or signs shall not exceed 25 percent of the side wall area visible from the street.

2.4.7.10.3 Projection

No wall sign shall extend above the top of the wall or beyond the ends of the wall to which it is attached. At any place where pedestrians may pass along a wall, any wall sign attached thereto shall not project more than 7.5 cm there from within a height of 8.2 ft (2.5 m) measured from the level of such place.

2.4.7.10.4 Supports and attachment

Every wall sign attached to walls shall be securely attached. Wooden blocks or anchorage with wood used in connection with screws, staples or nails shall not be considered proper anchorage, except in the case of wall signs attached to walls of wood.

2.4.7.11 Projecting signs**2.4.7.11.1 Material**

Every projecting sign and its support and framework shall be constructed entirely of non-combustible material.

2.4.7.11.2 Projection and height

No projecting sign or any part of its supports or frame work shall project more than 6.56 ft (2 m) beyond the building; however it shall not project beyond the plot line facing the street; when it projects into the street it shall be at clear height of 8.2 ft (2.5 m) from the road.

a) The axes of all projecting signs shall be at right angles to the main face of the building. Where a V-construction is employed for the faces, the base of the sign against the building shall not exceed the amount of the overall projection.

b) No projecting signs shall extend above the eaves of a roof or above the part of the building face to which it is attached.

c) The maximum height of a projecting sign shall be related to the height of the building to which it is attached in the following manners:

Table 2.4.2 Dimensions for Projecting Signs

No.	Height of Building	Height of Sign (Max)
1.	Not exceeding four storeys or 59 ft (18m)	30 ft (9 m)
2.	Five to eight storeys or exceeding 59 ft(18m) but not exceeding 118 ft(36m)	39 ft (12 m)
3.	Exceeding eight storeys or 118 ft (36 m)	49 ft (15 m)

2.4.7.11.3 Supports and attachment

Every projecting sign shall be securely attached to a building so that movement in any direction is prevented by corrosion-resistant metal brackets, rods, anchors, supports, chains or wire ropes so designed and arranged that half the number of such fixing devices may safely support the sign under all circumstances. Staples or nails shall not be used to secure any projecting sign to any building.

2.4.7.12 Marquee signs**2.4.7.12.1 Materials**

Marquee signs shall be constructed entirely of metal or other approved non-combustible materials.

2.4.7.12.2 Height

Such sign shall not exceed 6.56 ft (2 m) in height nor shall they project below the fascia of the marquee nor lower than 8.2 ft (2.5 m) above the fpath.

2.4.7.12.3 Length

Marquee signs may extend the full length but in no case shall they project beyond the ends of the marquee.

2.4.7.13 Sky Signs

In the case of the sky signs, the regulations laid down by the concerned Authority concerned shall apply.

2.4.7.14 Temporary advertising signs, travelling circus signs, fair signs and decorations during public rejoicing

2.4.7.14.1 Types

None of the following advertising signs shall be erected or maintained, other than as temporary signs erected in accordance with 2.4.7.14.2:

- a, Any advertising sign which is painted on or fixed on to or between the columns of a VERANDAH,
- b, Any advertising sign which projects above or below any fascia, bearer, beam or balustrade of a VERANDAH or balcony,
- c, Any advertising sign which is luminous or illuminated and which is fixed to any fascia bearer, beam or balustrade of any splayed or rounded corner of a VERANDAH or balcony,
- d, Any streamer sign erected across a road,
- e, Any sign not securely fixed so as to prevent the sign swinging from side to side;
- f, Any advertising sign made of cloth, paper mache, or similar or like material but excluding licensed paper signs on hoardings or fences,
- g, Any advertising sign on a plot used or intended to be used exclusively for residential purposes, other than a brass plate or board preferably not exceeding 600 mm x 450 mm in size, affixed to the fence or entrance door or gate of a dwelling, and in the case of a block of flats, affixed to the wall of the entrance hall or entrance door of any flat and
- h, Any sign on trees, rocks, hillsides and similar natural features.

2.4.7.14.2 Requirements for temporary signs

All temporary advertising, travelling circus and fair signs and decorations during public rejoicing shall be subject to the approval of the Authority and shall be subjected to the approval of the Authority and shall be erected so as not to obstruct any opening and to minimize fire risk.

The advertisement contained on any such sign shall pertain only to the business, industry or other pursuit conducted on or within the premises on which such sign is erected or maintained. Temporary advertising signs shall be removed as soon as torn or damaged and in any case within 14 days after erection unless extended.

The Authority shall be empowered to order the immediate removal of any temporary advertising sign or decoration, where, in its opinion such action is necessary in the interests of public amenity and safety.

2.4.7.14.2.1 Pole signs

Pole signs shall be constructed entirely of non-combustible materials and shall conform to the requirements for ground or roof signs as the case may be. Such signs may extend beyond the street line if they comply with the provisions for projecting signs.

2.4.7.14.2.2 Banner and cloth signs

Temporary signs and banners attached to or suspended from a building, constructed of cloth or other combustible material shall be strongly constructed and shall be securely attached to their supports. They shall be removed as soon as torn or damaged, and in no case later than 14 days after erection; except, that permits for temporary signs suspended from or attached to a canopy or marquee shall be limited to a period of 10 days.

2.4.7.14.2.3 Maximum size

Temporary signs shall not exceed 108 sq.ft (10 sq.m) in area.

2.4.7.14.2.4 Projection

Temporary signs of cloth and similar combustible construction shall not extend more than 300 mm over or into a street or other public space except that such signs when constructed without a frame may be supported flat against the face of a canopy or marquee or maybe suspended from the lower fascia thereof but shall not extend closer to the ftpath than 8.2 ft (2.5 m).

2.4.7.14.2.5 Bill boards

Bill boards set up by the Authority shall be used for temporary signs, symbols, bills for entertainment, etc, so that other walls of the city are not defaced.

Bills for entertainment and other functions shall not be affixed on to building walls other than the bill boards. The organization responsible for such bills and posters shall be held responsible for any such defacement and non-removal of signs.

2.4.8 Telecommunication and broadcast towers

2.4.8.1 Location and Access

Towers shall be located such that guy wires and other accessories shall not cross or encroach upon any street or other public space, or over above-ground electric utility lines, or encroach upon any privately owned property without the written consent of the owner of the encroached-upon property, space or above-ground electric utility lines.

2.4.9 Swimming Pool Enclosures

2.4.9.1 General

Swimming pools shall comply with the requirements of this section and other applicable sections of this code.

2.4.9.2 Definition

The following word and term shall, for the purposes of this section and as used elsewhere in this code, have the meaning shown herein.

SWIMMING POOLS. Any structure intended for swimming, recreational bathing or wading that contains water over 24 inches (610 mm) deep. This includes in-ground, above-ground and on-ground pools; hot tubs; spas and fixed-in-place wading pools.

2.4.9.3 Public swimming pools

Public swimming pools shall be completely enclosed by a fence at least 4 ft (1290 mm) in height or a screen enclosure. Openings in the fence shall not permit the passage of a 4-inch-diameter (102 mm) sphere. The fence or screen enclosure shall be equipped with self-closing and self-latching gates.

2.4.9.4 Residential swimming pools

Residential swimming pools shall comply with the followings.

2.4.9.4.1 Barrier height and clearances

The top of the barrier shall be at least 48 inches (1219 mm) above grade measured on the side of the barrier that faces away from the swimming pool. The maximum vertical clearance between grade and the bottom of the barrier shall be 2 inches (51 mm) measured on the side of the barrier that faces away from the swimming pool. Where the top of the pool structure is above grade, the barrier is authorized to be at ground level or mounted on top of the pool structure, and the maximum vertical clearance between the top of the pool structure and the bottom of the barrier shall be 4 inches (102 mm).

2.4.9.4.1.1 Openings

Openings in the barrier shall not allow passage of a 4-inch-diameter (102 mm) sphere.

2.4.9.4.1.2 Solid barrier surfaces

Solid barriers which do not have openings shall not contain indentations or protrusions except for normal construction tolerances and tooled masonry joints.

2.4.9.4.1.3 Closely spaced horizontal members

Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is less than 45 inches (1143 mm), the horizontal members shall be located on the swimming pool side of the fence. Spacing between vertical members shall not exceed $1\frac{3}{4}$ inches (44 mm) in width. Where there are decorative cutouts within vertical members, spacing within the cutouts shall not exceed $1\frac{3}{4}$ inches (44 mm) in width.

2.4.9.4.1.4 Widely spaced horizontal members

Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is 45 inches (1143 mm) or more, spacing between vertical members shall not exceed 4 inches (102 mm). Where there are decorative cutouts within vertical members, spacing within the cutouts shall not exceed $1\frac{3}{4}$ inches (44 mm) in width.

2.4.9.4.1.5 Chain link dimensions

Maximum mesh size for chain link fences shall be a $2\frac{1}{4}$ inch square (57 mm square) unless the fence is provided with slats fastened at the top or the bottom which reduce the openings to no more than $1\frac{3}{4}$ inches (44 mm).

2.4.9.4.1.6 Diagonal members

Where the barrier is composed of diagonal members, the maximum opening formed by the diagonal members shall be no more than $1\frac{3}{4}$ inches (44 mm).

2.4.9.4.1.7 Gates

Access doors or gates shall comply with the requirements of Sections 2.4.9.4.1.1 through 2.4.9.4.1.6 and shall be equipped to accommodate a locking device. Pedestrian access doors or gates shall open outward away from the pool and shall be self-closing and have a self-latching device.

2.4.9.4.1.8 Dwelling wall as a barrier

Where a wall of a dwelling serves as part of the barrier, the following shall apply:

Doors with direct access to the pool through that wall shall be equipped with an alarm that produces an audible warning when the door and/or its screen, if present, are opened. In dwellings not required to be Accessible units, the deactivation switch shall be located 54 inches (1372 mm) or more above the threshold of the door. In dwellings required to be Accessible units, the deactivation switch(es) shall be located at 54 inches (1372 mm) maximum and 48 inches (1219 mm) minimum above the threshold of the door.

2.4.9.4.1.9 Pool structure as barrier

Where an above-ground pool structure is used as a barrier or where the barrier is mounted on top of the pool structure, and the means of access is a ladder or steps, then the ladder or steps either shall be capable of being secured, locked or removed to prevent access, or the ladder or steps shall be surrounded by a barrier which meets the requirements of Sections 3109.4.1.1 through 3109.4.1.8. When the ladder or steps are secured, locked or removed, any opening created shall not allow the passage of a 4-inch-diameter (102 mm) sphere.

2.4.9.4.2 Indoor swimming pools

Walls surrounding indoor swimming pools shall not be required to comply with Section 2.4.9.4.1.8.

2.4.9.4.3 Prohibited locations

Barriers shall be located so as to prohibit permanent structures, equipment or similar objects from being used to climb the barriers.

2.4.10 Automatic Vehicular Gates

2.4.10.1 General

Automatic vehicular gates shall comply with the requirements of this section and other applicable sections of this code.

2.4.10.2 Definition

The following word and term shall, for the purposes of this section and as used elsewhere in this code, have the meaning shown herein.

VEHICULAR GATE. A gate that is intended for use at a vehicular entrance or exit to a facility, building or portion thereof, and that is not intended for use by pedestrian traffic.

PART 2 ARCHITECTURE AND URBAN DESIGN

SECTION 2.5 INTERIOR ENVIRONMENT

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.5 INTERIOR ENVIRONMENT

2.5.1 Scope

The provisions of this chapter shall govern ventilation, lighting, and courtyards, room dimensions and materials associated with the interior spaces of buildings. Exceptions to the provisions of this chapter are permitted for listed and historic buildings (see *Chapter 10*).

2.5.2 General

The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

2.5.2.1 Definitions

ATTIC: It means a room at the top of the house under the roof.

COURTYARD: It is an enclosed area surrounded by a building or parts of a building which is open to the sky.

GRADE: The grade (also called slope, incline, gradient, pitch or rise) of a physical feature, topographic landform or constructed element, refers to the amount of inclination of that surface to the horizontal.

HEADROOM: It means the clear vertical distance between the finished floor level or the lowest part of the room and the underside of the ceiling or the lower surface of the cover of that room.

RAMP: It means the sloping part of surface which joins two different levels.

SUNROOM ADDITION: A one-storey addition added to an existing building with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof.

HABITABLE SPACE: It means any inner space meant for human occupation of more than 8 hours per day.

OCCUPIED SPACE: It means any space used by human beings as storage or similar functions but not for living and sleeping.

2.5.3 Ventilation

2.5.3.1 General

All habitable inner spaces shall be provided with natural ventilation, or mechanical ventilation.

2.5.3.2 Attic spaces

Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof framing members shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain and snow. A minimum of 1 inch (25 mm) of airspace shall be provided between the insulation and the roof sheathing. The net free ventilating area shall not be less than 1/150 of the area of the space ventilated, with 50 percent of the required ventilating area provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet (914 mm) above eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents.

2.5.3.2.1 Openings into attic

Exterior openings into the attic space of any building intended for human occupancy shall be covered sufficiently to prevent the entry of undesirable animals and insects.

2.5.3.3 Under-floor ventilation

The space between the bottom of the floor joists and the earth under any building except spaces occupied by a basement or cellar shall be provided with ventilation openings through foundation walls or exterior walls. Such openings shall be placed so as to provide cross ventilation of the under-floor space.

2.5.3.4 Ceiling ventilation

The space between the ceiling and the roof shall be provided with openings for ventilation which shall be protected from intrusion of birds, insects and other animals.

2.5.3.5 Natural ventilation

Natural ventilation of an occupied space shall be through windows, doors, louvers or other openings to the outdoors. The operating mechanism for such openings shall be provided with ready access so that the openings are readily controllable by the building occupants.

2.5.3.5.1 Ventilation area required

All habitable spaces which are meant for human occupation of more than 8 hours daily shall be provided with openings of minimum 10 percent to the floor area for natural ventilation.

Exception : Exterior openings required for ventilation in stairwell, corridors, etc. shall be in accordance with Fire Code.

2.5.3.5.1.1 Openings below grade

Where openings below grade shall be required outside horizontal clear space measured perpendicular to the opening shall be one and one-half times the depth of the opening. The depth of the opening shall be measured from the average adjoining ground level to the bottom of the opening.

2.5.3.5.1.2 Openings for basement

The openings for basement shall have an area of not less than 10 percent of the floor area of the interior room or space. If enough natural ventilation cannot be provided, mechanical ventilation is required according to Part 5 Building Services.

2.5.3.5.1.3 Bathrooms

Rooms containing bathtubs, showers, spas and similar bathing fixtures shall have an area of not less than 4 percent of the floor area of the interior room or space if cannot be provided mechanically ventilated.

2.5.3.6 Mechanical space

The ventilation for mechanical space such as lift machine room, electrical room, generator room, etc. shall be provided in accordance with Part 5 Building Services.

2.5.3.7 Openings on courtyards

Where natural ventilation is to be provided by openings onto courtyards, such courtyards shall comply with Section 2.5.5.

2.5.3.8 Artificial or mechanical ventilation

This system may be regarded as generally desirable in all rooms occupied by more than 50 persons, where the space per occupant is less than 3 cu-m (105.86 cu-ft) and the opening area for through natural ventilation is less than 15% of habitable area.

2.5.4 Lighting

2.5.4.1 General

Every space intended for human occupancy shall be provided with natural light by means of exterior glazed openings or artificial light. Exterior glazed openings shall open directly onto a public way or onto a yard or court.

2.5.4.2 Natural light

The minimum net glazed area shall not be less than 8 percent of the floor area of the room.

2.5.4.2.1 Exterior openings

Exterior openings required for natural light shall open directly onto a public way, or courtyard. Exceptions:

a) Required exterior openings are permitted to open into a roofed porch where the porch:

- 1) Has a ceiling height of not less than 7 feet (2134 mm).
- 2) Has a longer side at least 65 percent open and unobstructed.

2.5.4.3 Artificial light

The artificial light shall be illuminated in accordance with Part 5 Building Services (Lighting).

2.5.5 Courtyards

2.5.5.1 General

This section shall apply to courtyards adjacent to exterior openings that provide natural light or ventilation. Such courtyards shall be on the same property as the building.

2.5.5.2 Courtyards

Courtyards shall not be less than 10 feet in width for one- and two-storey buildings. For buildings more than two stories in height, the minimum width of the courtyard shall be increased at the rate of 0.1 of the height increase of each additional storey.

2.5.5.3.1 Courtyard access

Access shall be provided to the bottom of courtyards for cleaning purposes.

2.5.5.3.2 Air intake

Courtyards more than two stories in height shall be provided with a horizontal air intake at the bottom not less than 10 square feet (0.93 m²) in area and leading to the exterior of the building unless abutting a public way.

2.5.5.3.3 Courtyard drainage

The bottom of every courtyard shall be properly graded and drained to a public sewer or other approved disposal system.

2.5.6 Internal Spaces

2.5.6.1 Unit sizes and room dimensions

The floor area, not including public stair of smallest residential unit, for one family in the urban areas is 500 square feet or at least 100 square feet per person, allowable to take the lesser figure. The minimum room size meant for human habitation of more than 8 hours daily is 60 clear square feet. The width of such habitable room in a residential building shall be not less than 6 feet.

2.5.6.2 Room height

2.5.6.2.1 Residential buildings

2.5.6.2.1.1 The minimum clear height of room (head room) in residential buildings excluding shop houses shall be:

For living rooms, bedrooms and kitchens, not less than 8 feet;

For bathrooms, water-closets, latrines, , balconies, verandas, and like, not less than 6.5 feet;

2.5.6.2.1.2 The minimum average height of rooms with sloping ceilings in residential buildings excluding shop houses shall be: -

For living rooms, bedrooms and kitchens, not less than 8 feet;

For attic rooms used as bedrooms, the minimum height immediately at roof edges is 4 feet, however the average room height must be 8 feet when used as bedroom;

The minimum headroom of other habitable rooms or space inside any building be 7.5 feet;

The minimum headroom for bathrooms, water-closets, latrines, , balconies, verandas, and the like, not less than 6.5 feet;

2.5.6.2.2 Others

In shop houses and retail shops, the height of areas used as shops shall be not less than 9.5 feet and the height or areas used as residential purposes shall follow the room heights of residential units.

In schools, the clear height of rooms (head room) used for teaching shall not be less than 9.5 feet.

In hospitals, the clear height of rooms (head room) used for the accommodation of patients shall not be less than 9.5 feet.

In hospitals, the height of the rooms used for operation, treatment etc. shall conform to concerned authorities.

The clear height of any room in a factory in which any person works shall not be less than 9.5 feet.

The height of any basement not being used as human habitation shall be 7 feet minimum.

Where the part of the ground floor is left open for use as car park or covered garden or for similar purpose, the height of such ground floor shall not be less than 8 feet.

The headroom of areas meant only for car parking shall not be less than 8 feet.

The headroom at stair cases shall not be less than 7 feet and the height of any covered footway shall not be less than 8 feet.

The height of rooms in public areas shall not be less than 9.5 feet (excluded the areas such as water-closets, lavatories, cloakrooms, corridors and rooms).

Where a balcony is provided in public resort or public places, the heights between the finished floor level and the ceiling over such balcony, shall be not less than 9.5 feet.

The height of non-habitable rooms on public places, such as water-closets, lavatories, corridors, etc, shall not be less than 8 feet.

Exception: When the clear room height is considered, the required height for all electrical and mechanical services such as duct lines, fire extinguishing systems, etc. should be noticed.

2.5.6.3 Inner connecting space widths

All inner connecting space widths in the building shall be complied with 2.6.8 Egress width

2.5.6.4 Doors and openings

All doors width entering any habitable room shall have minimum clear height of 6.5 feet and width of 2.75 feet.

a) All doors entering toilets and kitchens in residential units shall have minimum height of 6.5 feet and width of 2.75 feet.

- b) All exit doors shall open outwards and number of doors, door widths and width of openings shall comply with section 2.6 Means of Egress.
- c) Where the space beneath a roof is enclosed by a ceiling, access to such space shall be provided for inspection, cleaning and repairs by means of an opening with minimum 2feet width in any direction.

2.5.7 Stairs, Steps, Ramps and Lifts

2.5.7.1 Stairs

Stair in this chapter means only for internal stair whereas, the exit stair is described in *chapter*

2. 6-Means of Egress of this part and emergency stair is in *Part 5- Building Service (Fire)* of this code.

- a) All staircases shall be properly lighted and ventilated.
- b) All stairs in residential units have a landing after 12 risers maximum, in all other buildings there shall be not more than 16 risers between each such landing.
- c) All stairs shall have non-slip surface.
- d) In cases where stairs or steps begin after the doors and other openings, the distance between such openings and the beginning of stairs/ steps shall normally be the same as the width of the respective stairs, but minimum of 3 feet shall be required.
- e) Timber staircases may be permitted for the following building types, provided these are not more than three storeys in height:
 - 1) Detached residential buildings; duplex houses and terrace houses;
 - 2) In the upper floors of shop houses other than from the ground floor to the first floor provided that it is located within the protected area for its full height; and

2.5.7.1.1 Stair widths

All exit stair widths shall be referred to chapter 6 Egress width.

2.5.7.1.2 Stair ratios

- a) The dimensions of the riser and the tread of stairs in a building throughout all storeys or in a staircase shall be uniform and consistent. The tolerance of risers for each storey shall be +/- (5mm)3/16 in.
- b) Stair ratios for inner stairs in (R3) detached houses, duplex and terrace houses, which are not more than 3 storeys for single families, or units with less than 10 persons occupancy, must be calculated with the two given formulas:- $2R + T =$ between 23 and 26 inches, and $R+T=$ between 16 and 18 inches, and R should not be more than 8 inches and T should not be less than 10 inches. (Where R is the riser in inches; T is the tread in inches)
- c) Stair ratios for inner stairs in public buildings, including offices with more than occupancy of 10 persons, must be calculated with the given formulas:- $2R + T =$ between 23 and 26 inches, and $R+T=$ between 16 and 18 inches, where R shall not be more than 7 inches, T shall not be less than 10 inches. (Where R is the riser in inches; T is the tread in inches)

2.5.7.1.3 Spiral staircases

Spiral staircases with minimum tread length 2 ft 6 in(750mm) may be permitted as a secondary staircase not as an exit stair in multi storeyed buildings where the topmost floor does not exceed 50 feet in height.

2.5.7.2 Steps

Dimension of steps shall conform to the formulas given below:-

- a) Step in stadiums, cinema halls, theatres and similar buildings where many people use together at the same time, must be calculated with the two given formulas: $2R + T =$ more than 36 inches, and $R + T =$ more than 30 inches, R should not be more than 7 inches, T should be more than 24 inches, (where R is the riser in inches; T is the tread in inches)
- b) Steps in pagodas, parks and in similar places must be calculated with the two given formulas:- $2R + T =$ more than 30 inches, and $R + T =$ more than 24 inches; R should not be more than 7 inches, (where R is the riser in inches; T is the tread in inches)

2.5.7.3 Railings

The design of railings shall conform to following points

- a) All stairs having more than 6 risers must have railings on both sides, where the wall at one side can substitute the railing for stairs with clear width up to 5 feet, over the stair width of 5 feet, railings shall be constructed on both sides.
- b) All handrails shall project not more than 4 inches into the stair width and shall be located not less than 3 inches of the end /beginning of the stairs.
- c) Net railing height at stairs (measured from finished surface of stair to the top of railing) shall not exceed 3 feet and the spacing of balustrades or similar openings below the hand railing level shall be less than 6 inches.
- d) Net railing height of balconies, terraces, flat roofs and similar structures at buildings with less than 2 stories and not more than 25 feet above the ground level shall not be lower than 3 feet (measured from floor finishing to the top of railing) and the spacing of balustrades or similar openings below the hand railing level shall be less than 6 inches.
- e) Net railing height, (measured from floor finishing to the top of railing) of balconies, large windows reaching to the floor level, terraces, flat roofs and similar structures at buildings with more than 3 stories or more than 35 feet above the ground level shall not be lower than 3.5 feet, and the spacing of balustrades or similar openings below the hand railing level should be less than 6 inches.
- f) Net railing height of stairs, balconies, terraces and similar structures at schools shall not be lower than 4 feet (measured from floor finishing to the top of railing) and there shall be not horizontal divisions in the railing to avoid children stepping on the railings.
- g) Staircases exceeding 8 feet in width shall be provided with intermediate handrail and the distances of handrails shall be maximum 8 feet away from each other.
- h) All steps with more than 16 risers shall have an intermediate landing of minimum 3 feet in length.

2.5.7.4 Protection at elevated areas

Every flat roof, balcony or other elevated areas located at 4 feet or more above the adjacent area where normal access is provided shall be protected along the edges with suitable railings, parapets or similar elements with not less than the height given in the paragraph 38 mentioned above.

2.5.7.5 Ramps

The design of ramps shall conform to following points:-

- All ramps meant for wheel chair of handicapped persons must have the slopes less than 10 %, (Rise: run ratio 1:10).
- All ramps meant for light motor vehicles less than 2 tons net weight must have the slopes, less than 16 %, (Rise: run ratio 1: 6.25).
- All ramps meant for medium heavy vehicles less than 5 tons net weight must have the slopes less than 14 %, (Rise to run ration 1:7.2).
- The clear headroom of ramps at the entering points into the buildings, meant for light vehicles less than 2 tons shall not be lower than 7 feet, and meant for entrance of heavy vehicles with less than 5 tons shall not be less than 9 feet.

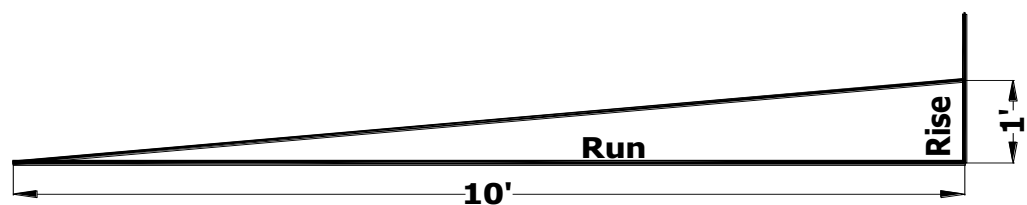


Figure 2.5.2 Schematic figure showing gradient of ramps (rise: run ratio)

2.5.8 Mechanical vertical transport in buildings

2.5.8.1 Lifts and Escalators

- Adequate number of lifts shall be provided in all residential buildings with more than 50 feet from the ground floor level up to the topmost habitable floor level.
- All office buildings with more than 4 stories or higher than 40 feet from the ground floor level, shall be equipped with adequate number of lifts.
- All buildings with public dealing functions like banks, shopping centres, hospitals, etc., which have more than 3 storeys and higher than 30 feet from ground level to the topmost floor, shall be equipped with adequate number of lifts or similar facilities.
- In the shopping centres with more than 3 storeys and more than 5000 square feet shopping area, shall be equipped with adequate number of additional mechanical means of vertical transport, such as lifts, escalators, etc.
- In places where mechanical means of vertical transportation, such as escalators or lifts are provided, ordinary stairs designed in line with these codes are necessary.
- The capacity of vertical transportation, size and number of lifts shall follow the norms and standards based on calculations done by qualified engineers of the respective field.

2.5.9 Access to Unoccupied Spaces

2.5.9.1 Crawl spaces

Crawl spaces shall be provided with a minimum of one access opening not less than 18 inches by 24 inches (457 mm by 610 mm).

2.5.9.2 Attic spaces

An opening not less than 20 inches by 30 inches (559 mm by 762 mm) shall be provided to any attic area having a clear height of over 30 inches (762 mm). A 30-inch (762 mm) minimum clear headroom in the attic space shall be provided at or above the access opening.

2.5.10 Surrounding Materials**2.5.10.1 Floors**

In other than dwelling units, toilet and bathing room floors shall have a smooth, hard, non absorbent surface that extends upward onto the walls at least 6 inches (152 mm).

2.5.10.2 Walls

Walls within 2 feet (610 mm) of urinals and water closets shall have a smooth, hard, non absorbent surface, to a height of 4 feet (1219 mm) above the floor, and except for structural elements, the materials used in such walls shall be of a type that is not adversely affected by moisture.

Exceptions: Dwelling units, sleeping units and toilet rooms those are not accessible to the public and which have not more than one water closet.

Accessories such as grab bars, towel bars, paper dispensers and soap dishes, provided on or within walls, shall be installed and sealed to protect structural elements from moisture.

2.5.10.3 Showers

Shower compartments and walls above bathtubs with installed shower heads shall be finished with a smooth, non absorbent surface to a height not less than 70 inches (1778 mm) above the drain inlet.

PART 2 ARCHITECTURE AND URBAN DESIGN

SECTION 2.6 MEANS OF EGRESS

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.6 MEANS OF EGRESS

2.6.1 Means of Egress System

Building or portions of any occupied portions shall be provided with the means of egress systems: the exit access, the exit and the exit discharge in accordance with this chapter. Exemptions from this code are permitted in the case of listed buildings that have been adaptive for alternative use under an agreed Conservation Management Plan. In this case, provision must be made for safe egress with the agreement of the planning authority.

2.6.2 General Requirements for Means of Egress

2.6.2.1 Ceiling Heights

Minimum ceiling heights of the exit routes shall not less than 7 feet 6 inches (2286 mm).

2.6.2.2 Protruding objects

Any protruding objects which extend below ceiling shall not be more than 25% of ceiling area of a means of egress and must provide 80 inches minimum headroom.

Exception: Door closer and stops shall not reduce less than 78 inches.

Any horizontal projections from either side shall not be more than 4 inches over any walking surface between the heights of 27 inches and 80 inches.

Any horizontal projections shall not reduce the minimum clear width of accessible routes.

2.6.2.3 Floor surface

Surface of floors of means of egress shall be a slip resistant surface.

2.6.2.4 Level changes

Where elevation changes is less than 12 inches, slopes not greater than 5% slope shall be used. Minimum 2 risers of steps shall be used at locations not required to be accessible by chapter 7 concerning the accessibility of building.

2.6.2.5 Egress continuity

The path along means of egress shall not be interrupted by any building elements, such as walls, furniture, vehicles etc.

2.6.2.6 Elevators, escalators and moving walks

Elevators, escalators and moving walks shall not be used in required means of egress system.

2.6.3 Occupant Load

The number of occupants shall be computed at the rate of one occupant per unit of area as prescribed in Table 2.6.1.

Table 2.6.1 Maximum Floor Area Allowances Per Occupant

Function of Space	Floor area in sq-ft per person
Accessory storage areas, mechanical ,equipment room,	300 gross
Agricultural building	300 gross
Aircraft hangars	500 gross

Airport terminal	
Baggage claim	20 gross
Baggage handling	300 gross
Concourse	100 gross
Waiting areas	15 gross
Assembly, Gaming floors (keno, slots, etc.)	11 gross
Assembly with fixed seats	no. of seats + wheel chair space
Assembly without fixed seats	
Concentrated (chairs only-not fixed)	7 net
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Bowling centers, allow 5 persons for each lane including 15 feet of runway, and for additional areas	7 net
Business areas	100 gross
Courtrooms-other than fixed seating areas	40 net
Day care	35 net
Dormitories	50 gross
Educational	
Classroom area	20 net
Shops and other vocational room areas	50 net
Exercise rooms	50 gross
H-5 Fabrication and manufacturing areas	200 gross
Function of Space	Floor area in sq-ft per person
Industrial areas	100 gross
Institutional areas	
Inpatient treatment areas	240 gross
Outpatient areas	100 gross
Sleeping areas	120 gross
Kitchens, commercial	200 gross
Library	
Reading rooms	50 net
Stack area	100 gross
Locker rooms	50 gross

Mercantile	
Areas on other floors	60 gross
Basement and grade floor areas	30 gross
Storage, stock, shipping areas	300 gross
Parking garages	200 gross
Residential	200 gross
Skating rinks, swimming pools	
Rink and pool	50 gross
Decks	15 gross
Stages and platforms	15 net
Warehouses	500 gross

gross = Gross floor area of a building, means the total floor area calculated based on center of exterior walls, including the circulation area such as stairs, corridors, etc. but excluding the shafts, ducts, lift wells etc.

net = Net floor area of a room or of a units means total floor calculated based on center of the walls of respective room or of unit.

2.6.3.1 Mixed Occupancy

Where building is designed for different types of occupancies or different purposes at the same time, the exit requirements shall meet the more stringent requirements of each building section and function of the respective portions.

2.6.3.2 Multiple occupancy or use

Where a building is designed for multiple purposes involving different activities at different times, the greatest number of occupants shall form the basis for determining the egress requirements.

2.6.3.3 Egress convergence

Where means of egress from floors above and below converge at an intermediate level, the capacity of the means of egress from the point of convergence shall not be less than the sum of the two floors.

2.6.3.4 Fixed seating

For areas having fixed seats and aisles, the occupant load shall be determined by the number of fixed seats installed. The occupant load for areas in which fixed seating is not installed, such as waiting spaces and wheelchair spaces, shall be determined in accordance with Table 2.6.1 and added to the number of fixed seats.

2.6.4 Exit Access

An exit access shall not pass through a room which can be locked and to prevent egress.

Means of egress from dwelling units shall not lead through other sleeping areas or toilet area.

2.6.5 Exit and Exit Access Doorways from Space

Two exits or exit access doorways shall be provided if the occupant load of the space exceeds as per table.

Table 2.6.2 Spaces with One Exit Or Exit Access Doorway

Types of Occupancy	Occupant Load
A, B, E(a), F, M, U	49
H-1, H-2, H-3	3
H-4, H-5, I-1, I-3, I-4, R	10
S	29

(a). Day care maximum occupant load is 10.

Number of exits shall be complying with the following table.

Table 2.6.3 Minimum no. of Exits per occupant load

Occupant Load	Minimum no of Exits
1-500	2
501-1000	3
More than 1000	4

Whenever there are two exit doors or two exit access doorways are required, the distance between the two exits are at least equal to or more than half the furthest distance from one point to another of that particular room and each exit shall be of equal capacity.

2.6.6 No. of Exit Staircase or Exits per Storey

Minimum two independent exit staircases of other exit shall be provided including basements of a building unless otherwise permitted under other provision of this chapter.

2.6.6.2 All Buildings apart from R1a, R2, R3 and R5

Only one exit shall be required if it complies with the following table.

Table 2.6.4 No. of Exit staircase or exits per storey

Storey	Occupancy	Maximum occupants per floor and travel distance
First Floor or basement	A, B(b), E(a), F(b), M, U, S(b)	49 occupants and 50 feet travel distance
	H-2, H-3	3 occupants and 25 feet travel distance
	H-4, H-5, I, R	10 occupants and 50 feet travel distance
	S	29 occupants and 50 feet travel distance
Second Floor	B, F, M,	29 occupants and 50 feet travel distance

- (a) Day care occupancies shall have a maximum occupant load of 10.
- (b) Group B, F and S occupancies in buildings equipped throughout with an automatic sprinkler system and shall have maximum travel distance of 100ft.

2.6.6.1 R1a, R2, R3 and R5

Means of escape for a building shall comply with the provision of 2.6.9 Exit stairs and 2.6.10 Exit discharge. In a block of residential apartments or maisonettes, at least two independent exit staircases or other exits from every storey unless otherwise permitted.

2.6.6.1.1 In a block of residential apartments or maisonettes not exceeding (78 ft) 24m in habitable height, one exit staircase only may be allowed to serve every upper storey, subject to:

- a) The exit staircase shall comply with the requirements of 2.6.9 Exit stairs & 2.6.10 Exit discharge.
- b) If the building consists of more than four storeys, approach to the exit staircase on all storeys shall be through smoke stop lobby or external corridor.
- c) Access to the building for fire fighting appliances being provided for in compliance with the requirements in Fire Department.

2.6.6.1.2 In a block of residential apartments or maisonettes exceeding (78 ft) 24 m in height, one exit staircase only may be allowed to serve every upper storey, subject to -

- a) The height not exceeding (197 ft) 60 m unless otherwise permitted by the Relevant Authority, and
- b) The single exit staircase shall serve not more than four apartments or maisonettes at each storey level, and
- d) Travel distance from the most remote exit door to the exit staircase from each apartment or maisonette shall not exceed (49 ft) 15 m, and
- e) Exit staircase shall comply with the requirements of 2.6.9 Exit stairs & 2.6.10 Exit discharge.
- f) Approach to the exit staircase shall be through cross-ventilated lobby. The ventilation openings having a minimum width of 2000mm (6ft 6in) and a minimum height of 1200mm (4ft) shall be unobstructed from parapet wall or balustrade level upwards and be positioned on opposite sides of the lobby such that they provide cross-ventilation throughout the entire space of the lobby. Where multiple ventilation openings are provided on opposite sides of the lobby, the minimum width and height of each opening shall not be less than 1000(3ft 4in) mm and 1200mm(4ft) respectively, provided the aggregate width of the openings at each opposite side is not less than 2000(6ft 6in)mm.
- g) Fire lift shall be provided to comply with the requirements of fire department, and

- h) Wet rising main shall be provided to comply with the requirements of fire department, and
- i) Access to the building for fire fighting appliances shall be provided to comply with the requirements of fire department.

2.6.7 Exit Access Travel Distance

Exit access travel distances are determined by type of occupancy and shall comply with the table given below in these codes.

Table 2.6.5 Exit Access Travel Distance

Type of Occupancy	Max Travel Distance (ft) (One-way travel)		Max Travel Distance (ft) (Two-way travel)		Max Dead End (ft)	
	Unsprinklered	Sprinklered	Unsprinklered	Sprinklered	Corridor	
					Unsprinklered	Sprinklered
High hazard	35	65	65	115	50	65
Industrial buildings (factories, workshops, godown/ warehouse)	50	80	100	200	50	65
Dormitories, hostels	50	100	145	245	50	65
Shops	50	80	145	200	50	65
Offices	50	100	145	245	50	65
Places of public resort & car parks	50	80	145	200	50	65
School & educational buildings	50	100	145	245	50	65
Hospitals	50	80	100	145	50	65
Hotels, boarding houses(a)	50	65	100	145	50	65
Blocks of flats/ Residents (a)	50b	100b	100	245	50	65
	65c	130c	145c			
Detached, semi-detached & terrace House, including townhouses	NR	NR	NR	NR	NR	NR

a. Measurement of travel distance is from the guestroom door (or) residential unit door to exit.

b. For travel distance in single stair case.

c. For travel distance to external corridor.

2.6.8 Egress Width

The total width of means of egress shall not be less than the total occupant load serves by means of egress multiply by defined width per occupant load as per table and the minimum width must conform to the following table.

Table 2.6.6 Egress Width

Type of Occupancy	Door openings per person (inch)				Min width (ft)	
	To outdoors at ground level (inches)	Other exit & corridor doors	Stair-cases	Ramps Corridors Exits Passageways	Stairs	Corridor
High hazard	0.4	0.5	0.65	0.4	3.5	3.5
Industrial buildings (factories, workshops, godown/ warehouse)	0.2	0.25	0.35	0.2	3.5	3.5
Dormitories, hotels	0.4	0.5	0.65	0.4	3.5	3.5
Shops	0.2	0.25	0.35	0.2	3.5	3.5
Offices	0.2	0.25	0.35	0.2	3.5	3.5
Places of public resort & car parks	0.2	0.25	0.35	0.2	3.5	3.5
School & educational buildings	0.2	0.25	0.35	0.2	3.5	5(a)
Hospitals	0.65	0.65	1.25	0.65	3.5	6.5(b)
Hotels, boarding houses	0.4	0.5	0.65	0.4	3.5	3.5
Blocks of flats/ residents	0.4	0.5	0.65	0.4	3.5(c)	3.5
Detached, semi-detached & terrace House, including townhouses	NR	NR	NR	NR	3	3

(a) Applies to corridors serving classrooms. Other corridors shall have a minimum width of 3ft 6 inches.

(b) Applies to corridors serving patients. Other corridors shall have a minimum 3ft 6 inches.

(c) Staircase within maisonette serving as an internal access to be at least 3ft width.

The maximum width of exit staircase shall be not more than 6 feet 6 inches. Where staircase exceeds 6 feet 6 inches in width, handrails shall be used to divide the staircase into sections of not less than 3 feet 6 inches of width or more than 6 feet 6 inches of width.

2.6.9 Exit Stairs

All exit stairs shall be constructed minimum 1 hour rated construction.

All exit stairs (except for R1a, R2, R3 and R5 which are not more than 3 storeys) riser heights shall be 7 inches maximum and 4 inches minimum.

All exits stairs shall be not more than 16 risers between each such landing.

Stair treads and risers shall be of uniform size and shape. The tolerance between the largest and smallest riser heights or between the largest and smallest tread depth shall not exceed 3/16 inch in any flight of stairs.

The width of landings shall not be less than the width of stairways they serve.

Winder stairs are not permitted in means of egress stairways except within a dwelling unit. Where circular/geometric staircases are used as exit staircases, the width of threads measured at the narrower end shall be not less than 4in in residential buildings and at a distance of 2ft from the narrower end shall be not less than 9in in residential buildings.

Spiral stair cases as exit stair with non-combustible material and minimum tread length 2 ft 6 in(750mm) can be used at residential detached and semi detached buildings not more than 3 storey.

2.6.9.1 Internal exit stair

An internal exit stair which serves as an exit shall be enclosed.

All services such as pipe/duct installation shall not be located inside protected staircase and no wash room is allowed to be located inside staircase.

There shall be no unprotected openings of occupancy area within 5ft horizontally and 10 ft vertically below any part of the ventilation opening in the external wall of internal exit staircase. Exceptional cases are public and commercial buildings like hotels and offices etc. which are properly provided and maintained with mechanical ventilation and lighting facilities as per Building services chapter.

The width of stair case shall be complying with egress width table.

If the stair serves more than 6 storeys, smoke free approach is needed.

2.6.9.2 External exit stair

a) An exit stair which serves as an exit must be located outside of the building or at least 50% of staircase must be protruded and the external exit staircase shall be located so as to lead directly to a street or open space with direct access to street.

b) The stair must be naturally ventilated with a minimum unobstructed opening area, larger or equal to 50% of area of stair case.

c) There shall be no unprotected openings within 3m (10 ft) horizontally or within 3m (10ft) vertically below, or adjacent or facing.

Exception: For residential walk up apartments which are located in CBD, having back lane and can't comply with 2.6.9.b, the building can be accessible by fire engine and it shall have one stair at the back of flat.

2.6.10 Exits Discharge

All exits shall be discharged at ground level directly into a safe open exterior space within its own property or public space.

Exception: In sprinkler protected building, maximum 50% of the total building exits are allowed to discharge directly to the ground level circulation space subject to the following:

- a) The discharge point shall be at a location in the circulation space at ground level with direct access and within sight of a safe exterior open space.
- b) The maximum distance of the discharge point to exterior open space is 30ft.

The sprinkler system shall conform to the Building services chapter.

2.6.11 Exit Passage Way

Exit passage way can be used as a horizontal extension of a vertical exit of exit staircase or a passage leading from a courtyard to an open exterior space, complying with the requirements of travel distance and exit discharge.

2.6.11.1 Internal Exit Passage way

- a) Exit passageways that serve as a means of escape shall be minimum 1 hour rated construction.
- b) The enclosure walls of an exit passageway shall have not more than two exit doors opening into the exit passageway
- c) Exit doors opening into an exit passageway shall have fire resistance rating as required for exit doors opening into exit staircases, fitted with automatic self-closing device.
- d) The minimum width and capacity of exit passageway shall comply with 2.6.8 Egress Width
- e) Changes in level along an exit passageway requiring less than two risers shall be by a ramp complying with the provisions under 2.6.2
- f) If the exit staircase which connects to the internal exit passageway is pressurised, the internal exit passageway shall not be naturally ventilated but shall be mechanically ventilated.

2.6.11.1 External exit passageway

- a) An external exit passageway can be used as a required exit in lieu of an internal exit passageway. The external wall between the exit passageway and the rest of the floor space can have ventilation openings of non-combustible construction, fixed at or above a level 1.8m (7ft), measured from the finished floor level of the passageway to the sill level of the openings and such ventilation openings shall be located not less than 3.0 m (10ft) from any opening of an exit staircase, and
- b) An external exit passageway may not be subjected to the limitations of a maximum of two exit doors opening into the exit passageway, and
- c) An external exit passageway may be roofed over provided the depth of the roofed over portion shall not exceed 3m(10ft) to avoid smoke logging, and
- d) An external exit passageway may be enclosed on the open side by only a parapet wall of not less than 1.0 m(3ft 4in) or more than 1.1m (4ft) in height and the vertical height of the unobstructed ventilation opening measured from the parapet wall up to the top edge of

the opening or eaves of overhang shall not be less than 1.2m (4ft), Exception: if external passage way is used on ground between building and fence, the farthest edge of roof or slab above the exit passage shall be 3ft apart from fence and the passage shall have minimum width of 4 ft.

e) Exit doors opening into an external exit passageway shall have fire resistance for at least half an hour and fitted with automatic self-closing device.

2.6.12 Exit Doors

2.6.12.1 Exit doors opening

Exit doors opening into exit staircases and exit passageways shall not impede the egress of occupants when such doors are swung open, and all doors which open into the corridor, shall not hinder movement of occupants. The corridor's clear width shall at least remain to be half of the required clear width as stipulated under Table 2.6.6 when such door(s) is swung open.

Exit doors and exit access doors shall open in the direction of exit travel:

- a) When leading to an access doors shall open in the direction of exit access way
- b) When used in exit enclosure, including smoke stop and fire fighting lobbies in a building. It shall not apply to doors of individual residential units that open directly into an exit enclosure, or
- c) When serving a high hazard area, or
- d) When serving a room or space with more than 50 persons

2.6.12.2 Locking of staircase and smoke stop/ fire lift lobby doors

One way locking device is allowed to be protected to doors of exit staircase, smoke stop/ fire lift lobby in the following situations, provided only one-way locking device is used, e g .panic bolt or thumb turn locking device:

- a) Exit door between staircase shaft and occupancy area; and
- b) Exit access door between smoke/ fire fighting lobby and occupancy area; and
- c) Exit door between staircase shaft and smoke stop lobby; and
- d) Exit door between staircase shaft and circulation area; and exit access door between smoke stop/ fire fighting lobby and circulation area.

2.6.13 Means of Egress Lighting

Emergency lighting system must be provided along Exit Access and Exits, Exits discharge.

2.6.14 Accessible Means of Egress

Accessible egress must be provided if there is "accessible place". Refer to Chapter 2.7

2.6.15 Smoke Free Approach to Exit Stair

A separate lobby adjoining the exit access way and exit stair with a minimum rated 1 hour construction.

Its area shall be minimum 32sq-ft and if it serves as a fire fighting lobby, floor area shall not be smaller than 60sq-ft and width no dimension less than 6ft 6 inches. Fire fighting lobby shall connect to exit stair and fire men lift.

There shall be permanent fixed ventilation openings in the external wall of lobby, not less than 15 percent of the floor area or mechanical ventilation comply with Building services chapter.

Cross ventilated corridor with fixed opening in at least 2 external walls shall be used as smoke stop lobby. Opening shall not be less than 50 per cent of walls area and minimum width shall not be less than 6ft 6inches, enclosing the corridor. And no part of the floor area of the lobby shall be farther than 43 ft of ventilation opening.

There shall be no unprotected openings of occupancy area within 5ft horizontally and 10 ft vertically below any part of the ventilation opening.

2.6.16 Exit Sign

All signage showing the emergency exit route must be visible from distance of 100 ft and they shall not be covered by other elements.

2.6.17 Emergency escape/ Refuge Area

In the third phase, the details of this section will be described depending on the resources' availability.

2.6.18 Special requirements

2.6.18.1 Hospitals

- a) All multi-storey hospitals with patients care of more than 24 hours must have all vertical transportation system (fire escape bed lift) only for the patients if the hospital is more than 4 storeys and
- b) Every storey shall have fire escape lobby or balcony that is designed for 2 hour fire rating.

2.6.18.2 Definitions

FIREMAN STAIR: The stairs generally meant for usage of fireman in case of emergency. The fireman stairs must be able to stand minimum 1000 pounds.

FIRE ESCAPE BED LIFT: Lift is to be used for the evacuation of patients in beds including wheelchairs or physically disabled, in a fire emergency, although it can be used as a passenger lift during normal time.

PART 2 ARCHITECTURE AND URBAN DESIGN

SECTION 2.7 ACCESSIBILITY

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.7 ACCESSIBILITY

2.7.1 Scope

The provisions of this chapter shall control the design and construction of facilities for accessibility to physically disabled persons.

2.7.2 Scoping Requirements

All public buildings shall be accessible for the disabled persons and must have minimum one accessible toilet comply with this chapter. Minimum provision for disabled persons based on building types shall be as per following table.

Table 2.7.1 Scoping requirements

Type of Building	Minimum provision
All public transportation building	At least one space shall be accessible to use public transport.
Banks Post offices, banks and financial service institutions	At least one accessible service desk shall be provided for every 10 service desk.
Hotels	At least one guest room shall be provided for every 250 guestrooms or part and thereof. Rooms designated for wheelchair users should, where possible, be placed at ground level so as to have a direct means of escape in case of fire.
Concert halls, Stadium, Cinema and theatres, sport buildings and other places of public assembly.	Accessible entrances, exists, aisles and main community or public gathering areas. Accessible toilet facilities should be nearby. At least one wheel chair space shall be provided for every 100 seats or part thereof.
Religious Building (If occupancy load is more than 1000)	The main worship shall be made accessible in accordance with this chapter.
Hostels and Halls	At least one level, preferably access level, shall be provided with facilities in accordance with 2.7.3.
Shopping Mall (if ground floor area is more than 10,000sq-ft)	At least ground floor shall be accessible in accordance with 2.7.3.
School/Educational buildings	At least ground floor shall be accessible in accordance with 2.7.3. All teaching, administrative and common areas should be accessible to a wheelchair user. Suitable arrangements should be made for stepped lecture halls or auditoriums.

Hospitals and health facilities	All entrances should be accessible to a wheelchair user. All rooms and administrative departments should be accessible for the benefit of patients, disabled visitors and disabled staff members.
Type of Building	Minimum provision
Libraries	All open book stack, library facilities and equipment should be accessible. A special room should be provided for sightless and for hearing-impaired people who need assistance while reading.
Food Centres, Cafeterias and restaurants	Accessible entrance. A minimum of 1 table without stools or seats attached to the floor for every 10 tables. Stools and high tables are not suitable for wheelchair users. Low tables should be provided as well. In self-service restaurants tray slides and counters should be mounted approximately 0.90 m from the floor.
Car parks	At least one car parking stall shall be reserved for first 100 parking stall and at least stalls shall be provided if the parking lots is more than 100.

2.7.3 Minimum Requirements

2.7.3.1 Parking Lot

- a) Minimum size of 16ft long and 11 ft wide parking lot shall be provided in accordance with 2.7.2.
- b) Accessible parking lots shall be located as close as possible to accessible entrance.

Entrances and doors

Entrance doors can be either the sliding type or the swinging type. Revolving doors are not suitable for the use of disabled people or people with prams.

- a) For double-leaf doors, at least one leaf should have a minimum clear width of 2ft 10 inches.
- b) At least one accessible entrance shall be provided near to parking lot reserved for disabled persons.
- c) Clear opening of doors for the wheelchair shall be minimum 3 ft.
- d) Door handles shall be easily handled and lever handles are preferred to door knobs.

- e) Door handles and other hard ware shall be located not more than 3ft6in from finished floor and not less than 3ft.
- f) Minimum clear space of 4ft 6in x 4ft 6in shall be provided where a door opens against the direction of approach.

2.7.3.2 Corridors and Walk ways

- a) Minimum width of corridor and walkway shall be 4ft and waiting area
- b) Turnabout, minimum space of 4ft 6in x 4ft 6in shall be provided at or within 12ft of dead end and in front of accessible doors along corridor.
- c) Recesses or turn about shall be spaced at a maximum of 40ft interval.

2.7.3.3. Guiding/warning floor material

The floor material to guide or to warn the visually impaired persons with a change of colour or material with conspicuously different texture and easily distinguishable from the rest of the surrounding floor materials is called **guiding or warning floor material**. This floor material shall be provided in the following areas:

- a) The access path to the building and to the parking area.
- b) The landing lobby towards the information board, reception, lifts, stair-cases and toilets.
- c) Immediately at the beginning/end of walkway where there is a vehicular traffic.
- d) At the location abruptly changing in level or beginning/end of a ramp.
- e) Immediately in front of an entrance/exit and the landing.
- f) The marking strip width should not be less than 0.60 m.

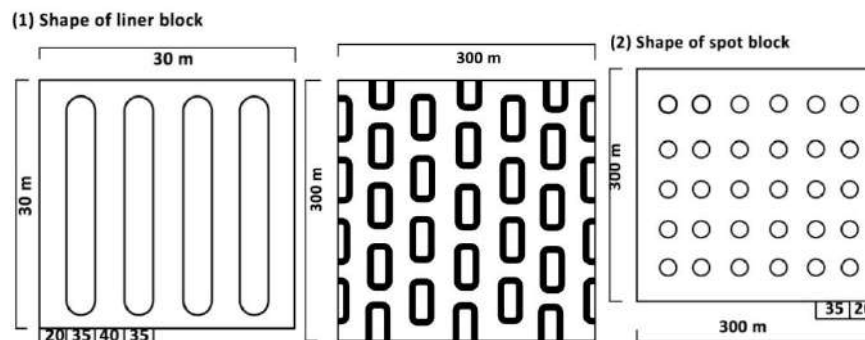


Fig: 2.7.3.4 Shapes of guiding blocks for persons with impaired vision

2.7.3.4 Handrail

- a) All grip rails and handrail shall be not less than 1 in diameter and not more than 2 in. and it shall have minimum 1.75 in. spacing from the surface of doors and walls.
- b) Handrails must be provided on both sides of the ramp and should not be installed beyond the width of any crossing not to obstruct pedestrian flow.

2.7.3.5 Buttons and switches

All buttons for the wheelchair bound such as switches, controls and lift buttons shall be located at not more than 4ft 9 in and not less than 3ft 3 in.

2.7.3.6. Signage

All types of signs should be visible, clear, simple, easy to read and understand at night.

Signs should not be placed behind glass because of possible reflection.

Accessible spaces and facilities should be identified by the international symbol of accessibility (see fig :)



Fig : 2.7.3.7b. Information boards in concourse

The symbol is composed of a wheelchair figure with either a square background or a square border (see fig.).



Fig : 2.7.3.7c. The international symbol of accessibility

The information board should be made easily readable by using sufficiently large text size, distinct contrast and illumination.

For hearing impaired persons, an electronic sign board of appropriate size & height should be displayed on each platform at conspicuous location for all announcements.

Visually impaired persons make use of other senses such as hearing and touch to compensate for the lack of vision.

International symbol mark for wheel chair as shown below be installed at the lift, toilet, staircase, parking areas etc., that have been provided for the handicapped.

2.7.3.7 Ramps

- a) All ramps meant for the wheelchairs must be the slopes less than 1:10 (rise: run ratio) and the minimum 4 ft. clear width of ramp shall be provided.

- b) The maximum horizontal run of ramp is 30 ft. and minimum 6 ft. wide of landing shall be provided at every 30 ft. horizontal run.
- c) If horizontal run is less than 1 ft. the ramp gradient can be steeper till up to 1:8.
- d) The ramp surface should be hard and non-slip.

2.7.3.8.Stairs

Circular stairs and stepped landings should be avoided.

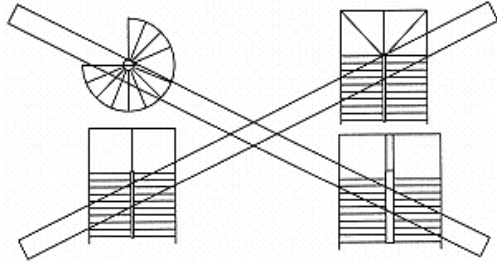
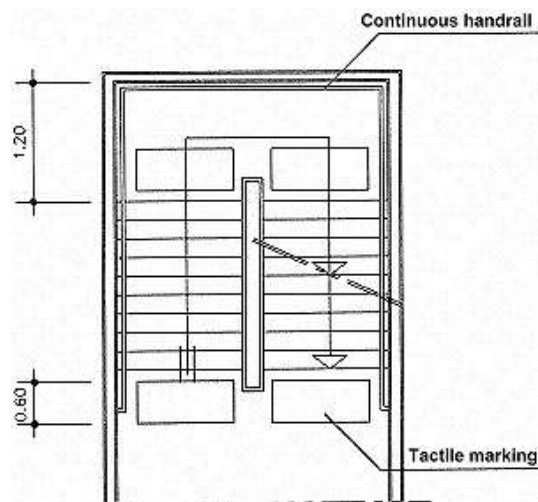


Fig :2.7.3.9a. Circular stairs and stepped landings

The edges of stairs should be painted in a contrasting color for the benefit of poor- sighted users.



Height of the riser shall not be more than 150 mm and width of the tread 300 mm. The steps shall not have abrupt (square) nosing.

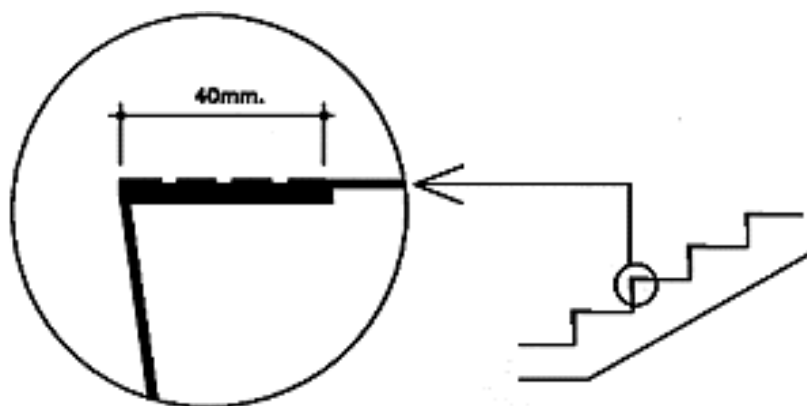


Fig : 2.7.3.9d. Slip-resistant nosing

2.7.3.9 Counter and desk

Writing or service counters for disabled person shall be not more than 2ft. 5 in. high and clear space below counter shall have minimum dimensions of 3 ft. wide x 1 ft. 9 in. deep x 2 ft.5 in. high.

2.7.3.10 Restrooms and Toilets

The dimensions of water closet compartment for wheelchair bound shall be accordance with the dimensions as shown in fig. 2.7.1. Rest rooms should be equipped with an alarm system.

Toilet floor shall have a non-slip surface without any level.

Mirrors should be suitable for use by both standing and seated persons. Low mirrors or downward tilted mirrors can be used. The bottom edge of mirrors should be located at a maximum height of 1.00 m from the finished floor level.

Toilet seats, bidets, shower seats and bath-tub seats are required to be mounted at the same height of the wheelchair seat, i.e. between 0.45m and 0.50 m above floor level.

Grab bars should be installed in water-closets, bath-tubs and showers to assist disabled persons to use the facilities safely and easily. Grab bars should have a diameter of 30 mm to 40 mm. Wall-mounted grab bars should extent between 35 mm and 45 mm from the wall.

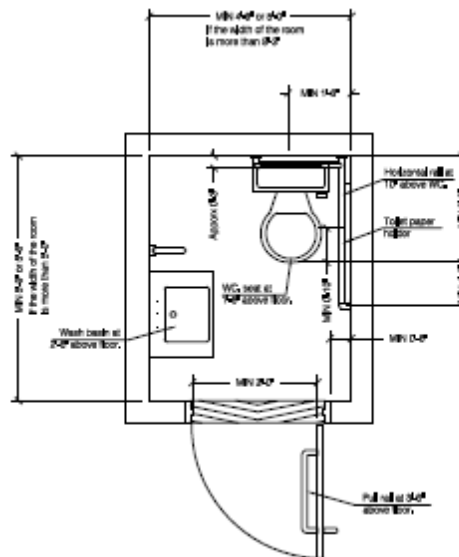


Fig. 2.7.1 Spacing in toilets for disabled persons

PART 2 ARCHITECTURE AND URBAN DESIGN

SECTION 2.8 EXTERIOR WALLS

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.8 EXTERIOR WALLS

2.8.1 Scope

The provisions of this chapter shall establish the minimum requirements for exterior walls; exterior wall coverings; exterior wall openings; exterior windows and doors; architectural trim; balconies and similar projections; and bay and oriel windows.

2.8.2 Definitions

ADHERED MASONRY VENEER. Veneer secured and supported through the adhesion of an approved bonding material applied to an approved backing.

ANCHORED MASONRY VENEER. Veneer secured with approved mechanical fasteners to an approved backing.

BACKING. The wall or surface to which the veneer is secured.

EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS). EIFS are nonstructural, nonload-bearing, exterior wall cladding systems that consist of an insulation board attached either adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat and a textured protective finish coat.

EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS) WITH DRAINAGE. An EIFS that incorporates a means of drainage applied over a water-resistive barrier.

EXTERIOR WALL. A wall, bearing or nonbearing, that is used as an enclosing wall for a building, other than a fire wall, and that has a slope of 60 degrees (1.05 rad) or greater with the horizontal plane.

EXTERIOR WALL COVERING. A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resisting barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, facias, gutters and leaders.

EXTERIOR WALL ENVELOPE. A system or assembly of exterior wall components, including exterior wall finish materials, that provides protection of the building structural members, including framing and sheathing materials, and conditioned interior space, from the detrimental effects of the exterior environment.

METAL COMPOSITE MATERIAL (MCM). A factory-manufactured panel consisting of metal skins bonded to both faces of a plastic core.

METAL COMPOSITE MATERIAL (MCM) SYSTEM. An exterior wall covering fabricated using MCM in a specific assembly including joints, seams, attachments, substrate, framing and other details as appropriate to a particular design.

VENEER. A facing attached to a wall for the purpose of providing ornamentation, protection or insulation, but not counted as adding strength to the wall.

WATER-RESISTIVE BARRIER. A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly.

2.8.3 Performance Requirements

The provisions of this section shall apply to exterior walls, wall coverings and components thereof.

2.8.3.1 Weather protection

Exterior walls shall provide the building with a weather-resistance exterior wall envelope. The exterior wall envelope shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior veneer, and a means for draining water that enters the assembly to the exterior. Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect it to the exterior. Flashing shall be installed at the perimeters of exterior door and window assemblies, penetrations and terminations of exterior wall assemblies, exterior wall intersections with roofs, chimneys, porches, decks, balconies and similar projections and at built-in gutters and similar locations where moisture could enter the wall. Flashing with projecting flanges shall be installed on both sides and the ends of copings, under sills and continuously above projecting trim.

2.8.3.2 Prevention of dampness

Damp rising from the ground up into the superstructure not only damages the masonry units, but also accelerates the decaying of timber and bamboo elements. Damp-Proof Course (dpc) shall be installed according to the manual of the manufacturers to prevent the penetration of dampness and moisture into the building. Where any part of the walls of a building is subject to water pressure, that portion of the floor or wall below ground level shall be waterproof.

2.8.3.3 Structural

Exterior walls, and the associated openings, shall be designed and constructed to resist safely the superimposed loads required by *Part 3- Structural Design*.

2.8.3.4 Fire resistance

Exterior wall shall be fire-resistance rated as required by *Part 5- Building Service (Fire)*.

2.8.3.5 Flood resistance

Exterior walls extending below the design flood elevation shall be resistant to water damage in flood hazard areas. The electrical mechanical and plumbing system components shall not be mounted on or penetrate through exterior walls that are designed to break away under flood loads.

2.8.4 Materials

Materials used for the construction of exterior walls shall comply with the provisions of this section. Materials not prescribed herein shall be permitted, provided that any such alternative has been approved. All wall cladding over 10 feet from the floor must have safety arrangement to protect falling of these material on the occupant.

2.8.4.1 Water-resistive barrier

A minimum of one layer of approved materials, shall be attached to the studs or sheathing, with flashing as described in Section 2.8.3.1, in such a manner as to provide a continuous water-resistive barrier behind the exterior wall veneer. Maintenance shall be followed regularly

2.8.4.2 Bamboo

Bamboo which is used for special and temporary shelter in public usage shall be mature and free from damage. It is preferable to use treated bamboo be used. The treatment may be carried out in a traditional manner. One of the simplest ways is to soak the bamboo in running water continuously for two to three weeks.

2.8.4.3 Wood

Exterior walls of wood construction shall be designed and constructed in accordance with *Part 3- Structural Design*.. Wood shall be performed according to the wood section in Material Chapter. Locally available timber can be used. Treated timber is preferable to untreated timber. The treatment may be done in a traditional manner.

2.8.4.4 Masonry

Exterior walls of masonry construction shall be designed and constructed in accordance with Masonry Section in *Part 3- Structural Design*.. Masonry units, mortar and metal accessories used in anchored and adhered veneer shall meet the physical requirements of Masonry Section in Material Chapter. The backing of anchored and adhered veneer shall be of concrete, masonry, steel framing or wood framing.

2.8.4.5 Metal

Exterior walls of formed steel construction, structural steel or lightweight metal alloys shall be designed and constructed in accordance with *Part 3- Structural Design*. and shall be performed according to Aluminium and Other Light Metals and Their Alloys Section in Material Chapter.

2.8.4.6 Concrete

Exterior walls of concrete construction shall be designed and constructed in accordance with Concrete Section in *Part 3- Structural Design*.. Concrete shall be performed according to Concrete Section in Material Chapter.

2.8.4.7 Glass-unit masonry

Exterior walls of glass-unit masonry construction shall be designed and constructed in accordance with Glass-unit masonry Section in *Part 3-Structural Design*.
Installation period is to be careful and safe.

2.8.4.8 Stone Veneer

Exterior walls of stone veneer construction shall be designed and constructed in accordance with *Part 3- Structural Design*. Stone shall be performed according to *Part 6- Material*.

2.8.4.9 Exterior insulation and finish systems

Exterior insulation and finish systems (EIFS) with or without drainage shall govern the materials, construction and quality for use as exterior wall coverings.

2.8.5 Projections in Brickwork

All projections in brickwork shall be corbelled gradually and no projection shall extend more than 9 inches from the face of any wall.

2.8.6 Recess

Where a recess in the load-bearing building is made in an external wall or a division wall (party wall):-

- a) The wall at the back of the recess shall not be less than 4.5 inches thick at an external wall and 9 inches thick at a division wall;
- b) A sufficiently strong members like lintel or arch of noncombustible material shall be built over the recess area;

c) If a recess or opening is made at the edge of a division wall or of an external wall, there shall be a space of not less than 1.5 feet between the beginning of opening and the extreme end of the wall.

2.8.7 Installation of Wall Coverings

2.8.7.1 Exterior covering materials in brick walls

In all cases where 4.5 inches brick walls or non-load-bearing walls of other materials should be attached to reinforced concrete frames, or other structural members, such walls shall be properly secured to the structural members.

2.8.7.2 Cement plaster

Cement plaster applied to exterior walls shall conform to the requirements specified in Cement and Concrete Section in *Part 6- Material*.

2.8.7.3 Fastening

Weather boarding and wall coverings shall be securely fastened with aluminum, copper, zinc, zinc-coated or other approved corrosion-resistant fasteners or the approved manufacturer's installation instructions.

2.8.8 Exterior Doors and Windows

The openings of exterior walls shall be provided the overhead sun shade and similar projections for weather protection. Exterior doors and windows shall be installed in accordance with approved manufacturer's instructions and shall be performed according to *Part 6- Material*. Fastener size and spacing shall be provided in such instructions and shall be calculated based on maximum loads and spacing. Any parts of the exterior doors and windows shall be water-proof. The protective bars and safety glazing are required for any fixed or operable opening extended to floor finished level. The protective bars or sill height of operable openings shall be 3 feet above adjacent floor finished level that is more than 30 inches above exterior ground level. The insulating glass shall be installed if required to give weather protection.

2.8.8.1 Curtain Walls

Any parts or members of curtain walls shall be water-proof and installed in accordance with approved manufacturer's instructions. The approved flexible fire barrier material that provides an effective firestop and smoke seal for perimeter voids and accommodates dynamic movement between the curtain wall and the floor shall be provided.

2.8.9 Balconies and Similar Projections, Bay and Oriel Windows

Balconies and similar projections, bay and oriel windows shall conform to the type of construction required for the building to which they are attached. Exterior balconies attached to or supported by wall required to be of masonry, shall have brackets or beams constructed of incombustible materials. 3 feet height railings shall be provided for balconies, landings, or porches which are more than 30 inches above exterior ground level.

2.8.10 Metal Composite Materials (MCM)

The provisions of this section shall govern the materials, construction and quality of metal composite materials (MCM) for use as exterior wall coverings.

2.8.10.1 Exterior wall finish

MCM used as exterior wall finish or as elements of balconies and similar projections and bay and oriel windows to provide cladding or weather resistance.

2.8.10.2 Architectural trim and embellishments

MCM used as architectural trim or embellishment shall comply with durability and fire resistance rating.

2.8.10.3 Structural design

MCM systems shall be designed and constructed to resist wind loads as required by Structural Design Chapter for components and cladding.

2.8.10.4 Weather resistance

MCM systems shall comply with Section 2.8.3 and shall be designed and constructed to resist wind and rain in accordance with this section and the manufacturer's installation instructions.

2.8.10.5 Durability

MCM systems shall be constructed of approved materials that maintain the performance characteristics required in Section 2.8.15. for the duration of use.

2.8.10.6 Fire-resistance rating

Where MCM systems are used on exterior walls required to have a fire-resistance rating in accordance with Section 2.8 evidence shall be submitted to the building official that the required fire-resistance rating is maintained.

PART 2 ARCHITECTURE AND URBAN DESIGN

**SECTION 2.9 ROOF CONSTRUCTION, ROOF COVERING AND ROOF TOP
STRUCTURES**

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.9 ROOF CONSTRUCTION, ROOF COVERING AND ROOF TOP STRUCTURES

2.9.1 General

2.9.1.1 Scope

Roofing construction, roof coverings and rooftop structures shall be as specified in this code and as otherwise required by this chapter.

2.9.1.2 Definitions

ATTIC STOREY: Any storey situated wholly or partly in a roof, so designed, arranged, or built as to be used for business, storage, or habitation.

CHIMNEY CLASSIFICATIONS:

(a) RESIDENTIAL APPLIANCE TYPE

A factory-built or masonry chimney suitable for removing products of combustion from residential type appliance producing combustion gases not in excess of 538°C measured at the appliance flue outlet.

(b) LOW-HEAT APPLIANCE TYPE

A factory-built masonry or metal chimney suitable for removing the product of combustion from fuel-burning low-heat appliances producing combustor gases not in excess of 538°C under normal operating conditions but capable of producing combustible gases of 760°C during intermittent forced firing for periods up to one hour. All temperatures are measured at the appliance flue outlet.

(c) MEDIUM-HEAT APPLIANCE TYPE

A factory built masonry or metal chimney suitable for removing the products of combustion from fuel-burning medium-heat appliances producing combustion gases not in excess of 1093°C measured at the appliance flue outlet.

CHIMNEY CONNECTOR: The pipe which connects a flue-burning appliance to a chimney.

CHIMNEY LINER: The lining materials of fire clay or other approved material.

CHIMNEY, MASONRY: The chimney of solid masonry units bricks, stones, listed hollow unit masonry units, or reinforced concrete.

INCOMBUSTIBLE MATERIAL: When referred to as structural material, means brick, stone, terracotta, concrete, iron, steel, sheet metal, or tiles, used either singly or in combination.

INCOMBUSTIBLE ROOFING: A covering of not less than two thicknesses of roofing felt and a good coat of tar and gravel or tin, corrugated iron or other approved fire-resisting material with standing seam on lap joint.

INTERLAYMENT is a layer of felt or no bituminous saturated felt not less than 18 inches (457 mm) wide, shingled between each course of roofing material.

METAL ROOF COVERING is metal shingles or sheets for application on solid roof surfaces, and corrugated or otherwise shaped metal sheets or sections for application on roof frameworks or on solid roof surfaces.

PENT HOUSE:An enclosed, unoccupied structure above the roof of a building, other than a tank, tower, spire, dome cupola or bulkhead.

POSITIVE ROOF DRAINAGE: The drainage condition in which consideration has been made for all loading deflections of the roof deck, and additional slope has been provided to ensure drainage of the roof within 48 hours of precipitation.

ROOF COVERING: Roof covering is a durable exterior surface material that provides weather protection for the building at the roof.

ROOFING ASSEMBLY:Roofing assembly includes the roof deck, substrate or thermal barrier, insulation, vapour retarder, underlayment, inter-laymen, base plies, roofing plies, and roof covering that is assigned a roofing classification.

ROOF VENTILATION: The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, attics, cathedral ceilings or other enclosed spaces over which a roof assembly is installed.

SCUPPER: An opening in a wall or parapet that allows water to drain from a roof.

UNDERLAYMENTis one or more layers of felt, sheathing paper, no bituminous saturated felt or other approved material over which a roofing system is applied.

2.9.2 Roof Covering

Roof covering for all buildings shall be either fire-retardant or ordinary depending upon the fire-resistive requirements: of the particular type of construction. The use of combustible roof insulation shall be permitted in all type of construction provided it is covered with approved roof covering applied directly thereto.

2.9.3 Roof Trusses

All roofs shall be so framed and tied into the framework and supporting walls so as to form an integral part of the whole building. **Roof trusses and joineries shall be well supported and fitted.** All tension members shall be well tightened before any load is placed in the truss. Diagonal and sway bracing shall be used to brace all roof trusses. The allowable working stresses of materials in trusses shall conform to this Code. Camber shall be provided to prevent sagging.

2.9.3.1 Attics

2.9.3.1.1 Access

An attic access opening shall be provided in the ceiling of the top floor of buildings with a combustible ceiling or roof construction. The opening shall be located in a corridor or hallway of buildings of three (3) or more stories in height and readily, accessible in buildings of any height. An opening shall not be less than 600 millimetres square (23.4") or 600 millimetres diameter (0.78"). The minimum clear headroom of 800 millimeters (31.2") shall be provided above the access opening.

2.9.3.1.2 Area separation

Enclosed attic spaces of combustible construction shall be divided into horizontal areas not exceeding 250 sq. meters (2691 sq.ft) by fire-resistive partitions extending from the ceiling to the roof. Except, that where the entire attic is equipped with approved automatic fire-extinguishing system, the attic space may be divided into areas not to exceed 750 sq. meters (8073 sq.ft). Openings in the partitions shall be protected by self-closing doors.

2.9.3.1.3 Draft stops

Regardless of the type of construction, draft stops shall be installed in trusses roofs, between roof and bottom chords or trusses, in all buildings exceeding 2000 sq.meter (21528 sq.ft). Draft stops shall be constructed as for attic area separations.

2.9.3.1.4 Ventilation

Enclosed attics including rafter spaces formed where ceilings are applied direct to the underside or roof rafters shall be provided with adequate ventilation protected against the entrance of rain.

2.9.4 Roof Drainage System**2.9.4.1 Roof drains**

Roof drains shall be installed at low points of the roof and shall be adequate in size to discharge all tributary waters.

2.9.4.2 Overflow drains and scuppers

Where roof drains are required adequate overflow drains shall be provided.

2.9.4.3 Concealed piping

Roof drains and overflows drains, when concealed within the, construction of the building, shall be installed in accordance with the provisions of this Code.

2.9.4.4 over public property

Roof drainage water from a building shall not be permitted to flow over public property except for Group "R" and "U₁" Occupancies.

2.9.5 Flashing

Flashing and counter flashing shall be provided at the juncture of the roof and vertical surfaces.

2.9.6 Skylights

All skylights shall be constructed with metal frames except those for Groups "R" and "U₁" Occupancies, Frame's of skylights shall be designed to carry loads required for roofs. All skylights the glass of which is set at an angle of less than 45° from the horizontal, if located above the first storey, shall be set at least 100 millimeters (4") above the roof. Curbs on which the skylights rest shall be constructed of incombustible materials except for Types I or II Construction.

Spacing between supports in one direction for flat wired glass in skylights shall not exceed 625 millimeters (24"). laminated glass may have supports 1.50 meters (5") apart in the direction of the corrugation, All glass in skylights shall be laminated glass; Except, that skylights over vertical shafts extending through two (2) or more storey shall be glazed with plain glass as specified in the Code. Provided, that wired glass may be used in ventilation equal to not less than one-eighth (1/8) the cross-sectional area of the shaft but never less than 1.20 meters (4") provided at the top of such shaft. Any glass not wired glass shall be protected above and below with a screen constructed of wire not smaller than 2.5 millimeters (0.098") in diameter with a mesh not larger than 25 millimeters (0.98"). The screen shall be substantially supported below the glass.

Ordinary glass may be used in the roof and skylights for greenhouses. Provided that height of the greenhouses at the ridge does not exceed 6.00 meters (19.6 ft) above the grade. The use of wood in the frames of skylights will be permitted in greenhouses outside of highly restrictive Fire Zones

if the height of the skylight does not exceed 6.00 meters (19.6 ft) above the grade, but in other cases metal frames and metal sash bars shall be used.

Glass used for the transmission of light, if placed in floors or sidewalks, shall be supported by metal or reinforced concrete frames, and such glass shall not be less than 12.5 millimeters (0.5") in thickness. Any such glass over 100 sq. centimeters (15.5 sq.inches) in area shall have wire mesh embedded in the same or shall be provided with, a wire screen underneath as specified for skylights in the Code. All portions of the floor lights or sidewalk lights shall be of the same strength as required for floor or sidewalk construction, except in cases where the floor is surrounded by a railing not less 1.10 meters (3.6 ft) in height, in which case the construction shall be calculated for not less than roof loads.

2.9.7 Penthouses and Roof top structures

2.9.7.1 Height

No penthouse or other projection above the roof in structures of other than Type V construction shall exceed 8.40 meters (28 ft) above the roof when used as an enclosure for tanks or for elevators which run to the roof and in all other cases shall not extend more than 3.60 meters (12 ft) in height with the roof. **Pent House floor is to be water proofed.**

2.9.7.2 Area

The aggregate area of all penthouses and other roof structures shall not exceed 50% of the area of the supporting roof.

2.9.7.3 Prohibited uses

No penthouse, bulkhead, or any other similar projection above the roof shall be used for purposes other than shelter of mechanical equipment or shelter of vertical shaft openings in the roof. A penthouse or bulkhead used for purposes other than that allowed by this Section shall conform to the requirements of the Code for an additional storey.

2.9.7.4 Construction

Roof structures shall be constructed with walls, floors, and roof as required for the main portion of the building except in the following cases:

On Types III and IV constructions, the exterior walls and roofs of penthouses which are 1.50 meters (4.5 ft) or more from an adjacent property line may be of one-hour fire-resistive incombustible construction.

Walls not less than 1.50 meters (4.5 ft) from an exterior wall of a Type IV construction may be of one-hour fire-resistive incombustible construction. The above restrictions shall not prohibit the placing of wood flagpoles or similar structures on the roof of any building.

2.9.8 Chimneys

2.9.8.1 Structural design

Chimneys shall be designed, anchored, supported, reinforced constructed, and installed in accordance with generally accepted principles of engineering. Every chimney shall be capable of producing a draft at the appliance not less than that required for the safe operation of the appliance connected thereto. No chimney shall support any structural load other than its own weight unless it is designed to act as a supporting member. Chimneys in a wood-framed building shall be anchored laterally at the ceiling line and at each floor line which is more than 1.80 meters (6 ft) above grade, except when entirely within the framework or when designed to be free standing.

2.9.8.2 Walls

Every masonry chimney shall have walls of masonry units, bricks, stones, listed masonry chimney units, reinforced concrete or equivalent solid thickness of hollow masonry and lined with suitable liners in accordance with the following requirements.

2.9.8.2.1 Masonry chimneys for residential type appliances

Masonry Chimneys shall be constructed of Masonry units or reinforced concrete with walls not less than 100 millimeters (4 in) thick: or rubble stone masonry not less than 300 millimeters (12 in) thick. The chimney liner shall be in accordance with the code.

2.9.8.2.2 Masonry chimneys for low heat appliances

Masonry Chimneys shall be constructed of Masonry units or reinforced concrete with walls not less than 200 millimeters (8 in) thick. Except that rubble stone masonry not less than 300 millimeters (12 in) thick. The chimney liner shall be in accordance with the code.

2.9.8.2.3 Masonry chimneys for medium-heat appliances

Masonry chimneys for medium-heat appliances shall be constructed of solid masonry units of reinforced concrete not less than 200 millimeters (8 in) thick. Except, that stone masonry shall be not less than 300 millimeters (12 in) thick and, in addition shall be lined with not less than 100 millimeters (4 in) of firebrick laid in a solid bed of fire clay mortar with solidly filled head, bed, and wall joints, starting not less than 600 millimeters (24 in) below the chimney connector entrance, Chimneys extending 7.50 meters (22.5 ft) or less above the chimney connector shall be lined to the top.

2.9.8.2.4 Masonry chimneys for high-heat appliances

Masonry chimneys for high-heat appliances shall be constructed with double walls of solid masonry units or reinforced concrete not less than 200 millimeters (8 in) in thickness, with an air space of not less than 50 millimeters (2 in) between walls. The inside of this Interior walls shall be of firebrick not less than 100 millimeters (4 in) in thickness laid in a solid bed of fire clay mortar with solidly filled head, bed, and Wall joints.

2.9.8.2.5 Masonry chimneys for incinerators installed in multi-storey buildings (apartment-type incinerators)

Chimneys for incinerators installed in multi-storey buildings using the chimney passageway as a refuse chute where the horizontal grate area of combustion chamber does not exceed 0.80 sq. Meters shall have walls of solid masonry or reinforced concrete, not less than 100 millimeters thick with, a chimney lining as specified in the Code. If the grate area of such an incinerator exceeds 0.80 sq. meters, the walls shall not be less than 100 millimeters of firebrick except that higher than 9.00 meters (27") above the roof of the combustion chamber, common brick alone 200 millimeters in thickness may be used.

2.9.8.2.6 Masonry chimneys for commercial and industrial type incinerators

Masonry chimneys for commercial and industrial type Incinerators of a size designed for not more than 110 kilograms of refuse per hour and having a horizontal grate area not exceeding 0.50 sq. meter shall have walls of solid masonry or reinforced concrete not less than 100 millimeters thick with lining of not less than 100 millimeters (4 in) of firebrick, which lining shall extend for not less than 12.00 meters (36 ft) above the roof of the combustion chamber If the design capacity of grate area of such an incinerator exceeds 110 kilograms per hour and 0.80 sq. meter (

80 sqft) respectively, walls shall not be less than 200 millimeters (8 in) thick, lined with not less than 100 millimeters (4 in) of firebrick extending the full height of the chimney.

2.9.8.3 Linings

Fire clay chimney lining shall not be less than 15 millimeters (1/2 in) thick. The lining shall extend from 200 millimeters (8 in) below the lowest inlet or, in the case of fireplace, from the throat of the fireplace to a point above enclosing masonry walls. Fire clay chimney linings shall be installed ahead of the construction of the chimney as it is carried up, carefully bedded one on the other in the fire clay mortar, with close-fitting joints left smooth on the inside. Firebrick not less than 50 millimeter thick may be used in place of fireclay chimney.

2.9.8.4 Area

No chimney passageway shall be smaller in area, than the vent connection of the appliance attached thereto.

2.9.8.5 Height

Every masonry chimney shall extend at least 600 millimeters (24 in) above the part of the roof through which it passes and at least 600 millimeters (24 in) above the highest elevation of any part of a building within 3.00 meters (9") to the chimney.

2.9.8.6 Corbelling

No masonry chimney shall be corbelled from a wall more than 150 millimeters, (6 in) nor shall a masonry chimney be corbelled from a wall which is less than 300 millimeters (12 in) in thickness unless it projects equally on each side of the wall. In the second storey of a two-storey building of Group "R" Occupancy, corbelling of masonry chimneys on the exterior of the enclosing walls may equal the wall thickness. In every case the corbelling shall not exceed 25 millimeters (1 in) projection for each course of brick.

2.9.8.7 Change in size or shape

No change in the size or shape of a masonry chimney shall be made within a distance of 150 millimeters (6 in) above or below the roof joints or rafters where the chimney passes through the roof.

2.9.8.8 Separation

When more than one passageway is contained in the same chimney, masonry separation at least 100 millimeters (4 in) thick bonded into the masonry wall of the chimney shall be provided to separate passageways.

2.9.8.9 Inlets

Every inlet to any masonry chimney shall enter the side thereof and shall be of not less than millimeters thick metal or 16 millimeters refractory material.

2.9.8.10 Clearance

Combustible materials shall not be placed within 50 millimeters of smoke chamber or masonry chimney walls when built within a structure or within 25 millimeters (10 in) when the chimney is built entirely outside the structure.

2.9.8.11 Termination

All incinerator chimneys shall terminate in a substantially constructed spark arrester having a mesh not exceeding 20 millimeters.

2.9.8.12 Cleanout

Cleanout openings shall be provided at the base of every masonry chimney.

PART 2 ARCHITECTURE AND URBAN DESIGN

2.10 REGULATIONS FOR HISTORICAL BUILDINGS

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.10 REGULATIONS FOR HISTORICAL BUILDINGS

Note: The *Historical Building Chapter*, Part 2 TWGII Architecture and Urban Design, governs for all heritage places or properties or areas in the Republic of the Union of Myanmar.

2.10-1 Administration

2.10-1.1 Title, purpose and Intent

2.10-1.1.1 Title. These regulations shall be known as the *Historical Building Chapter of TWGII Architecture and Urban Design, Myanmar National Building Code* and will be referred to herein as "the HBC."

2.10-1.1.2 Purpose. The purpose of the HBC is to provide regulation to guide works affecting heritage places during conservation, restoration, rehabilitation, relocation, reconstruction, adaptation, or new works to buildings or properties designated as heritage places or properties within heritage conservation areas (Chapter 2.10-2). The HBC is intended to provide solutions for the proper conservation of heritage places or properties, to promote sustainability, to provide access for persons with disabilities, to provide a cost-effective approach to conservation, and to provide for the reasonable safety of the occupants or users. The HBC requires enforcing agencies to accept solutions that are reasonably equivalent to the regular rules and regulations (as defined in Chapter 2.10-2) when dealing with heritage places or properties.

2.10-1.1.3 Intent. The intent of the HBC is to facilitate the proper conservation and continuing use of heritage places or properties while providing reasonable safety for the building occupants and access for persons with disabilities.

2.10-1.2 Application

2.10-1.2.1 Application. The HBC is applicable to all issues regarding code compliance for heritage places or properties. The HBC may be used in conjunction with the regular rules and regulations to provide solutions to facilitate the conservation of Heritageplaces or properties. The HBC shall be used by any agency with jurisdiction and whenever compliance with the code is required for Heritageplaces or properties.

1. The relevant Union or Regional government department shall apply the provisions of the HBC in permitting repairs, alterations and additions necessary for the conservation, restoration, reconstruction, rehabilitation, relocation, adaptation or continued use of a Heritageplace or property when so elected by the private property owner.
2. All relevant government departments shall apply the provisions of the HBC in permitting repairs, alterations and additions necessary for the conservation, restoration, rehabilitation, safety, relocation, reconstruction or continued use of Heritageplaces or properties.

2.10-1.2.2 Additions, alterations and repairs. It is the intent of the HBC to allow new expansion or addition to a Heritageplace or property, provide new additions shall conform to the requirements of the regular rules and regulations and relevant heritage guidelines and requirements. See Chapter 2.10-2.

2.10-1.2.3 Relocation. Relocated Heritageplaces or properties shall be sited to comply with the regular code or with the solutions listed in the HBC. New construction related to relocation shall comply with the regular rules and regulations. Reconstruction and restoration related to relocation is permitted to comply with the provisions in the HBC.

2.10-1.2.4 Change of occupancy. For change of use or occupancy, see Chapter 2.10-3, Use and Occupancy.

2.10-1.2.5 Continued use. Heritageplaces or properties may have their existing use or occupancy continued if such use or occupancy conformed to the code or to the standards of construction in effect at the time of construction, and such use or occupancy does not constitute a distinct hazard to life safety as defined in the HBC.

2.10-1.2.6 Unsafe buildings or properties. When a Heritageplace or property is determined to be unsafe as defined in the regular rules and regulations, the requirements of the HBC are applicable to the work necessary to correct the unsafe conditions. Work to remediate the buildings or properties need only address the correction of the unsafe conditions, and it shall not be required to bring the entire Heritageplace or property into compliance with regular code.

2.10-1.2.7 Additional work. Heritageplaces or properties shall not be subject to additional work required by the regular code, regulations or bylaws beyond that required to complete the work undertaken. Certain exceptions for accessibility and for distinct hazards exist by mandate and may require specific action, within the parameters of the HBC.

2.10-1.3 Organization and enforcement

2.10-1.3.1 Authority. The relevant Union or Regional or Local government department shall administer and enforce the provisions of the HBC in permitting repairs, alterations and additions necessary for the conservation, restoration, reconstruction, rehabilitation, relocation, adaptation or continued use of a Heritageplace or property.

2.10-1.3.2 Enforcement. All relevant government departments shall administer and enforce the HBC with respect to Heritageplaces or properties under their respective jurisdiction.

2.10-1.3.3 Liability. Prevailing law regarding immunity of the relevant government departments is unaffected by the use and enforcement of the HBC.

2.10-1.4 Review and appeals

2.10-1.4.1 An appeal and review body. Building Department of Local Governing Authority shall review preliminary appeal and the City Committee shall act as an appeal and review body to state and local agencies or any affected party.

2.10-1.4.2 Union and Regional-level agencies. All Union and Regional-level agencies with ownership of, or that act on behalf of state agency owners of, heritage places and properties, shall consult and obtain review prior to taking action or making decisions or appeals that affect Heritageplaces or properties.

2.10-1.4.2.1 Imminent threat. Where an emergency is declared and a Heritageplace or property is declared an imminent threat to life and safety, the state agency assessing such a threat shall consult with the City Committee before any demolition is undertaken.

2.10-1.4.3 Local agency fees. Local agencies, when actively involved in the appeal, may also charge affected persons reasonable fees not to exceed the cost of obtaining reviews and appeals from the Board.

2.10-1.5 Construction methods and materials

2.10-1.5.1 Repairs. Repairs to any portion of a Heritageplace or property may be made in-kind with historical materials and the use of original or existing historical methods of construction, subject to conditions of the HBC. (See Chapter 2.10-8.)

2.10-1.5.2 Solutions to the HBC. Solutions provided in the HBC, or any other acceptable regulation or methodology of design or construction and used in whole or in part, with the regular code, or with any combination of the regular rules and regulations and the HBC, shall be allowed. The HBC does not preclude the use of any proposed alternative or method of design or construction not specifically prescribed or otherwise allowed by these regulations. Any alternative may be submitted for evaluation to the appropriate enforcing agency for review and acceptance. The enforcing agency may request that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding such solutions. Any alternative offered in lieu of that prescribed or allowed in the HBC shall be reasonably equivalent in quality, strength, effectiveness, durability and safety to that of the HBC.

2.10-1.6 Rulings

2.10-1.6.1 General. Rulings of the Local government or Committee (i.e., formal appeals, case decisions, code interpretations and administrative resolutions, etc.) that are issues of State-wide and Region-wide application are required to be recorded in printed form and be made available to the public. These rulings may be used to provide guidance for similar cases or issues.

2.10-2 Definitions

2.10-2.1 Definitions

For the purpose of the HBC, certain terms and phrases, words and their derivatives shall be construed as specified in this chapter. Additional definitions and/or terms may appear in the various other chapters relative to terms or phrases primarily applicable thereto.

ADDITION. A nonhistorical extension or increase in floor area or height of a building or property.

ALTERATION. A modification to a Heritageplace or property that affects the usability of the building or property, or part thereof. Alterations include, but are not limited to, remodeling, renovation, rehabilitation, reconstruction, historical restoration, changes or rearrangement of the structural parts or elements, and changes or rearrangements in the plan configuration of walls and full-height partitions.

ANCIENT MONUMENT. Ancient monument is a monument which has been determined as cultural heritage that have existed since 100 years before the date on which the Department of Archaeology, National Museum and Library, Ministry of Culture made inquiries.

BUILDING STANDARD. Any guideline, regulation or code that may be applied to a Heritageplace or property.

CHARACTER-DEFINING FEATURE. Those visual aspects and physical elements that comprise the appearance of a historical building or property, and that are significant to its historical, architectural and cultural values, including the overall shape of the historical building or property, its materials, craftsmanship, decorative details, interior spaces and features, as well as the various aspects of its site and environment.

CONSERVATION. The act or process of applying measures necessary to sustain the existing form, integrity and materials of a Heritageplace or property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical and plumbing systems and other code-related work to make properties functional is appropriate within a conservation project.

CONSERVATION MANAGEMENT PLAN (CMP). A conservation management plan is a document that explains what the building or site is, why it is culturally significant and how the significance is vulnerable or sensitive to change. It sets out the policies for managing and protecting the significance in any future use or development. The CMP includes detailed information concerning the most significant elements of a building or site and suggests measures to conserve them. It may also suggest options of adaptive reuse of buildings and sites, so that the inherent significance is retained while permitting continued use and thus maintaining the building and site for future generations.

CONSERVATION AREAS/ZONES. Areas of significant historical, social, cultural, architectural and scientific values as designated by the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities in which by-laws and zoning regulations require projects to follow specific guidelines including but not limited to height, color, character, views, materials and scale to protect the nature and character of the areas.

CULTURAL RESOURCE. Building, site, property, object or district evaluated as having significance in prehistory or history.

DISASTER MANAGEMENT PLAN (DMP). A Disaster Management Plan is a document that assess hazards/risks from severe weather, earthquake, flood, etc. The plan shall clearly lay out prevention/mitigation strategies, response and recovery strategies, fire prevention plans, disaster preparation plan such as before and aftermath of cyclones, earthquakes, etc. so that the loss of heritage places and properties may be mitigated and prevented.

DISTINCT HAZARD. Any clear and evident condition that exists as an immediate danger to the safety of the occupants or public right of way. Conditions that do not meet the requirements of current regular codes and ordinances do *not*, of themselves, constitute a distinct hazard.

ENFORCING AGENCY. Authority having Jurisdiction, Local Agency with Jurisdiction in consultation with the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities. An entity with the responsibility for regulating, enforcing, reviewing or otherwise that exerts control of or administration over the process of gaining permits, approvals, decisions, variances, appeals for heritage places and properties.

EXIT LADDER DEVICE. An exit ladder device is a permanently installed, fixed, folding, retractable or hinged ladder intended for use as a means of emergency egress from areas of the second or third stories. Unless approved specifically for a longer length, the ladder shall be limited to 25 feet (7620 mm) in length. Exit ladders are permitted where the area served by the ladder has an occupant load less than 10 persons.

FIRE HAZARD. Any condition which increases or may contribute to an increase in the hazard or menace of fire to a greater degree than customarily recognized by the authority having jurisdiction, or any condition or act which could obstruct, delay, hinder or interfere with the operations of firefighting personnel or the egress of occupants in the event of fire.

HERITAGE IMPACT ASSESSMENT (HIA). Heritage Impact Assessment is a document that investigates and analyses the impact of new development, redevelopment, and adaptive-reuse development on and/or in the vicinity of the heritage place or property or in conservation zones or ancient monuments and regions designated or deemed eligible under the Protection and Preservation of Cultural Heritage Regions Law. Its investigation shall encompass historical, social, cultural, environmental and architectural impact on the Heritageplace or property. The document shall clearly state the impacts on the Heritageplace or property or conservation zone and shall provide resolution to avoid, minimize, and mitigate the adverse effects on the Heritageplace or property.

HERITAGE PLACE OR PROPERTY. Any habitable building, site, place, location, district or collection of structures, and their associated sites, deemed of importance to the history, architecture or cultural landscape of an area either listed by an appropriate local, regional or union level jurisdiction or with cultural significance. This shall include habitable historical buildings or properties on, or determined by city or county historical buildings lists, inventories or surveys of historical or architecturally significant sites, places or landmarks, identified and determined by the relevant local authorities, communities and concerned organizations to be included.

HISTORIC BUILDING STRUCTURE REPORT (HBSR). A historic building structural report is a document that reports on the structural conditions of a historical building to understand the scope of work for structural repairs and that provides recommendation for remedial solutions by a licensed structure

engineer or a licensed architect. Structural conditions to survey includes all major load-bearing structures including but not limited to columns, beams, walls, floors, roofs, windows, doors, protruding members of a structure, cornice, pediments, etc.

HISTORICAL FABRIC OR MATERIALS.Original and later-added historically significant construction materials, architectural finishes or elements in a particular pattern or configuration which form a qualified historical property, as determined by the authority having jurisdiction.

HISTORICAL SIGNIFICANCE.Importance for which a property has been evaluated and found to be historical, as determined by the authority having jurisdiction.

IMMINENT THREAT. Any condition within or affecting a Heritageplace or property which, in the opinion of the authority having jurisdiction, would qualify a building or property as dangerous to the extent that the life, health, property or safety of the public, its occupants or those performing necessary repair, stabilization or shoring work are in immediate peril due to conditions affecting the building or property. Potential hazards to persons using, or improvements within, the right-of-way may not be construed to be "imminent threats" solely for that reason if the hazard can be mitigated by shoring, stabilization, barricades or temporary fences.

INTEGRITY.Authenticity of a building or property's historical identity, evidenced by the survival of physical characteristics that existed during the property's historical or prehistorical period of significance.

LIFE·SAFETY EVALUATION. An evaluation of the life-safety hazards of a Heritageplace or property based on procedures laid out by the local authorities

LIFE SAFETY HAZARD. See Distinct Hazard.

PERIOD OF SIGNIFICANCE.The period of time when a qualified historical building or property was associated with important events, activities or persons, or attained the characteristics for its listing or registration.

RECONSTRUCTION. The act or process of depicting, by means of new construction, the form, features and detailing of a non-surviving site, landscape, building, property or object for the purpose of replicating its appearance at a specific period of time.

REGULAR RULES AND REGULATIONS.The adopted regulations that govern the design and construction or alteration of nonhistorical buildings and properties within the jurisdiction of the enforcing agency.

REHABILITATION. The act or process of making possible a compatible use for heritage place or property through repair, alterations and additions while preserving those portions or features which convey its qualified historical, cultural or architectural values.

RELOCATION. The act or process of moving any qualified historical building or property or a portion of a qualified historical building or property to a new site, or a different location on the same site.

REPAIR. Renewal, reconstruction or renovation of any portion of an existing property, site or building for the purpose of its continued use.

RESTORATION. The act or process of accurately depicting the form, features and character of a qualified building or property as it appeared at a particular period of time by the means of the removal of

features from other periods in its history and reconstruction of missing features from the restoration period. The limited and sensitive upgrading of mechanical, electrical and plumbing systems and other code-required work to make properties functional is appropriate within a restoration project.

STRUCTURE. That which is built or constructed, an edifice or a building of any kind, or any piece of work artificially built up or composed of parts joined together in some definite manner.

TREATMENT. An act of work to carry out conservation, restoration, stabilization, rehabilitation or reconstruction.

2.10-3 Use and occupancy

2.10-3.1 Purpose and scope

2.10-3.1.1 Purpose. The purpose of the HBC is to provide regulations for the determination of occupancy classifications and conditions of use for heritage places or properties.

2.10-3.1.2 Scope. Every heritage place or property for which a permit or approval has been requested shall be classified prior to permit issuance according to its use or the character of its occupancy in accordance with the regular rules and regulations and applicable provisions of this chapter.

2.10-3.2 General

2.10-3.2.1 Existing use. The use or character of occupancy of a heritage place or property, or portion thereof, shall be permitted to continue in use regardless of any period of time in which it may have remained unoccupied or in other uses, provided such building or property otherwise conforms to all applicable requirements of the HBC.

2.10-3.2.2 Change in occupancy. The use or character of the occupancy of a heritage place or property may be changed from or returned to its historical use or character, provided the heritage place or property conforms to the requirements applicable to the new use or character of occupancy as set forth in the HBC. Such in occupancy shall not mandate conformance with new construction requirements as set forth in regular rules and regulations.

2.10-3.2.3 Light and ventilation. Existing provisions for light and ventilation which do not, in the opinion of the enforcing agency, constitute a safety hazard may remain.

2.10-3.2.4.Means of Egress. Heritage places and properties shall be granted reasonable exceptions to regular chapter and fire code in consultation with the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities.

2.10-3.2.5.Means of Accessibility. Heritage places and properties shall be granted reasonable exceptions to regular chapter in consultation with the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities.

2.10-4 Fire protection

2.10-4.1 Purpose, Intent and Scope

2.10-4.1.1 Purpose. The purpose of this chapter is to provide for fire protection of heritage places or properties. The HBC requires enforcing agencies to accept any reasonably equivalent to the regular rules and regulations when dealing with heritage places and properties.

2.10-4.1.2 Intent. The intent of the HBC is to preserve the integrity of heritage places or properties while maintaining a reasonable degree of fire protection based primarily on the life safety of the occupants and firefighting personnel.

2.10-4.1.3 Scope. This chapter shall apply when required by the provisions of Section 2.10-2.

2.10-4.2 fire-resistive construction

2.10-4.2.1 Fire-resistive construction. Heritage places and properties shall be granted reasonable exceptions or restrictions to regular fire code. in consultation with the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities.

2.10-4.2.2 Exterior wall construction. In case of highly significant heritage places or properties, the fire-resistance requirement for existing exterior walls and existing opening protection shall be satisfied.

2.10-4.2.3 One-hour construction. Upgrading an existing qualified historical building or property to one-hour fire-resistive construction and one-hour fire-resistive corridors shall not be required regardless of construction or occupancy when one of the following is provided:

1. An automatic sprinkler system throughout.
2. An approved life-safety evaluation.
3. Other alternative measures as approved by the enforcing agency.

2.10-4.2.4 Openings in fire-rated systems. Historical glazing materials and solid wood unrated doors in interior walls required to have one-hour fire rating may be approved when operable windows and doors are provided with appropriate smoke seals and when the area affected is provided with an automatic sprinkler system.

2.10-4.3 Interior finish materials

New nonhistorical interior wall and ceiling finish shall conform to the provisions of the regular rules and regulations.

2.10-4.4 Vertical shafts

Vertical shafts need not be enclosed when such shafts are blocked at every floor level by the installation of not less than 2 full inches (51 mm) of solid wood or equivalent construction installed so as to prevent the initial passage of smoke and flame. Automatic sprinkler systems or other solutions may be considered on a case-by-case basis, in lieu of enclosure of vertical shafts and stairwells.

2.10-4.5 Roof covering

Existing or original roofing materials may be repaired or reconstructed subject to the following requirements:

1. The Original or historical roofing system shall be detailed or modified as necessary in order to be capable of providing shelter while preserving the historical materials and appearance of the roof.
2. Wooden roof materials may be utilized where fire resistance is required, provided they are treated with fire-retardant treatments to achieve a Class "B" roof covering rating.

2.10-4.6 Fire alarm systems

Every heritage place or property shall be provided with fire alarm systems as required for the use or occupancy by the regular code or other approved alternative.

2.10-4.7 Automatic sprinkler systems

2.10-4.7.1 Every heritage place or property which cannot be made to conform to the construction requirements specified in the regular rules and regulations for the occupancy or use, and which constitutes a distinct fire hazard (for definition of "distinct hazard," see Chapter 2.10-2), shall be deemed to be in compliance if provided with an automatic sprinkler system or a life-safety system or other technologies as approved by the enforcing agency. ("Automatic" is defined in the regular code. Sprinkler System is defined in this section.)

2.10-4.7.2 Automatic sprinkler systems shall not be used to substitute for or act as an alternate to the required number of exits from any facility. (See Chapter 2.10-5 for exiting requirements.)

2.10-4.7.3 An automatic sprinkler system shall be provided in all detention facilities.

2.10-4.8 Other technologies

Fire alarm systems, smoke and heat detection systems, occupant notification and annunciation systems, smoke control systems and fire modeling, times egress analysis and modeling, as well as other engineering methods and technologies may be accepted by the enforcing agency to address areas of nonconformance.

2.10-5 Structural regulations

2.10-5.1 Purpose, intent and scope

2.10-5.1.1 Purpose. The purpose of the HBC is to provide alternative regulations to the regular rules and regulations for the structural safety of buildings designated as heritage places or properties. The HBC requires enforcing agencies to accept any reasonably equivalent alternatives to the regular rules and regulations when dealing with heritage places or properties.

2.10-5.1.2 Intent. The intent of this section is to encourage the conservation of heritage places or structures while providing standards for a minimum level of building performance with the objective of

preventing partial or total structural collapse such that the overall risk of life-threatening injury as a result of structural collapse is low.

2.10-5.1.3 Application. The alternative structural regulations provided by Section 2.10-5.5 are to be applied in conjunction with the regular rules and regulations whenever a structural upgrade or reconstruction is undertaken for heritage places or properties.

2.10-5.2 General

2.10-5.2.1 The HBC shall not be construed to allow the enforcing agency to approve or permit a lower level of safety of structural design and construction than that which is reasonably equivalent to the regular code provisions in occupancies which are critical to the safety and welfare of the public at large, including, but not limited to, public and private schools, hospitals, municipal police and fire stations and essential services facilities.

2.10-5.2.2 Nothing in these regulations shall prevent voluntary and partial seismic upgrades when it is demonstrated that such upgrades will improve life safety and when a full upgrade would not otherwise be required.

2.10-5.3 Structural survey

2.10-5.3.1 Scope. When a structure or portion of a structure is to be evaluated for structural capacity under the HBC, it shall be surveyed for structural conditions by an architect or engineer knowledgeable in historical structures. The survey shall evaluate deterioration or of distress. The survey shall determine the details of the structural framing and the system for resistance of gravity and lateral loads. Details, reinforcement and anchorage of structural systems and veneers shall be determined and documented where these members are relied on for seismic lateral resistance.

2.10-5.3.2 The results of the survey shall be utilized for evaluating the structural capacity and for designing modifications to the structural system to reach compliance with this code.

2.10-5.3.3 Historical records. Past historical records of the structure or similar structures may be used in the evaluation, including the effects of subsequent alterations.

2.10-5.4 Nonhistorical additions and nonhistorical alterations

2.10-5.4.1 New nonhistorical additions and nonhistorical alterations which are structurally separated from an existing historical building or structure shall comply with regular code requirements.

2.10-5.4.2 New nonhistorical additions which impose vertical or lateral loads on an existing structure shall not be permitted unless the affected part of the supporting structure is evaluated and strengthened, if necessary, to meet regular code requirements.

Note: For use of archaic materials, see Chapter 2.10-6.

2.10-5.5 Structural regulations

2.10-5.5.1 Gravity loads. The capacity of the structure to resist gravity loads shall be evaluated and the structure strengthened as necessary. The evaluation shall include all parts of the load path. Where no distress is evident, and a complete load path is present, the structure may be assumed adequate by having withstood the test of time if anticipated dead and live loads will not exceed those historically present.

2.10-5.5.2 Wind and seismic loads. The ability of the structure to resist wind and seismic loads shall be evaluated. Wind loads shall be considered when appropriate, but need not exceed 75% of the wind loads prescribed for structural design required of new building construction. The evaluation shall be based on the requirements of Section 2.10-5.6.

2.10-5.5.2.1 Any unsafe conditions in the lateral-load-resisting system shall be corrected, or alternative resistance shall be provided. When strengthening is required, additional resistance shall be provided to meet the minimum requirements of the HBC. The strengthening measures shall be selected with the intent of meeting the performance objectives set forth in Section 2.10-5.1.2. The evaluation of structural members and structural systems for seismic loads shall consider the inelastic performance of structural members and their ability to maintain load-carrying capacity during the seismic loadings prescribed by the regular rules and regulations.

2.10-5.5.2.2 The architect or engineer shall consider additional measures with minimal loss and impact to, historical materials which will reduce damage and needed repairs in future earthquakes to better preserve the historical structure in perpetuity. These additional measures shall be presented to the owner for consideration as part of the rehabilitation or restoration.

2.10-5.6 Lateral load regulations

2.10-5.6.1 Seismic forces. Strength-level seismic forces used to evaluate the structure for resistance to seismic loads shall be based on the R-values tabulated in the regular code for similar lateral-force-resisting systems including consideration of the structural detailing of the members where such R-values exist. Where such R-values do not exist, an appropriate R-value shall be rationally assigned considering the structural detailing of the members.

Exceptions:

1. The forces need not exceed 0.75 times the seismic forces prescribed for structural design required of new building construction.
2. For Occupancy Category I, II or III structures, near-fault increases in ground motion (maximum considered earthquake ground motion of 0.2 second spectral response greater than 150 percent at 5 percent damping) need not be considered when the fundamental period of the building is 0.5 seconds in the direction under consideration.
3. For Occupancy Category I or II structures, the seismic base shear need not exceed 0.30W.
4. For Occupancy Category III or IV structures, the seismic base shear need not exceed 0.40W.

2.10-5.6.1.1 When a building is to be strengthened with the addition of a new lateral force resisting system, the R value of the new system can be used when the new lateral force resisting system resists at least 75 percent of the building's base shear regardless of its relative rigidity.

2.10-5.6.1.2 Unreinforced masonry bearing wall buildings shall comply with MNBC, and as modified by the HBC. Alternative standards may be used on a case-by-case basis when approved by the authority having jurisdiction. It shall be permitted to exceed the strength limitation of 100

psi in MNBC when test data and building configuration supports higher values subject to the approval of the authority having jurisdiction.

2.10-5.6.1.3 All deviations from the detailing provisions of the lateral-force-resisting systems shall be evaluated for stability and the ability to maintain load-carrying capacity at the expected inelastic deformations.

2.10-5.6.2 Existing building performance. The seismic resistance may be based upon the ultimate capacity of the structure to perform, giving due consideration to ductility and reserve strength of the lateral-force-resisting system and materials while maintaining a reasonable factor of safety. Broad judgment may be exercised regarding the strength and performance of materials not recognized by regular code requirements. (See Chapter 2.10-6, Archaic Materials and Methods of Construction.)

2.10-5.6.2.1 All structural materials or members that do not comply with detailing and proportioning requirements of the regular rules and regulations and provisions for new building construction shall be evaluated for potential seismic performance and the consequence of non-compliance. All members that would be reasonably expected to fail and lead to collapse or life threatening injury when subjected to seismic demands shall be judged unacceptable, and appropriate structural strengthening shall be developed.

2.10-5.6.3 Load path. A complete and continuous load path, including connections, from every part or portion of the structure to the ground shall be provided for the required forces. It shall be verified that the structure is adequately tied together to perform as a unit when subjected to earthquake forces.

2.10-5.6.4 Parapets. Parapets and exterior decoration shall be investigated for conformance with regular code requirements for anchorage and ability to resist prescribed seismic forces.

An exception to regular code requirements shall be permitted for those parapets and decorations which are judged not to be a hazard to life safety.

2.10-5.6.5 Nonstructural features. Nonstructural features of historical structure, such as exterior veneer, cornices and decorations, which might fall and create a life-safety hazard in an earthquake, shall be evaluated. Their ability to resist seismic forces shall be verified, or the feature shall be strengthened with improved anchorage when appropriate.

2.10-5.6.5.1 Partitions and ceilings of corridors and stairways serving an occupant load of 30 or more shall be investigated to determine their ability to remain in place when the building is subjected to earthquake forces.

2.10-6 Archaic materials and methods of construction

2.10-6.1 Purpose, intent and scope

2.10-6.1.1 Purpose. The purpose of the HBC is to provide regulations for the use of historical methods and materials of construction that are at variance with the requirement of regular rules and regulations or are not otherwise codified, in buildings or structures designated as Heritageplaces or properties. The HBC require enforcing agencies to accept any reasonably equivalent alternatives to the regular rules and regulations when dealing with heritage places and properties.

2.10-6.1.2 Intent. It is the intent of the HBC to provide for the use of historical methods and materials of construction that are at variance with specific code requirements or are not otherwise codified.

2.10-6.1.3 Scope. Any construction type or material that is, or was, part of the historical fabric of a structure is covered by this chapter. Archaic materials and methods of construction present in a historical structure may remain or be reinstalled or be installed with new materials of the same class to match existing conditions.

2.10-6.2 General engineering approaches

Strength values for archaic materials shall be assigned based upon similar conventional codified materials, or on tests as hereinafter indicated. The archaic materials and methods of construction shall be thoroughly investigated for their details of construction in accordance with Section 2.10-5.3. Testing shall be performed when applicable to evaluate existing conditions. The architect or structural engineer in responsible charge of the project shall assign allowable stresses or strength levels to archaic materials. Such assigned strength values shall not be greater than those provided for in the following sections without adequate testing, and shall be subject to the concurrence of the enforcing agency.

2.10-6.3 Nonstructural archaic materials

Where nonstructural historical materials exist in uses which do not meet the requirements of the regular rules and regulations, their continued use is allowed by this rules and regulations, provided that any public health and life-safety hazards are mitigated subject to the concurrence of the enforcing agency.

2.10-6.4 Allowable conditions for specific materials

Archaic materials which exist and are to remain in qualified historical buildings or structures shall be evaluated for their condition and for loads required by this code. The structural survey required in Section 2.10-5.3 of the HBC shall document existing conditions, reinforcement, anchorage, deterioration and other factors pertinent to establishing allowable stresses, strength levels and adequacy of the archaic materials. The remaining portion of this section provides additional specific requirements for commonly encountered archaic materials.

2.10-6.5 Masonry

2.10-6.5.1 Existing solid masonry. Existing solid masonry walls of any type, except adobe, may be allowed, without testing, a maximum ultimate strength of nine pounds per square inch (62.1 kPa) in shear where there is a qualifying statement by the architect or engineer that an inspection has been made, that mortar joints are filled and that both brick and mortar are reasonably good. The shear stress above applies to unreinforced masonry, except adobe, where the maximum ratio of unsupported height or length to thickness does not exceed 13, and where minimum quality mortar is used or exists. Wall height or length is measured to supporting or resisting elements that are at least twice as stiff as the tributary wall. Stiffness is based on the gross section. Shear stress may be increased by the addition of 10 percent of the axial direct stress due to the weight of the wall directly above.

2.10-6.5.2 Reconstructed walls. Totally reconstructed walls utilizing original brick or masonry, constructed similar to original, shall be constructed in accordance with the rules and regulations. Repairs or infills may be constructed in a similar manner to the original walls without conforming to the regular rules and regulations.

2.10-6.6 Wood

2.10-6.6.1 Existing wood diaphragms or walls. Existing wood diaphragms or walls of straight or diagonal sheathing shall be assigned shear resistance values appropriate with the fasteners and materials

functioning in conjunction with the sheathing. The structural survey shall determine fastener details and spacings and verify a load path through floor construction. Shear values of Tables 2.10-6-A and 2.10-6-B.

2.10-6.6.2 Existing wood framing. Existing wood framing members may be assigned allowable stresses consistent with codes in effect at the time of construction. Existing or new replacement wood framing may be of archaic types originally used if properly researched, such as balloon and single wall. Wood joints such as dovetail and mortise and tendon types may be used structurally, provided they are well made. Lumber selected for use and type need not bear grade marks, and greater or lesser species such as low-level pine and fir, boxwood and indigenous hardwoods and other variations may be used for specific conditions where they were or would have been used. Wood fasteners such as square or cut nails may be used with a maximum increase of 50 percent over wire nails for shear.

2.10-6.7 Concrete

2.10-6.7.1 Materials. Natural cement concrete, unreinforced rubble concrete and similar materials may be utilized wherever that material is used historically. Concrete of low strength and with less reinforcement than required by the regular code may remain in place. The architect or engineer shall assign appropriate values of strength based on testing of samples of the materials. Bond and development lengths shall be determined based on historical information or tests.

2.10-6.7.2 Detailing. The architect or engineer shall carefully evaluate all detailing provisions of the regular rules and regulations which are not met and shall consider the implications of these variations on the ultimate performance of the structure, giving due consideration to ductility and reserve strength.

2.10-6.8 Steel and iron

The hand-built, untested use of wrought or black iron, the use of cast iron or grey iron, and the myriad of joining methods that are not specifically allowed by code may be used wherever applicable and wherever they have proven their worth under the considerable span of years involved with most qualified historical buildings or structures. Uplift capacity should be evaluated and strengthened where necessary. Fixed conditions or mid height lateral loads on cast iron columns that could cause failure should be taken into account. Existing structural wrought, forged steel or grey iron may be assigned the maximum working stress prevalent at the time of original construction.

2.10-6.9 Veneers

2.10-6.9.1 Terra cotta and stone. Terra cotta, cast stone and natural stone veneers shall be investigated for the presence of suitable anchorage. Steel anchors shall be investigated for deterioration or corrosion. New or supplemental anchorage shall be provided as appropriate.

2.10-6.10 Glass and glazing

2.10-6.10.1 Glazing subject to human impact. Historical glazing material located in areas subject to human impact may be approved subject to the concurrence of the enforcing agency when alternative protective measures are provided. These measures may include, but not be limited to, additional glazing panels, protective film, protective guards or systems, and devices or signs which would provide adequate public safety.

2.10-6.10.2 Glazing in fire-rated systems. See Section 2.10-4.2.3.

TABLE 2.10-6A

STRENGTH VALUES FOR EXISTING MATERIALS

EXISTING MATERIALS OR CONFIGURATIONS OF MATERIALS ¹	STRENGTH LEVEL CAPACITY x14.594 for N/m
1. Horizontal diaphragms ² 1.1 Roofs with straight sheathing and roofing applied directly to the sheathing 1.2 Roofs with diagonal sheathing and roofing applied directly to the sheathing 1.3 Floors with straight tongue-and-groove sheathing 1.4 Floors with straight sheathing and finished wood flooring with board edges offset or perpendicular 1.5 Floors with diagonal sheathing and finished	300 lbs per foot for seismic shear 750 lbs per foot for seismic shear 300 lbs per foot for seismic shear 1,500 lbs per foot for seismic shear 1,800 lbs per foot for seismic shear
2. Crosswalls ^{2,3} 2.1 Plaster on wood or metal lath 2.2 Plaster on gypsum lath 2.3 Gypsum wallboard, unblocked edges 2.4 Gypsum wallboard, blocked edges	Per side: 600 lbs per foot for seismic shear 550 lbs per foot for seismic shear 200 lbs per foot for seismic shear 400 lbs per foot for seismic shear
3. Existing footings, wood framing, structural steel and reinforcing steel 3.1 Plain concrete footings 3.2 Douglas fir wood 3.3 Reinforcing steel 3.4 Structural steel	$f'_c = 1,500$ psi (10.34 MPa) unless otherwise shown by tests ³ Allowable stress same as D.F. No. 1 ³ $f_t = 40,000$ lbs per square inch (124.1 N/mm ²) maximum $f_t = 33,000$ lbs per square inch (137.9 N/mm ²) maximum

¹Material must be sound and in good condition.

²Shear values of these materials may be combined, except the total combined value shall not exceed 900 pounds per foot (13,140 N/m).

³Stresses given may be increased for combinations of loads as specified in the regular code.

TABLE 2.10-6B
STRENGTH VALUES OF NEW MATERIALS USED IN CONNECTION WITH EXISTING CONSTRUCTION

NEW MATERIALS OR CONFIGURATIONS OF MATERIALS	STRENGTH LEVEL CAPACITY ¹
1. Horizontal diaphragms ²	
1.1 ¹⁵ / ₃₂ inch minimum plywood sheathing fastened directly over existing straight sheathing with edges of plywood located on center of individual sheathing boards and fastened with minimum #8x 1 ¹ / ₄ inch wood screws or nails with helical threads 0.13 inch min. diameter and 1 ¹ / ₄ inch min. length at 4 inch centers all panel edges and 12 inch centers each way in field.	1,500 lbs per foot
1.2 Same plywood and attachments as 1.1 fastened directly over existing diagonal sheathing.	1,800 lbs per foot
1.3 ³ / ₈ inch plywood sheathing fastened directly over existing straight or diagonal sheathing with ends and edges on centers of individual sheathing boards and fastened with #6 wood screws or nails with helical threads 0.13 inch minimum diameter and 1 ¹ / ₄ inch min. length at 6 inch centers all panel edges and 12 inch centers each way in field.	900 lbs per foot
2. Shear walls: Plywood sheathing applied directly over wood studs. No value shall be given to plywood applied over existing plaster or wood sheathing	100 percent of the value specified in the regular code for shear walls
3. Crosswalls: (special procedure only)	
3.1 Plywood sheathing applied directly over wood studs. No value shall be given to plywood applied over existing plaster or wood sheathing	133 percent of the value specified in the regular code for shear walls
3.2 Drywall or plaster applied directly over wood studs	100 percent of the values in the regular code
3.3 Drywall or plaster applied to sheathing over existing wood studs	50 percent of the values specified in the regular code
4. Tension bolts	
a. Bolts extending entirely through unreinforced masonry walls secured with bearing plates on far side of a three-wythe-minimum wall with at least 30 square inches (19 350 mm ²) of area ^{4,5}	5,400 lbs (24,010 N) per bolt ⁶ 2,700 lbs (12,009 N) per bolt for two-wythe walls ⁶
b. All thread rod extending to the exterior face of the wall installed in adhesive ⁹	3,600 lbs (16,014 N) per bolt
5. Shear bolts Bolts embedded a minimum of 8 inches (203 mm) into unreinforced masonry walls and centered in a 2 ¹ / ₂ -inch-diameter (63.5 mm) hole filled with dry-pack or nonshrink grout. Through bolts with first 8 inches (203 mm) as noted above and embedded all thread rod as noted in Item 4.b ^{5,7,9}	¹ / ₂ inch (12.7 mm) diameter = 1050 lbs (4671 N) ⁶ ³ / ₈ inch (15.9 mm) diameter = 1500 lbs (6672 N) ⁶ ³ / ₄ inch (19 mm) diameter = 2250 lbs (10,008 N) ⁶
6. Infilled walls Reinforced masonry infilled openings in existing unreinforced masonry walls. Provide keys or dowels to match reinforcing.	Same as values specified for unreinforced masonry walls
7. Reinforced masonry Masonry piers and walls reinforced per the regular code	Same as values specified in the regular code ⁸
8. Reinforced concrete Concrete footings, walls and piers reinforced as specified in the regular code and designed for tributary loads	Same values as specified in the regular code ⁸

¹Values are for strength level loads as defined in regular code standards.

²Values may be adjusted for other fasteners when approved by the enforcing authority.

³In addition to existing sheathing value.

⁴Bolts to be ¹/₂-inch (12.7 mm) minimum diameter.

⁵Other bolt sizes, values and installation methods may be used provided a testing program is conducted in accordance with regular code standards. Bolt spacing shall not exceed 6 feet. (1830 mm) on center and shall not be less than 12 inches (305 mm) on center

⁶Other masonry based on tests or other substantiated data.

⁷Embedded bolts to be tested as specified in regular code standards.

⁸Stresses given may be increased for combinations of loads as specified in the regular code.

⁹Adhesives shall be approved by the enforcing agency and installed in accordance with the manufacturer's recommendations. All drilling dust shall be removed from drilled holes prior to installation.

2.10-7 Mechanical, plumbing and electrical requirements

2.10-7.1 Purpose, intent and scope

Heritage places and properties shall be granted reasonable exceptions to regular chapter and fire code in consultation with the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities.

2.10-8 Qualified historical districts, sites and open spaces

2.10-8.1 Purpose and scope

2.10-8.1.1 Purpose. The purpose of this section is to provide regulations for the conservation, rehabilitation, restoration and reconstruction of associated historical features of qualified historical buildings, properties or districts (as defined in Chapter 2.10-2), and for which Chapters 2.10-3 through 2.10-7 of the HBC may not apply.

2.10-8.1.2 Scope. This section applies to the associated historical features of heritage places or properties such as historical districts that are beyond the buildings themselves which include, but are not limited to, natural features and designed site and landscape plans with natural and man-made landscape elements that support their function and aesthetics. This may include, but will not be limited to:

1. Site plan layout configurations and relationships (pedestrian, equestrian and vehicular site circulation, topographical grades and drainage, and use areas).
2. Landscape elements (plant materials, site structures other than the heritage place, bridges and their associated structures, lighting, water features, art ornamentation, and pedestrian, equestrian and vehicular surfaces).
3. Functional elements (utility placement, erosion control and environmental mitigation measures).

2.10-8.2 Application

2.10-8.2.1 The HBC shall apply to all sites and districts and their features associated with heritage places or qualified historical districts as outlined in 2.10-8.1.2 Scope.

2.10-8.2.2 Where the application of regular rules and regulations may impact the associated features of qualified historical properties beyond their footprints, by work performed secondarily, those impacts shall also be covered by the HBC.

2.10-8.2.3 This section shall be applied for all issues regarding code compliance or other standard or regulation as they affect the purpose of this chapter.

2.10-8.2.4 The application of any rules and regulations or building standard shall not unduly restrict the use of a heritage place or property that is otherwise permitted pursuant to Chapter 2.10-3.

2.10-8.3 Site relations

The relationship between a building or property and its site, or the associated features of a district (including qualified historical landscape), site, objects and their features are critical components

that may be one of the criteria for these buildings and properties to be qualified under the HBC. The HBC recognizes the importance of these relationships. This section shall be used to provide context sensitive solutions for treatment of heritage places, properties, district or their associated historical features, or when work to be performed secondarily impacts the associated historical features of a heritage place or property.

2.10-9 Conservation management plan and heritage impact assessment

2.10-9.1 Purpose and scope

2.10-9.1.1 Purpose. The purpose of this section is to provide regulations for the conservation, rehabilitation, restoration and reconstruction of associated historical features of heritage places and buildings (as defined in Chapter 2.10-2), and to make sure building conservation follows proper investigations, guidelines and planning procedures for historic buildings.

2.10-9.1.2 Scope. Every listed heritage place or property for which a permit or approval has been requested shall be classified prior to permit issuance according to conservation management plan and heritage impact assessment as required. In addition, the process shall be complied to any other heritage places or properties if required by the relevant planning authority, and/or a committee formed by the relevant planning authority and/or the commission formed by Union, Regional and/or Local authorities.

2.10-9.2 Application

2.10-9.2.1 The requirement shall apply to all heritage place or property and conservation zones as defined in Chapter 2.10-2.

2.10-9.2.2 When a historical building is to be adaptively reused or propose an adaptive reuse plan, Conservation Management Plan (defined in Chapter 2.10-2) is required before any planning or building permission for development is given.

2.10-9.2.2.1 Historic Building Structure Report (HBSR) can be required as part of the CMP for surveying extensive structural conditions of a historical building.

2.10-9.2.2.2 Disaster Management Plan (DMP) is required as part of CMP to access hazards/risks, to clearly lay out prevention/mitigation strategies, response and recovery strategies, fire prevention plans, disaster preparation plan such as before and aftermath of cyclones, earthquakes, etc. so that the loss of heritage places and properties may be mitigated and prevented.

2.10-9.2.2.3 Conservation Management Plan, as defined in Chapter 2.10-2, shall be undertaken by independent team of experts, commissioned and shall be reported to the relevant planning authority and/or committee or commission formed by relevant planning authority.

2.10-9.2.2.4 Any cost relating to Conservation Management Plan must be paid for by the developer or the project proponent.

2.10-9.2.2.5 Conservation Management Plan shall be made available to the public as public record.

ARCHITECTURE AND URBAN DESIGN

2.10-9.2.3 Any project, regardless of its status, falling in the conservation zone or adjacent to or in the vicinity of heritage places and properties shall require to undertake Heritage Impact Assessment before any planning or building permission for development is given.

2.10-9.2.3.1 Heritage Impact Assessment, as defined in Chapter 2.10-2, shall be undertaken by independent team of experts, commissioned and shall be reported to the relevant planning authority and/or committee or commission formed by relevant planning authority.

2.10-9.2.3.2 Any cost relating to Heritage Impact Assessment must be paid for by the developer or the project proponent.

2.10-9.2.3.3 Heritage Impact Assessment shall be made available to the public as public record.

2.10-9.2.4 HIA and CMP must clearly explain, with facts, drawings with scale, and/or any other medium, how the proposed project shall avoid the adverse effects on the heritage place or property and/or conservation zones.

2.10-9.2.4.1 When avoidance of adverse effects become reasonably unfeasible, HIA and CMP shall provide resolutions to minimize and/or mitigate the adverse effects on the heritage place or property and/or conservation zone, satisfactory to the relevant local and planning authority before approval.

PART 2 ARCHITECTURE AND URBAN DESIGN

SECTION 2.11 URBAN DESIGN AND ENVIRONMENT

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PART 2 ARCHITECTURE AND URBAN DESIGN

2.11 URBAN DESIGN AND ENVIRONMENT

2.11.1 Urban Design and Outside spaces

2.11.1.1 Zoning Regulations

The regulations regarding the “Urban Design Portion” of this code are to be followed in addition to the regulations written in the TWG I of “Myanmar National Building Codes”, and the Zoning Regulations of the respective towns and urban areas, where available, and are to apply in all areas of the Republic of the Union of Myanmar.

2.11.1.2 Definitions

Unless otherwise specifically defined, the meanings are to be interpreted as the followings:

ACCESS WAY: means driveway that provides to the parking place and that does not have parking stalls adjacent to them

BOUNDARY OR BOUNDARY LINE: means the official line that divides one area of land from another.

BUILDING LINE: means the line prescribed by either the competent authority beyond which no part of a building may project, except as otherwise permitted by the relevant respective laws or these codes.

BUILDING SPACING: means the space to maintain between buildings in order to provide ventilation, light, etc., to avoid disturbances in noise and view, and to leave space for infrastructural systems.

BUILT ENVIRONMENT: means areas of the environment, where human beings reside or occupy to practice their activities; contrary to natural environment, to which forests, woods, etc. belong, which is not directly or rarely intervened by human beings.

BUILT-UP AREA: means the area occupied by a building on the land or on the premises.

BUILDING COVERAGE RATIO: means the ratio between the building coverage area and the total land area.

CBD OR CENTRAL BUSINESS DISTRICT: means area or locality in a city or town having business, cultural and other functions concentrated in that district or locality.

DEPTH: In respect of a building, means the measured distance between the front line of the building and the back line of the rear main wall which separates the main building from the open space or in case of row blocks, the side shorter than the longer side.

DETACHED BUILDING: means any building not attached to any other buildings. Normally, single family houses are detached buildings.

DIVISION WALL OR (PARTY WALL) means a wall forming part of a building and used or constructed for separation of adjoining buildings belonging to different owners or occupants or constructed to be occupied by different persons constructed at the abutting common boundary.

DUPLEX HOUSE: It means any building with two residential units designed to be abutting to each other separated by a division wall. Each unit has its own separate entrance and each unit shall have one or more storeys used only by the same people.

EXTERNAL WALL: It means an outer wall of a building and not immediately adjoining a wall of another building.

FIRE WALL: It means any wall of materials having the fire resistance as required under Part 9 and 10 of these codes and constructed to be used for the separation of adjoining buildings or premises or separation of parts of building to prevent or reduce the spreading of fire from one building to another or from one part of a building to another part of that building.

FLOOR AREA IN SHOPPING FACILITIES: It means total floor area of shops, shopping centres and other shopping facilities; this include storage areas, staff area and circulation area

FLOOR AREA RATIO (FAR) or PLOT AREA RATIO: Floor area ratio means the total gross floor area (GFA) excluding basements divided by the land area belonging to the particular building. There are zonal FAI indicating the floor area densities of zones and estates FAI which indicates the floor area densities of estates.

For the purpose of urban planning, the floors which are only covered but not within the walls, such as terraces, verandahs, balconies are calculated as 50 % of the floors.

FIRST CLASS AREA: Area which is defined by authorities of the respective towns and cities which have basically residential characters with larger plot sizes.

GREEN AREA: It means not occupied by any structures including the traffic and parking areas and covered only by grass and trees or bear land covered by vegetations.

GROUND STOREY: It means the storey at the ground level of a building to which there is an entrance from outside on or above the level of the ground.

GROSS FLOOR AREA (GFA): It means the total floor area calculated based on centre of exterior walls, including the circulation area such as stairs, corridors, etc. but excluding the technical area without floors shafts, ducts, lift wells etc.

HUMAN HABITATION: It means usage of people as living, sleeping, studying or other functions where the people stay more than 6 hours per day.

HUMAN SETTLEMENT: It means areas where human beings reside or occupy to practice their activities.

INFRASTRUCTURE: It means the systems or part of systems like roads, water supply, electricity, waste disposal, etc. that are essential for proper functioning of human settlements, group of buildings or separate buildings.

LANES FOR MOTOR CYCLES: It shall be provided at the side of pedestrian footways, where it is possible and are required at motor vehicle free zones such as parks and green areas.

LANES FOR SLOW-MOVING VEHICLES: Lanes such as bicycles and tricycles shall be provided at the side of roads where it is possible and are required at motor roads planned besides the busy streets or as required in the detailed plans of respective settlements.

PARKING AISLE: It means an access lane or driveway with adjacent parking stalls.

PARKING STALL: It means space for a parking of motor vehicle, a car or a motor cycle parking lot.

PLOT: It means land area defined by the concerned authority with measurements.

POINT BLOCK: It means a building with the lengths less than two times the widths of respective buildings.

ROW BLOCK: It means buildings with the lengths more than two times the widths of respective buildings

SETBACK DISTANCE: It means the distance, a building or any part of a building has to maintain from other buildings, boundary line or any other element.

SHOPPING AREA: It means areas in shops and shopping centres, where people have direct access and where items for sales are placed or displayed. The areas like stores, offices, etc. belonging to the staff areas are not included.

STOREY: It means the space between the upper surface of every floor and the surface of the floor next above it, or if there be no such floor, then the underside of the ceiling or roof or other covering above the respective floor.

TERRACE HOUSE: It means any building with more than three residential units designed to be in a row. Each unit has its own separate entrance and each unit may have more than one storey but used only by the same family and the units are separated by division wall.

2.11.1.3 Classification of Roads

All roads outside the urban areas are classified as follows:

a) Union highway roads or Inter-Region roads:

These are roads planned to connect from one region to others and are free of all vehicles which are not motorized and which maximum speed 50 miles per hours. These are roads planned to connect from one region to others must have minimum of two lanes in one direction in addition to one side lane meant for emergency stopping or for police and lifesaving vehicles. The lane widths must have minimum 14 feet each and the side lane width shall be minimum 8 feet.

b) Township roads:

Township roads are the roads connecting between the rural settlements or between the rural settlements or connecting between small urban centres.

Such roads must have the minimum of two lanes and shoulders on each side where each lane having minimum 12 feet and shoulders minimum 4 feet. For such rural roads, there shall be pedestrian path at least at one side with minimum of 6 feet width.

c) Rural roads:

Rural roads are the roads connecting between the rural settlements or between the rural settlements and their urban centres.

Such roads must have the minimum of two lanes and shoulders on each side where each lane having minimum 10 feet and shoulders minimum 3 feet. For such rural roads, there shall be pedestrian path at least at one side with minimum of 5 feet width.

d) Urban roads:

All urban roads have the following classifications:

1) **Urban Avenues/ Boulevard:** Urban Avenues are the roads connecting zones in the urban areas and are longer than 5 miles. These are roads must have minimum of two lanes in one direction in addition to paved platforms on each side. The urban avenues must have a green dividing strip minimum in the middle and the lane widths must have minimum 14 feet each and the platform width shall be minimum 6 feet.

- 2) Urban Main Road: Urban main roads are the roads connecting one the zone in the urban areas and which are not longer than 5 miles. These are roads must have minimum of two lanes in one direction in addition to paved platforms on each side. The lane widths must have minimum 12 feet each and the platform width shall be minimum 5 feet.
- 3) Feeder Roads: Feeder roads are the roads connecting collector roads and urban avenues or the urban main roads where several collector roads are connected. These are roads which have minimum two lanes in addition to paved platforms on each side. The lane widths must have minimum 12 feet each and the platform width shall be minimum 4 feet.
- 4) Collector Roads: Collector roads are the roads connecting between the feeder roads and residential areas. These are roads which have minimum two lanes in addition to paved platforms on each side. The lane widths shall have minimum 12 feet each and the platform width shall be minimum 4 feet.
- 5) Residential roads: Residential roads are the roads in the residential areas. These are roads which have minimum two lanes in addition to paved platforms on each side. The lane widths shall have minimum 10 feet each and the platform width shall be minimum 4 feet.
- 6) Short residential roads: Residential roads serving less than 4 units can be of one lane unless the roads do not exceed 300 feet in length, and these roads must be consist of two lanes if these served more than 4 units and longer than 300 feet.
- 7) Cul-de-sacs: All cul-de-sacs longer than 300 feet in length must have the minimum width of 20 feet, such cul-de-sacs must be provided turning circle.
- 8) One Way roads: One way roads can be planned in the residential areas meant only for one direction. These have minimum lane widths of 14 feet.
- 9) Service roads: Service roads are the roads where the usage is limited only to delivery vehicles. These roads shall have minimum road width of 10 feet.
- 10) All gradient roads longer than 300 feet must have maximum gradient for 10%.
- 11) The gradients of minor roads adjoining the major roads must have the maximum gradient of 12%.

2.11.2 Environmental Issues

- a) Every building to be erected shall generally be considered as non-disturbing and non-polluting to the environment, for that reason the first and foremost consideration of all architects is the “Environmental Issue”.
- b) Whenever any building is planned, the architect should first make the environmental assessments, these include:-
 - 1) The role and position of the planned building in the environment, whether or not the building to be constructed is disturbing to environment visually or physically.
 - 2) The building to be constructed shall consider the laws concerning the conservation of heritage in Myanmar.
 - 3) The concepts on sources of infrastructure and waste disposal of the building, during the construction process and after the completion of building.
 - 4) The expected traffic generated during and after the building completion.
 - 5) The concept of facilities for entering, parking and departing the building

f) The concept for public facilities such as green areas, schools, shopping, social amenities, etc.

2.11.3 Urban Densities

a) In registered urban heritage places and zones and the CBD areas of cities and towns, or in the areas defined as high density zones, the densities should be in line with by-laws and zoning plans of respective towns where available.

b) Outside registered urban heritage places and zones and CBD areas or outside quasi such areas, the following estate densities should be maintained:

1) In multi-storeyed residential estates, the built-up area ratios(BCR) shall be within the range of 0.4 to 0.65 according to concerned Zoning Plan and Municipal Authority; site locations and road building ratio of the respective areas. (open area including traffic area should not be less than 0.35, including pervious area not less than 0.1)

2) In the areas with single family units or duplexes, there shall not be more than 20 units per acre and according to Concerned Zoning Plan and Municipal Authority.

c) Outside registered urban heritage places and zones and CBD areas or outside quasi CBD areas, the open space for buildings abutting a street shall be:-

1) In respect of other buildings used for non-residential purposes, not less than one-tenth of the built-up area of the building lot;

2) In respect of a building with mixed residential and commercial buildings, not less than one-third of the built-up area of the building lot;

d) The plot sizes in the urban settlements are defined in TWG 1 of this code, and these are to be followed accordingly.

2.11.4 Open Spaces

a) There shall be not less than 10 square feet per child of play area for educational buildings meant for children younger than 6 years.

b) There shall be not less than 15 square feet per child of play area for educational buildings meant for children between 7 to 16 years.

c) There shall be not less than 20 square feet per child of play area for educational buildings meant for students of age above 16 years.

d) In the residential areas with multi-storeyed units, there shall be minimum of 200 square feet per family as play and recreation areas, additional to parking and road areas.

2.11.4.1 For the purpose of counting the open space

a) Half the width of the backline abutting a building can be counted as open space;

b) Balconies, passage-ways and sun-shades may project over any open space provided these do not project more than 5 feet and have 10 feet clear height from the ground level, such projection can be counted as open space and not as built-up area;

c) The open space provided between the street and the setback for a building line and legally not belonging to the lot where the building is constructed, shall not be counted as open space;

d) The structures such as septic tanks, drains covers, and other elements meant for building services, can be counted as open spaces, provided that people can step on these for purpose using these areas

e) In the residential areas, the parking spaces and road areas can be counted as open spaces but not as play and recreation areas.

f) Where open space not abutting a backline is provided for, such open space shall have a minimum clear width of not less than 8 feet.

2.11.4.2 Alteration of open spaces

Whenever any open space has been provided in connection with any building, no person shall, without the approval in writing of the local authority:-

- a) Make any alteration in such open spaces; or
- b) Construct a roof over any portion thereof so as to diminish the area of such open space, provided that the local authority in its discretion may issue such a permit if the authority is satisfied that the free movement of air is not impeded or hindered and environmental quality of the area under consideration is not reduced by such alteration.
- c) The local authority may, by notice in writing, the owner or any person acting in contravention of this part, instruct to remove any such alteration or roof or otherwise to do such works as will restore such open spaces.

2.11.5 Building Spacing

2.11.5.1 Spaces between buildings and setback distances

a) For detached buildings in the areas defined as first class areas or quasi equivalent to such areas, which are not more than 36 feet height, there shall be minimum of 6 feet clear space measured between external walls of the building and the boundary of the plot; and 3 feet clear space between the extreme projections of the buildings such as roof edges, gutters, etc. In cases where the buildings exceed 36 feet height, the space mentioned here shall increase with the rate of 1 foot or one tenth of floor to floor height for every increase of a story (or floor to floor height, whichever is greater).

b) For areas outside registered urban heritage places and zones and Central Business District which are not defined as first class areas there shall be minimum of 3 feet clear space between external walls of the building or any elements of the building and one side of the plot shall have the minimum space of 6 feet clear space, and the boundary of the plot, for the buildings up to 8 storeys. There shall be 6 feet clear space between external walls of the building or any elements of the building and the boundary of the plot for the buildings up to 12 stories. There shall be 8 feet clear space between external walls of the building or any elements of the building and the boundary of the plot for the buildings up to 18 stories. If the buildings exceed 18 storeys, there shall be 10 feet clear space between external walls of the building or any elements of the building and the boundary of the plot.

c) For duplex houses and terrace houses, clear space of 3 feet must be maintained between the extreme projections of the buildings (roof edges, balconies, etc.) and the boundary of the plot.

d) For multi-storeyed residential buildings, in the estates outside CBD areas or quasi equivalent to such areas, unless otherwise mentioned in the specific bye-laws of some cities:-

1) For multi-storeyed row blocks with several units parallel and in front to front position, the wall to wall distance shall be not less than the height of the higher building, in the cases where the building heights are different, and minimum 50 feet must be maintained for driveway, parking, aprons and platforms

2) For multi-storeyed row blocks with several units parallel to each other and having back to back position, the wall to wall distance shall be not less than half the height of the higher building, in the cases where the building heights are different and minimum of 30 feet must be maintained as service back lane meant for septic tanks, other infrastructural requirements and as free spaces.

3) For buildings where the gable side abuts the longitudinal side of the building, the space between the buildings shall be not less than half the height of the higher building; in the cases the building heights are different and minimum of 30 feet shall be provided for free flow of air and for other infrastructural requirements. (the different cases are shown in Figure 1 and 2)

4) For multi-storeyed point blocks with several units facing each other, the spacing shall be not less than half the height of the higher building, and that distance shall be minimum 40 feet for residential road and for other infrastructural requirements.

(Multi-storeyed point blocks in these codes are defined in part I of these codes)

e) For buildings in the CBD areas or quasi equivalent to such areas, the building spacing rules are to follow the local codes wherever available.

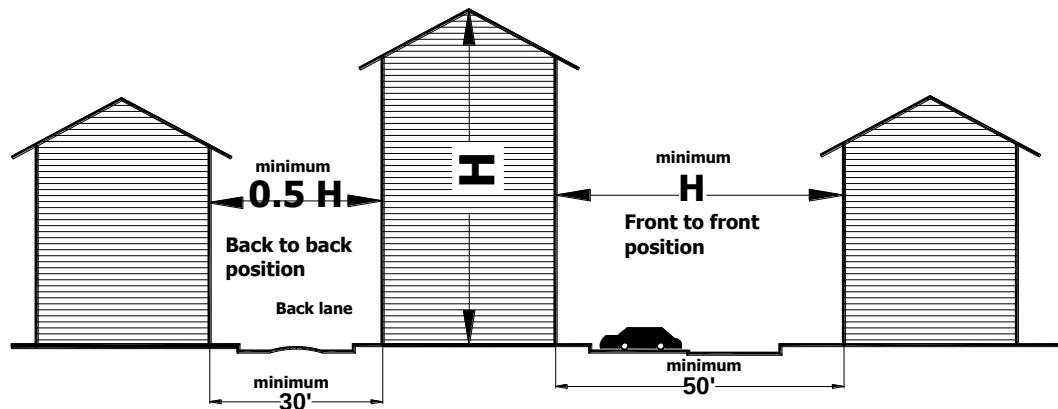


Fig. 2.11.1 Schematic figure showing spacing of row blocks, front to front and back to back positions and distances

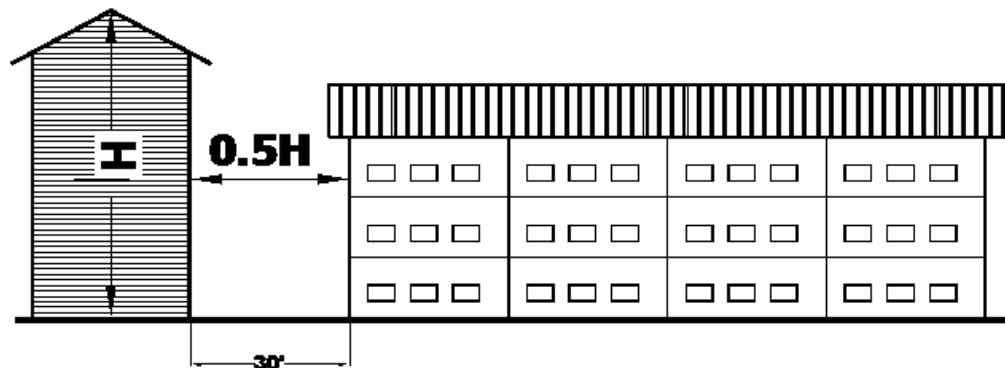


Fig. 2.11.2 Schematic figure showing spacing of row blocks, gable to longitudinal side and distance

2.11.5.2 Fences or walls

Fences or walls to the boundaries of detached properties other than the boundary which abuts the street or backline shall be constructed to a maximum height of 6 feet in the case of solid fences or walls and to a maximum height of 9 feet in the case of fences which are so constructed as to permit the passage of light and air.

2.11.5.3 Spaces on the street network

a) Where a building is erected at the junction of two streets and in cases where the degree of splay or rounding off is not shown on the layout plan or any statutory maps, modification or replacement thereof maintained by the competent planning authority, the corner of such building shall be splayed or rounded off to a height of not less than 15 feet above the street level at the point of intersection of the street lines so that no part of the building below this height shall project beyond the straight line drawn across the corner of the building plot joining each street line at a point 10 feet from the point of intersection of the street lines.

b) Where buildings abut on a street, there shall not be permanent structures like verandahs, balconies, sun-shades, canopies, etc. built beyond the property line of respective buildings.

2.11.5.4 Walkways and covered walkways

a) The width of any covered or uncovered walkway shall not be less than 7 feet if the walkway is in a confined walls and not less than 4 feet in the open space.

b) Where there is a change in levels along the walkway there shall be steps with risers not exceeding 7 inches and treads not less than 16 inches or a pedestrian ramp of gradient not exceeding 10 % or rise: run ratio of 1:10. (see also part 5 of these codes)

c) Where a service road is designed in the residential areas, the walkway is required to be provided along the street.

2.11.6 Roads and Parking Spaces

a) The width of one lane of the road for motor vehicles is minimum 12 feet, in the residential areas; the paved area of the road meant for both ways must be at least be 16 feet with 2 feet shoulder at both sides.

b) The internal turning radius of roads in the residential areas shall be 12 feet minimum and the internal turning radius of parking access way shall be 10 feet minimum.

c) Parking (A parking stall means a space for a parking of motor car and a parking aisle means an access lane or driveway with adjacent parking stalls.) The general requirement for parking spaces for cars shall be:

1) Minimum dimensions of parking stalls are 8 feet width and 16 feet in length when stalls are perpendicular to or with angle to the aisles.

2) Minimum dimensions of parking stalls are 8 feet width and 18 feet in length when stalls are parallel to the aisles.

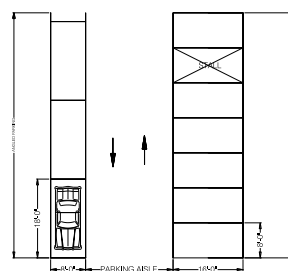


Fig. 2.11.3 Position of parking stalls and required dimensions (Above figure)

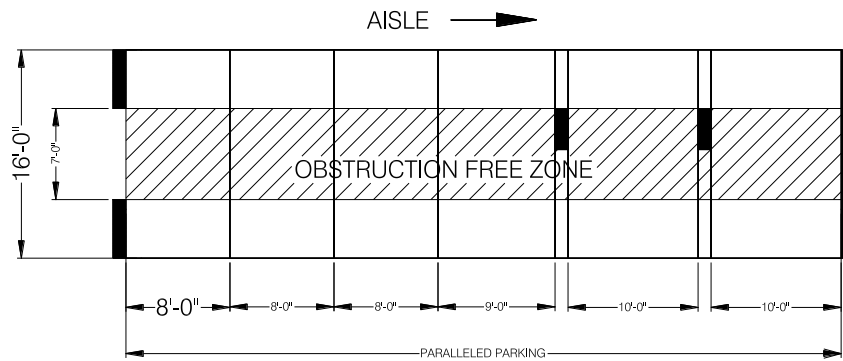


Fig. 2.11.4 Places to maintain obstruction free zones and parking stalls with adjacent obstructions

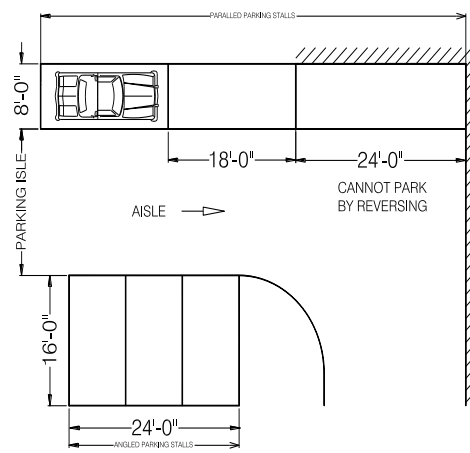


Fig. 2.11.5 Parking stalls which cannot park by reversing

(For parallel parking, where a car cannot be parked by reversing, the length of stall shall be 24'.)

2.11.6.1 The minimum width of parking aisle

The minimum width of parking aisle shall be as follows:

Table 2.11.1 Minimum widths of parking aisles

Parking Angle	One -way traffic flow		Two -way traffic flow
	Stalls on 1 side	Stalls on 2 sides	Stalls on 1 or 2 sides
Parallel	12'	12'	18'
30	12'	14'	18'
45	14'	16'	18'
60	16'	16'	20'
90	18'	18'	20'

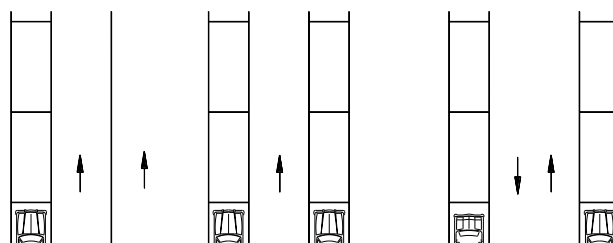


Fig. 2.11.6 Dimensions of parallel parking aisles

30°-60° angled parking aisle

‘A’ refers to the width of parking aisle

Minimum dimension of 90° angled parking aisle

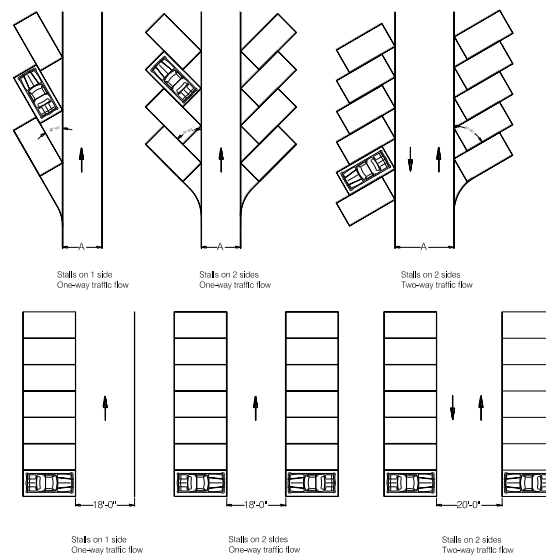


Fig. 2.11.7 Dimensions of parking aisles with parking stalls at different angles

2.11.6.2 Clearway Ramps and Access-Ways

Design and dimensions of Clearway Ramps and Access-Ways are to conform to table 2, presented below. (Clearway Ramps are inclined floors that provide access between two levels; they do not have parking stalls adjacent to them. Access-Ways are driveways that provide access to the parking stalls.)

- The slope of curved ramp shall be that of the centre line of its path.
- Adequate blending of ramp grades at floor levels shall be provided, this can be achieved by the provision of straight slope 9 ft. to 12 ft. long at half the grade of the ramps.
- The clear ramps and access-ways shall have physical separations (with raised brickwork, concrete blocks, etc.) if these are used in two directions at one level, with minimum height of 9 inches above the driveway level.
- There shall be a straight landing of minimum 30 feet in length every after 160 feet of ramps with gradients given in the table below.

Table 2.11.2 Type of Ramps and Access ways and widths

Type of Ramps and Access ways	Minimum width
Straight clearway ramp and access way	11 ft. for single-lane 10 ft. (per lane) for multi lane
Innermost lane of curved clearway ramp and access way	12 ft. for single-lane 11 ft. per lane for multi lane
Outside lane of curved clearway ramp and access way	12 ft. for single-lane 10 ft. (per lane) for multi lane
Inside radius of curved clearway ramp	15 ft.
Maximum and preferred gradient of clearway ramps and access ways for vehicles	1: 6.25 (16%) for light vehicles less than 2 tons 1:7.2(14%) for medium vehicles less than 5 tons Preferred gradient 1:8.3 (12%) (see also paragraph 40)

2.11.6.3 Minimum headroom

The headroom for car parking shall not be less than 8 ft .The clear headroom of ramps at the entering points to the buildings shall not be less than 7ft 6in.

2.11.6.4 Heavy vehicle parking spaces

Heavy vehicles include Lorries, trailers, containers, coaches and other similar commercial vehicles. These are categorized into three groups.

- a) Rigid-framed vehicles of length <25'-0"
- b) Rigid-framed vehicles of length >=25'-0"
- c) Articulated vehicles such as prime movers, 20', 40' and 45'

Table 2.11.3 Minimum dimensions required for heavy vehicles parking

Items	Rigid-framed vehicles of length <25'		Rigid-framed vehicles of length ≤ 25'		Articulated vehicles, eg. Prime movers, 20'40' and 45' trailers	
Dimensions of parking stall:						
-Parallel parking	30'-6"x10'-0"		46'-0"x11'-0"		63'-0"x11'-0"	
-Angled parking	25'-0"x10'-0"		40'-0"x11'-0"		46'-0"x11'-0"	
Width of parking aisle:	1-Way flow	2-Way flow	1-Way flow	2-Way flow	1-Way flow	2-Way flow
-Parallel parking	12'-0"	24'-0"	15'-0"	24'-0"	15'-0"	24'-0"
-30 parking	12'-0"	24'-0"	15'-0"	24'-0"	22'-0"	24'-0"
-45 parking	16'-0"	24'-0"	18'-0"	24'-0"	32'-0"	32'-0"
-60 parking	21'-0"	24'-0"	22'-0"	24'-0"	36'-0"	36'-0"
-90 parking	30'-0"	30'-0"	36'-0"	36'-0"	40'-0"	40'-0"
Width of clear Access way: per lane	1-Way flow	2-Way flow	1-Way flow	2-Way flow	1-Way flow	2-Way flow
-On straight	15'-0"	24'-0"	15'-0"	24'-0"	15'-0"	24'-0"
-On Curve	15'-0"	25'-0"	15'-0"	25'-0"	15'-0"	30'-0" 6.0m for 20'
Inside turning radius of curve	20'-0"		20'-0"		20'-0"	
Maximum gradient of ramp:						
-Straight ramp	1:12 or 8.3%		1:12 or 8.3%		1:15 or 6.7%	
-Curved ramp	1:15 or 6.7%		1:15 or 6.7%		1:20 or 5%	
Headroom Clearance	14'-0"		14'-0" exclude double-decker		15'-0", 16'-0"at ramp	

2.11.6.5 Motor cycle parking

Motor cycle parking stall can be provided in any available space within parking, the stalls should not obstruct movement of other vehicles and pedestrians. Minimum dimensions of motor-cycle parking stall 3 ft. x 8 ft.

2.11.6.6 Type of Building

a) In the urban residential areas with multi-storeyed units, there should be minimum one parking space for one residential unit, planned separately as parking lots or in the garages or as specified by Regional Governments, and concerned authorities of respected towns and regions. The road

and parking areas cannot be counted as play and green areas as required in part 2, paragraph 6 of these codes.

b) For shopping centres, there shall be minimum one parking space for 1000 square feet sales floor area, planned separately as parking lots or as parking spaces; **or as specified by Regional Governments, and concerned authorities of respected towns and regions.**

c) For offices in the urban areas, there should be minimum one parking space for 10 employees, planned separately as parking lots or as parking space; **or as specified by Regional Governments, and concerned authorities of respected towns and regions.**

d) For other commercial establishments like banks, restaurants, clubs, hotels, etc. the additional calculation for parking requirements must be submitted together with planning and building permit.

2.11.7 Recreation Areas

This sub-section will be added in next edition.

SECTION 2.12 ARCHITECTURE FOR ENERGY EFFICIENCY AND GREEN

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2.12 ARCHITECTURE FOR ENERGY EFFICIENCY AND GREEN

2.12.1 INTRODUCTION

The purpose of Section 2.12 is to provide minimum design requirements that will promote efficient utilization of energy and green building criteria in buildings. The requirements are directed toward the design of building envelopes with adequate thermal resistance and low air leakage, and toward the design and selection of mechanical, water heating, water resources development and groundwater extraction plans, electrical and illumination systems that promote effective use of depletable water and energy resources.

This section will later include the compliance method of design and construction of green building to reduce the overall impact of the built environment on human health and the natural environment for the climate of Yangon and similar one in Myanmar.

2.12.2 CRITERIA FOR GREEN BUILDINGS IN MYANMAR

a. ENERGY

- Energy efficiency (design and practice)
- Low embodied energy (Life cycle of materials)
- Provision of Natural lighting and ventilation
- Conservation of materials and resources
- Utilizing renewable energy

b. WATER

- Safeguarding water and water efficiency (design and practice)
- Rain water harvesting
- managing waste water
- Water recycling

c. HUMAN COMFORT & HEALTH

- thermal comfort
- Indoor air quality
- Adequate Lighting

d. ENVIRONMENTAL IMPACT

- Low carbon emission
- Maximize greenery
- reduce pollution
- reduce landfill waste

2.12.3 SCOPE

The provisions of this code shall apply to

- all new Commercial building works (except Religious, low cost public apartment projects, non-profitable social release and assisted public based building projects provided by Government or NGOs) which involve a gross floor area of 100,000 sqft or more,
- additions or extensions to existing commercial buildings, which involve increasing the gross floor area of the existing buildings by 100,000 sqft or more,
- Commercial building works which involve major retrofitting to existing buildings with gross floor area of 100,000.sqft or more;
- building works located in an area which is identified as an environmentally sensitive area
- all building works which required EIA and SIA assessments
- building works which the government officially states for compliance with this code

The above building works shall fully comply with the following Environmental sustainability standard with apart from the “*Optional*” sections unless it is stated for compliance by the Authority.

2.12.4 ENVIRONMENTAL SUSTAINABILITY STANDARD

2.12.4.1 ENERGY EFFICIENCY AND RENEWABLE ENERGY

BUILDING ENVELOPE

A building envelope is the physical separator between the conditioned and unconditioned environment of a building including the resistance to air, water, heat, light, and noise transfer. Components of the envelope are typically: walls, floors, roofs, fenestrations and doors. Fenestrations are any opening in the structure: windows, skylights, clerestories, etc.

The heat transferred through the building envelope and the dynamic storage of heat in building components is important to control indoor temperature variations.

The building is to be designed in a way to enhance overall thermal performance of building envelope to minimize heat gain (for Hot regions) thus reducing the overall cooling load requirement. For this purpose, orientation of the building, calculated shading devices, the

utilization of building materials with appropriate thermal performance, the size of window openings,... are taken into a consideration during the design process.

Requirement

Maximum Permissible ETTV will be stated by the Authority
(*ETTV stands for Envelope Thermal Transfer Value*)

ROOF

In most cases, the roof is the building element which has maximum exposure to the sun thus designing the roof for minimum heat penetration makes significant effect in reducing the temperature of the building.

Requirement

Without skylight, thermal transmittance U.value will be stated by the Authority
With skylight, the roof thermal transfer value RTTV will be stated by the Authority
(*U value stands for the heat transmission through a building part (as a wall or window)*
or a
given thickness of a material and RTTV , Roof Thermal Transfer Value)

NATURAL VENTILATION IN COMMON AREA*Optional*

Natural ventilation, also called passive ventilation, uses natural outside air movement and pressure differences to both passively cool and ventilate a building. For hot climates, it can help reducing the Indoor air temperature and thus reduce the cooling loads of mechanical air conditioning systems.

Common area such as stairs, toilets, lifts, lobby, walkways, passage ways are advised to be naturally ventilated as much as possible rather than using air-conditioning system or mechanical ventilation readily.

LIGHTING

Daylight should be used as much as possible to light a home, both for energy efficiency and for the health and comfort of occupants. Design requirements for daylighting must be balanced with the requirements for views and privacy. Daylighting must also be considered alongside building location, orientation and layout, in order to control solar access for passive cooling.

It must be designed with illumination refer to Myanmar National Building Code Chapter 5A, Table.1 Recommended Value of illuminance. And based on illumination calculations it is come out with electrical power consumption. See below for main category and requirements of illumination in lux level with required power consumption.

Requirement

Table: Lux requirement

<u>Category</u>	<u>Lux Requirements</u>	<u>Power Consumption</u>
<i>Office Area</i> (By Table 14 of BS to Maximum 15W/m ² Standards BSRIA Technical Notes 17/95 Rule of Thumbs 2nd Edition ByN.Pavey)	<i>300 lux to 500 lux</i>	<i>Average 10W/m²</i>
<i>Server Room</i>	<i>750 lux</i>	<i>Average 25W/m²</i>
<i>Sewing/Heavy Duty</i> (Concentrated Works Calculations Manually methods as per Chapter 5A, Code 5A.3.2)	<i>1000 lux</i>	<i>Average 30W/m²</i>

With reference to the above table,

- appropriate Lux meter in working places,
- Occupancy sensors, in common areas are to be installed
- Day Light harvesting technologies are to be integrated in the design wherever is applicable.

Type of Lightings

High efficient fluorescent lamp lighting like T5, compact Fluorescent lights (CFL) and Light Emitting Diode lamps (LED) are to be essentially used in place of conventional lightings. For façade lighting shall be only used with LED strip lighting or new innovation lighting products with less wattages.

Low mercury lamps are recommended with exception of appliance, black light, bug, colored, germicidal, plant, shatter-resistant/shatter-proof/shatter- protected, showcase, suntan, T-8 and T-12 lamps with a color rendering index of 87 or higher, lamps with RDC bases, and lamps used for special-needs.

Straight fluorescent lamps, Straight, double-ended fluorescent lamps less than 6 feet in nominal length and with bi-pin bases shall contain not more than 5 milligrams of mercury

per lamp. Exception: Lamps with a rated lifetime greater than 22,000 hours at 3 hours per start operated on an ANSI reference ballast shall not exceed 8 milligrams of mercury per lamp.

Compact Fluorescent Lamps, Single-ended pin-base and screw-base compact fluorescent lamps shall contain not more than 5 milligrams of mercury per lamp. Exception: Lamps rated at 25 watts or greater shall contain not more than 6 milligrams of mercury per lamp.

But all kinds of sensors, lighting fixtures and lighting control system must not be emitting human health hazard radioactive wave in any form and also must meet the minimum level of illumination lux level for human health and comfort or easy to workable.

Operation Control

A specialized automatic or manual device or system such as captive key control or time switch control is to be used to regulate the operation of lighting, equipment or appliances (*Captive key control stands for an automatic control device or system that energizes circuits when the key that unlocks the sleeping unit is inserted into the device and that de-energizes those circuits when the key is removed*)

Also it shall be included with occupancy sensor, PIR(Passage Infrared Relay) sensor for non assisted corridor area, and Photo Illumination control based sensor to be used to achieved mandatory required illumination lux level.

Designing to Lighting Illumination

Above mention category of profitable buildings must included proper lighting illumination design with energy consumption calculation. Dialux, EXCEL spreadsheet computer basis application softwares are such kind of Energy calculations included.

Light pollution

In term of Light pollution control purpose, the uplight, light trespass, and glare shall be limited for all exterior lighting equipment. Exceptions: Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the non-exempt lighting:

- Specialized signal, directional, and marker lighting associated with transportation;
- Advertising signage or directional signage;
- Lighting integral to equipment or instrumentation and installed by its manufacturer;
- Theatrical purposes, including performance, stage, film production, and video production;
- Athletic playing areas where lighting is equipped with hoods or louvers for glare control;

- Temporary lighting;
- Lighting for industrial production, material handling, transportation sites, and associated storage areas where lighting is equipped with hoods or louvers for glare control;
- Theme elements in theme and amusement parks
- Roadway lighting required by governmental authorities;
- Lighting used to highlight features of public monuments and registered landmark structures.

ENERGY MANAGEMENT AND CONTROL SYSTEM (EMCS) Optional

Energy management system (EMCS) is a computer-aided tool which is commonly used by individual commercial entities to monitor, measure, and control their electrical building loads and HVAC system for the building. Energy management and control systems can be used to centrally control devices like HVAC units and lighting systems in different zones of the building. Also it shall be open for integration to adding other computer/IT based automatic control systems such as security systems, door access systems, fire alarm system, PA systems and so on.

Energy management and control system can also provide metering, sub metering, and power monitoring functions, logging systems included such as adding additional power energy monitoring units that allow facility and building managers to gather data and insight that allows them to make more informed decisions about energy automatic control activities across the building. Also it is already acknowledge by that log data about power failure situation and able how to prevent necessary control ad fixing action in future.

RENEWABLE ENERGY Optional

Renewable energy is energy generated from natural resources—such as sunlight, wind, rain, tides and geothermal heat—which are renewable (naturally replenished). Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, biomass and biofuels for transportation. This energy cannot be exhausted and is constantly renewed.

In Myanmar, there are a lot potential to widely utilize renewable energy for water heating, space heating and power supply in buildings. It is encouraged to promote integration of larger scales or individual renewable energy generation systems as an alternative of the government power supply.

2.12.4.2 SAFEGUARDING WATER, WATER EFFICIENCY

Water is the most vital element in nature for the survival of all living systems. About 70% of the Earth's surface is covered with water and only three percent of it is fresh water that is fit for human consumption. (Ref: CEF conserve energy future).

Some 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. At the current consumption rate, this situation will only get worse. By 2025, two-thirds of the world's population may face water shortages. (Ref: WWF) Solutions for water efficiency focus not only on reducing the amount of potable water used, but also on reducing the use of non-potable water where appropriate (i.e. flushing toilet, watering landscape, etc.). It also emphasizes the influence consumers can have in water efficiency by making small behavioral changes to reduce water wastage and by choosing more water efficient products.

Requirements

WATER EFFICIENT FITTINGS

All fittings should be specified for efficient use of water and minimize wastage in public area. And they have to be installed and tested to ensure zero leakage in the whole system.

WATER USAGE MONITORING

Sufficient water sub-metering is required to monitor amount of water usage by different area, and to take action if required during building operation. Separate water meter is to be installed for major water use like swimming pool.

Water metering diagram and ground water exploitation plan should be submitted together with the building plan.

SURFACE WATER RUN-OFF *Optional*

Surface water runoff (also known as overland flow) is the flow of water that occurs when excess storm water, meltwater, or other sources flows over the earth's surface. This might occur because

soil is saturated to full capacity, because rain arrives more quickly than soil can absorb it, or because impervious areas (roofs and pavement) send their runoff to surrounding soil that cannot absorb all of it.

It is the primary agent in soil erosion by water. In addition to causing water erosion and pollution, surface runoff in urban areas is a primary cause of urban flooding which can result in property damage, damp and mold in basements, and street flooding.

So much paving is not advisable as it encourages the buildup of heat in and around cities and towns. Asphalt and concrete absorb sunlight and convert it to heat. The buildup of extra heat around cities and towns is known as the “heat island effect.”

In order to reduce surface water run-off, permeable pavers: patios, walkways, and driveways made of Porous Pavement should be used instead of conventional pavers.

Some permeable materials allow grass to grow in them by permitting water to drain into the ground. So it helps reducing heat accumulation around buildings.

RAIN WATER HARVESTING SYSTEM *optional*

Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. The harvested water can also be used as drinking water, longer-term storage and for other purposes such as groundwater recharge.

It also helps in the availability of potable water as rainwater is substantially free of salinity and other salts. Application of rainwater harvesting in urban water system provides a substantial benefit for both water supply and wastewater subsystems by reducing the need for clean water in water distribution system, less generated stormwater in sewer system,^[1] as well as a reduction in stormwater runoff polluting freshwater bodies.

For that environmental benefits, appropriate rainwater harvesting system is to be integral part of the entire building design.

EFFICIENT IRRIGATION SYSTEM

Irrigation is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall.

Four distinct methods of irrigating are sprinkling, flooding, furrow-irrigation and drip irrigation. Since the design stage, it is required to consider the equipment and technique involved in each method before selecting the “right” system. Select a system that will give plants sufficient moisture without wasting water.

DRAINAGE SYSTEM

Well-designed drainage system that is in harmony with prevailing topography and manmade drainage design system should be included.

2.12.4.3 MINIMISATION OF ENVIRONMENTAL IMPACT

GREENERY

The urban air temperature is gradually rising in all cities and some effective measures are needed to mitigate it. Planting of vegetation is one of the main strategies to mitigate the urban heat island (UHI) effect. Large greenery can extend positive effects to the surrounding built environment.

It is encouraged for greater use of greenery and restoration of existing trees to reduce heat island effect. This requirement is applicable to building developments with landscaping areas.

Requirement

Minimum requirement “Greenery provision GnP” will be stated by the Authority.

SEWAGE TREATMENT SYSTEM

The buildings must use central sewage treatment system or centralized waste water treatment system instead of conventional system which gives negative impact to the environment. Water

treatment technologies like Membrane Bio Reactor System (MBR), Activated Sludge System, and Sequential Batch Reactor System (SBR) and as such are to be used in the buildings.

The details of the proposed system with chemicals dosing plan has to be clearly demonstrated. And calculation of final B.O.D level is to be provided by taking reference to current YCDC regulations and other requirements stated by respective local authority and environmental authority.

Treated Gray Water is advised to be utilized back for the site irrigation, landscaping, firefighting and at least toilet water. It means WWTP treatment system covered to not only just urban buildings but also industrial buildings.

GRAY WATER MANAGEMENT

Greywater is any household wastewater with the exception of wastewater from toilets, which is known as blackwater. Typically, 50-80% of household wastewater is greywater from kitchen sinks, dishwashers, bathroom sinks, tubs and showers.

Non-potable water systems used for irrigation shall comply with the gray water, municipal reclaimed water and collected rainwater provisions of this section.

Gray water systems used for landscape irrigation purposes shall be limited to subsurface and surface irrigation applications. Gray water to be used and to be discharged shall comply with the provisions of local regulations.

WASTE MANAGEMENT

Disposing of waste has huge environmental impacts and can cause serious problems. Some waste will eventually rot, but not all, and in the process it may smell or generate methane gas, which is explosive and contributes to the greenhouse effect.

Incinerating waste also causes problems, because plastics tend to produce toxic substances, such as dioxins, when they are burnt. Gases from incineration may cause air pollution and contribute to acid rain, while the ash from incinerators may contain heavy metals and other toxins.

Throwing away things wastes resources. It wastes the raw materials and energy used in making the items and it wastes money. Reducing waste means less environmental impact, less resources and energy used and saves money.

Waste management such as segregation is to be practiced in building works in all activities and action

required to manage waste from its inception to its final disposal. Segregation means dividing waste into dry and wet. Dry waste includes wood and related products, metals and glass. Wet waste, typically refers to organic waste usually generated by eating establishments and are heavy in weight due to dampness. Waste can also be segregated on basis of biodegradable or non-biodegradable waste.

2.12.4.4 INDOOR ENVIRONMENTAL QUALITY (IEQ)

Indoor environmental quality (IEQ) refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including temperature, lighting, air quality, and damp conditions.

THERMAL COMFORT

Good indoor thermal comfort improves productivity at workplace. The indoor air temperature is to be maintained in a comfort zone (where at least 80% of the occupants feels neither cold nor hot with the air temperature, relative humidity and air movement) by means of either natural ventilation or air conditioning system.

Air-conditioning system is to be installed if the indoor temperature couldn't achieve that level. It should be designed to take into consideration the fluctuation in ambient air temperature to ensure the following thermal comfort:

Have in place a system for continuous tracking and optimization of systems that regulate indoor comfort and conditions (air temperature, radiant temperature, humidity, and air speed) in occupied spaces.

Have a permanent monitoring system to ensure ongoing building performance to the desired comfort criteria, Thermal Comfort Conditions for Human occupancy.

The monitoring system must meet the following requirements.

Continuous monitoring. Monitor at least air temperature and humidity in occupied spaces, at

sampling intervals of 15 minutes or less.

Periodic testing. Monitor air speed and radiant temperature in occupied spaces. Using handheld meters is permitted.

Alarms. An alarm must indicate conditions that require system adjustment or repair.

Prompt repair. Specify procedures for adjustments or repairs to be made in response to problems identified.

Calibration. All monitoring devices must be calibrated within the manufacturer's recommended interval.

NOISE POLLUTION CONTROL

Any sound which is unnecessary, excessive, unnatural, annoying, prolonged, or unusually loud in relation to its time, place and use effect is stated as noise pollution.

Sound transmission

Buildings and tenant spaces shall maximum permissible sound levels stated in the table below. Exception: The following buildings and spaces need not comply with this section:

Building or structures that have the interior environment open to the exterior environment.

Parking structures. Concession stands and toilet facilities in Group A-4 and A-5 occupancies.

Mechanical and emergency generator equipment and systems.

Building mechanical and emergency generator systems shall be designed to control airborne noise.

Mechanical and emergency generator equipment outside of buildings.

Where mechanical equipment and emergency generators are located outside of the building envelope or are exposed to the exterior environment, an adjacent property shall not be subjected to a sound level greater than indicated in below Table Special inspections shall be required and conducted in accordance in order to demonstrate compliance.

HVAC background sound.

HVAC system caused background sound levels for all modes of operation within rooms shall be in accordance with the lower and upper noise criteria (NC) limits as shown in Table. Special inspections shall be required and conducted in order to demonstrate compliance.

Table. Maximum permissible a-weighted sound levels

Initiating Property	Adjacent Property	Maximum A-Weighted Sound Level (dB)	
		Day Time	Night Time
		7:00 AM to 10:00 PM	10:00 PM to 7:00 AM
All, except factory, industrial, or storage	All, except factory, industrial, or storage	65	50
Factory, industrial, or storage	All other, except factory, industrial,	65	50
Factory, industrial, or storage	Factory, industrial, or storage	75	75

Overall building sound level

The design sound level of building should be as follows:

Table: Recommended ambient sound level

Area	Low dBA	Average dBA	High dBA
Cinemas, Theatres	-	35	40
Private executive offices	35	40	45
General offices , other private or semi-private offices	40	45	50
Conference rooms	35	40	45
Air-conditioned classrooms	40	45	50
Hotel Bedrooms	35	40	45
Hospital wards	35	40	45
Places of public resorts	40	50	55
Circulation area(staircases, lobbies, car parks)	50	55	60

Testing for mechanical and emergency generator equipment outside of buildings

All mechanical and emergency generator equipment shall be field tested in accordance with Table Testing shall be conducted following the complete installation of the equipment or generators, the installation of sound reduction barriers, and balancing and operation of the equipment or generators. Testing shall be at locations representing the four cardinal directions from the face of the project building. Such testing shall occur on a Tuesday, Wednesday or Thursday at both the day and night times within the periods shown in Table.

Testing for building system background noise

Testing shall be executed within not less than 50 percent of the total number of rooms contained in a building or structure, exclusive of closets and storage rooms less than 50 square feet in area, and exclusive of toilet facilities in accordance with Table. Testing shall occur following the complete installation of the equipment and systems, the installation of any sound reduction barriers, and balancing and operation of the equipment and systems.

INDOOR AIR QUALITY

Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Understanding and controlling common pollutants indoors can help reduce your risk of indoor health concerns. Health effects from indoor air pollutants may be experienced soon after exposure or, possibly, years later.

To contribute to the comfort and well-being of building occupants, minimum standards for indoor air quality (IAQ) will be set in a suitable time.

ENVIRONMENTAL TOBACCO SMOKE CONTROL

It is required to prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke.

Requirement

Prohibit smoking in the building

Smoking outside the building is to be allowed only in designated smoking areas located at a good distance from all entries, outdoor air intakes, and operable windows. Also prohibit smoking outside the property line in spaces used for business purposes.

Signage must be posted within 10 feet (3 meters) of all building entrances indicating the no-smoking policy.

Sensors must be tested and calibrated at least once every five years or per the manufacturer's recommendation, whichever is shorter.

Monitor CO₂ sensors with a system configured to trend CO₂ concentrations in intervals no greater than 30 minutes.

VENTILATION IN CARPARKING (CO SENSORS)

Mechanical ventilation systems may reduce the 1.5 CFM/SF ventilation requirement when the system operates automatically upon detection of a concentration of CO (carbon monoxide) of 25 ppm averaged over an eight-hour period by approved automatic detection devices.

Mechanical ventilation system in residential car parking areas may be switched off whenever CO concentration is below 9 ppm .

Mechanical ventilation system incorporating a supply part and exhaust part, and capable of providing air changes 6/hr is required for car parking areas in building.

For the exhaust part , at least 50% of the exhaust air shall be extracted at low level not exceeding 650 mm above the finished floor, as measured from the top of the grille to the finished floor.

For the supply part, the supply air shall be drawn directly from external and its intake shall not less than 5m from any exhaust discharge openings. Outlets for the supply air shall be adequately distributed over the car park area

REFRIGERANT ODP AND GWP

Air-conditioning system should be provided without refrigerants or with refrigerants which have an Ozone Depletion Potential (ODP) of zero. HFCs do not contain any chlorine and do not cause depletion of the ozone layer. Example: HFC-32, 125, 134a, 143a, 152a, etc.

The use of CFCs and HCFCs as refrigerants has been addressed under the Montreal Protocol. However, the replacements currently favoured by the industry are Hydrofluorocarbons (HFCs) which have a high global warming potential (GWP).

The GWP provides a measure of the potential for damage that a chemical has relative to 1 unit of CO₂, the primary Greenhouse gas. Hydrocarbons and ammonia-based refrigerants have low or zero GWP. These refrigerants are valid alternative to HFCs.

REFRIGERANT LEAK DETECTION

A refrigerant leak detection system should be designed to cover high-risk parts of the plant (evaporator or condenser coils can be omitted from this). For new buildings, permanently installed multi-point sensing detectors should be specified.

Refrigerant leaks are responsible for substantial releases of ozone depleting and greenhouse gasses to the atmosphere. Reducing the leakage levels of refrigerants can also have direct economic benefit as leakage can result in loss of efficiency in air-conditioning plants.

Examples of leak detectors are as follows:

Indicator Dyes

Fluorescent or a coloured dye is inserted into the system.

When the refrigerant leaks, the dye will show the leakage site.

Halide Torch

A halide torch leak detector can only be used to detect chlorinated refrigerants such as CFCs and HCFCs. The dye may be considered as contaminate to the sealed system and it is difficult to get into the system without moisture contamination. The use of the dye should be approved by the compressor manufacturer. Non-ozone depleting refrigerants such as HFCs cannot be detected by a halide torch leak detector.

REFRIGERANT RECOVERY

Automatic refrigerant pump down should be installed to the heat exchanger (or dedicated storage tanks) with isolation valves.

Refrigerants can cause damage to the environment even when their ozone depletion potential is zero. The specification of the automatic refrigerant pump down can further limit potential losses and damage to the environment.

2.12.4.5 MATERIAL EFFICIENCY AND GREEN INNOVATIONS *Optional*

In order to achieve better environmental performance, building works should integrate the concept of material efficiency, and suitable green innovation ideas in some way since the planning stage until its completion.

MATERIAL EFFICIENCY

Material efficiency concerns the use of materials or physical processes that uses less material, produces higher outputs/outcomes, and generates less wastes. It is a key pillar in achieving the objectives of a 3R policy.(*Reduce-Reuse-Recycle*)

Material efficiency strategies include, for example, products that last longer, remanufacturing and modular manufacturing, reuse and recycling of product components, using less material in

product designs, or redesigning manufacturing processes to use less energy, less water or less raw materials. It can also include replacement of scarce and expensive elements, notably those critical for energy applications.

Greater material efficiency can be achieved through strategies such as Design for Environment, Life-cycle Assessment, Energy and Water Efficiency etc. In fact, material efficiency and energy efficiency go together, and help not only in reducing manufacturing costs, but also in reducing emissions and wastes (and associated costs).

Best results in material efficiency are achieved by influencing early on through planning and promoting Design for Environment. In an optimal situation the whole value chain will benefit from life cycle considerations in product development.

LIFE CYCLE ANALYSIS OF MATERIALS

The life cycle of a product incorporates all of the activities that go into making, transporting, using and disposing of that product. The typical life cycle consists of a series of stages running from the extraction of raw materials, through design and formulation, processing, manufacturing, packaging, distribution, use, re-use, recycling and, ultimately, waste disposal.

RECYCLING

Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Recycling can benefit your community and the environment.

Benefits of Recycling

- Reduces the amount of waste sent to landfills and incinerators
- Conserves natural resources such as timber, water, and minerals
- Prevents pollution by reducing the need to collect new raw materials
- Saves energy
- Reduces greenhouse gas emissions that contribute to global climate change (Ref: EPA)

LOW CARBON BUILDING

Buildings alone are responsible for 38% of all human Greenhouse gas (GHG) emissions (Ref:IPCC). It is the industrial sector which contributes the most to global warming. Low-carbon

buildings (LCB) are buildings which are specifically engineered with GHG reduction in mind. So a LCB is a building which emits significantly less GHG than regular buildings.

2.12.5 LIST OF REFERENCES

1. International Green Construction Code (IGCC-Public Version 2.0, Nov. 2010.)
2. ASHRAE books
3. Singapore Standard for Air Conditioning and Mechanical Ventilation (CP-13, 1999)
4. Green Building Design Guide: Air Conditioned Buildings by Building and Construction Authority, Singapore
5. Code for environmental sustainability of buildings (Version 1.0) by Building and Construction Authority, Singapore
6. ASHRAE (<http://www.ashrae.org>)

PART 2 ARCHITECTURE AND URBAN DESIGN

2.13 REGULATIONS FOR EXISTING BUILDINGS AND STRUCTURES

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2.13 REGULATIONS FOR EXISTING BUILDINGS and STRUCTURES

Note: For historical buildings, refer to Part 2 TWGII Architecture and Urban Design, Chapter 2.10 Regulations for Historical Buildings, for compliance.

2.13-1 General

2.13-1.1 Scope

The provisions of this chapter control work related to alterations, repairs, additions, changes of occupancy of all existing buildings and structures.

2.13-1.2 Maintenance

Buildings and structures, and parts thereof, shall be maintained in a safe and sanitary condition. The owner or the owner's designated agent shall be responsible for the maintenance of buildings and structures. To determine compliance with this subsection, the relevant planning authority shall have the authority to inspect a building or structure before making the decision. The requirements of this chapter shall not provide the basis for removal or abrogation of fire protection and safety systems and devices in existing structures.

2.13-1.3 Building materials

Building materials shall comply with the requirements of this section.

2.13-1.3.1 Existing materials

Materials already in use in a building in compliance with requirements or approvals in effect at the time of the building's erection or the installation of the materials shall be encouraged in the conservation works and permitted to remain in use unless determined by the relevant planning authority to be dangerous to life, health or safety. Where such conditions are determined to be dangerous to life, health or safety, they shall be mitigated to be made safe.

2.13-1.3.2 New and replacement materials

Materials permitted by Part 6, Material for new construction shall be used. Hazardous materials shall not be used where Part 6, Material would not permit their use in buildings of similar occupancy, purpose and location.

2.13-2 Definitions

2.13-2.1 Definitions. The following words and terms shall, for the purposes of this chapter and as used elsewhere in the code, have the meanings shown herein.

DANGEROUS. Any building or structure or portion thereof shall be deemed dangerous if it has collapsed, partially collapsed, moved off its foundation or lacks the support of ground necessary to support it or there exists a significant risk of collapse, detachment or dislodgment of any portion, member, appurtenance or ornamentation of it under service loads.

EXISTING STRUCTURE. A structure erected prior to the date of adoption of this code or one for which a legal building permit has been issued.

PRIMARY FUNCTION. A primary function is a major activity for which the facility is intended.

SUBSTANTIAL STRUCTURAL DAMAGE. A condition, if in any story, the vertical elements of the lateral force-resisting system have suffered damage such that the lateral load-carrying capacity of the structure in any horizontal direction has been reduced by more than 20 per cent from its pre-damage condition; or the capacity of any vertical gravity load-carrying component or any group of such components that supports more than 30 per cent of the total area of the structure's floor(s) and

roof(s) has been reduced more than 20 per cent from its pre-damage condition and the remaining capacity of such affected elements, with respect to all dead and live loads, is less than 75 per cent of that required by this code for new buildings of similar structure, purpose and location.

TECHNICALLY UNFEASIBLE. An alteration of a building or a facility that has little likelihood of being accomplished because the existing structural conditions require the removal or alteration of a load-bearing member that is an essential part of the structural frame or because other existing physical or site constraints prohibit modification or addition of elements, spaces or features which are in full and strict compliance with the minimum requirements for new construction and which are necessary to provide accessibility.

2.13-3 Additions

2.13-3.1 General

Additions to any building or structure shall comply with the requirements of this code for new construction. Alterations to an existing building or structure shall be made to ensure that the existing building or structure together with the addition are no less conforming with the provisions of this code than the existing building or structure was prior to the addition. An existing building together with its additions shall comply with the height and area provisions of Chapter 3, General Building Heights and Areas.

2.13-3.2 Flood hazard areas

For buildings and structures in flood hazard areas, any addition that constitutes substantial improvement (basically having a value of 50 per cent market value of the existing structure) of a building or existing structure, shall comply with the flood design requirements for new construction, and all aspects of the existing building or structure shall be brought into compliance with the flood design requirements for new construction. For buildings and structures in flood hazard areas, additions that do not constitute substantial improvement or do not have a negative impact on heritage attributes are not required to comply with the flood design requirements for new construction.

2.13-3.3 Existing structural elements carrying gravity load

Any existing gravity load-carrying structural element for which an addition and its related alterations cause an increase in design gravity load of more than 5 percent shall be strengthened, supplemented, replaced or otherwise altered as needed to carry the increased load required by this code for new structures.

Any existing gravity load-carrying structural element whose gravity load-carrying capacity is decreased shall be considered an altered element subject to the requirements of Section 2.10.4.3. Any existing element that will form part of the lateral load path for any part of the addition shall be considered an existing lateral load-carrying structural element subject to the requirements of Section 2.10.3.4.

2.13-3.3.1 Design live load

Where the addition does not result in increased design live load, existing gravity load-carrying structural elements shall be permitted to be evaluated and designed for live loads approved prior to the addition. If the approved live load is less than that required by Part 3, Structural Design, Live Load Section, the area designed for the nonconforming live load shall be posted with placards of approved design indicating the approved live load. Where the addition does result in increased design live load, the live load required by Part 3, Structural Design, Live Loads Section shall be used.

2.13-3.4 Existing structural elements carrying lateral load

Where the addition is structurally independent of the existing structure, existing lateral load-carrying structural elements shall be permitted to remain unaltered. Where the addition is not structurally independent of the existing structure, the existing structure and its addition acting together as a single

structure shall be shown to meet the requirements of Part 3, Structural Design, Wind Loads and Earthquake Loads.

Exception: Any existing lateral load-carrying structural element whose demand-capacity ratio with the addition considered is no more than 10 per cent greater than its demand-capacity ratio with the addition ignored shall be permitted to remain unaltered. For purposes of calculating demand-capacity ratios, the demand shall consider applicable load combinations with design lateral loads or forces in accordance with Part 3, Structural Design, Wind Loads and Earthquake Loads Sections. For purposes of this exception, comparisons of demand-capacity ratios and calculation of design lateral loads, forces and capacities shall account for the cumulative effects of additions and alterations since original construction.

2.13-3.4.1 Seismic

Seismic requirements for alterations shall be in accordance with Part 3 structure of this code.

2.13-4 Alterations

2.13-4.1 General

Except as provided by Section 2.13-1.3 or this section, alterations to any building or structure shall comply with the requirements of the code for new construction. Alterations to listed heritage buildings or structures require prior consent and must conform to the relevant Conservation Management Plan and be consistent with the general principles for conservation. Alterations shall be such that the existing building or structure, including, if relevant, the heritage building or structure, is no less complying with the provisions of this code than the existing building or structure was prior to the alteration.

2.13-4.2 Flood hazard areas

For buildings and structures in flood hazard areas, any alteration that constitutes substantial improvement (basically having a value of 50 per cent market value of the existing structure) of a building or existing structure, shall comply with the flood design requirements for new construction, and all aspects of the existing building or structure shall be brought into compliance with the flood design requirements for new construction. For buildings and structures in flood hazard areas, any alterations that do not constitute substantial improvement or do not have a negative impact on heritage attributes are not required to comply with the flood design requirements for new construction.

2.13-4.3 Existing structural elements carrying gravity load

Any existing gravity load-carrying structural element for which an alteration causes an increase in design gravity load of more than 5 percent shall be strengthened, supplemented, replaced or otherwise altered as needed to carry the increased gravity load required by this code for new structures. Any existing gravity load-carrying structural element whose gravity load-carrying capacity is decreased as part of the alteration shall be shown to have the capacity to resist the applicable design gravity loads required by this code for new structures.

2.13-4.3.1 Design live load

Where the alteration does not result in increased design live load, existing gravity load-carrying structural elements shall be permitted to be evaluated and designed for live loads approved prior to the alteration. If the approved live load is less than that required by Part 3, Structural Design, Live Loads Section, the area designed for the nonconforming live load shall be posted with placards of approved design indicating the approved live load. Where the alteration does result in increased design live load, the live load required by Part 3, Structural Design, Live Loads Section of this code shall be used.

2.13-4.4 Existing structural elements carrying lateral load

Except as permitted by Section 2.10.4.5, where the alteration increases design lateral loads in accordance with Part 3, Structural Design, Wind Loads and Earthquake Load Sections or where the

alteration decreases the capacity of any existing lateral load-carrying structural element, the structure of the altered building or structure shall be shown to meet the requirements of Part 3, Structural Design, Wind Loads and Earthquake Load Sections of this code.

Exception: Any existing lateral load-carrying structural element whose demand-capacity ratio with the alteration considered is no more than 10 per cent greater than its demand-capacity ratio with the alteration ignored shall be permitted to remain unaltered. For purposes of calculating demand-capacity ratios, the demand shall consider applicable load combinations with design lateral loads or forces per Part 3, Structural Design, Wind Loads and Earthquake Load Sections of this code. For purposes of this exception, comparisons of demand-capacity ratios and calculation of design lateral loads, forces, and capacities shall account for the cumulative effects of additions and alterations since original construction.

2.13-4.4.1 Seismic

Seismic requirements for alterations shall be in accordance with this section. Where the existing seismic force-resisting system is a type that can be designated ordinary, values of R , Ω_0 and C_d for the existing seismic force-resisting system shall be those specified by this code for an ordinary system unless it is demonstrated that the existing system will provide performance equivalent to that of a detailed intermediate or special system.

2.13-4.5 Voluntary seismic improvements

Alterations to existing structural elements or additions of new structural elements that are not otherwise required by this chapter and are initiated for the purpose of improving the performance of the seismic force-resisting system of an existing structure or the performance of seismic bracing or anchorage of existing non-structural elements shall be permitted, provided that an engineering analysis is submitted demonstrating the following:

- a) The altered structure and the altered non-structural elements are no less in compliance with the provisions of this code with respect to earthquake design than they were prior to the alteration.
- b) New structural elements are detailed and connected to the existing structural elements as required by Part 3, Structural Design.
- c) New or relocated non-structural elements are detailed and connected to existing or new structural elements as required by Part 3, Structural Design.
- d) The alterations do not create a structural irregularity as defined in ASCE 7 or make an existing structural irregularity more severe.
- e) In the case of listed buildings and structures and unlisted buildings and structures in conservation zones, the alterations shall be approved by an expert conservation structural engineer with demonstrable specialist experience in repairing and strengthening historic buildings and structures and have prior consent the relevant planning authority and conform to the general conservation principles.

2.13-4.6 Means of egress capacity factors

Alterations to any existing building or structure shall not be affected by the egress width factors for new construction in determining the minimum egress widths or the minimum number of exits in an existing building or structure. The means of egress shall be considered as complying means of egress for any alteration if, in the opinion of the building code official, they do not constitute a distinct hazard to life.

2.13-5 Repairs

2.13-5.1 General

Buildings and structures, and parts thereof, shall be repaired in compliance with Section 2.10.1.2. Work on non-damaged components that is necessary for the required repair of damaged components shall be considered part of the repair and shall not be subject to the requirements for 2.10.4

Alterations in this chapter. Routine maintenance required by Section 2.10.1.2, ordinary repairs exempt from permit with work exempt from Part 1, Planning Environment, Administration and Legislation, Permit section, and abatement of wear due to normal service conditions shall not be subject to the requirements for repairs in this section.

Regardless of the extent of structural or non-structural damage, the relevant planning authority shall have the authority to require the elimination of conditions deemed dangerous.

2.13-5.2 Substantial structural damage to vertical elements of the lateral force-resisting system

A building that has sustained substantial structural damage to the vertical elements of its lateral force-resisting system shall be evaluated and repaired in accordance with the applicable provisions of Sections 2.13-5.2.1 through 2.13-5.2.3.

2.13-5.2.1 Evaluation

The building shall be evaluated by a licensed engineer/architect. The evaluation shall establish whether the damaged building, if repaired to its pre-damage state, would comply with the provisions of Part 3, Structural Design, wind and earthquake loads. Evaluation for Part 3, Structural Design, earthquake loads shall be required if the substantial structural damage was caused by or related to earthquake effects or if the building is in Part 3, Structural Design, Seismic Design Category C, D, E or F.

Wind loads for this evaluation shall be those prescribed in Part 3, Structural Design, Wind Loads Section. Earthquake loads for this evaluation, if required, shall be permitted to be 75 per cent of those prescribed in Part 3, Structural Design, and Earthquake Loads Section. Values of R , Ω_0 and C_d for the existing seismic force-resisting system shall be those specified by this code for an ordinary system unless it is demonstrated that the existing system will provide performance equivalent to that of an intermediate or special system.

2.13-5.2.2 Extent of repair for compliant buildings

If the evaluation establishes compliance of the pre-damage building in accordance with Section 2.13-5.2.1, then repairs shall be permitted that restore the building to its pre-damage state using materials and strengths that existed prior to the damage.

2.13-5.2.3 Extent of repair for noncompliant buildings

If the evaluation does not establish compliance of the pre-damage building in accordance with Section 2.13-5.2.1, then the building shall be rehabilitated to comply with applicable provisions of this code for load combinations, including wind or seismic loads. The wind loads for the repair shall be as required by the building code in effect at the time of original construction, unless the damage was caused by wind, in which case the wind loads shall be as required by the code in effect at the time of original construction or as required by this code, whichever are greater. Earthquake loads for this rehabilitation design shall be those required for the design of the pre-damage building, but not less than 75 per cent of those prescribed in Part 3, Structural Design, Earthquake Loads Section. New structural members and connections required by this rehabilitation design shall comply with the detailing provisions of this code for new buildings of similar structure, use and location.

2.13-5.3 Substantial structural damage to gravity load-carrying components

Gravity load-carrying components that have sustained substantial structural damage shall be rehabilitated to comply with the applicable provisions of this code for dead and live loads. Existing gravity load-carrying structural elements shall be permitted to be designed for live loads approved prior to the damage. Non-damaged gravity load-carrying components that receive dead and live loads from rehabilitated components shall also be rehabilitated or shown to have the capacity to carry the design loads of the rehabilitation design. New structural members and connections required by this rehabilitation design shall comply with the detailing provisions of this code for new buildings of similar structure, purpose and location.

2.13-5.3.1 Lateral force-resisting elements

Regardless of the level of damage to vertical elements of the lateral force-resisting system, if substantial structural damage to gravity load-carrying components was caused primarily by wind or earthquake effects, then the building shall be evaluated in accordance with Section 2.13-5.2.1.

2.13-5.4 Less than substantial structural damage

For damage less than substantial structural damage, repairs shall be allowed that restore the building to its pre-damage state using materials and strengths that existed prior to the damage. New structural members and connections used for this repair shall comply with the detailing provisions of this code for new buildings of similar structure, purpose and location.

2.13-5.5 Flood hazard areas

For buildings and structures in flood hazard areas, any repair that constitutes substantial improvement (basically having a value of 50 per cent market value of the existing structure) of a building or existing structure, shall comply with the flood design requirements for new construction, and all aspects of the existing building or structure shall be brought into compliance with the flood design requirements for new construction. For buildings and structures in flood hazard areas, any repairs that do not constitute substantial improvement or do not have a negative impact on heritage attributes are not required to comply with the flood design requirements for new construction.

2.13-6 Fire Escapes

2.13-6.1 Where permitted. Fire escapes shall be permitted only as provided for in [Chapter 6, Means of Egress](#).

2.13-6.2 Construction

The fire escape shall be designed to support a live load of 100 pounds per square foot (4788 Pa) and shall be constructed of fire-proof steel or other approved non-combustible materials.

2.13-7 Glass Replacement

2.13-7.1 Conformance. The installation or replacement of glass shall be as required for new installations.

2.13-8 Change of Occupancy

2.13-8.1 Conformance

No change shall be made in the use or occupancy of any building that would place the building in a different division of the same group of occupancies or in a different group of occupancies, unless such building is made to comply with the requirements of this code for such division or group of occupancies. Subject to the approval of the relevant planning authority, the use or occupancy of existing buildings shall be permitted to be changed and the building is allowed to be occupied for purposes in other groups without conforming to all the requirements of this code for those groups, provided the new or proposed use is less hazardous, based on life and fire risk, than the existing use.

2.13-8.2 Certificate of occupancy

A certificate of occupancy shall be issued where it has been determined that the requirements for the new occupancy classification have been met.

2.13-8.3 Stairways

Existing stairways in an existing building or structure, shall not be required to comply with the requirements of a new stairway where the existing space and construction will not allow a reduction in pitch or slope.

2.13-8.4 Change of occupancy

When a change of occupancy results in a structure being reclassified to a higher occupancy category, the structure shall conform to the seismic requirements for a new structure of the higher occupancy category unless the building is a historic building in which case would be decided on case by case basis. Where the existing seismic force-resisting system is a type that can be designated ordinary, values of R , Ω_0 and C_d for the existing seismic force-resisting system shall be those specified by this code for an ordinary system unless it is demonstrated that the existing system will provide performance equivalent to that of a detailed, intermediate or special system.

Exceptions:

- a) Specific seismic detailing requirements of this code or Part 3, Structural Design, Earthquake Loads Section for a new structure shall not be required to be met where it can be shown that the level of performance and seismic safety is equivalent to that of a new structure. Such analysis shall consider the regularity, over strength, redundancy and ductility of the structure within the context of the existing and retrofit (if any) detailing provided.
- b) When a change of use results in a structure being reclassified from Part 3, Structural Design, Occupancy Category I or II to Occupancy Category III and the structure is located in a seismic map area where $SDS < 0.33g$, compliance with Part 3, Structural Design, the seismic requirements of this code and Earthquake Loads Section are not required.

2.13-9 Historic Buildings

Refer to Part 2 TWGII Architecture and Urban Design, Chapter 2.10 Regulations for Historical Buildings, for compliance.

2.13-10 Accessibility for Existing Buildings**2.13-10.1 Scope**

The provisions of Sections 2.13-11.1 through 2.13-11.9 apply to maintenance, change of occupancy, additions and alterations to existing buildings, including those identified as heritage buildings.

2.13-10.2 Maintenance of facilities

A building, facility or element that is constructed or altered to be accessible shall be maintained accessible during occupancy.

2.13-10.3 Change of occupancy

Existing buildings that undergo a change of group or occupancy shall comply with this section.

2.13-10.3.1 Partial change in occupancy

Where a portion of the building is changed to a new occupancy classification, any alterations shall comply with Sections 2.10.10.5 and 2.10.10.6.

2.13-10.3.2 Complete change of occupancy

Where an entire building undergoes a change of occupancy, it shall comply with Section 2.13-10.3.1 and shall have all signage complying with Signage Section.

2.13-10.4 Additions

Provisions for new construction shall apply to additions. An addition that affects the accessibility to, or contains an area of, a primary function shall comply with the requirements in Section 2.13-10.7.

2.13-10.5 Alterations

A building, facility or element that is altered shall comply with the applicable provisions in Chapter 7, Accessibility of this code.

2.13-10.6 Scoping for alterations

The provisions of Sections 2.13-10.7.1 through 2.13-10.7.6 shall apply to alterations to existing buildings and facilities.

2.13-10.6.1 Entrances

Accessible entrances shall be provided in accordance with [Chapter 7, Accessibility, Accessible Entrances Section](#).

2.13-10.6.2 Ramps

The slope of ramps in or providing access to existing buildings or facilities shall comply with [Chapter 7, Accessibility](#).

2.13-11 Investigation

For proposed work covered by this section, the building owner shall cause the existing building to be investigated in accordance with the provisions of this section.

2.13-11.1 Structural analysis

The owner shall have a structural analysis of the existing building made by a certified engineer to determine adequacy of structural systems for the proposed alterations, additions or change of occupancy. The analysis shall demonstrate that the building with the work completed is capable of resisting the loads specified in Chapter 3, Structural Design.

2.13-11.2 Submittal

The results of the investigation as required in Section 2.10.12.4, along with proposed compliance alternatives, shall be submitted to the relevant planning authority.

2.13-11.3 Determination of compliance

The relevant planning authority shall determine whether the existing building, with the proposed additions, alterations or change of occupancy, complies with the provisions of this section.

2.13-11.4 APPLICATION FORMS AND SUBMISSION REQUIREMENTS

Applications on buildings should be made and the information required should be provided.

In addition to the normal requirements, the following is required for applications within the urban heritage places and zones/areas which should comply with part 1 of this code :

1. When an application involves the demolition of a building within an area, two streetscape elevations (scale 1:100) are required, one indicating the relationship of the existing building with adjacent buildings, and another showing the new construction in the context of the streetscape;
2. When an application involves the opening of a garage or construction of a garage cluster, a block plan (scale 1:500) is required, indicating the site in relation to the street network and the street width adjacent to the site access. Proper elevations are to be submitted of the entrance to the garage cluster along the street alignment, including drawings of the adjacent facades on either side of the main site entrance;
3. Elevations (scale 1:50) should show in detail all proposed materials and colour schemes. Any signage and/or advertisements proposed on commercial premises are to be included in the elevations. In particularly sensitive cases, 1:20 detailed drawings will be required;
4. When an application involves construction in a backyard/garden or courtyard, photographs showing all sides of the backyard/garden or courtyard are required.

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PART 3 & PART 4

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PART 3STRUCTURAL DESIGN

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SECTION 3.1 GENERAL

3.1.1 - Definitions and Notation

3.1.1.1 Definitions

The following words and terms shall, for the purposes of this PART, have the meanings shown herein.

ALLOWABLE STRESS DESIGN: A method of proportioning structural members, such that the astically computed stresses produced in the members by nominal loads do not exceed specified allowable stresses (also called “working stress design”).

BALCONY, EXTERIOR: An exterior floor projecting from and supported by a structure without additional independent supports.

DEAD LOADS: The weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and others similarly incorporated architectural and structural items, and the weight of fixed service equipment, such as cranes, plumbing stacks and risers, electrical feeders, heating, ventilating and air-conditioning systems and fire sprinkler systems.

DECK: An exterior floor supported on at least two opposing sides by an adjacent structure, and/or posts, piers or other independent supports.

DESIGN STRENGTH: The product of the nominal strength and a resistance factor (or strength reduction factor).

DIAPHRAGM: A horizontal or sloped system acting to transmit lateral forces to the vertical-resisting elements. When the term “diaphragm” is used, it shall include horizontal bracing systems.

Diaphragm blocked: In light-frame construction, a diaphragm in which all sheathing edges not occurring on a framing member are supported on and fastened to blocking.

Diaphragm boundary: In light-frame construction, a location where shear is transferred into or out of the diaphragm sheathing. Transfer is either to a boundary element or to another force-resisting element.

Diaphragm chord: A diaphragm boundary element perpendicular to the applied load that is assumed to take axial stresses due to the diaphragm moment.

Diaphragm, flexible: A diaphragm is flexible for the purpose of distribution of storey shear and torsional moment where so indicated in Section 12.3.1.1 of ASCE 7, as modified in Section 3.4.2.3.1.1 of this PART.

Diaphragm, rigid: A diaphragm is rigid for the purpose of distribution of storey shear and torsional moment when the lateral deformation of the diaphragm is less than or equal to two times the average storey drift.

DURATION OF LOAD: The period of continuous application of a given load, or the aggregate of

periods of intermittent applications of the same load.

ESSENTIAL FACILITIES: Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind or earthquakes.

FABRIC PARTITIONS: A partition consisting of a finished surface made of fabric, without a continuous rigid backing, that is directly attached to a framing system in which the vertical framing members are spaced greater than 4 feet (1219 mm) on centre.

FACTORED LOAD: The product of a nominal load and a load factor.

IMPACT LOAD: The load resulting from moving machinery, elevators, crane ways, vehicles and other similar forces and kinetic loads, pressure and possible surcharge from fixed or moving loads.

LIMIT STATE: A condition beyond which a structure or member becomes unfit for service and is judged to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).

LIVE LOADS: Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, rain load, earthquake load, flood load or dead load.

LIVE LOADS (ROOF): Those loads produced (1) during maintenance by workers, equipment and materials; and (2) during the life of the structure by movable objects such as planters and by people.

LOAD AND RESISTANCE FACTOR DESIGN (LRFD): A method of proportioning structural members and their connections using load and resistance factors such that no applicable limit state is reached when the structure is subjected to appropriate load combinations. The term “LRFD” is used in the design of steel and timber structures.

LOAD EFFECTS: Forces and deformations produced in structural members by the applied loads.

LOAD FACTOR: A factor that accounts for deviations of the actual load from the nominal load, for uncertainties in the analysis that transform the load into a load effect, and for the probability that more than one extreme load will occur simultaneously.

LOADS: Forces or other actions that result from the weight of building materials, occupants and their possessions, environmental effects, differential movement and restrained dimensional changes. Permanent loads are those loads in which variation over time are rare or of small magnitude, such as dead loads. All other loads are variable loads (see also “Nominal loads”).

NOMINAL LOADS: The magnitudes of the loads specified in this PART (dead, live, soil, rain, wind, and earthquake).

OCCUPANCY CATEGORY: A category used to determine structural requirements based

on occupancy.

OTHER STRUCTURES: Structures other than buildings

PANEL(PART OF A STRUCTURE): The section of a floor, wall or roof comprised between the supporting frame of two adjacent rows of columns and girders or column bands of floor or roof construction.

RESISTANCE FACTOR: A factor that accounts for deviations of the actual strength from the nominal strength and the manner and consequences of failure (also called “strength reduction factor”).

STRENGTH, NOMINAL: The capacity of a structure or member to resist the effects of loads, as determined by computations using specified material strengths and dimensions and equations derived from accepted principles of structural mechanics or by field tests or laboratory tests of scaled models, allowing for modeling effects and differences between laboratory and field conditions.

STRENGTH, REQUIRED: Strength of a member, cross section or connection required to resist factored loads or related internal moments and forces in such combinations as stipulated by these provisions.

STRENGTH DESIGN: A method of proportioning structural members such that the computed forces produced in the members by factored loads do not exceed the member design strength [also called “load and resistance factor design” (LRFD)]. The term “strength design” is used in the design of concrete and masonry structural elements.

VEHICLE BARRIER SYSTEM: A system of building components near open sides of a garage floor or ramp or building walls that act as restraints for vehicles.

3.1.1.2 Notation

D=Dead load

E=Combined effect of horizontal and vertical earthquake induced forces as defined in Section 12.4.2 of ASCE 7 (Section 3.4.2.4.2)

E_m =Maximum seismic load effect of horizontal and vertical seismic forces as set forth in Section 12.4.3 of ASCE 7 (Section 3.4.2.4.3) (Seismic load effect including overstrength factor)

F=Load due to fluids with well-defined pressures and maximum heights

H=Load due to lateral earth pressures, groundwater pressure or pressure of bulk materials

L=Live load, except roof live load, including any permitted live load reduction

L_r =Roof live load including any permitted live load reduction

R=Rain load

T=Self-straining force arising from contraction or expansion resulting from temperature change, shrinkage, moisture change, creep in component materials, movement due to differential

settlement or combinations thereof

W=Load due to wind pressure

3.1.2 - Design and Construction Documents

3.1.2.1 General

Construction documents shall show the size, section and relative location of structural members with floor levels, column centres and offsets dimensioned, as well as structural specifications.

The design loads and other information pertinent to the structural design required by Sections 3.1.2.1.1 through 3.1.2.1.6 as well as structural specifications shall be indicated on the design documents.

3.1.2.1.1 Floor liveload

The uniformly distributed, concentrated and impact floor live load (if any) used in the design shall be indicated in the design document. Use of floor live load reduction in accordance with Section 3.2.9 is permitted in the design.

3.1.2.1.2 Roof liveload

The roof liveload used in the design shall be indicated in the design document. Roof live load reduction in accordance with Section 3.2.3.11.2 is permitted in the design.

3.1.2.1.3 Wind design data

The following information related to wind loads shall be stated in the design document, regardless of whether wind loads govern the design of the lateral-force-resisting system of the building:

1. Basic wind speed (3-second gust), miles per hour
2. Wind importance factor, I , and occupancy category
3. Wind exposure parameters and wind coefficients

3.1.2.1.4 Earthquake design data

The following information related to seismic loads shall be stated in the design document, regardless of whether seismic loads govern the design of the lateral force resisting system of the building:

1. Seismic importance factor, I , and occupancy category
2. Specified spectral response accelerations, S_s and S_1 , and long period transition period T_L for the location of the structure in question
3. Site class
4. Seismic design category (SDC)
5. Basic seismic-force-resisting system(s)

6. Response modification factor(s), R
7. Analysis procedure used
8. Detailing category or type

3.1.2.1.5 Special loads

Special loads that are applicable to the design of the building, structure or portions thereof shall be indicated in the design document.

3.1.2.1.6 Material properties

The properties of the materials as used in the design calculations shall be mentioned in the design document.

3.1.2.1.7 Soil and foundation data

The relevant soil and foundation data as used in the design calculations shall be mentioned in the design document.

3.1.2.2 Systems and Components Requiring Special Inspections for Seismic Resistance

Design and construction documents or specifications shall be prepared for those systems and components requiring special inspection for seismic resistance (if any).

3.1.2.3 Restrictions on Loading.

It shall be unlawful to place, or cause or permit to be placed, on any floor or roof of a building, structure or portion thereof, a load greater than is permitted by the provisions of this PART, unless approved by the authority having jurisdiction for special situation.

3.1.2.4 Structural Designs.

Structural designs shall be carried out by qualified structural designer(s) and the design calculations, specifications and the detail drawings shall be checked and signed by a recognized licensed structural engineer, as specified by the building authority, before submitting the structural documents to the authority department for obtaining approval and building construction permit.

3.1.3 – General Design Requirements

3.1.3.1. General

Buildings, and parts thereof, shall be designed and constructed in accordance with strength design, load and resistance factor design, allowable stress design, empirical design or conventional construction methods, as permitted by the applicable material sections of this PART. Analysis shall be carried out by following the guidelines of Section 3.1.3.4 and, where relevant, by using the methods permitted by this PART.

3.1.3.2 Strength

Buildings, and parts thereof, shall be designed and constructed to support safely the factored loads in load combinations defined in this PART without exceeding the appropriate strength limit states for the materials of construction.

Alternatively, buildings, and parts thereof, shall be designed and constructed to support safely the nominal loads in load combinations defined in this PART without exceeding the appropriate specified allowable stresses for the materials of construction.

Loads and forces for occupancies or uses not covered in this PART shall be subject to the approval of the building official.

3.1.3.3 Serviceability

Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections and lateral drift. See Section 12.12 of ASCE 7 for drift limits applicable to earthquake loading.

3.1.3.3.1 Deflections

The deflections of structural members shall not exceed the more restrictive of the limitations of Sections 3.1.3.3.2 through 3.1.3.3.5 or that permitted by Table 3.1.1

TABLE 3.1.1 DEFLECTION LIMITS^{a,b,g,h}

CONSTRUCTION	L	W^e	$D + L^{c,f}$
Roof members: ^d			
Supporting plaster ceiling	$l/360$	$l/360$ $l/240$	$l/240$
Supporting nonplaster ceiling Not supporting ceiling	$l/240$ $l/180$	$l/180$	$l/180$
Floor members	$l/360$	—	$l/240$
Exterior walls and interior partitions:			
With brittle finishes	—	$l/240$	—
Farm buildings	—	—	$l/180$
Greenhouses	—	—	$l/120$

For SI: 1 foot = 304.8 mm.

- a. For structural roofing and siding made of formed metal sheets, the total load deflection shall not exceed $l/60$. For secondary roof structural members supporting formed metal roofing, the live load deflection shall not exceed

l/150. For secondary wall members supporting formed metal siding, the design wind load deflection shall not exceed l/90. For roofs, this exception only applies when the metal sheets have no roof covering.

- b. Interior partitions not exceeding 6 feet in height and flexible, folding and portable partitions are not governed by the provisions of this section. The deflection criterion for interior partitions is based on the horizontal load.
- c. For wood structural members having a moisture content of less than 16 percent at time of installation and used under dry conditions, the deflection resulting from $L + 0.5D$ is permitted to be substituted for the deflection resulting from $L + D$.
- d. The above deflections do not ensure against ponding. Roofs that do not have sufficient slope or camber to assure adequate drainage shall be investigated for ponding. See Section 2.4 for rain and ponding requirements and Section 2.4.2 for roof drainage requirements.
- e. The wind load is permitted to be taken as 0.7 times the “component and cladding” loads for the purpose of determining deflection limits herein.
- f. For steel structural members, the dead load shall be taken as zero.
- g. For aluminum structural members or aluminum panels used in skylights and sloped glazing framing, roofs or walls of sunroom additions or patio covers, not supporting edge of glass or aluminum sandwich panels, the total load deflection shall not exceed l/120.
- h. For cantilever members, l shall be taken as twice the length of the cantilever.

3.1.3.3.2 Reinforced concrete

The deflection of reinforced concrete structural members shall not exceed that permitted by ACI 318-05.

3.1.3.3.3 Steel

The deflection of steel structural members shall not exceed that permitted by AISC 360, AISI-NAS, AISI-General, AISI-Truss, ASCE 3, ASCE 8, SJI JG-1.1, SJI K-1.1 or SJI LH/DLH-1.1, as applicable.

3.1.3.3.4 Masonry

The deflection of masonry structural members shall not exceed that permitted by ACI 530/ASCE 5/TMS 402.

3.1.3.3.5 Aluminum

The deflection of aluminum structural members shall not exceed that permitted by AA ADM1.

3.1.3.3.6 Limits

Deflection of structural members over span, l, shall not exceed that permitted by Table 1.1.

3.1.3.4 Analysis

Load effects on structural members and their

connections shall be determined by methods of structural analysis that take into account equilibrium, general stability, geometric compatibility and both short- and long-term material properties.

Members that tend to accumulate residual deformations under repeated service loads shall have included in their analysis the added eccentricities expected to occur during their service life.

Any system or method of construction to be used shall be based on a rational analysis in accordance with well-established principles of mechanics. Such an analysis shall result in a system that provides a complete load path capable of transferring loads from their point of origin to the load-resisting elements.

The total lateral forces shall be distributed to the various vertical elements of the lateral-force-resisting system in proportion to their rigidities, considering the rigidity of the horizontal bracing system or diaphragm. Rigid elements assumed not to be a part of the lateral-force-resisting system are permitted to be incorporated into buildings provided their effect on the action of the system is considered and provided for in the design. Except where diaphragms are flexible, or are permitted to be analyzed as flexible, provisions shall be made for the increased forces induced on resisting elements of the structural system resulting from torsion due to eccentricity between the centre of application of the lateral forces and the centre of rigidity of the lateral-force-resisting system.

Structures shall be designed to resist the overturning effects caused by the lateral forces specified in this PART if it is required to consider lateral loads. See Section 3.3 for wind loads, Section 3.2.2 for lateral soil loads and hydrostatic pressures and Section 3.4 for earthquake loads.

3.1.3.5 Occupancy Category

Buildings shall be assigned an occupancy category in accordance with Table 3.1.2.

3.1.3.5.1 Multiple occupancies

Where a structure is occupied by two or more occupancies not included in the same occupancy category, the structure shall be assigned the classification of the highest occupancy category corresponding to the various occupancies. Where structures have two or more portions that are structurally separated, each portion shall be separately classified. Where a separated portion of a structure provides required access to, required egress from or shares life safety components with another portion having a higher occupancy category, both portions shall be assigned to the higher occupancy category.

3.1.3.6 In-Situ Load Tests

The building official is authorized to require an engineering analysis or a strength test or a load test, or any combination, of any construction whenever there is reason to question the safety of the construction for the intended occupancy.

3.1.3.7 Preconstruction Load Tests

Materials and methods of construction that are not capable of being designed by approved engineering analysis or that do not comply with the

applicable material design standards listed shall be load tested or tested for strength and deformation characteristics.

TABLE 3.1.2

OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES

OCCUPANCY CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities
II	Buildings and other structures except those listed in Occupancy Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Covered structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures with elementary school, secondary school or day care facilities with an occupant load greater than 250. • Buildings and other structures with an occupant load greater than 500 for colleges or adult education facilities. • Health care facilities with an occupant load of 50 or more resident patients, but not having surgery or emergency treatment facilities. • Jails and detention facilities. • Any other occupancy with an occupant load greater than 5,000. • Power-generating stations, water treatment for potable water, wastewater treatment facilities and other public utility facilities not included in Occupancy Category IV. • Buildings and other structures not included in Occupancy Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities. • Fire, rescue and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Occupancy Category IV structures. • Structures containing highly toxic materials. • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water treatment facilities required to maintain water pressure for fire suppression.

3.1.3.8 Anchorage

3.1.3.8.1 General

Anchorage of the roof to walls and columns, and of walls and columns to foundations, shall be provided to resist the uplift and sliding forces that result from the application of the prescribed loads.

3.1.3.8.2 Concrete and masonry walls

Concrete and masonry walls shall be anchored to floors, roofs and other structural elements that provide lateral support for the wall. Such anchorage shall provide a positive direct connection capable of resisting the horizontal forces specified in this part but not less than a minimum strength design horizontal force of 280 plf (4.10 kN/m) of wall, substituted for "E" in the load combinations of Section 3.2.1.2 or 3.2.1.3. Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 feet (1219 mm). Required anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall. See Sections 3.3 for wind design requirements and see Section 3.4 for seismic design requirements.

3.1.3.9 Decks

Where supported by attachment to an exterior wall, decks shall be positively anchored to the primary structure and designed for both vertical and lateral loads as applicable. Such attachment shall not be accomplished by the use of toenails or nails subject to withdrawal. Where positive connection to the primary building structure cannot be verified during inspection, decks shall be self-supporting.

3.1.3.10 Counteracting Structural Actions

Structural members, systems, components and claddings shall be designed to resist forces due to earthquake and wind, with consideration of overturning, sliding, and uplift. Continuous load paths shall be provided for transmitting these forces to the foundation. Where sliding is used to isolate the elements, the effects of friction between sliding elements shall be included as a force.

3.1.3.11 Wind and Seismic Detailing

Where required by the authority department, lateral-force-resisting systems shall meet seismic detailing requirements and limitations prescribed in this PART and ASCE 7, excluding Chapter 14 and Appendix 11A, even when wind code prescribed load effects are greater than seismic load effects.

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PART 3 STRUCTURAL DESIGN

NO.	TITLE	PAGE
3.2	LOAD COMBINATIONS AND LOADS	
3.2.1	Load Combinations	
3.2.2	Dead Loads, Soil Loads and Hydrostatic Pressure	
3.2.3	Live Loads	
3.2.4	Rain Loads	

SECTION 3.2: LOAD COMBINATIONS AND LOADS**3.2.1 – Load Combinations****3.2.1.1 General**

Buildings and portions thereof shall be designed using the provisions of either Section 3.2.1.2 or 3.2.1.3. Either Section 3.2.1.2 or 3.2.1.3 shall be used exclusively for proportioning elements of a particular construction material throughout the structure. Each load combination shall also be investigated with one or more of the variable loads set to zero.

3.2.1.2 Combining Factored Loads Using Strength Design or Load and Resistance Factor Design**3.2.1.2.1 Applicability**

The load combinations and load factors given in Section 3.2.1.2.2 shall be used only in those cases in which they are specifically authorized by the applicable material design standard. Otherwise, the provisions of the applicable material design standard shall be used.

3.2.1.2.2 Basic load combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the most critical effects of the factored loads in the following combinations:

1.	$1.4 (D + F)$	Eq. (3.2.1)
2.	$1.2(D + F + T) + 1.6(L + H) + 0.5 (L_r \text{ or } R)$	Eq. (3.2.2)
3.	$1.2D + 1.6(L_r \text{ or } R) + (L \text{ or } 0.8W)$	Eq. (3.2.3)
4.	$1.2D + 1.6W + L + 0.5(L_r \text{ or } R)$	Eq. (3.2.4)
5.	$1.2D + 1.0E + L$	Eq. (3.2.5)
6.	$0.9D + 1.6W + 1.6H$	Eq. (3.2.6)
7.	$0.9D + 1.0E + 1.6H$	Eq. (3.2.7)

EXCEPTIONS:

1. The load factor on L in combinations (3), (4), and (5) is equal to 0.5 for all occupancies in which L_0 in Table 3.2.2 is less than or equal to 100 psf, with the exception of garages or areas occupied as places of public assembly.
2. The load factor on H shall be set equal to zero in combinations (6) and (7) if the structural action due to H counteracts that due to W or E. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Each relevant strength limit state shall be investigated. Effects of one or more loads not acting shall be investigated. The most unfavorable effects from both wind and earthquake loads shall be investigated, where appropriate, but they need not be considered to act simultaneously.

As an exception, where other factored load combinations are specifically required by the provisions of this PART, such combinations shall take precedence.

3.2.1.3 Combining Nominal Loads Using Allowable Stress Design or Working Stress Design

3.2.1.3.1 Basic load combinations

Loads listed herein shall be considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered. Effects of one or more loads not acting shall be considered.

1. $D + F$ Eq. (3.2.8)
2. $D + H + F + L + T$ Eq. (3.2.9)
3. $D + H + F + (L_r \text{ or } R)$ Eq. (3.2.10)
4. $D + H + F + 0.75(L + T) + 0.75 (L_r \text{ or } R)$ Eq. (3.2.11)
5. $D + H + F + (W \text{ or } 0.7E)$ Eq. (3.2.12)
6. $D + H + F + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75 (L_r \text{ or } R)$ Eq. (3.2.13)
7. $0.6D + W + H$ Eq. (3.2.14)
8. $0.6D + 0.7E + H$ Eq. (3.2.15)

The most unfavorable effects from both wind and earthquake loads shall be considered, where appropriate, but they need not be assumed to act simultaneously.

3.2.1.3.2 Stress increases

Increases in allowable stress shall not be used with the loads or load combinations given in Section 3.2.1.3.1 unless it can be demonstrated that such an increase is justified by structural behaviour caused by rate or duration of load (see section on timber and bamboo)

3.2.1.4 Load Combinations for Extraordinary Events

Where required by the applicable code, standard, or the authority having jurisdiction, strength and stability shall be checked to ensure that structures are capable of withstanding the effects of extraordinary (i.e., low-probability) events, such as fires, explosions, and vehicular impact.

3.2.1.5 Special Seismic Load Combinations

For both strength and allowable stress design methods where specifically required by relevant material design standards, elements and components shall be designed to resist the forces calculated using Eq. (2.16) when the effects of the seismic ground motion are additive to gravity forces and those calculated using Eq. (2.17) when the effects of the seismic ground motion counteract gravity forces.

$$1. \quad 1.2D + f_1L + E_m \quad \text{Eq. (3.2.16)}$$

$$2. \quad 0.9D + E_m \quad \text{Eq. (3.2.17)}$$

where E_m = the maximum effect of horizontal and vertical forces as set forth in Section 12.4.3 of ASCE 7-05.

The load factor f_L for L in combination Eq. (3.2.16) is equal to 0.5 for all occupancies when live load is less than or equal to 100 psf (4.79 kN/m²), with the exception of garages or areas of public assembly. Otherwise, f_L is equal to 1.

SECTION 3.2 LOAD COMBINATIONS AND LOADS (CONTINUED)

3.2.2 Dead Loads, Soil Loads and Hydrostatic Pressure

3.2.2.1 Dead Loads

3.2.2.1.1 Definition

Dead loads consist of the weight of all materials of construction incorporated into the building including, but not limited to, walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment including the weight of cranes.

3.2.2.1.2 Weight of materials and constructions

In determining dead loads for purposes of design, the actual weights of materials and constructions shall be used provided that in the absence of definite information, values approved by the authority having jurisdiction shall be used.

3.2.2.1.3 Weight of fixed service equipment

In determining dead loads for purposes of design, the weight of fixed service equipment, such as plumbing stacks and risers, electrical feeders, and heating, ventilating, and air conditioning systems shall be included.

3.2.2.2 Soil Loads and Hydrostatic Pressure

3.2.2.2.1 Lateral pressures

In the design of structures below grade, provision shall be made for the lateral pressure of adjacent soil. If soil loads are not given in a soil investigation report approved by the authority having jurisdiction, then the soil loads specified in Table 3.2.1 shall be used as the minimum design lateral loads. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or the whole of the adjacent soil is below a free-water surface, computations shall be based upon the weight of the soil diminished by buoyancy, plus full hydrostatic pressure.

The lateral pressure shall be increased if soils with expansion potential are present at the site as determined by a geotechnical investigation.

Basement walls and other walls in which horizontal movement is restricted at the top shall be designed for at-rest pressure. Retaining walls free to move and rotate at the top are permitted to be designed for active pressure. As an exception, basement walls extending not more than 8 feet (2438 mm) below grade and supporting flexible floor system shall be permitted to be designed for active pressure.

3.2.2.2.2 Uplift on floors and foundations

In the design of basement floors and similar approximately horizontal elements below grade, the upward pressure of water, where applicable, shall be taken as the full

hydrostatic pressure applied over the entire area. The hydrostatic load shall be measured from the underside of the construction. Any other upward loads shall be included in the design.

Where expansive soils are present under foundations or slabs-on-ground, the foundations, slabs, and other components shall be designed to tolerate the movement or resist the upward loads caused by the expansive soils, or the expansive soil shall be removed or stabilized around and beneath the structure.

TABLE 3.2.1

DESIGN LATERAL SOIL LOAD

DESCRIPTION OF BACKFILL MATERIAL ^c	UNIFIED SOIL CLASSIFICATION	DESIGN LATERAL SOIL LOAD ^a (pound per square foot per foot of depth)	
		Active pressure	At-rest pressure
Well-graded, clean gravels; gravel-sand mixes	GW	30	60
Poorly graded clean gravels; gravel-sand mixes	GP	30	60
Silty gravels, poorly graded gravel-sand mixes	GM	40	60
Clayey gravels, poorly graded gravel-and-clay mixes	GC	45	60
Well-graded, clean sands; gravelly sand mixes	SW	30	60
Poorly graded clean sands; sand-gravel mixes	SP	30	60
Silty sands, poorly graded sand-silt mixes	SM	45	60
Sand-silt clay mix with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixes	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	ML-CL	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt clays, low plasticity	OL	Note b	Note b
Inorganic clayey silts, elastic silts	MH	Note b	Note b
Inorganic clays of high plasticity	CH	Note b	Note b
Organic clays and silty clays	OH	Note b	Note b

For SI: 1 pound per square foot per foot of length = 0.157 kPa/m , 1 foot = 304.8 mm

^a Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.

^b Unsuitable as backfill material.

^c The definition and classification of soil materials shall be in accordance with ASTM D2487.

SECTION 3.2: LOAD COMBINATIONS AND LOADS (CONTINUED)

3.2.3 – Live Loads

3.2.3.1 Definitions

The following definitions apply only to the provision of Section 3.2.3.

LIVE LOAD: A load produced by the use and occupancy of the building or other structure that does not include construction or environmental loads, such as wind load, snow load, rain load, earthquake load, flood load, or dead load.

ROOF LIVE LOAD: A load on a roof produced (1) during maintenance by workers, equipment, and materials and (2) during the life of the structure by movable objects, such as planters or other similar small decorative appurtenances that are not occupancy related.

FIXED LADDER: A ladder that is permanently attached to a structure, building, or equipment.

GRAB BAR SYSTEM: A bar provided to support body weight in locations such as toilets, showers, and tub enclosures.

GUARDRAIL SYSTEM: A system of building components near open sides of an elevated surface for the purpose of minimizing the possibility of a fall from the elevated surface by people, equipment, or material.

HANDRAIL: A rail grasped by hand for guidance and support. A handrail assembly includes the handrail, supporting attachments, and structures.

VEHICLE BARRIER SYSTEM: A system of building components near open sides of a garage floor or ramp, or building walls that act as restraints for vehicles.

3.2.3.2 Uniformly Distributed Loads

3.2.3.2.1 Required live loads

The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy, but shall in no case be less than the minimum uniformly distributed unit loads required by Table 3.2.2.

TABLE 3.2.2

MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_0 , AND MINIMUM CONCENTRATED LIVE LOAD

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs.)	OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs.)
1. Apartments (see residential)	—	—	27. Penal institutions		
2. Access floor systems			Cell blocks	40	—
Office use	50	2,000	Corridors	100	—
Computer use	100	2,000			
3. Armories and drill rooms	150	—	28. Residential		
4. Assembly areas and theaters			One- and two-family dwellings	10	
Fixed seats (fastened to floor)	60		Uninhabitable attics without storage	20	
Follow spot, projections and control rooms	50	—	Uninhabitable attics with limited storage ^{h,i,j}	30	—
Lobbies	100		Habitable attics and sleeping areas All other areas except balconies and decks	40	
Movable seats	100		Hotels and multiple-family dwellings	40	
Stages and platforms	125		Private rooms and corridors serving them	100	
5. Balconies			29. Reviewing stands, grandstands and bleachers	Note c	
On one- and two-family residences only, and not exceeding 100 sq ft	100		30. Roofs		
6. Bowling alleys	75	—	All roof surfaces subject to maintenance workers		300
7. Catwalks	40	300	Awnings and canopies	5	
8. Dance halls and ballrooms	100	—	Fabric construction supported by a light weight rigid skeleton structure All other construction	Non reducible	
9. Decks	Same as occupancy served ^g	—	Ordinary flat, pitched, and curved roofs		
10. Dining rooms and restaurants	100	—	Primary roof members, exposed to a work floor		
11. Dwellings (see residential)	—	—	Single panel point of lower chord of roof trusses or any point along primary structural members supporting roofs:		
12. Cornices	60	—	Over manufacturing, storage	20	
13. Corridors, except as otherwise indicated	100	—	All other occupancies		
14. Elevator machine room grating (on area of 4 in ²)	—	300	Roofs used for other special purposes Roofs used for promenade purposes Roofs used for roof gardens or assembly purposes	Note k	2,000
15. Finish light floor plate construction (on area of 1 in ²)	—	200		60	300
16. Fire escapes	100			100	Note k
On single-family dwellings only	40	—	31. Schools		
17. Garages (passenger vehicles only) Trucks and buses	40 Note a		Classrooms	40	1,000
See Section 2.3.4			Corridors above first floor	80	1,000
18. Grandstands (see stadium and arena bleachers)	—	—	First-floor corridors	100	1,000
19. Gymnasiums, main floors and balconies	100	—	32. Scuttles, skylight ribs and accessible ceilings	—	200
20. Handrails, guards and grab bars	See Section 2.3.5		33. Sidewalks, vehicular driveways and yards, subject to trucking	250d	8,000e
21. Hospitals			34. Skating rinks	100	—
Corridors above first floor	80	1,000	35. Stadiums and arenas	100c	
Operating rooms, laboratories	60	1,000	Bleachers	60c	—
Patient rooms	40	1,000	Fixed seats (fastened to floor)		
22. Hotels (see residential)	—	—	36. Stairs and exits		
23. Libraries			One- and two-family dwellings	40	Note f
Corridors above first floor	80	1,000	All other	100	
Reading rooms	60	1,000	37. Storage warehouses (shall be designed for heavier loads if required for anticipated storage)		
Stack rooms	150 ^b	1,000	Heavy	250	
24. Manufacturing			Light	125	
Heavy	250	3,000	38. Stores		
Light	125	2,000	Retail	100	1,000
25. Marquees	75	—	First floor	75	1,000
26. Office buildings			Upper floors	125	1,000
Corridors above first floor	80	2,000	Wholesale, all floors		
File and computer rooms shall be designed for heavier loads based on anticipated occupancy Lobbies and first-floor corridors	—	—	39. Vehicle barriers	See Section 2.3.5.3	
Offices	100	2,000	40. Walkways and elevated platforms (other than exit ways)	60	—
	50	2,000	41. Yards and terraces, pedestrians	100	—

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm²,1 square foot = 0.0929 m²,1 pound per square foot = 0.0479 kN/m², 1 pound = 0.004448 kN,1 pound per cubic foot = 16 kg/m³

- a Floors in garages or portions of buildings used for the storage of motor vehicles shall be designed for the uniformly distributed live loads of Table 3.2.2 or the following concentrated loads: (1) for garages restricted to vehicles accommodating not more than nine passengers, 3,000 pounds acting on an area of 4.5 inches by 4.5 inches; (2) for mechanical parking structures without slab or deck which are used for storing passenger vehicles only, 2,250 pounds per wheel.
- b The loading applies to stack room floors that support nonmobile, double-faced library bookstacks, subject to the following limitations:
 - 1. The nominal bookstack unit height shall not exceed 90 inches;
 - 2. The nominal shelf depth shall not exceed 12 inches for each face; and
 - 3. Parallel rows of double-faced bookstacks shall be separated by aisles not less than 36 inches wide.
- c Design in accordance with the ICC Standard on Bleachers, Folding and Telescopic Seating and Grandstands.
- d Other uniform loads in accordance with an approved method which contains provisions for truck loadings shall also be considered where appropriate.
- e The concentrated wheel load shall be applied on an area of 20 square inches.
- f Minimum concentrated load on stair treads (on area of 4 square inches) is 300 pounds
- g See Section 3.1.3.9 for decks attached to exterior walls.
- h Attics without storage are those where the maximum clear height between the joist and rafter is less than 42 inches, or where there are not two or more adjacent trusses with the same web configuration capable of containing a rectangle 42 inches high by 2 feet wide, or greater, located within the plane of the truss. For attics without storage, this live load need not be assumed to act concurrently with any other live load requirements.
- i For attics with limited storage and constructed with trusses, this live load need only be applied to those portions of the bottom chord where there are two or more adjacent trusses with the same web configuration capable of containing a rectangle 42 inches high by 2 feet wide or greater, located within the plane of the truss. The rectangle shall fit between the top of the bottom chord and the bottom of any other truss member, provided that each of the following criteria is met:
 - i. The attic area is accessible by a pull-down stairway or framed opening and
 - ii. The truss shall have a bottom chord pitch less than 2:12.
 - iii. Bottom chords of trusses shall be designed for the greater of actual imposed dead load or 10 psf, uniformly distributed over the entire span.
- j Attic spaces served by a fixed stair shall be designed to support the minimum live load specified for habitable attics and sleeping rooms.

- k Roofs used for other special purposes shall be designed for appropriate loads as approved by the building official.

3.2.3.2 Provision for partitions

In office buildings or other buildings where partitions will be erected or rearranged, provision for partition weight shall be made, whether or not partitions are shown on the construction documents. Partition load shall not be less than uniformly distributed live load of 15 psf.

EXCEPTION: A partition live load is not required where the minimum specified live load exceeds 80 psf (3.83 kN/m²).

3.2.3.3 Concentrated Loads

Floors, roofs, and other similar surfaces shall be designed to support safely the uniformly distributed live loads prescribed in Section 3.2.3.2 or the concentrated load, in pounds or kiloNewton (kN), given in Table 3.2.2, whichever produces the greater load effects. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area 2.5 ft (762 mm) square [6.25 ft² (0.58 m²)] and shall be located so as to produce the maximum load effects in the structural members.

3.2.3.4 Truck and bus garages

Minimum live loads for garages having trucks or buses shall be as specified in Table 3.2.3, but shall not be less than 50 psf (2.40 kN/m²), unless other loads are specifically justified and approved by the building official. Actual loads shall be used where they are greater than the loads specified in the table.

3.2.3.4.1 Truck and bus garage live load application

The concentrated load and uniform load shall be uniformly distributed over a 10-foot (3048 mm) width on a line normal to the centreline of the lane placed within a 12-foot-wide (3658 mm) lane. The loads shall be placed within their individual lanes so as to produce the maximum stress in each structural member. Single spans shall be designed for the uniform load in Table 3.2.3 and one simultaneous concentrated load positioned to produce the maximum effect. Multiple spans shall be designed for the uniform load in Table 3.2.3 on the spans and two simultaneous concentrated loads in two spans positioned to produce the maximum negative moment effect. Multiple span design loads, for other effects, shall be the same as for single spans.

TABLE 3.2.3
UNIFORM AND CONCENTRATED LOADS

LOADING CLASS ^a	UNIFORM LOAD (pounds/linear foot of lane)	CONCENTRATED LOAD (pounds) ^b	
		For moment design	For shear design
H20-44 and HS20-44	640	18,000	26,000
H15-44 and HS15-44	480	13,500	19,500

For SI: 1 pound per linear foot = 0.01459 kN/m, 1 pound = 0.004448 kN, 1 ton = 8.90 kN.

^a An H loading class designates a two-axle truck with a semitrailer. An HS loading class designates a tractor truck with a semitrailer. The numbers following the letter classification indicate the gross weight in tons of the standard truck and the year the loadings were instituted.

^b See Section 3.2.3.4.1 for the loading of multiple spans.

3.2.3.5 Load on Handrails, Guardrail Systems, Grab Bar Systems, Vehicle Barrier Systems, and Fixed Ladders

3.2.3.5.1 Load on handrails and guardrail systems

All handrail assemblies and guardrail systems shall be designed to resist a single concentrated load of 200 lb (0.89 kN) applied in any direction at any point along the top and to transfer this load through the supports to the structure.

Further, all handrail assemblies and guardrail systems shall be designed to resist a load of 50 lb/ft (pound-force per linear foot) (0.73 kN/m) applied in any direction at the top and to transfer this load through the supports to the structure. This load need not be assumed to act concurrently with the load specified in the preceding paragraph, and this load need not be considered for the following occupancies:

1. One- and two-family dwellings.
2. Factory, industrial, and storage occupancies, in areas that are not accessible to the public and that serve an occupant load not greater than 50, the minimum load in that area shall be 20 lb/ft (0.29 kN/m).

Intermediate rails (all those except the handrail), balusters, and panel fillers shall be designed to withstand a horizontally applied normal load of 50 lb (0.22 kN) on an area not to exceed 1 ft square (305 mm square) including openings and space between rails. Reactions due to this loading are not required to be superimposed with those of either preceding paragraph.

Where handrails and guards are designed using working stress design exclusively for the loads specified in this section, the allowable stress for the members and their attachments are permitted to be increased by one-third.

3.2.3.5.2 Load on grab bars systems

Grab bar systems shall be designed to resist a single concentrated load of 250 lb (1.11 kN) applied in any direction at any point.

3.2.3.5.3 Load on vehicle barrier systems

Vehicle barrier systems for passenger cars shall be designed to resist a single load of 6,000 lb (26.70 kN) applied horizontally in any direction to the barrier system, and shall have anchorages or attachments capable of transferring this load to the structure. For design of the system, the load shall be assumed to act at a minimum height of 1 ft 6 in. (460 mm) above the floor or ramp surface on an area not to exceed 1 foot square (305 mm square), and is not required to be assumed to act concurrently with any handrail or guardrail loadings specified in Section 3.2.3.4.1. Garages accommodating trucks and

buses shall be designed in accordance with an approved method, which contains provision for traffic railings.

3.2.3.5.4 Loads on fixed ladders

The minimum design live load on fixed ladders with rungs shall be a single concentrated load of 300 lb (1.33 kN), and shall be applied at any point to produce the maximum load effect on the element being considered. The number and position of additional concentrated live load units shall be a minimum of 1 unit of 300 lb (1.33 kN) for every 10 ft (3,048 mm) of ladder height.

Where rails of fixed ladders extend above a floor or platform at the top of the ladder, each side rail extension shall be designed to resist a concentrated live load of 100 lb (0.445 kN) in any direction at any height up to the top of the side rail extension. Ship ladders with treads instead of rungs shall have minimum design loads as stairs, defined in Table 3.2.2.

3.2.3.6 Loads Not Specified

For occupancies or uses not designated in Sections 3.2.3.2 or 3.2.3.3, the live load shall be determined in accordance with a method approved by the authority having jurisdiction.

3.2.3.7 Partial Loading

The full intensity of the appropriately reduced live load applied only to a portion of a structure or member shall be accounted for if it produces a more unfavorable effect than the same intensity applied over the full structure or member. Roof live loads are to be distributed as specified in Table 3.2.2.

3.2.3.8 Impact Loads

The live loads specified in Sections 3.2.3.5.1 and 3.2.3.5.2 shall be assumed to include adequate allowance for ordinary impact conditions. Provision shall be made in the structural design for uses and loads that involve unusual vibration and impact forces.

3.2.3.8.1 Elevators

All elevator loads shall be increased by 100 percent for impact and the structural supports shall be designed within the limits of deflection prescribed by ANSI A17.2 and ANSI/ASME A17.1.

3.2.3.8.2 Machinery

For the purpose of design, the weight of machinery and moving loads shall be increased as follows to allow for impact: (1) elevator machinery, 100 percent; (2) light machinery, shaft- or motor-driven, 20 percent; (3) reciprocating machinery or power-driven units, 50 percent; and (4) hangers for floors or balconies, 33 percent. All percentages shall be increased where specified by the manufacturer.

3.2.3.9 Reduction in Live Loads

Except for roof uniform live loads, all other minimum uniformly distributed live loads, L_0 in Table 3.2.2, may be reduced according to the following provisions.

3.2.3.9.1 General

Subject to the limitations of Sections 3.2.3.9.2 through 3.2.3.9.5, members for which a value of $K_{LL}A_T$ is 400 ft² (37.16 m²) or more are permitted to be designed for a reduced live load in accordance with the following equation:

$$L = L_0 \left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}} \right) \quad \text{Eq. (3.2.18)}$$

In SI:

$$L = L_0 \left(0.25 + \frac{4.57}{\sqrt{K_{LL}A_T}} \right)$$

where

L = reduced design live load per ft² (m²) of area supported by the member

L_0 = unreduced design live load per ft² (m²) of area supported by the member (see Table 3.2.2)

K_{LL} = live load element factor (see Table 3.2.4)

A_T = tributary area in ft² (m²)

L shall not be less than 0.50 L_0 for members supporting one floor and L shall not be less than 0.40 L_0 for members supporting two or more floors.

TABLE 3.2.4
LIVE LOAD ELEMENT FACTOR, K_{LL}

Element	K_{LL}
Interior columns	4
Exterior columns without cantilever slabs	4
Edge columns with cantilever slabs	3
Corner columns with cantilever slabs	2
Edge beams without cantilever slabs	2
Interior beams	2
All other members not identified above including: Edge beams with cantilever slabs Cantilever beams Two-way slabs Members without provisions for continuous shear transfer normal to their span	1

3.2.3.9.1.1 Heavy live loads

Live loads that exceed 100 lb/ft² (4.79 kN/m²) shall not be reduced.

EXCEPTIONS: (1) Live loads for members supporting two or more floors may be reduced by a maximum of 20 percent, but the live load shall not be less than L as calculated in Section 3.2.3.9.1.

(2) For uses other than storage, where approved, additional live load reductions shall be permitted where shown by the registered design engineer that a rational approach has been used and that such reduction are warranted.

3.2.3.9.1.2 Passenger car garages

The live loads shall not be reduced in passenger car garages.

EXCEPTION: Live loads for members supporting two or more floors may be reduced by a maximum of 20 percent, but the live load shall not be less than L as calculated in Section 3.2.3.9.1.

3.2.3.9.1.3 Special occupancies

Live loads of 100 lb/ft² (4.79 kN/m²) or less shall not be reduced in public assembly occupancies.

3.2.3.9.1.4 Special structural elements

Live load shall not be reduced for one-way slabs except as permitted in Section 3.2.3.9.2. Live loads of 100 psf (4.79 kN/m²) or less shall not be reduced for roof members except as specified in Section 3.2.3.10.

3.2.3.9.2 Alternative floor live load reduction

As an alternative to Section 3.2.3.9.1, floor live loads are permitted to be reduced in accordance with the following provisions. Such reductions shall apply to slab systems, beams, girders, columns, piers, walls and foundation.

1. A reduction shall not be permitted in group A occupancies (i.e., Assembly Group A)
2. A reduction shall not be permitted where the live load exceeds 100 psf (4.79 kN/m²) except that the design live load for members supporting two or more floors is permitted to be reduced by 20 percent.
3. A reduction shall not be permitted in passenger vehicle parking garages except that the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent.
4. For live loads, not exceeding 100 psf (4.79 kN/m²), the design live load for any structural member supporting 150 square feet (13.94 m²) or more is permitted to be reduced in accordance with the following equation:

$$R = 0.08 (A - 150)$$

Eq. (3.2.19)

In SI: $R = 0.861 (A - 13.94)$

Such reduction shall not exceed the smallest of:

40 percent for horizontal members;

60 percent for vertical members; or

R as determined by the following equation.

$$R = 23.1 (1 + D/L_0) \quad \text{Eq. (3.2.20)}$$

where A = area of floor supported by the member, ft² (m²)

D = dead load per ft² (m²) of area supported

L_0 = unreduced live load per ft² (m²) of area supported

R = reduction in percentage

3.2.3.10 Distribution of Floor Live Loads

Where uniform floor live loads are involved in the design of structural members arranged so as to create continuity, the minimum applied loads shall be the full dead loads on all spans in combination with the floor live loads on spans selected to produce the greatest effect at each location under consideration. It shall be permitted to reduce floor live loads in accordance with Section 3.2.3.9.

3.2.3.11 Roof Loads

The structural supports of roofs and marquees shall be designed to resist wind and, where applicable, earthquake load, in addition to the dead load of construction and appropriate live loads as prescribed in this section, or set forth in Table 3.2.2. The live loads acting on a sloping surface shall be assumed to act vertically on the horizontal projection of that surface.

3.2.3.11.1 Distribution of roof loads

Where uniform roof live loads are reduced to less than 20 psf (0.958 kN/m²) in accordance with Section 3.2.3.11.2.1 and are involved in the design of structural members arranged so as to create continuity, the minimum applied loads shall be the full dead loads on all spans in combination with the roof live loads on adjacent spans or on alternate spans, whichever produces the greatest effect. See Section 3.2.3.11.2 for minimum roof live loads.

3.2.3.11.2 Reduction in roof live loads

The minimum uniformly distributed roof live loads, L_0 in Table 3.2.2, are permitted to be reduced according to the following provisions.

3.2.3.11.2.1 Flat, pitched, and curved roofs

Ordinary flat, pitched, and curved roofs are permitted to be designed for a reduced roof live load, as specified in Eq. (2.21) or other controlling combinations of loads, as discussed in Section 3.2.1, whichever produces the greater load. In structures such as greenhouses, where special scaffolding is used as a work surface for workmen and materials during maintenance and repair operations, a lower roof load than specified in Eq. (2.21) shall not be used unless approved by the authority having jurisdiction. On such structures, the minimum roof live load shall be 12 psf (0.58 kN/m²).

$$L_r = L_0 R_1 R_2 \quad \text{where } 12 \leq L_r \leq 20 \quad \text{Eq. (3.2.21)}$$

In SI:

$$L_r = L_o R_1 R_2 \quad \text{where } 0.58 \leq L_r \leq 0.96$$

where

L_r = reduced roof live load per ft² (m²) of horizontal projection in pounds per ft² (kN/m²)

The reduction factors R_1 and R_2 shall be determined as follows:

$$R_1 = \begin{cases} 1 & \text{for } A_t \leq 200 \text{ ft}^2 \\ 1.2 - 0.001 A_t & \text{for } 200 \text{ ft}^2 < A_t < 600 \text{ ft}^2 \\ 0.6 & \text{for } A_t \geq 600 \text{ ft}^2 \end{cases} \quad \begin{array}{l} \text{Eq. (3.2.22a)} \\ \text{Eq. (3.2.22b)} \\ \text{Eq. (3.2.22c)} \end{array}$$

In SI:

$$R_1 = \begin{cases} 1 & \text{for } A_t \leq 18.58 \text{ m}^2 \\ 1.2 - 0.011 A_t & \text{for } 18.58 \text{ m}^2 < A_t < 55.74 \text{ m}^2 \\ 0.6 & \text{for } A_t \geq 55.74 \text{ m}^2 \end{cases}$$

where A_t = tributary area (i.e., span length multiplied by effective width) in ft² (m²) supported by any structural member and

$$R_2 = \begin{cases} 1 & \text{for } F \leq 4 \\ 1.2 - 0.05 F & \text{for } 4 < F < 12 \\ 0.6 & \text{for } F \geq 12 \end{cases} \quad \begin{array}{l} \text{Eq. (3.2.23a)} \\ \text{Eq. (3.2.23b)} \\ \text{Eq. (3.2.23c)} \end{array}$$

where, for a pitched roof, F = number of inches of rise per foot (in SI: $F = 0.12 \times$ slope, with slope expressed as a percentage) and, for an arch or dome, F = rise-to-span ratio multiplied by 32.

3.2.3.11.2.2 Special purpose roofs

Roofs that have an occupancy function, such as roof gardens, assembly purposes, promenade purposes, or other special purposes shall be designed for a minimum live load as required in Table 3.2.2 and are permitted to have their uniformly distributed live load reduced in accordance with the requirements of Section 3.2.3.9.

3.2.3.11.2.3 Landscaped roofs

Where roofs are to be landscaped, the uniform design live load in the landscaped area shall be 20 psf (0.958 kN/m²). The weight of the landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil.

3.2.3.11.2.4 Awnings and canopies

Awnings and canopies shall be designed for uniform live loads as required in Table 3.2.2 as well as for wind loads as specified in Section 3.

3.2.3.12 Crane Loads

The crane live load shall be the rated capacity of the crane. Design loads for the runway beams, including connections and support brackets, of moving bridge cranes and

monorail cranes shall include the maximum wheel loads of the crane and the vertical impact, lateral, and longitudinal forces induced by the moving crane.

3.2.3.12.1 Maximum Wheel Load

The maximum wheel loads shall be the wheel loads produced by the weight of the bridge, as applicable, plus the sum of the rated capacity and the weight of the trolley with the trolley positioned on its runway at the location where the resulting load effect is maximum.

3.2.3.12.2 Vertical impact force

The maximum wheel loads of the crane shall be increased by the percentages shown below to determine the induced vertical impact or vibration force:

Monorail cranes (powered)	25
Cab-operated or remotely operated bridge cranes (powered)	25
Pendant-operated bridge cranes (powered)	10
Bridge cranes or monorail cranes with hand-gear bridge, trolley, and hoist	0

3.2.3.12.3 Lateral force

The lateral force on crane runway beams with electrically powered trolleys shall be calculated as 20 percent of the sum of the rated capacity of the crane and the weight of the hoist and trolley. The lateral force shall be assumed to act horizontally at the traction surface of a runway beam, in either direction perpendicular to the beam, and shall be distributed according to the lateral stiffness of the runway beam and supporting structure.

3.2.3.12.4 Longitudinal force

The longitudinal force on crane runway beams, except for bridge cranes with hand-gear bridges, shall be calculated as 10 percent of the maximum wheel loads of the crane. The longitudinal force shall be assumed to act horizontally at the traction surface of a runway beam in either direction parallel to the beam.

3.2.3.13 Interior Walls and Partitions

Interior walls and partitions that exceed 6 feet (1829 mm) in height, including their finish materials, shall have adequate strength to resist the loads to which they are subjected but not less than a horizontal load of 5 psf (0.240 kN/m²).

EXCEPTION: Fabric partitions complying with Section 3.2.3.13.1 shall not be required to resist the minimum horizontal load of 5 psf (0.240 kN/m²).

3.2.3.13.1 Fabric partition

Fabric partitions that exceed 6 ft (1829 mm) in height, including their finish materials, shall have adequate strength to resist the following load conditions:

1. A horizontal distributed load of 5 psf (0.240 kN/m²) applied to the partition framing. The total area used to determine the distributed load shall be the area of the fabric face between the framing members to which the fabric is attached. The total distributed load shall be

uniformly applied to such framing members in proportion to the length of each member.

2. A concentrated load of 40 pounds (0.176 kN) applied to an 8-in. diameter (203 mm) area [(50.3 m² (32452 mm²))] of the fabric face at a height of 54 inches (1372 mm) above the floor.

3.2.4 – Rain Loads

3.2.4.1 Symbols and Notation

R = rain load on the undeflected roof, in lb/ft² (kN/m²). When the phrase "undeflected roof" is used, deflections from loads (including dead loads) shall not be considered when determining the amount of rain on the roof.

d_s = depth of water on the undeflected roof up to the inlet of the secondary drainage system when the primary drainage system is blocked (i.e., the static head), in inches (mm).

d_h = additional depth of water on the undeflected roof above the inlet of the secondary drainage system at its design flow (i.e., the hydraulic head), in inches (mm).

3.2.4.2 Roof Drainage

Roof drainage systems shall be designed in accordance with the provisions of the code having jurisdiction. The flow capacity of secondary (overflow) drains or scuppers shall not be less than that of the primary drains or scuppers.

3.2.4.3 Design Rain Loads

Each portion of a roof shall be designed to sustain the load of all rainwater that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow.

$$R = 5.2 (d_s + d_h) \quad \text{Eq. (3.2.24)}$$

In SI:

$$R = 0.0098 (d_s + d_h)$$

If the secondary drainage systems contain drain lines, such lines and their point of discharge shall be separate from the primary drain lines.

3.2.4.4 Ponding Instability

"Ponding" refers to the retention of water due solely to the deflection of relatively flat roofs. Roofs with a slope less than 1/4" per foot [1.19 degrees (0.0208 rad)] shall be investigated by structural analysis to assure that they possess adequate stiffness to preclude progressive deflection (i.e., instability) as rain falls on them. The primary drainage system within an area subjected to ponding shall be considered to be blocked in this analysis.

3.2.4.5 Controlled Drainage

Roofs equipped with hardware to control the rate of drainage shall be equipped with a secondary drainage system at a higher elevation that limits accumulation of water on the roof above that elevation. Such roofs shall be designed to sustain the load of all rainwater that will accumulate on them to the elevation of the secondary drainage system plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow (determined from Section 3.2.4.3).

Such roofs shall also be checked for ponding instability (determined from Section 3.2.4.4).

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PART 3 STRUCTURAL DESIGN

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SECTION 3.3 WIND DESIGN CRITERIA

3.3.1 General

3.3.1.1 Scope

Buildings, including the Main Wind-Force Resisting System (MWFRS) and all components and cladding thereof, shall be designed and constructed to resist wind loads as specified herein. Decreases in wind loads shall not be made for the effect of shielding by other structures.

3.3.1.2 Allowed Procedures

The design wind loads for buildings, including the MWFRS and component and cladding elements thereof, shall be determined using one of the following procedures: (1) Method 1 – Simplified Procedure as specified in Section 3.3.4 for buildings meeting the requirements specified therein; (2) Method 2 – Analytical Procedure as specified in Section 3.3.5 for buildings meeting the requirements specified therein; (3) Method 3 – Wind Tunnel Procedure as specified in Section 3.3.6.

3.3.1.3 Wind Pressures Acting on Opposite Faces of Each Building Surface

In the calculation of design wind loads for the MWFRS and for components and cladding of buildings, the algebraic sum of the pressures acting on opposite faces of each building surface shall be taken into account.

3.3.1.4 Minimum Design Wind Loading

The design wind load, determined by any one of the procedures specified in Section 3.3.1.2, shall be not less than that specified in this section.

3.3.1.4.1 Main wind-force resisting system

The wind load to be used in the design of the MWFRS for an enclosed or partially enclosed building or other structure shall not be less than 10 lb/ft² (0.48 kN/m²) multiplied by the area of the building or structure projected onto a vertical plane normal to the assumed wind direction. The design wind force for open buildings and other structures shall be not less than 10 lb/ft² (0.48 kN/m²) multiplied by the area A_f .

3.3.1.4.2 Components and cladding

The design wind pressure for components and cladding of buildings shall not be less than a net pressure of 10 lb/ft² (0.48 kN/m²) acting in either direction normal to the surface.

3.3.2 DEFINITIONS

The following definitions apply only to the provisions of Section 3.3.

APPROVED: Acceptable to the authority having jurisdiction.

BASIC WIND SPEED, V: Three-second gust speed at 33 ft (10 m) above the ground in Exposure C (see Section 3.3.5.6.3) as determined in accordance with Section 3.3.5.4.

BUILDING, ENCLOSED: A building that does not comply with the requirements for open or partially enclosed buildings.

BUILDING ENVELOPE: Cladding, roofing, exterior walls, glazing, door assemblies, window

assemblies, skylight assemblies, and other components enclosing the building.

BUILDING, FLEXIBLE: Slender buildings that have a fundamental natural frequency less than 1 Hz.

BUILDING, LOW-RISE: Enclosed or partially enclosed buildings that comply with the following conditions:

1. Mean roof height h less than or equal to 60 ft (18 m).
2. Mean roof height h does not exceed least horizontal dimension.

BUILDING, OPEN: A building having each wall at least 80 percent open. This condition is expressed for each wall by the equation $A_0 \geq 0.8 A_g$ where

A_0 = total area of openings in a wall that receives positive external pressure, in ft^2 (m^2)

A_x = the gross area of that wall in which A_0 is identified, in ft^2 (m^2)

BUILDING, PARTIALLY ENCLOSED: A building that complies with both of the following conditions:

1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent.
2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft^2 (0.37 m^2) or 1 percent of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20 percent.

These conditions are expressed by the following equations:

1. $A_0 > 1.10 A_{0i}$;
2. $A_0 > 4 \text{ sqft}$ (0.37 m^2) or $> 0.01 A_g$, whichever is smaller,
and $A_{0i} / A_g \leq 0.20$

where

A_0, A_g are as defined for Open Building

A_{0i} = the sum of the areas of openings in the building envelope (walls and roof) not including A_0 , in ft^2 (m^2)

A_g = the sum of the gross surface areas of the building envelope (walls and roof) not including A_g , in ft^2 (m^2)

BUILDING, REGULAR-SHAPED: A building having no unusual geometrical irregularity in spatial form.

BUILDING, RIGID: A building whose fundamental frequency is greater than or equal to 1 Hz.

BUILDING, SIMPLE DIAPHRAGM: A building in which both windward and leeward wind loads are transmitted through floor and roof diaphragms to the same vertical MWFRS (e.g., no structural separations).

COMPONENTS AND CLADDING: Elements of the building envelope that do not qualify as part of the MWFRS.

DESIGN FORCE, F: Equivalent static force to be used in the determination

of wind loads for open buildings.

DESIGN PRESSURE, p : Equivalent static pressure to be used in the determination of wind loads for buildings.

EAVE HEIGHT, h : The distance from the ground surface adjacent to the building to the roof eave line at a particular wall.

If the height of the eave varies along the wall, the average height shall be used.

EFFECTIVE WIND AREA, A : The area used to determine $G C_p$. For component and cladding elements, the effective wind area in Figs. 3.3.10 through 3.3.16 and Fig. 3.3.18 is the span length multiplied by an effective width that need not be less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

ESCARPMENT: Also known as scarp, with respect to topographic effects in Section 3.3.5.7, a cliff or steep slope generally separating two levels or gently sloping areas (see Fig. 3.3.4).

FREE ROOF: Roof with a configuration generally conforming to those shown in Figs. 3.3.17A through 3.3.17D (monoslope, pitched, or troughed) in an open building with no enclosing walls underneath the roof surface.

GLAZING: Glass or transparent or translucent plastic sheet used in windows, doors, skylights, or curtain walls.

GLAZING, IMPACT RESISTANT: Glazing that has been shown by testing in accordance with ASTM E1886 and ASTM E1996 or other approved test methods to withstand the impact of wind-borne missiles likely to be generated in wind-borne debris regions during design winds.

HILL: With respect to topographic effects in Section 3.3.5.7, a land surface characterized by strong relief in any horizontal direction (see Fig. 3.3.3).

IMPORTANCE FACTOR, I : A factor that accounts for the degree of hazard to human life and damage to property.

MAIN WIND-FORCE RESISTING SYSTEM (MWFRS): An assemblage of structural elements assigned to provide support and stability for the overall structure. The system generally receives wind loading from more than one surface.

MEAN ROOF HEIGHT, h : The average of the roof eave height and the height to the highest point on the roof surface, except that, for roof angles of less than or equal to 10° , the mean roof height shall be the roof eave height.

OPENINGS: Apertures or holes in the building envelope that allow air to flow through the building envelope and that are designed as "open" during design winds as defined by these provisions.

RECOGNIZED LITERATURE: Published research findings and technical papers that are approved.

RIDGE: With respect to topographic effects in Section 3.3.5.7 an elongated crest of a hill characterized by strong relief in two directions (see Fig. 3.3.3).

3.3.3 SYMBOLS AND NOTATION

The following symbols and notation apply only to the provisions of Section 3.3.

A =effective wind area, in ft² (m²)

A_f =area of open buildings either normal to the wind direction or projected on a plane normal to the wind direction, in ft² (m²)

A_g =the gross area of that wall in which A_o is identified, in ft² (m²)

A_{gi} =the sum of the gross surface areas of the building envelope (walls and roof) not including A_g , in ft² (m²)

A_o =total area of openings in a wall that receives positive external pressure, in ft² (m²)

A_{oi} =the sum of the areas of openings in the building envelope (walls and roof) not including A_o , in ft² (m²)

A_{og} =total area of openings in the building envelope, in ft² (m²)

A_s =gross area of the solid freestanding wall or solid sign, in ft² (m²)

a =width of pressure coefficient zone, in ft (m)

B =horizontal dimension of building measured normal to wind direction, in ft (m)

$\bar{b}$ =mean hourly wind speed factor in Eq. (3.14) from Table 3.3.3

$\hat{b}$ =3-s gust speed factor from Table 3.3.3

C_f =force coefficient to be used in determination of wind loads for other structures

C_N =net pressure coefficient to be used in determination of wind loads for open buildings

C_p =external pressure coefficient to be used in determination of wind loads for buildings

c =turbulence intensity factor in Eq. (3.5) from Table 3.3.3

D =diameter of a circular structure or member, in ft (m)

D' =depth of protruding elements such as ribs and spoilers, in ft (m)

F =design wind force for other structures, in lb (N)

G =gust effect factor

G_f =gust effect factor for MWFRSs of flexible buildings

GC_{pn} = combined net pressure coefficient for a parapet

GC_p =product of external pressure coefficient and gust effect factor to be used in determination of wind loads for buildings

GC_{pf} =product of the equivalent external pressure coefficient and gust-effect factor to be used in determination of wind loads for MWFRS of low-rise buildings

GC_{pi} =product of internal pressure coefficient and gust-effect factor to be used in determination of wind loads for buildings

g_Q =peak factor for background response in Eqs. (3.4) and (3.8)

g_R =peak factor for resonant response in Eq. (3.8)

g_v =peak factor for wind response in Eqs. (3.4) and (3.8)

H =height of hill or escarpment in Fig. 3.3.3, in ft(m)

h =mean roof height of a building, except that eave height shall be used for roof angle θ of less than or equal to 10° , in ft(m)

h_e =roof eave height at a particular wall, or the average height if the eave varies along the wall

I =importance factor

I_z =intensity of turbulence from Eq.(3.5)

K_1, K_2, K_3 =multipliers in Fig.3.3.3 to obtain K_z

K_d =wind directionality factor in Table 3.3.5

K_h =velocity pressure exposure coefficient evaluated at height $z=h$

K_z =velocity pressure exposure coefficient evaluated at height z

K_{zt} =topographic factor as defined in Section 3.3.5.7

L =horizontal dimension of a building measured parallel to the wind direction, in ft (m)

L_h =distance upwind of crest of hill or escarpment in Fig.3.3.3 to where the difference in ground elevation is half the height of hill or escarpment, in ft(m)

L_z =integral length scale of turbulence, in ft(m)

L_r =horizontal dimension of return corner for a solid freestanding wall or solid sign from Fig.3.3.19, in ft(m)

ℓ =integral length scale factor from Table 3.3.3, ft(m)

N_1 =reduced frequency from Eq.(3.12)

n_1 =building natural frequency, Hz

p =design pressure to be used in determination of wind loads for buildings, in lb/ft² (N/m²)

p_L =wind pressure acting on leeward face in Fig.3.3.8, in lb/ft² (N/m²)

p_{net} =net design wind pressure from Eq.(3.2), in lb/ft² (N/m²)

p_{net30} =net design wind pressure for Exposure B at $h=30$ ft and $I=1.0$ from Fig.3.3.1, in lb/ft² (N/m²)

p_p =combined net pressure on a parapet from Eq.(3.20), in lb/ft² (N/m²)

p_s =net design wind pressure from Eq.(3.1), in lb/ft² (N/m²)

p_{s30} =simplified design wind pressure for Exposure B at $h=30$ ft and $I=1.0$ from Fig.3.3.1, in lb/ft² (N/m²)

p_w =wind pressure acting on windward face in Fig.3.3.8, in lb/ft² (N/m²)

Q =background response factor from Eq.(3.6)

q =velocity pressure, in lb/ft² (N/m²)

q_h =velocity pressure evaluated at height $z=h$, in lb/ft² (N/m²)

q_i =velocity pressure for internal pressure determination, in lb/ft² (N/m²)

q_p =velocity pressure at top of parapet, in lb/ft² (N/m²)

q_z =velocity pressure evaluated at height z above ground, in lb/ft² (N/m²)

R =resonant response factor from Eq. (3.10)

R_B, R_h, R_L =values from Eq. (3.13)

R_f =reduction factor from Eq. (3.16)

R_n =value from Eq. (3. 11)

s =vertical dimensionof the solid freestanding wall or solid sign from Fig. 3.3.20, in ft (m)

r =rise-to-span ratio for arched roofs

V =basic wind speed obtained from Table 3.3.1, in mi/h(m/s). The basic wind speedcorrespondsto a3-s gust speed at 33 ft (10 m) above ground in exposure Category C

V_i =un-partitionedinternalvolume, ft³(m³)

$\bar{V}_z$ =meanhourlywindspeedatheight z , ft/s(m/s)

W =widthofbuildinginFigs.3.3.11and3.3.14AandBandwidthofspaninFigs.3.3.12and 3.3.14, inft (m)

X =distancetocentreofpressurefromwindward edgeinFig.3.3.17, inft(m)

x =distanceupwindordownwindofcrestin Fig.3.3.3, inft(m)

z =heightabovegroundlevel, inft(m)

$\bar{z}$ =equivalentheightofstructure, inft(m)

z_g =nominalheightoftheatmosphericboundary layerusedinthisstandard.Valuesappearin Table3.3.3

z_{min} =exposureconstantfromTable3.3.3

α =3-s gust-speedpowerlawexponentfromTable 3.3.2

$\hat{\alpha}$ =reciprocalof α fromTable3.3.3

$\bar{\alpha}$ =meanhourlywind-speedpowerlawexponent inEq.3.14fromTable3.3.3

B =dampingratio, percentcriticalforbuildings

ϵ =ratioofsolidareatogrossareaforsolidfree-standingwall, solidsign, opensign, faceofa trussedtower, orlatticestructure

λ =adjustmentfactorforbuildingheightandexposurefromFigs.3.3.1and3.3.2

$\overline{\epsilon}$ =integral length scale power law exponent in Eq.(3.7) fromTable3.3.3

η =valueusedinEq.(3.13)(seeSection3.3.5.8.2)

θ =angleofplaneofroof fromhorizontal, indegrees

v =height-to-widthratioforsolidsign

3.3.4 – Method 1 - Simplified Procedure

3.3.4.1Scope

A building whose design wind loads are determined in accordance with this section shall meet all the conditions of 3.3.4.1.1 or 3.3.4.1.2. If a building qualifies only under 3.3.4.1.2 for design of its components and cladding, then its MWFRS shall be designed by Method 2 or Method 3.

3.3.4.1.1 Main wind-force resisting systems

For the design of MWFRSs the building must meet all of the following conditions:

1. The building is a simple diaphragm building as defined in Section 3.3.2.
2. The building is a low-rise building as defined in Section 3.3.2.
3. The building is enclosed as defined in Section 3.3.2
4. The building is a regular-shaped building or structure as defined in Section 3.3.2.
5. The building is not classified as a flexible building as defined in Section 3.3.2.
6. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
7. The building has an approximately symmetrical cross section in each direction with either a flat roof or a gable or hip roof with $\theta \leq 45^\circ$.
8. The building is exempted from torsional load cases as indicated in Note 5 of Fig. 3.9, or the torsional load cases defined in Note 5 do not control the design of any of the MWFRSs of the building.

3.3.4.1.2 Components and cladding

For the design of components and cladding the building must meet all the following conditions:

1. The mean roof height h must be less than or equal to 60 ft ($h \leq 60$ ft).
2. The building is enclosed as defined in Section 3.3.2
3. The building is a regular-shaped building or structure as defined in Section 3.3.2.
4. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
5. The building has either a flat roof, a gable roof with, or a hip roof with $\theta \leq 45^\circ$, or a hip roof with $\theta \leq 27^\circ$.

3.3.4.2 Design Procedure

1. The basic wind speed V shall be determined in accordance with Section 3.5.4. The wind shall be assumed to come from any horizontal direction.

2. An importance factor I shall be determined in accordance with Section 3.5.5.
3. An exposure category shall be determined in accordance with Section 3.5.6.
4. A height and exposure adjustment coefficient, λ , shall be determined from Fig. 3.3.1.

3.3.4.2.1 Main wind-force resisting system

Simplified design wind pressures, p_s , for the MWFRSs of low-rise simple diaphragm buildings represent the net pressures (sum of internal and external) to be applied to the horizontal and vertical projections of building surfaces as shown in Fig. 3.3.1. For the horizontal pressures (zones A, B, C, D), p_s is the combination of the windward and leeward net pressures. p_s shall be determined by the following equation:

$$p_s = \lambda K_{zt} I p_{s30} \quad \text{Eq. (3.3.1)}$$

where

λ =adjustment factor for building height and exposure from Fig. 3.3.1

K_{zt} =topographic factor as defined in Section 3.5.7 evaluated at mean roof height, h

I =importance factor as defined in Section 3.2

p_{s30} =simplified design wind pressure for Exposure B, at $h = 30$ ft, and for $I = 1.0$, from Fig. 3.3.1

3.3.4.2.1.1 Minimum pressures

The load effects of the design wind pressures from Section 3.3.4.2.1 shall not be less than the minimum load case from Section 3.1.4.1 assuming the pressures, p_s , for zones A, B, C, and D all equal to +10 psf, while assuming zones E, F, G, and H all equal to 0 psf.

3.3.4.2.2 Components and cladding

Net design wind pressures, p_{net} , for the components and cladding of buildings designed using Method 1 represent the net pressures (sum of internal and external) to be applied normal to each building surface as shown in Fig. 3.2. p_{net} shall be determined by the following equation:

$$p_{net} = \lambda K_{zt} I p_{net30} \quad \text{Eq. (3.2)}$$

where

λ = adjustment factor for building height and exposure from Fig. 3.3.2

K_{zt} = topographic factor as defined in Section 3.3.5.7 evaluated at mean roof height, h

I = importance factor as defined in Section 3.3.2

p_{net30} = net design wind pressure for exposure B, at $h = 30$ ft, and for $I = 1.0$, from Fig. 3.3.2

3.3.4.2.2.1 Minimum pressures

The positive design wind pressures, p_{net} , from Section 3.3.4.2.2 shall not be less than +10 psf, and the negative design wind pressures, p_{net} , from Section 3.3.4.2.2 shall not be less than - 10 psf.

3.3.4.3 Air Permeable Cladding

Design wind loads determined from Fig. 3.3.2 shall be used for all air permeable cladding unless approved test data or the recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

3.3.5 – Method 2 -Analytical Procedure

3.3.5.1 Scope

A building whose design wind loads are determined in accordance with this section shall meet all of the following conditions:

1. The building is a regular-shaped building as defined in Section 3.3.2.
2. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; or does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.

3.3.5.2 Limitations

The provisions of Section 3.3.5 take into consideration the load magnification effect caused by gusts in resonance with along wind vibrations of flexible buildings. Buildings not meeting the requirements of Section 3.3.5.1, or having unusual shapes or response characteristics, shall be designed using recognized literature documenting such wind load effects or shall use the wind tunnel procedure specified in Section 3.3.6.

3.3.5.2.1 Shielding

There shall be no reductions in velocity pressure due to apparent shielding afforded by buildings or terrain features.

3.3.5.2.2 Air permeable cladding

Design wind loads determined from Section 3.3.5 shall be used for air permeable cladding unless approved test data or recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

3.3.5.3 Design Procedure

1. The basic wind speed V and wind directionality factor K_d shall be determined in accordance with Section 3.3.5.4.
2. An importance factor I shall be determined in accordance with Section 3.3.5.5.
3. An exposure category or exposure categories and velocity pressure exposure coefficient K_z or K_h , as applicable, shall be determined for each wind direction in accordance with Section 3.3.5.6.

4. A topographic factor K_z shall be determined in accordance with Section 3.3.5.7.
5. A gust effect factor G or G_f , as applicable, shall be determined in accordance with Section 3.3.5.8.
6. An enclosure classification shall be determined in accordance with Section 3.3.5.9.
7. Internal pressure coefficient G_{Cpi} , shall be determined in accordance with Section 3.3.5.11.1.
8. External pressure coefficients C_p or G_{Cpf} , or force coefficients C_f , as applicable, shall be determined in accordance with Section 3.3.5.11.2 or 3.3.5.11.3, respectively.
9. Velocity pressure q_z or q_h , as applicable, shall be determined in accordance with Section 3.3.5.10.
10. Design wind load p or F shall be determined in accordance with Sections 3.3.5.12, 3.3.5.13, 3.3.5.14, and 3.3.5.15, as applicable.

3.3.5.4 Basic Wind Speed

The basic wind speed, V , used in the determination of design wind loads on buildings shall be as given in Table 3.1 except as provided in Sections 3.3.5.4.1 and 3.3.5.4.2. The wind shall be assumed to come from any horizontal direction.

3.3.5.4.1 Special wind regions

The basic wind speed shall be increased where records or experience indicate that the wind speeds are higher than those reflected in Table 3.3.1. Mountainous terrain, gorges, and special regions shall be examined for unusual wind conditions. The authority having jurisdiction shall, if necessary, adjust the values given in Table 3.3.1 to account for higher local wind speeds. Such adjustment shall be based on meteorological information and an estimate of the basic wind speed obtained in accordance with the provisions of Section 3.3.5.4.2.

3.3.5.4.2 Estimation of basic wind speeds from regional climatic data

Regional climatic data shall only be used in lieu of the basic wind speeds given in Table 3.3.1 when (1) approved extreme-value statistical-analysis procedures have been employed in reducing the data; and (2) the length of record, sampling error, averaging time, anemometer height, data quality, and terrain exposure of the anemometer have been taken into account. Reduction in basic wind speed below that of Table 3.3.1 shall not be permitted.

When the basic wind speed is estimated from regional climatic data, the basic wind speed shall be not less than the wind speed associated with an annual probability of 0.02 (50- year mean recurrence interval), and the estimate shall be adjusted for equivalence to a 3-s gust wind speed at 33 ft (10 m) above ground in exposure Category C. The data analysis shall be performed in accordance with this section.

3.3.5.4.3 Wind directionality factor

The wind directionality factor, K_d , shall be determined from Table 3.3.5. This factor shall only be applied when used in conjunction with load combinations specified in Sections 3.2.1.2 and 3.2.1.3.

3.3.5.5 Importance Factor

An importance factor, I , for the building shall be determined from Table 3.3.2 based on building categories listed in Table 3.1.2.

3.3.5.6 Exposure

For each wind direction considered, the upwind exposure category shall be based on ground surface roughness that is determined from natural topography, vegetation, and constructed facilities.

3.3.5.6.1 Wind directions and sectors

For each selected wind direction at which the wind loads are to be evaluated, the exposure of the building or structure shall be determined for the two upwind sectors extending 45° either side of the selected wind direction. The exposures in these two sectors shall be determined in accordance with Sections 3.3.5.6.2 and 3.3.5.6.3 and the exposure resulting in the highest wind loads shall be used to represent the winds from that direction.

3.3.5.6.2 Surface roughness categories

A ground surface roughness within each 45° sector shall be determined for a distance upwind of the site as defined in Section 3.3.5.6.3 from the categories defined in the following text, for the purpose of assigning an exposure category as defined in Section 3.3.5.6.3.

Surface Roughness B: Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m).

Surface Roughness D: Flat, unobstructed areas and water surfaces. This category includes smooth mud flats and salt flats.

3.3.5.6.3 Exposure categories

Exposure B: Exposure B shall apply where the ground surface roughness condition, as defined by Surface Roughness B, prevails in the upwind direction for a distance of at least 2, 600 ft (792 m) or 20 times the height of the building, whichever is greater.

EXCEPTION: For buildings whose mean roof height is less than or equal to 30 ft, the upwind distance may be reduced to 1, 500 ft (457 m).

Exposure C: Exposure C shall apply for all cases where Exposures B or D do not apply.

Exposure D: Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance greater than 5, 000 ft (1, 524 m) or 20 times the building height, whichever is greater. Exposure D shall extend into downwind areas of Surface Roughness B or C for a distance of 600 ft (200 m) or 20 times the height of the building, whichever is greater.

For a site located in the transition zone between exposure categories, the category resulting in the largest wind forces shall be used.

EXCEPTION: An intermediate exposure between the preceding categories is permitted in a transition zone provided that it is determined by a rational analysis method defined in the recognized literature.

3.3.5.6.4 Exposure category for main wind-force resisting system

3.3.5.6.4.1 Buildings and other structures

For each wind direction considered, wind loads for the design of the MWFRS determined from Fig. 3.3.5 shall be based on the exposure categories defined in Section 3.3.5.6.3.

3.3.5.6.4.2 Low-rise buildings

Wind loads for the design of the MWFRSs for low-rise buildings shall be determined using a velocity pressure q_h based on the exposure resulting in the highest wind loads for any wind direction at the site where external pressure coefficients GC_p given in Fig. 3.3.9 are used.

3.3.5.6.5 Exposure category for components and cladding

Components and cladding design pressures for all buildings shall be based on the exposure resulting in the highest wind loads for any direction at the site.

3.3.5.6.6 Velocity pressure exposure coefficient

Based on the exposure category determined in Section 3.3.5.6.3, a velocity pressure exposure coefficient K_z or K_h , as applicable, shall be determined from Table 3.3.4. For a site located in a transition zone between exposure categories, that is, near to a change in ground surface roughness, intermediate values of K_z or K_h , between those shown in Table 3.3.4, are permitted, provided that they are determined by a rational analysis method defined in the recognized literature.

3.3.5.7 Topographic Effects

3.3.5.7.1 Wind speed-up over hills, ridges, and escarpments

Wind speed-up effects at isolated hills, ridges, and escarpments constituting abrupt changes in the general topography, located in any exposure category, shall be included in the design when buildings and other site conditions and locations of structures meet all of the following conditions:

1. The hill, ridge, or escarpment is isolated and unobstructed upwind by other similar topographic features of comparable height for 100 times the height of the topographic feature ($100H$) or 2 mi (3.22 km), whichever is less. This distance shall be measured horizontally from the point at which the height H of the hill, ridge, or escarpment is determined.
2. The hill, ridge, or escarpment protrudes above the height of upwind terrain features within a 2-mi (3.22 km) radius in any quadrant by a factor of two or more.

3. The structure is located as shown in Fig. 3.3.3 in the upper one-half of a hill or ridge or near the crest of an escarpment
4. $H/L_h \geq 0.2$.
5. H is greater than or equal to 15 ft (4.5 m) for Exposures C and D and 60 ft (18 m) for Exposure B.

3.3.5.7.2 Topographic factor

The wind speed-up effect shall be included in the calculation of design wind loads by using the factor K_{zt} :

$$K_{zt} = (1 + K_1 K_2 K_3)^2 \quad \text{Eq. (3.3.3)}$$

where K_1 , K_2 , and K_3 are given in Fig. 3.3.3

If site conditions and locations of structures do not meet all the conditions specified in section 3.3.5.7.1 then $K_{zt} = 1.0$.

3.3.5.8 Gust Effect Factor

3.3.5.8.1 Rigid structures

For rigid structures as defined in Section 3.3.2, the gust-effect factor shall be taken as 0.85 or calculated by the equation:

$$G = 0.925 \left(\frac{(1 + 1.7 g_Q I_z Q)}{1 + 1.7 g_v I_z} \right) \quad \text{Eq. (3.3.4)}$$

$$I_z = c \left(\frac{33}{z} \right)^{1/6} \quad \text{Eq. (3.3.5)}$$

$$\text{In SI: } I_z = c \left(\frac{10}{z} \right)^{1/6}$$

where

I_z = the intensity of turbulence at height z where z = the equivalent height of the structure defined as $0.6h$, but not less than z_{min} for all building heights h . z_{min} and c are listed for each exposure in Table 3.2.3 ; g_Q and g_v shall be taken as 3.4. The background response Q is given by

$$Q = \sqrt{\frac{1}{1 + 0.63 \left(\frac{B + h}{L_z} \right)^{0.63}}} \quad \text{Eq. (3.3.6)}$$

where B , h are defined in Section 3.3; and L_z = the integral length scale of turbulence at the equivalent height given by

$$L_z = l \left(\frac{z}{33} \right)^{\epsilon} \quad \text{Eq. (3.3.7)}$$

$$\text{In SI: } L_z = l \left(\frac{z}{10} \right)^{\epsilon}$$

in which ℓ and ϵ are constants listed in Table 3.3.3.

3.3.5.8.2 Flexible or dynamically sensitive structures

For flexible or dynamically sensitive structures as defined in Section 3.3.2, the gust-effect factor shall be calculated by

$$G_f = 0.925 \left(\frac{1 + 1.7 I_z \sqrt{g_Q^2 Q^2 + g_R^2 R^2}}{1 + 1.7 g_v I_z} \right) \quad \text{Eq.(3.3.8)}$$

g_Q and g_v shall be taken as 3.4 and g_R is given by

$$g_R = \sqrt{2 \ln(3,600 n_1)} + \frac{0.577}{\sqrt{2 \ln(3,600 n_1)}} \quad \text{Eq.(3.3.9)}$$

R , the resonant response factor, is given by

$$R = \sqrt{\frac{1}{\beta} R_n R_h R_B (0.53 + 0.47 R_L)} \quad \text{Eq.(3.3.10)}$$

$$R_n = \frac{7.47 N_1}{(1 + 10.3 N_1)^{5/3}} \quad \text{Eq.(3.3.11)}$$

$$N_1 = \frac{n_1 L_z}{\bar{V}_z} \quad \text{Eq.(3.3.12)}$$

$$R_\ell = \frac{1}{\eta} - \frac{1}{2\eta^2} (1 - e^{-2\eta}) \quad \text{for } \eta > 0 \quad \text{Eq.(3.3.13a)}$$

$$R_\ell = 1 \text{ for } \eta = 0 \text{ for } \eta > 0 \quad \text{Eq.(3.3.13b)}$$

where the subscript l in Eq. (3.3.13) shall be taken as h , B , and L , respectively, where h , B , and L are defined in Section 3.3.3.

n_1 = building natural frequency

$$R_l = R_h \text{ setting } \eta = 4.6 n_1 h / \bar{V}_z$$

$$R_l = R_B \text{ setting } \eta = 4.6 n_1 B / \bar{V}_z$$

$$R_l = R_L \text{ setting } \eta = 15.4 n_1 L / \bar{V}_z$$

β = damping ratio, percent of critical

$\bar{V}_z$ = mean hourly wind speed (ft/s) at height z determined from Eq.(3.14)

$$v_z = \bar{v} \left(\frac{z}{33} \right)^{\alpha} V \left(\frac{88}{60} \right) \quad \text{Eq. (3.14)}$$

$$\text{In SI: } v_z = \bar{b} \left(\frac{z}{10} \right)^{\bar{\alpha}} V$$

where $\bar{b}$ and $\bar{\alpha}$ are constants listed in Table 3.3.3 and V is the basic wind speed in mile/hr.

3.3.5.8.3 Rational analysis

In lieu of the procedure defined in Sections 3.5.8.1 and 3.5.8.2, determination of the gust-effect factor by any rational analysis defined in the recognized literature is permitted.

3.3.5.8.4 Limitations

Where combined gust-effect factors and pressure coefficients (GC_p , GC_{pi} , and GC_{pf}) are given in figures and tables, the gust-effect factor shall not be determined separately.

3.3.5.9 Enclosure Classifications

3.3.5.9.1 General

For the purpose of determining internal pressure coefficients, all buildings shall be classified as enclosed, partially enclosed, or open as defined in Section 3.3.2.

3.3.5.9.2 Openings

A determination shall be made of the amount of openings in the building envelope to determine the enclosure classification as defined in Section 3.3.5.9.1.

3.3.5.9.3 Multiple classifications

If a building by definition complies with both the "open" and "partially enclosed" definitions, it shall be classified as an "open" building. A building that does not comply with either the "open" or "partially enclosed" definitions shall be classified as an "enclosed" building.

3.3.5.10 Velocity Pressure

Velocity pressure, q_z , evaluated at height z shall be calculated by the following equation:

$$q_z = 0.00256 K_z K_{zt} K_d V^2 I \quad (\text{lb/ft}^2) \quad \text{Eq. (3.3.15)}$$

$$\left[\text{In SI: } q_z = 0.613 K_z K_{zt} K_d V^2 I \quad (\text{N/m}^2); V \text{ in m/s} \right]$$

where K_d is the wind directionality factor defined in Section 3.3.5.4.4, K_z is the velocity pressure exposure coefficient defined in Section 3.3.5.6.6, K_{zt} is the topographic factor defined in Section 3.3.5.7.2, and q_h is the velocity pressure calculated using Eq. (3.15) at mean roof height h .

The numerical coefficient 0.00256 (0.613 in SI) shall be used except where sufficient climatic data are available to justify the selection of a different value of this factor for a design application.

3.3.5.11 Pressure and Force Coefficients

3.3.5.11.1 Internal pressure coefficient

Internal pressure coefficients, GC_{pi} , shall be determined from Fig. 3.3.4 based on building enclosure classifications determined from Section 3.3.5.9.

3.3.5.11.1.1 Reduction factor for large volume buildings, R_i

For a partially enclosed building containing a single, unpartitioned large volume, the internal pressure coefficient, GC_{pi} , shall be multiplied by the following reduction factor, R_i :

$$R_i = 1.0 \text{ or}$$

$$R_i = 0.5 \left(1 + \frac{1}{\sqrt{1 + \frac{V_i}{22.8A_{og}}}} \right) \leq 1.0 \quad \text{Eq. (3.3.16)}$$

where

A_{og} = total area of openings in the building envelope (walls and roof, in ft²)

V_i = unpartitioned internal volume, in ft³

3.3.5.11.2 External pressure coefficients

3.3.5.11.2.1 Main wind-force resisting systems

External pressure coefficients for MWFRSs C_p are given in Figs. 3.5, 3.6 and 3.7. Combined gust effect factor and external pressure coefficients, GC_{pf} , are given in Fig. 3.9 for low-rise buildings. The pressure coefficient values and gust effect factor in Fig. 3.9 shall not be separated.

3.3.5.11.2.2 Components and cladding

Combined gust effect factor and external pressure coefficients for components and cladding GC_p are given in Figs. 3.10 through 3.16. The pressure coefficient values and gust-effect factor shall not be separated.

3.3.5.11.3 Force coefficients

Force coefficients C_p are given in Figs. 3.19 through 3.3.22

3.3.5.11.4 Roof overhangs

3.3.5.11.4.1 Main wind-force resisting system

Roof overhangs shall be designed for a positive pressure on the bottom surface of windward roof overhangs corresponding to $C_p = 0.8$ in combination with the pressures determined from using Figs. 3.3.5 and 3.3.9.

3.3.5.11.4.2 Components and cladding

For all buildings, roof overhangs shall be designed for pressures determined from pressure coefficients given in Figs. 3.3.10 B, C, D.

3.3.5.11.5 Parapets

3.3.5.11.5.1 Main wind-force resisting system

The pressure coefficients for the effect of parapets on the MWFRS loads are given in Section 3.3.5.12.2.4.

3.3.5.11.5.2 Components and cladding

The pressure coefficients for the design of parapet component and cladding elements are taken from the wall and roof pressure coefficients as specified in Section 3.3.5.12.4.4.

3.3.5.12 Design Wind Loads on Enclosed and Partially Enclosed Buildings

3.3.5.12.1 General

3.3.5.12.1.1 Sign convention

Positive pressure acts toward the surface and negative pressure acts away from the surface.

3.3.5.12.1.2 Critical load condition

Values of external and internal pressures shall be combined algebraically to determine the most critical load.

3.3.5.12.1.3 Tributary areas greater than 700 ft² (65 m²)

Component and cladding elements with tributary areas greater than 700 ft² (65 m²) shall be permitted to be designed using the provisions for MWFRSs.

3.3.5.12.2 Main wind-force resisting systems

3.3.5.12.2.1 Rigid buildings of all heights

Design wind pressures for the MWFRS of buildings of all heights shall be determined by the following equation:

$$p = qG C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2) \quad (\text{N/m}^2) \quad \text{Eq. (3.3.17)}$$

where

$q = q_z$ for windward walls evaluated at height z above the ground

$q = q_h$ for leeward walls, side walls, and roofs, evaluated at height h

$q_i = q_h$ for windward walls, side walls, leeward walls, and roofs of enclosed buildings and for negative internal pressure evaluation in partially enclosed buildings

$q_i = q_z$ for positive internal pressure evaluation in partially enclosed buildings where height z is defined as the level of the highest opening in the building that could affect the positive internal pressure. For buildings sited in wind-borne debris regions, glazing that is not impact resistant or protected with an impact resistant covering, shall be treated as an opening in accordance with Section 3.3.5.9.3. For positive internal pressure evaluation, q_i may conservatively be evaluated at height h ($q_i = q_h$)

$G =$ gust effect factor from Section 3.3.5.8

$C_p =$ external pressure coefficient from Fig. 3.3.5 or 3.3.7

$(G C_{pi}) =$ internal pressure coefficient from Fig. 3.3.4

q and q_i shall be evaluated using exposure defined in Section 3.3.5.6.3. Pressure shall be applied simultaneously on windward and leeward walls and on roof surfaces as defined in Figs. 3.3.5 and 3.3.7

3.3.5.12.2.2 Low-rise buildings

Alternatively, design wind pressures for the MWFRS of low-rise buildings shall be determined by the following equation:

$$p = q_h((GC_{pf}) - (GC_{pi})) \text{ (lb/ft}^2\text{) (N/m}^2\text{)} \quad \text{Eq. (3.3.18)}$$

where

q_h = velocity pressure evaluated at mean roof height h using exposure defined in Section 3.3.5.6.3

(GC_{pf}) = external pressure coefficient from Fig. 3.3.9

(GC_{pi}) = internal pressure coefficient from Fig. 3.3.4

3.3.5.12.2.3 Flexible buildings

Design wind pressures for the MWFRS of flexible buildings shall be determined from the following equation:

$$p = qG_fC_p - q_i(GC_{pi}) \text{ (lb/ft}^2\text{) (N/m}^2\text{)} \quad \text{Eq. (3.3.19)}$$

where

q , q_i , C_p , and (GC_{pi}) are as defined in Section 3.3.5.12.2.1 and

G_f = gust effect factor is defined as in Section 3.3.5.8.2.

3.3.5.12.2.4 Parapets

The design wind pressure for the effect of parapets on MWFRSs of rigid, low-rise, or flexible buildings with flat, gable, or hip roofs shall be determined by the following equation:

$$p_p = q_p GC_{pn} \text{ (lb/ft}^2\text{)} \quad \text{Eq. (3.3.20)}$$

where

p_p = combined net pressure on the parapet due to the combination of the net pressures from the front and back parapet surfaces. Plus (and minus) signs signify net pressure acting toward (and away from) the front (exterior) side of the parapet

q_p = velocity pressure evaluated at the top of the parapet

GC_{pn} = combined net pressure coefficient

= +1.5 for windward parapet

= -1.0 for leeward parapet

3.3.5.12.3 Design wind load cases

The MWFRS of buildings of all heights, whose wind loads have been determined under the provisions of Sections 3.3.5.12.2.1 and 3.3.5.12.2.3, shall be designed for the wind load

cases as defined in Fig. 3.3.8. The eccentricity e for rigid structures shall be measured from the geometric centre of the building face and shall be considered for each principal axis (e_x , e_y). The eccentricity e for flexible structures shall be determined from the following equation and shall be considered for each principal axis (e_x , e_y):

where

$$e = \frac{e_Q + 1.7I_{\bar{z}}\sqrt{(g_Q Q e_Q)^2 + (g_R R e_R)^2}}{1 + 1.7I_{\bar{z}}\sqrt{(g_Q Q)^2 + (g_R R)^2}} \quad \text{Eq. (3.3.21)}$$

e_Q = eccentricity e as determined for rigid structures in Fig. 3.3.8

e_R = distance between the elastic shear centre and centre of mass of each floor

$I_{\bar{z}}$, g_Q , Q , g_R , R , shall be as defined in Section 3.3.5.8

The sign of the eccentricity e shall be plus or minus, whichever causes the more severe load effect.

EXCEPTION: One-storey buildings with h less than or equal to 30 ft, buildings two storeys or less framed with light-frame construction, and buildings two storeys or less designed with flexible diaphragms need only be designed for Load Case 1 and Load Case 3 in Fig. 3.3.8.

3.3.5.12.4 Components and cladding

3.3.5.12.4.1 Low-rise buildings and buildings with $h \leq 60$ ft (18.3 m)

Design wind pressures on component and cladding elements of low-rise buildings and buildings with $h \leq 60$ ft (18.3 m) shall be determined from the following equation:

$$p = q_h((GC_p) - (GC_{pi})) \quad (\text{lb/ft}^2) \quad (\text{N/m}^2) \quad \text{Eq. (3.3.22)}$$

where

q_h = velocity pressure evaluated at mean roof height h using exposure defined in Section 3.3.5.6.3

(GC_p) = external pressure coefficients given in Figs. 3.3.10 through 3.3.15

(GC_{pi}) = internal pressure coefficient given in Fig. 3.3.4

3.3.5.12.4.2 Buildings with $h > 60$ ft (18.3 m)

Design wind pressures on components and cladding for all buildings with $h > 60$ ft (18.3 m) shall be determined from the following equation:

$$p = q(GC_p) - q_i(GC_{pi}) \quad (\text{lb/ft}^2) \quad (\text{N/m}^2) \quad \text{Eq. (3.3.23)}$$

where

$q = q_z$ for windward walls calculated at height z above the ground

$q = q_h$ for leeward walls, side walls, and roofs, evaluated at height h

$q_i = q_h$ for windward walls, side walls, leeward walls, and roofs of enclosed buildings and for negative internal pressure evaluation in partially enclosed buildings

$q_i = q_z$ for positive internal pressure evaluation in partially enclosed buildings where height z is defined as the level of the highest opening in the building that could affect the positive internal pressure. For buildings sited in wind-borne debris regions, glazing that is not impact resistant or protected with an impact-resistant covering, shall be treated as an opening in accordance with Section 3.5.9.3. For positive internal pressure evaluation, q_i may conservatively be evaluated at height h ($q_i = q_h$)

(GC_p) = external pressure coefficient from Fig. 3.16

(GC_{pi}) = internal pressure coefficient given in Fig. 3.4.

q and q_s shall be evaluated using exposure defined in Section 3.5.6.3.

3.3.5.12.4.3 Alternative design wind pressures for components and cladding in buildings with 60 ft (18.3 m) < h < 90 ft (27.4 m)

Alternative to the requirements of Section 3.3.5.12.4.2, the design of components and cladding for buildings with a mean roof height greater than 60 ft (18.3 m) and less than 90 ft (27.4 m) values from Figs. 3.3.10 through 3.3.16 shall be used only if the height to width ratio is one or less (except as permitted by Note 6 of Fig. 3.3.16) and Eq. (3.22) is used.

3.3.5.12.4.4 Parapets

The design wind pressure on the components and cladding elements of parapets shall be designed by the following equation:

$$p = q_p(GC_p - GC_{pi}) \quad \text{Eq. (3.3.24)}$$

where

q_p = velocity pressure evaluated at the top of the parapet

GC_p = external pressure coefficient from Figs. 3.3.10 through 3.3.17

GC_{pi} = internal pressure coefficient from Fig. 3.3.4, based on the porosity of the parapet envelope

Two load cases shall be considered. Load Case A shall consist of applying the applicable positive wall pressure from Fig. 3.3.10A or Fig. 3.3.16 to the front surface of the parapet while applying the applicable negative edge or corner zone roof pressure from Figs. 3.3.10 through 3.3.16 to the back surface. Load Case B shall consist of applying the applicable positive wall pressure from Fig. 3.3.10A or Fig. 3.3.16 to the back of the parapet surface, and applying the applicable negative wall pressure from Fig. 3.3.10A or Fig. 3.3.16 to the front surface. Edge and corner zones shall be arranged as shown in Figs. 3.3.10 through 3.3.16. GC_p shall be determined for appropriate roof angle and effective wind area from Figs. 3.3.10 through 3.3.16. If internal pressure is present, both load cases should be evaluated under positive and negative internal pressure.

3.3.5.13 Design Wind Loads on Open Buildings with Monoslope, Pitched, or

Troughed Roofs

3.3.5.13.1 General

3.3.5.13.1.1 Sign convention

Plus and minus signs signify pressure acting toward and away from the top surface of the roof, respectively.

3.3.5.13.1.2 Critical load condition

Net pressure coefficients C_N include contributions from top and bottom surfaces.

All load cases shown for each roof angle shall be investigated.

3.3.5.13.2 Main wind-force resisting systems

The net design pressure for the MWFRSs of monoslope, pitched, or troughed roofs shall be determined by the following equation:

$$p = q_h G C_N \quad \text{Eq.(3.3.25)}$$

where

q_h = velocity pressure evaluated at mean roof height h using the exposure as defined in Section 3.3.5.6.3 that results in the highest wind loads for any wind direction at the site

G = gust effect factor from Section 3.3.5.8

C_N = net pressure coefficient determined from Figs. 3.3.17A through 3.3.17D

For free roofs with an angle of plane of roof from horizontal θ less than or equal to 5° and containing fascia panels, the fascia panel shall be considered an inverted parapet. The contribution of loads on the fascia to the MWFRS loads shall be determined using Section 3.3.5.12.2.4 with q_p equal to q_h .

3.3.5.13.3 Component and cladding elements

The net design wind pressure for component and cladding elements of monoslope, pitched, and troughed roofs shall be determined by the following equation:

$$p = q_h G C_N \quad \text{Eq.(3.3.26)}$$

where

q_h = velocity pressure evaluated at mean roof height h using the exposure as defined in Section 3.3.5.6.3 that results in the highest wind loads for any wind direction at the site

G = gust-effect factor from Section 3.3.5.8

C_N = net pressure coefficient determined from Figs. 3.3.18A through 3.3.18C

3.3.5.14 Design Wind Loads on Solid Freestanding Walls and Solid Signs

The design wind force for solid freestanding walls and solid signs shall be determined by the following formula:

$$F = q_h G C_F A_s (\text{lb}) (\text{N}) \quad \text{Eq. (3.3.27)}$$

where

q_h = the velocity pressure evaluated at height h (defined in Fig. 3.3.20) using exposure defined in Section 3.3.5.6.4.1

G = gust-effect factor from Section 3.3.5.8

C_F = net force coefficient from Fig. 3.3.19

A_s = the gross area of the solid freestanding wall or solid sign, in ft² (m²)

3.3.5.15 Design Wind Loads on Other Structures

The design wind force for other structures shall be determined by the following equation:

$$F = q_z G C_F A_f \text{ (lb) (N)} \quad \text{Eq. (3.3.28)}$$

where

q_z = velocity pressure evaluated at height z of the centroid of area A_f using exposure defined in Section 3.3.5.6.3

G = gust-effect factor from Section 3.3.5.8

C_F = force coefficients from Figs. 3.3.20 through 3.3.22

A_f = projected area normal to the wind except where C_F is specified for the actual surface area, ft² (m²)

3.3.5.15.1 Rooftop structures and equipment for buildings with $h \leq 60$ ft (18.3 m)

The force on rooftop structures and equipment with A_f less than $(0.1 B h)$ located on buildings with $h \leq 60$ ft (18.3 m) shall be determined from Eq. (3.28), increased by a factor of 1.9. The factor shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of A_f is increased from $(0.1 B h)$ to $(B h)$.

3.3.6 – Method 3 -Wind Tunnel Procedure

3.3.6.1 Scope

Wind tunnel tests shall be used where required by Section 3.3.5.2. Wind tunnel testing shall be permitted in lieu of Methods 1 and 2 for any building.

3.3.6.2 Test Conditions

Wind tunnel tests, or similar tests employing fluids other than air, used for the determination of design wind loads for any building, shall be conducted in accordance with this section. Tests for the determination of mean and fluctuating forces and pressures shall meet all of the following conditions:

1. The natural atmospheric boundary layer has been modeled to account for the variation of wind speed with height.
2. The relevant macro- (integral) length and micro-length scales of the longitudinal component of atmospheric turbulence are modeled to approximately the same scale as that used to model the building.
3. The modeled building and surrounding structures and topography are

geometrically similar to their full-scale counterparts, except that, for low-rise buildings meeting the requirements of Section 3.3.5.1, tests shall be permitted for the modeled building in a single exposure site as defined in Section 3.3.5.6.3.

4. The projected area of the modeled building and surroundings is less than 8 percent of the test section cross-sectional area unless correction is made for blockage.
5. The longitudinal pressure gradient in the wind tunnel test section is accounted for.
6. Reynolds number effects on pressures and forces are minimized.
7. Response characteristics of the wind tunnel instrumentation are consistent with the required measurements.

3.3.6.3 Dynamic Response

Tests for the purpose of determining the dynamic response of a building shall be in accordance with Section 3.3.6.2. The structural model and associated analysis shall account for mass distribution, stiffness, and damping

.

3.3.6.4 Limitations

3.3.6.4.1 Limitations on wind speeds

Variation of basic wind speeds with direction shall not be permitted unless the analysis for wind speeds conforms to the requirements of Section 3.3.5.4.2.

Main Wind Force Resisting System - Method 1		$h \leq 60$ ft
Figure 3.3.1	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		

Notes:

- Pressures shown are applied to the horizontal and vertical projections, for exposure B, at $h=30$ ft (9.1 m), $I = 1.0$, and $K_{zt} = 1.0$. Adjust to other condition using Equation 6-1.
- The load patterns shown shall be applied to each corner of the building in turn as the reference corner (See Fig.6-10).
- For the design of the longitudinal WFRS use $\theta = 0^\circ$, and locate the zone E/F, G/H boundary at the mid-length of the building.
- Load cases 1 and 2 must be checked for $25^\circ < \theta \leq 45^\circ$. Load case 2 at 25° is provided only for interpolation between 25° to 30° .
- Plus and minus signs signify pressures acting toward and away from the projected surfaces, respectively.
- For roof slopes other than those shown, linear interpolation is permitted.
- The total horizontal load shall not be less than that determined by assuming $p_s = 0$ in zones B & D.
- The zone pressures represent the following:
Horizontal pressure zones - Sum of the windward and leeward net (sum of internal and external) pressures on vertical projection of:
A - End zone of wall ; C - Interior zone of wall
B - End zone of roof ; D - Interior zone of roof
Vertical pressure zones - Net (sum of internal and external) pressures on horizontal projection of:
E - End zone of windward roof ; G - Interior zone of windward roof
F - End zone of leeward roof ; H - Interior zone of leeward roof
- Where zone E or G falls on a roof overhang on the windward side of the building, use E_{OH} and G_{OH} for the pressure on the horizontal projection of the overhang. Overhangs on the leeward and side edges shall have the basic zone pressure applied.
- Notation:
 a = 10 percent of least horizontal dimension or $0.4h$, whichever is smaller, but not less than either 4 % of least horizontal dimension or 3 ft (0.9 m)
 h = mean roof height, in feet (meters), except that eave height shall be used for roof angles $< 10^\circ$.
 θ = angle of plane of roof from horizontal, in degrees.

Main Wind Force Resisting Syatem - Method 1										h ≤ 60 ft			
Figure 3.3.1 (cont'd)		Design Wind Pressures						Walls & Roofs					
Enclosed Buildings													
Simplified Design Wind Pressure, p _{s30} (psf) (<i>Exposure B at h = 30 ft, K_{z1} = 1.0, with I = 1.0</i>)													
Basic Wind Speed (mph)	Roof Angle (degrees)	Load Case	Zones										
			Horizontal Pressures				Vertical Pressures				Overhangs		
			A	B	C	D	E	F	G	H	E _{OH}	G _{OH}	
85	0 to 5°	1	11.5	-5.9	7.6	-3.5	-13.8	-7.8	-9.6	-6.1	-19.3	-15.1	
	10°	1	12.9	-5.4	8.6	-3.1	-13.8	-8.4	-9.6	-6.5	-19.3	-15.1	
	15°	1	14.4	-4.8	9.6	-2.7	-13.8	-9.0	-9.6	-6.9	-19.3	-15.1	
	20°	1	15.9	-4.2	10.6	-2.3	-13.8	-9.6	-9.6	-7.3	-19.3	-15.1	
	25°	1	14.4	2.3	10.4	2.4	-6.4	-8.7	-4.6	-7.0	-11.9	-10.1	
		2	—	—	—	—	-2.4	-4.7	-0.7	-3.0	—	—	
	30 to 45°	1	12.9	8.8	10.2	7.0	1.0	-7.8	0.3	-6.7	-4.5	-5.2	
		2	12.9	8.8	10.2	7.0	5.0	-3.9	4.3	-2.8	-4.5	-5.2	
90	0 to 5°	1	12.8	-6.7	8.5	-4.0	-15.4	-8.8	-10.7	-6.8	-21.6	-16.9	
	10°	1	14.5	-6.0	9.6	-3.5	-15.4	-9.4	-10.7	-7.2	-21.6	-16.9	
	15°	1	16.1	-5.4	10.7	-3.0	-15.4	-10.1	-10.7	-7.7	-21.6	-16.9	
	20°	1	17.8	-4.7	11.9	-2.6	-15.4	-10.7	-10.7	-8.1	-21.6	-16.9	
	25°	1	16.1	2.6	11.7	2.7	-7.2	-9.8	-5.2	-7.8	-13.3	-11.4	
		2	—	—	—	—	-2.7	-5.3	-0.7	-3.4	—	—	
	30 to 45°	1	14.4	9.9	11.5	7.9	1.1	-8.8	0.4	-7.5	-5.1	-5.8	
		2	14.4	9.9	11.5	7.9	5.6	-4.3	4.8	-3.1	-5.1	-5.8	
100	0 to 5°	1	15.9	-8.2	10.5	-4.9	-19.1	-10.8	-13.3	-8.4	-26.7	-20.9	
	10°	1	17.9	-7.4	11.9	-4.3	-19.1	-11.6	-13.3	-8.9	-26.7	-20.9	
	15°	1	19.9	-6.6	13.3	-3.8	-19.1	-12.4	-13.3	-9.5	-26.7	-20.9	
	20°	1	22.0	-5.8	14.6	-3.2	-19.1	-13.3	-13.3	-10.1	-26.7	-20.9	
	25°	1	19.9	3.2	14.4	3.3	-8.8	-12.0	-6.4	-9.7	-16.5	-14.0	
		2	—	—	—	—	-3.4	-6.6	-0.9	-4.2	—	—	
	30 to 45°	1	17.8	12.2	14.2	9.8	1.4	-10.8	0.5	-9.3	-6.3	-7.2	
		2	17.8	12.2	14.2	9.8	6.9	-5.3	5.9	-3.8	-6.3	-7.2	
105	0 to 5°	1	17.5	-9.0	11.6	-5.4	-13.8	-11.9	-14.7	-9.3	-29.4	-23.0	
	10°	1	19.7	-8.2	13.1	-4.7	-13.8	-12.8	-14.7	-9.8	-29.4	-23.0	
	15°	1	21.9	-7.3	14.7	-4.2	-13.8	-13.7	-14.7	-10.5	-29.4	-23.0	
	20°	1	24.3	-8.4	16.1	-3.5	-13.8	-14.7	-14.7	-11.1	-29.4	-23.0	
	25°	1	21.9	3.5	15.9	3.5	-6.4	-13.2	-7.1	-10.7	-18.2	-15.4	
		2	—	—	—	—	-2.4	-7.3	-1.0	-4.6	—	—	
	30 to 45°	1	19.6	13.5	15.7	10.8	1.0	-11.9	0.6	-10.3	-6.9	-7.9	
		2	19.6	13.5	15.7	10.8	5.0	-5.8	6.5	-4.2	-6.9	-7.9	
110	0 to 5°	1	19.2	-10.1	12.7	-5.9	-13.8	-13.1	-16.0	-10.1	-32.3	-25.3	
	10°	1	21.6	-9.0	14.4	-5.2	-13.8	-14.1	-16.0	-10.8	-32.3	-25.3	
	15°	1	24.1	-8.0	16.0	-4.6	-13.8	-15.1	-16.0	-11.5	-32.3	-25.3	
	20°	1	26.6	-7.0	17.7	-3.9	-13.8	-16.0	-16.0	-12.2	-32.3	-25.3	
	25°	1	24.1	3.9	17.4	4.0	-6.4	-14.6	-7.7	-11.7	-19.9	-17.0	
		2	—	—	—	—	-2.4	-7.9	-1.1	-5.1	—	—	
	30 to 45°	1	21.6	14.8	17.2	11.8	1.0	-13.1	0.6	-11.3	-7.6	-8.7	
		2	21.6	14.8	17.2	11.8	5.0	-6.5	7.2	-4.6	-7.6	-8.7	
120	0 to 5°	1	22.8	-11.9	15.1	-6.2	-13.8	-16.8	-19.1	-12.1	-38.4	-30.1	
	10°	1	25.8	-10.7	17.1	-5.4	-13.8	-17.9	-19.1	-12.9	-38.4	-30.1	
	15°	1	28.7	-9.5	19.1	-4.6	-13.8	-19.1	-19.1	-13.7	-38.4	-30.1	
	20°	1	31.6	-8.3	21.1	4.7	-13.8	-17.3	-19.1	-14.5	-38.4	-30.1	
	25°	1	28.6	4.6	20.7	2.4	-6.4	-9.4	-9.2	-13.9	-23.7	-20.2	
		2	—	—	—	—	-2.4	-15.6	-1.3	-6.0	—	—	
	30 to 45°	1	25.7	17.6	20.4	14.0	1.0	-7.7	0.7	-13.4	-9.0	-10.3	
		2	25.7	17.6	20.4	14.0	5.0	-3.9	8.6	-5.5	-9.0	-10.3	

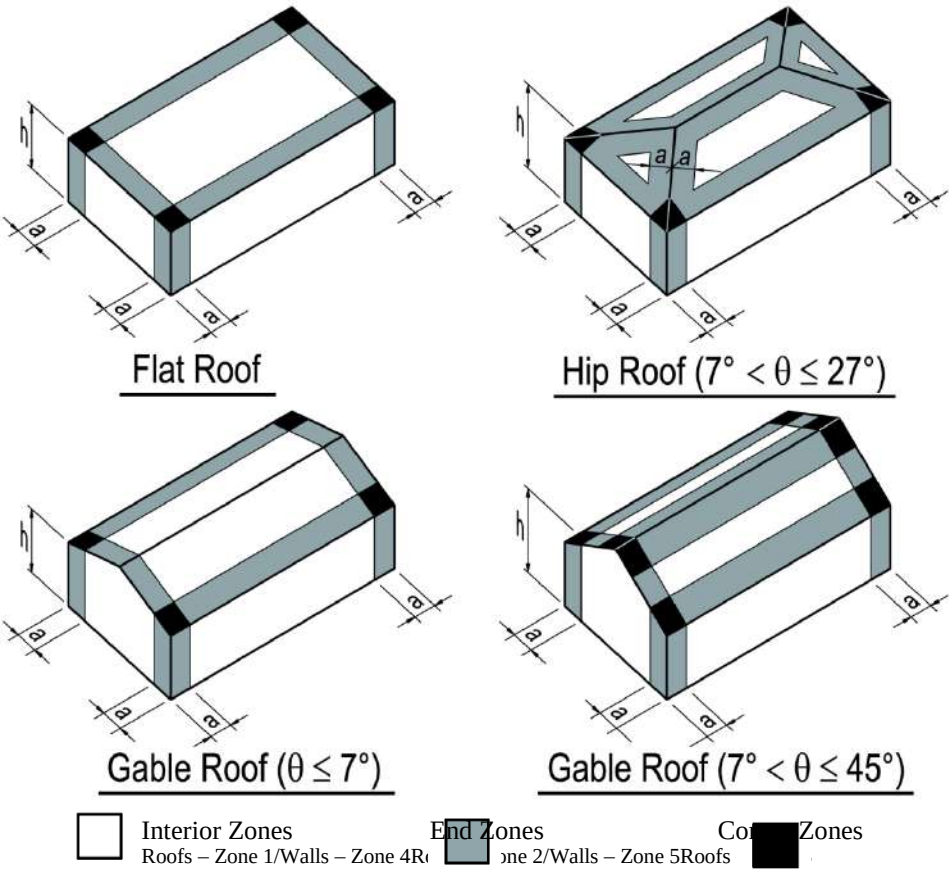
Unit Conversions — 1 ft = 0.3048 m ; 1 psf = 0.0479 kN/m²

Main Wind Force Resisting System - Method 1										h ≤ 60 ft			
Figure 3.3.1 (cont'd)			Design Wind Pressures							Walls & Roofs			
Enclosed Buildings													
Simplified Design Wind Pressure, p _{s30} (psf) (Exposure B at h = 30 ft, K _{z1} = 1.0, with I = 1.0)													
Basic Wind Speed (mph)	Roof Angle (degrees)	Load Case	Zones										
			Horizontal Pressures				Vertical Pressures				Overhangs		
			A	B	C	D	E	F	G	H	E _{OH}	G _{OH}	
125	0 to 5°	1	24.7	-12.9	16.4	-7.6	-29.7	-16.9	-20.7	-13.1	-41.7	-32.7	
	10°	1	28.0	-11.6	18.6	-6.7	-29.7	-18.2	-20.7	-14.0	-41.7	-32.7	
	15°	1	31.1	-10.3	20.7	-5.9	-29.7	-19.4	-20.7	-14.9	-41.7	-32.7	
	20°	1	34.3	-9.0	22.9	-5.0	-29.7	-20.7	-20.7	-15.7	-41.7	-32.7	
	25°	1	31.0	5.0	22.5	5.1	-13.8	-18.8	-10.0	-15.1	-25.7	-21.9	
	2	—	—	—	—	-5.2	-10.2	-1.4	-6.5	—	—		
130	30 to 45°	1	27.9	19.1	22.1	15.2	2.2	-16.9	0.8	-14.5	-9.8	-11.2	
	2	27.9	19.1	22.1	15.2	10.7	-8.4	9.3	-6.0	-9.8	-11.2		
	0 to 5°	1	26.8	-13.9	17.8	-8.2	-32.2	-18.3	-22.4	-14.2	-45.1	-35.3	
	10°	1	30.2	-12.5	20.1	-7.3	-32.2	-19.7	-22.4	-15.1	-45.1	-35.3	
	15°	1	33.7	-11.2	22.4	-6.4	-32.2	-21.0	-22.4	-16.1	-45.1	-35.3	
	20°	1	37.1	-9.8	24.7	-5.4	-32.2	-22.4	-22.4	-17.0	-45.1	-35.3	
140	25°	1	33.6	5.4	24.3	5.5	-14.9	-20.4	-10.8	-16.4	-27.8	-23.7	
	2	—	—	—	—	-5.7	-11.1	-1.5	-7.1	—	—		
	30 to 45°	1	30.1	20.6	24.0	16.5	2.3	-18.3	0.8	-15.7	-10.6	-12.1	
	2	30.1	20.6	24.0	16.5	11.6	-9.0	10.0	-6.4	-10.6	-12.1		
	0 to 5°	1	31.1	-16.1	20.6	-9.6	-37.3	-21.2	-26.0	-16.4	-52.3	-40.9	
	10°	1	35.1	-14.5	23.3	-8.5	-37.3	-22.8	-26.0	-17.5	-52.3	-40.9	
145	15°	1	39.0	-12.9	26.0	-7.4	-37.3	-24.4	-26.0	-18.6	-52.3	-40.9	
	20°	1	43.0	-11.4	28.7	-6.3	-37.3	-26.0	-26.0	-19.7	-52.3	-40.9	
	25°	1	39.0	6.3	28.2	6.4	-17.3	-23.6	-12.5	-19.0	-32.3	-27.5	
	2	—	—	—	—	-6.6	-12.8	-1.8	-8.2	—	—		
	30 to 45°	1	35.0	23.9	27.8	19.1	2.7	-21.2	0.9	-18.2	-12.3	-14.0	
	2	35.0	23.9	27.8	19.1	13.4	-10.5	11.7	-7.5	-12.3	-14.0		
150	0 to 5°	1	33.4	-17.3	22.1	-10.3	-40.0	-22.7	-27.9	-17.6	-56.1	-43.9	
	10°	1	37.7	-15.6	25.0	-9.1	-40.0	-24.5	-27.9	-18.8	-56.1	-43.9	
	15°	1	41.8	-13.8	27.9	-7.9	-40.0	-26.2	-27.9	-20.0	-56.1	-43.9	
	20°	1	46.1	-12.2	30.9	-6.8	-40.0	-27.9	-27.9	-21.1	-56.1	-43.9	
	25°	1	41.8	6.8	30.3	6.9	-18.6	-25.3	-13.4	-20.4	-34.6	-29.5	
	2	—	—	—	—	-7.1	-13.7	-1.9	-8.8	—	—		
155	30 to 45°	1	37.5	25.6	29.8	20.5	2.9	-22.7	1.0	-19.5	-13.2	-15.0	
	2	35.7	25.6	29.8	20.5	14.4	-11.3	12.6	-8.0	-13.2	-15.0		
	0 to 5°	1	35.7	-18.5	23.7	-11.0	-42.9	-24.4	-29.8	-18.9	-60.0	-47.0	
	10°	1	40.2	-16.7	26.8	-9.7	-42.9	-26.2	-29.8	-20.1	-60.0	-47.0	
	15°	1	44.8	-14.9	29.8	-8.5	-42.9	-28.0	-29.8	-21.4	-60.0	-47.0	
	20°	1	49.4	-13.0	32.9	-7.2	-42.9	-29.8	-29.8	-22.6	-60.0	-47.0	
160	25°	1	44.8	7.2	32.4	7.4	-19.9	-27.1	-14.4	-21.8	-37.0	-31.6	
	2	—	—	—	—	-7.5	-14.7	-2.1	-9.4	—	—		
	30 to 45°	1	40.1	27.4	31.9	22.0	3.1	-24.4	1.0	-20.9	-14.1	-16.1	
	2	40.1	27.4	31.9	22.0	15.4	-12.0	13.4	-8.6	-14.1	-16.1		
	0 to 5°	1	45.8	-23.8	30.4	-14.1	-55.1	-31.3	-38.3	-24.2	-77.1	-60.4	
	10°	1	51.7	-21.4	34.4	-12.5	-55.1	-33.6	-38.3	-25.8	-77.1	-60.4	
170	15°	1	57.6	-19.1	38.3	-10.9	-55.1	-36.0	-38.3	-27.5	-77.1	-60.4	
	20°	1	63.4	-16.7	42.3	-9.3	-55.1	-38.3	-38.3	-29.1	-77.1	-60.4	
	25°	1	57.5	9.3	41.6	9.5	-25.6	-34.8	-18.5	-28.0	-47.6	-40.5	
	2	—	—	—	—	-9.7	-18.9	-2.6	-12.1	—	—		
	30 to 45°	1	51.5	35.2	41.0	28.2	4.0	-31.3	1.3	-26.9	-18.1	-20.7	
	2	51.5	35.2	41.0	28.2	19.8	-15.4	17.2	-11.0	-18.1	-20.7		

-31.3

Main Wind Force Resisting Syatem - Method 1		h ≤ 60 ft	
Figure 3.3.1 (cont'd)	Design Wind Pressures		Walls & Roofs
Enclosed Buildings			
Adjustment Factor			
for Building Height and Exposure, λ			
Mean Roof Height (ft)	Exposure		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

Components and Cladding - Method 1		$h \leq 60 \text{ ft}$
Figure 3.3.2	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		



- Notes:**
- Pressures shown are applied normal to the surface, for exposure B, at $h=30 \text{ ft}$ (9.1 m), $I = 1.0$, and $K_{zt} = 1.0$. Adjust to other condition using Equation 6 – 2.
 - Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
 - For hip roofs with $\theta \leq 25^\circ$, Zone 3 shall be treated as Zone 2.
 - For effective wind areas between those given, value may be interpolated, otherwise use the value associated with the lower effective wind area.
 - Notation:
 $a = 10 \text{ percent of least horizontal dimension or } 0.4h$, whichever is smaller, but not less than either 4 % of least horizontal dimension or 3 ft (0.9 m)
 $h = \text{mean roof height, in feet (meters), except that eave height shall be used for roof angles } < 10^\circ$.
 $\theta = \text{angle of plane of roof from horizontal, in degrees.}$

Components and Cladding Method 1										h ≤ 60 ft				
Figure 3.3.2 (cont'd)	Net Design Wind Pressures									Walls & Roofs				
Enclosed Buuildings														
Net Design Wind Pressure, p_{net30} (psf) (<i>Exposure B at h = 30 ft, with I = 1.0, and $K_n= 1.0$</i>)														
	Zone	Effective wind area (sf)	Basic Wind Speed											
			85		90		100		105		110		120	
Roof 0 to 7 degrees	1	10	5.3	-13.0	5.9	-14.6	7.3	-18.0	8.1	-19.8	8.9	-21.8	10.5	-25.9
	1	20	5.0	-12.7	5.6	-14.2	6.9	-17.5	7.6	-19.3	8.3	-21.2	9.9	-25.2
	1	50	4.5	-12.2	5.1	-13.7	6.3	-16.9	6.9	-18.7	7.6	-20.5	9.0	-24.4
	1	100	4.2	-11.9	4.7	-13.3	5.8	-16.5	6.4	-18.2	7.0	-19.9	8.3	-23.7
	2	10	5.3	-21.8	5.9	-24.4	7.3	-30.2	8.1	-33.3	8.9	-36.5	10.5	-13.5
	2	20	5.0	-39.5	5.6	-21.8	6.9	-27.0	7.6	-29.7	8.3	-32.6	9.9	-38.8
	2	50	4.5	-16.4	5.1	-18.4	6.3	-22.7	6.9	-25.1	7.6	-27.5	9.0	-32.7
	2	100	4.2	-14.1	4.7	-15.8	5.8	-19.5	6.4	-21.5	7.0	-23.6	8.3	-28.1
	3	10	5.3	-32.8	5.9	-36.8	7.3	-45.4	8.1	-50.1	8.9	-55.0	10.5	-65.4
	3	20	5.0	-27.2	5.6	-30.5	6.9	-37.6	7.6	-41.5	8.3	-45.5	9.9	-54.2
	3	50	4.5	-19.7	5.1	-22.0	6.3	-27.3	6.9	-30.1	7.6	-33.1	9.0	-39.3
	3	100	4.2	-14.1	4.7	-15.8	5.8	-19.5	6.4	-21.5	7.0	-23.6	8.3	-28.1
Roof > 7 to 27 degrees	1	10	7.5	-11.9	8.4	-13.3	10.4	-16.5	11.4	-18.2	12.5	-19.9	14.9	-23.7
	1	20	6.8	-11.6	7.7	-13.0	9.4	-16.0	10.4	-17.6	11.4	-19.4	13.6	-23.0
	1	50	6.0	-11.1	6.7	-12.5	8.2	-15.4	9.1	-17.0	10.0	-18.6	11.9	-22.2
	1	100	5.3	-10.8	5.9	-12.1	7.3	-14.9	8.1	-16.5	8.9	-18.1	10.5	-21.5
	2	10	7.5	-20.7	8.4	-23.2	10.4	-28.7	11.4	-31.6	12.5	-34.7	14.9	-41.3
	2	20	6.8	-19.0	7.7	-21.4	9.4	-26.4	10.4	-29.1	11.4	-31.9	13.6	-38.0
	2	50	6.0	-16.9	6.7	-18.9	8.2	-23.3	9.1	-25.7	10.0	-28.2	11.9	-33.6
	2	100	5.3	-15.2	5.9	-17.0	7.3	-21.0	8.1	-23.2	8.9	-25.5	10.5	-30.3
	3	10	7.5	-30.6	8.4	-34.3	10.4	-42.4	11.4	-46.7	12.5	-51.3	14.9	-61.0
	3	20	6.8	-28.6	7.7	-32.1	9.4	-39.6	10.4	-43.7	11.4	-47.9	13.6	-57.1
	3	50	6.0	-26.0	6.7	-29.1	8.2	-36.0	9.1	-39.7	10.0	-43.5	11.9	-51.8
	3	100	5.3	-24.0	5.9	-26.9	7.3	-33.2	8.1	-36.6	8.9	-40.2	10.5	-47.9
Roof > 27 to 45 degrees	1	10	11.9	-13.0	13.3	-14.6	16.5	-18.0	18.2	-19.8	19.9	-21.8	23.7	-25.9
	1	20	11.6	-12.3	13.0	-13.8	16.0	-17.1	17.6	-18.8	19.4	-20.7	23.0	-24.6
	1	50	11.1	-11.5	12.5	-12.8	15.4	-15.9	17.0	-17.5	18.6	-19.2	22.2	-22.8
	1	100	10.8	-10.8	12.1	-12.1	14.9	-14.9	16.5	-16.5	18.1	-18.1	21.5	-21.5
	2	10	11.9	-15.2	13.3	-17.0	16.5	-21.0	18.2	-23.2	19.9	-25.5	23.7	-30.3
	2	20	11.6	-14.5	13.0	-16.3	16.0	-20.1	17.6	-22.2	19.4	-24.3	23.0	-29.0
	2	50	11.1	-13.7	12.5	-15.3	15.4	-18.9	17.0	-20.8	18.6	-22.9	22.2	-27.2
	2	100	10.8	-13.0	12.1	-14.6	14.9	-18.0	16.5	-19.8	18.1	-21.8	21.5	-25.9
	3	10	11.9	-15.2	13.3	-17.0	16.5	-21.0	18.2	-23.2	19.9	-25.5	23.7	-30.3
	3	20	11.6	-14.5	13.0	-16.3	16.0	-20.1	17.6	-22.2	19.4	-24.3	23.0	-29.0
	3	50	11.1	-13.7	12.5	-15.3	15.4	-18.9	17.0	-20.8	18.6	-22.9	22.2	-27.0
	3	100	10.8	-13.0	12.1	-14.6	14.9	-18.0	16.5	-19.8	18.1	-21.8	21.5	-25.9
Wall	4	10	13.0	-14.1	14.6	-15.8	18.0	-19.5	19.8	-21.5	21.8	-23.6	25.9	-28.1
	4	20	12.4	-13.5	13.9	-15.1	17.2	-18.7	18.9	-20.6	20.8	-22.6	24.7	-26.9
	4	50	11.6	-12.7	13.0	-14.3	16.1	-17.6	17.8	-19.4	19.5	-21.3	23.2	-25.4
	4	100	11.1	-12.2	12.4	-13.6	15.3	-16.8	16.9	-18.5	18.5	-20.4	22.0	-24.2
	4	500	9.7	-108.0	10.9	-12.1	13.4	-14.9	14.8	-16.5	16.2	-18.1	19.3	-21.5
	5	10	13.0	-174.0	14.6	-19.5	18.0	-24.1	19.8	-26.6	21.8	-29.1	25.9	-34.7
	5	20	12.4	-16.2	13.9	-18.2	17.2	-22.5	18.9	-24.8	20.8	-27.2	24.7	-32.4
	5	50	11.6	-14.7	13.0	-16.5	16.1	-20.3	17.8	-22.4	19.5	-24.6	23.2	-29.3
	5	100	11.1	-13.5	12.4	-15.1	15.3	-18.7	16.9	-20.6	18.5	-22.6	22.0	-26.9
	5	500	9.7	-10.8	10.9	-12.1	13.4	-14.9	14.8	-16.5	16.2	-18.1	19.3	-21.5

Unit Conversion — 1.0 ft = 0.3048 m ; 1.0 psf = 0.479 kN/m²

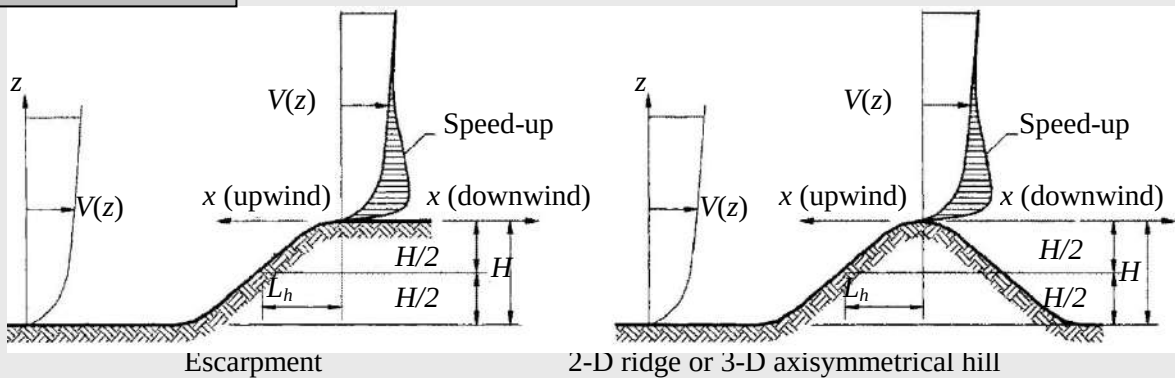
Components and Cladding - Method 1							h ≤ 60 ft							
Figure 3.3.2 (cont'd)	Net Design Wind Pressures						Walls & Roofs							
Enclosed Buuildings														
Net Design Wind Pressure, p_{net30} (psf) (<i>Exposure B at h = 30 ft. with I = 1.0 and Kzt= 1.0</i>)														
	Zone	Effective wind area (sf)	Basic Wind Speed V (mph)											
			125		130		140		145		150		170	
Roof 0 to 7 degrees	1	10	11.4	-28.1	12.4	-30.4	14.3	-35.3	15.4	-37.8	16.5	-40.5	21.1	-52.0
	1	20	10.7	-27.4	11.6	-29.6	13.4	-34.4	14.4	-36.9	15.4	-39.4	19.8	-50.7
	1	50	9.8	-26.4	10.6	-28.6	12.3	-33.2	13.1	-35.6	14.1	-38.1	18.1	-48.9
	1	100	9.1	-25.7	9.8	-27.8	11.4	-32.3	12.2	-34.6	13.0	-37.0	16.7	-47.6
	2	10	11.4	-47.2	12.4	-51.0	14.3	-59.2	15.4	-63.5	16.5	-67.9	21.1	-87.2
	2	20	10.7	-42.1	11.6	-45.6	13.4	-52.9	14.4	-56.7	15.4	-60.7	19.8	-78.0
	2	50	9.8	-35.5	10.6	-38.4	12.3	-44.5	13.1	-47.8	14.1	-51.1	18.1	-65.7
	2	100	9.1	-30.5	9.8	-33.0	11.4	-38.2	12.2	-41.0	13.0	-43.9	16.7	-56.4
	3	10	11.4	-71.0	12.4	-76.8	14.3	-89.0	15.4	-95.5	16.5	-102.2	21.1	-131.3
	3	20	10.7	-58.5	11.6	-63.6	13.4	-73.8	14.4	-79.1	15.4	-84.7	19.8	-108.7
	3	50	9.8	-42.7	10.6	-46.2	12.3	-53.5	13.1	-57.4	14.1	-61.5	18.1	-78.9
	3	100	9.1	-30.5	9.8	-33.0	11.4	-38.2	12.2	-41.0	13.0	-43.9	16.7	-56.4
Roof > 7 to 27 degrees	1	10	16.2	-25.7	17.5	-27.8	20.3	-32.3	21.8	-34.6	23.3	-37.0	30.0	-47.6
	1	20	14.8	-25.0	16.0	-27.0	18.5	-31.4	19.9	-33.7	21.3	-36.0	27.3	-46.3
	1	50	12.9	-24.1	13.9	-26.0	16.1	-30.2	17.3	-32.4	18.5	-34.6	23.8	-44.5
	1	100	11.4	-23.2	12.4	-25.2	14.3	-29.3	15.4	-31.4	16.5	-33.6	21.1	-43.2
	2	10	16.2	-44.8	17.5	-48.4	20.3	-56.2	21.8	-60.3	23.3	-64.5	30.0	-82.8
	2	20	14.8	-41.2	16.0	-44.6	18.5	-51.7	19.9	-55.4	21.3	-59.3	27.3	-76.2
	2	50	12.9	-36.5	13.9	-39.4	16.1	-45.7	17.3	-49.1	18.5	-52.5	23.8	-67.4
	2	100	11.4	-32.9	12.4	-35.6	14.3	-41.2	15.4	-44.2	16.5	-47.3	21.1	-60.8
	3	10	16.2	-66.2	17.5	-71.6	20.3	-83.1	21.8	-89.1	23.3	-95.4	30.0	-122.5
	3	20	14.8	-61.9	16.0	-67.0	18.5	-77.7	19.9	-83.3	21.3	-89.2	27.3	-114.5
	3	50	12.9	-56.2	13.9	-60.8	16.1	-70.5	17.3	-75.7	18.5	-81.0	23.8	-104.0
	3	100	11.4	-51.9	12.4	-56.2	14.3	-65.1	15.4	-69.9	16.5	-74.8	21.1	-96.0
Roof > 27 to 45 degrees	1	10	25.7	-28.1	27.8	-30.4	32.3	-35.3	34.6	-37.8	37.0	-40.5	47.6	-52.0
	1	20	25.0	-26.7	27.0	-28.9	31.4	-33.5	33.7	-35.9	36.0	-38.4	46.3	-49.3
	1	50	24.1	-24.8	26.0	-26.8	30.2	-31.1	32.4	-33.3	34.6	-35.7	44.5	-45.8
	1	100	23.3	-23.3	25.2	-25.2	29.3	-29.3	31.4	-31.4	33.6	-33.6	43.2	-43.2
	2	10	25.7	-32.9	27.8	-35.6	32.3	-41.2	34.6	-44.2	37.0	-47.3	47.6	-60.8
	2	20	25.0	-31.4	27.0	-34.0	31.4	-39.4	33.7	-42.3	36.0	-45.3	46.3	-58.1
	2	50	24.1	-29.5	26.0	-32.0	30.2	-37.1	32.4	-39.8	34.6	-42.5	44.5	-54.6
	2	100	23.2	-28.1	25.2	-30.4	29.3	-35.3	31.4	-37.8	33.6	-40.5	43.2	-52.0
	3	10	25.7	-32.9	27.8	-35.6	32.3	-41.2	34.6	-44.2	37.0	-47.3	47.6	-60.8
	3	20	25.0	-31.4	27.0	-34.0	31.4	-39.4	33.7	-42.3	36.0	-45.3	46.3	-58.1
	3	50	24.1	-29.5	26.0	-32.0	30.2	-37.1	32.4	-39.8	34.6	-42.5	44.5	-54.6
	3	100	23.3	-28.1	25.2	-30.4	29.3	-35.3	31.4	-37.8	33.6	-40.5	43.2	-52.0
Wall	4	10	28.1	-30.5	30.4	-33.0	35.3	-38.2	37.8	-41.0	40.5	-43.9	52.0	-56.4
	4	20	26.8	-29.2	29.0	-31.6	33.7	-36.7	36.1	-39.3	38.7	-42.1	49.6	-54.1
	4	50	25.2	-27.5	27.2	-29.8	31.6	-34.6	33.9	-37.1	36.2	-39.7	46.6	-51.0
	4	100	23.9	-26.3	25.9	-28.4	30.0	-33.0	32.2	-35.4	34.4	-37.8	44.2	-48.6
	4	500	21.0	-23.3	22.7	-25.2	26.3	-29.3	28.2	-31.4	30.2	-33.6	38.8	-43.2
	5	10	28.1	-37.6	30.4	-40.7	35.3	-47.2	37.8	-50.6	40.5	-54.2	52.0	-69.6
	5	20	26.8	-35.1	29.0	-38.0	33.7	-44.0	36.1	-47.2	38.7	-50.5	49.6	-64.9
	5	50	25.2	-31.8	27.2	-34.3	31.6	-39.8	33.9	-42.7	36.2	-45.7	46.6	-58.7
	5	100	23.9	-29.2	25.9	-31.6	30.0	-36.7	32.2	-39.3	34.4	-42.1	44.2	-54.1
	5	500	21.0	-23.2	22.7	-25.2	26.3	-29.3	28.2	-31.1	30.2	-33.6	38.8	-43.2
Unit Conversion — 1.0 ft = 0.3048 m ; 1.0 psf = 0.479 kN/m ²														

Unit Conversion — 1.0 ft = 0.3048 m ; 1.0 psf = 0.479 kN/m²

Components and Cladding - Method 1						h ≤ 60 ft.																																																											
Figure 3.3.2 (contd.)		Net Design Wind Pressures				Walls & Roofs																																																											
Enclosed Buildings																																																																	
Roof Overhang Net Design wind Pressure, p_{net30} (psf) (Exposure B at h = 30 ft, with I = 1.0)																																																																	
	Zone	Effective Wind Area (sf)	Basic Wind Speed V(mph)																																																														
			90	100	110	120	130	140	150	170																																																							
Roo 0 to 7 degrees	2	10	-21.0	-25.9	-31.4	-37.3	-43.8	-50.8	-58.3	-74.9																																																							
	2	20	-20.6	-25.5	-30.8	-36.7	-43.0	-49.9	-57.3	-73.6																																																							
	2	50	-20.1	-24.9	-30.1	-35.8	-42.0	-48.7	-55.9	-71.8																																																							
	2	100	-19.8	-24.4	-29.5	-35.1	-41.2	-47.8	-54.9	-70.5																																																							
	3	10	-34.6	-42.7	-51.6	-61.5	-72.1	-83.7	-96.0	-123.4																																																							
	3	20	-27.1	-33.5	-40.5	-48.3	-56.6	-65.7	-75.4	-96.8																																																							
	3	50	-17.3	-21.4	-25.9	-30.8	-36.1	-41.9	-48.1	-61.8																																																							
	3	100	-10.0	-12.2	-14.8	-17.6	-20.6	-23.9	-27.4	-35.2																																																							
Roo 0 > 7 to 27 degrees	2	10	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9																																																							
	2	20	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9																																																							
	2	50	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9																																																							
	2	100	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9																																																							
	3	10	-45.7	-56.4	-68.3	-81.2	-95.3	-110.6	-126.9	-163.0																																																							
	3	20	-41.2	-50.9	-61.1	-73.3	-86.0	-99.8	-114.5	-147.1																																																							
	3	50	-35.3	-43.6	-52.8	-62.8	-73.7	-85.5	-98.1	-126.1																																																							
	3	100	-30.9	-38.1	-46.1	-54.9	-64.4	-74.7	-85.8	-110.1																																																							
Roo 0 > 27 to 45 degrees	2	10	-24.7	-30.5	-36.9	-43.9	-51.5	-59.8	-68.6	-88.1																																																							
	2	20	-24.0	-29.6	-35.8	-42.6	-50.0	-58.0	-66.5	-85.5																																																							
	2	50	-23.0	-28.4	-34.4	-40.8	-47.9	-55.6	-63.8	-82.0																																																							
	2	100	-22.2	-27.4	-33.2	-39.5	-46.4	-53.8	-61.7	-79.3																																																							
	3	10	-24.7	-30.5	-36.9	-43.9	-51.5	-59.8	-68.6	-88.1																																																							
	3	20	-24.0	-29.6	-35.8	-42.6	-50.0	-58.0	-66.5	-85.5																																																							
	3	50	-23.0	-28.4	-34.4	-40.8	-47.9	-55.6	-63.8	-82.0																																																							
	3	100	-22.2	-27.4	-33.2	-39.5	-46.4	-53.8	-61.7	-79.3																																																							
<table><tr><th colspan="4">Adjustment Factor</th></tr><tr><th colspan="4">for Building Height and Exposure, λ</th></tr><tr><th rowspan="2">Mean Roof Height (ft)</th><th colspan="3">Exposure</th></tr><tr><th>B</th><th>C</th><th>D</th></tr><tr><td>15</td><td>1.00</td><td>1.21</td><td>1.47</td></tr><tr><td>20</td><td>1.00</td><td>1.29</td><td>1.55</td></tr><tr><td>25</td><td>1.00</td><td>1.35</td><td>1.61</td></tr><tr><td>30</td><td>1.00</td><td>1.40</td><td>1.66</td></tr><tr><td>35</td><td>1.05</td><td>1.45</td><td>1.70</td></tr><tr><td>40</td><td>1.09</td><td>1.49</td><td>1.74</td></tr><tr><td>45</td><td>1.12</td><td>1.53</td><td>1.78</td></tr><tr><td>50</td><td>1.16</td><td>1.56</td><td>1.81</td></tr><tr><td>55</td><td>1.19</td><td>1.59</td><td>1.84</td></tr><tr><td>60</td><td>1.22</td><td>1.62</td><td>1.87</td></tr></table>											Adjustment Factor				for Building Height and Exposure, λ				Mean Roof Height (ft)	Exposure			B	C	D	15	1.00	1.21	1.47	20	1.00	1.29	1.55	25	1.00	1.35	1.61	30	1.00	1.40	1.66	35	1.05	1.45	1.70	40	1.09	1.49	1.74	45	1.12	1.53	1.78	50	1.16	1.56	1.81	55	1.19	1.59	1.84	60	1.22	1.62	1.87
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15	1.00	1.21	1.47																																																														
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Unit Conversion — 1.0 ft = 0.3048 m ; 1.0 psf = 0.479 kN/m ²																																																																	

Topographic Factor, K_{zt} - Method 2

Figure 3.3.3



Topographic multipliers for Exposure C

H/L_h	K_1 multiplier			x/L_h	K_2 multiplier		z/L_h	K_3 multiplier		
	2-D ridge	2-D escarp.	3-D axisym. hill		2-D escarp.	All other cases		2-D ridge	2-D escarp.	3-D axisym. hill
0.20	0.29	0.17	0.21	0.00	1.00	1.00	0.00	1.00	1.00	1.00
0.25	0.36	0.21	0.26	0.50	0.88	0.67	0.10	0.74	0.78	0.67
0.30	0.43	0.26	0.32	1.00	0.75	0.33	0.20	0.55	0.61	0.45
0.35	0.51	0.30	0.37	1.50	0.63	0.00	0.30	0.41	0.47	0.30
0.40	0.58	0.34	0.42	2.00	0.50	0.00	0.40	0.30	0.37	0.20
0.45	0.65	0.38	0.47	2.50	0.38	0.00	0.50	0.22	0.29	0.14
0.50	0.72	0.43	0.53	3.00	0.25	0.00	0.60	0.17	0.22	0.09
				3.50	0.13	0.00	0.70	0.12	0.17	0.06
				4.00	0.00	0.00	0.80	0.09	0.14	0.04
							0.90	0.07	0.11	0.03
							1.00	0.05	0.08	0.02
							1.50	0.01	0.02	0.00
							2.00	0.00	0.00	0.00

Notes:

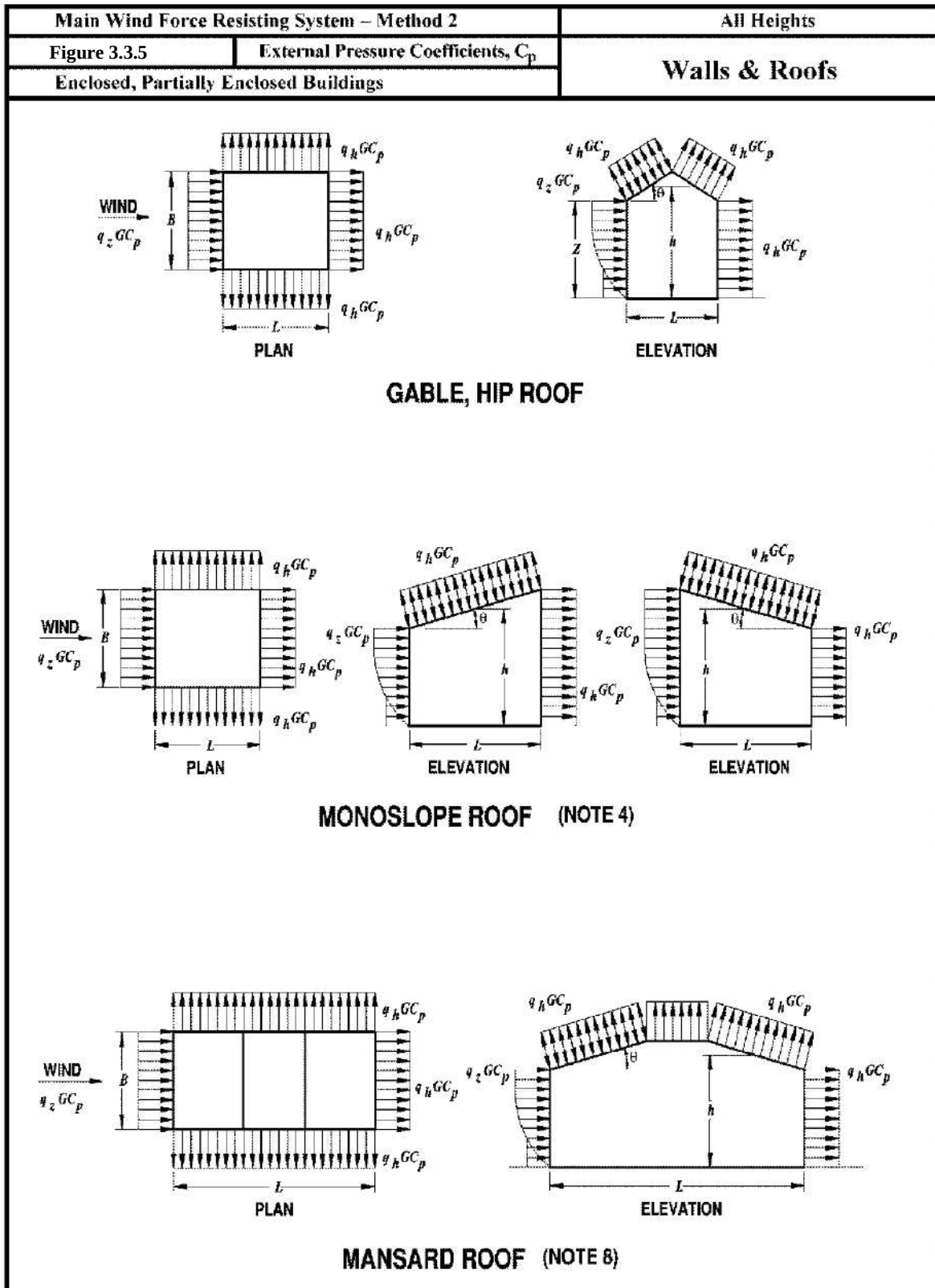
- For values of H/L_h , x/L_h and z/L_h other than those shown, linear interpolation is permitted.
- For $H/L_h > 0.5$, assume $H/L_h = 0.5$ for evaluating K_1 and substitute $2H$ for L_h for evaluating K_2 and K_3 .
- Multipliers are based on the assumption that wind approaches the hill or escarpment along the direction of maximum slope.
- Notation:
 H : Height of hill or escarpment relative to the upwind terrain, in feet (meters).
 L_h : Distance upwind of crest to where the difference in ground elevation is half the height of hill or escarpment, in feet (meters).
 K_1 : Factor to account for shape of topographic feature and maximum speed-up effect.
 K_2 : Factor to account for reduction in speed-up with distance upwind or downwind of crest.
 K_3 : Factor to account for reduction in speed-up with height above local terrain.
 x : Distance (upwind or downwind) from the crest to the building site, in feet (meters).
 z : Height above local ground level, in feet (meters).
 μ : Horizontal attenuation factor.

Topographic Factor , K_{zt} - Method 2**Figure 3.3.3 (contd.)**

$$K_{zt} = (1 + K_1 K_2 K_3)^2, K_1 \text{ determined from table below, } K_2 = \left(1 - \frac{|x|}{\mu L_h}\right), K_3 = e^{-\gamma z/L_h}$$

Parameters for speed-up over hills and escarpments						
Hill shape	$K_1/(H/L_h)$			γ	μ	
	Exposure				Upwind of crest	Downwind of crest
	B	C	D			
2-dimensional ridges (or valleys with negative H in $K_1/(H/L_h)$)	1.30	1.45	1.55	3	1.5	1.5
2-dimensional escarpments	0.75	0.85	0.95	2.5	1.5	4
3-dimensional axisym. hill	0.95	1.05	1.15	4	1.5	1.5

Main Wind Force Res. Sys. / Comp and Clad. - Method 2		All heights
Figure 3.3.4	Internal Pressure Coefficient, $G C_{pi}$	Walls & Roofs
Enclosed, Partially Enclosed and Open Buildings		



Main Wind Force Resisting System – Method 2										All Heights		
IFigure 3.3.5 (con't)		External Pressure Coefficients, C_p								Walls & Roofs		
Enclosed, Partially Enclosed Buildings												
Wall Pressure Coefficients, C_p												
Surface		L/B		C_p		Use With						
Windward Wall		All values		0.8		q_z						
Leeward Wall		0-1		-0.5		q_h						
		2		-0.3								
		≥ 4		-0.2								
Side Wall		All values		-0.7		q_h						

Roof Pressure Coefficients, C_{ps} , for use with q_h												
Wind Direction	Windward									Leeward		
	Angle, θ (degrees)									Angle, θ (degrees)		
	h/L	10	15	20	25	30	35	45	$\geq 60^\circ$	10	15	≥ 20
Normal to ridge for $\theta \geq 10^\circ$	≤ 0.25	-0.7 -0.18	-0.5 0.0*	-0.3 0.2	-0.2 0.3	-0.2 0.3	0.0* 0.4	0.4	0.01 θ	-0.3 -0.5	-0.5 -0.6	
	0.5	-0.9 -0.18	-0.7 -0.18	-0.4 0.0*	-0.3 0.2	-0.2 0.2	-0.2 0.3	0.0* 0.4	0.01 θ	-0.5 -0.5	-0.6 -0.6	
	≥ 1.0	-1.3** -0.18	-1.0 -0.18	-0.7 -0.18	-0.5 0.0*	-0.3 0.2	-0.2 0.2	0.0* 0.3	0.01 θ	-0.7 -0.6	-0.6 -0.6	
Normal to ridge for $\theta < 10^\circ$ and Parallel to ridge for all θ	≤ 0.5	Horiz distance from windward edge				C_p		*Value is provided for interpolation purposes. **Value can be reduced linearly with area over which it is applicable as follows				
		0 to $h/2$				-0.9, -0.18						
		$h/2$ to h				-0.9, -0.18						
		h to $2h$				-0.5, -0.18						
	≥ 1.0	$> 2h$				-0.3, -0.18						
		0 to $h/2$				-1.3**, -0.18		Area (sq ft)		Reduction Factor		
		$> h/2$						200 (23.2 sq m)		0.9		
								≥ 1000 (92.9 sq m)		0.8		

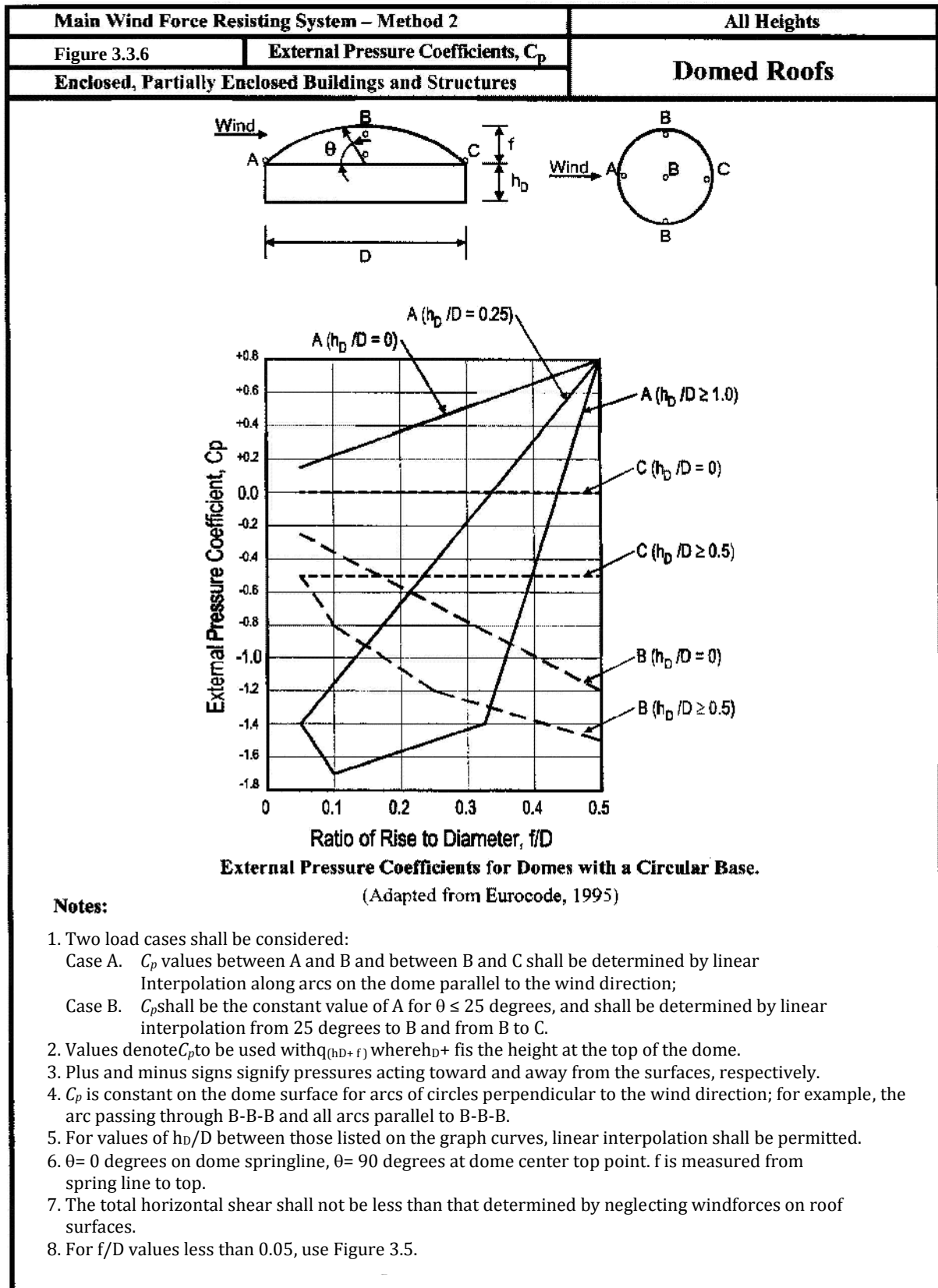
Notes:

1. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
2. Linear interpolation is permitted for values of L/B , h/L and θ other than shown. Interpolation shall only be carried out between values of the same sign. Where no value of the same sign is given, assume 0.0 for interpolation purposes.
3. Where two values of C_p are listed, this indicates that the windward roof slope is subjected to either positive or negative pressures and the roof structure shall be designed for both conditions. Interpolation for intermediate ratios of h/L in this case shall only be carried out between C_p values of like sign.
4. For monoslope roofs, entire roof surface is either a windward or leeward surface.
5. For flexible buildings use appropriate G_f as determined by ASCE Section 6.5.8.
6. Refer to ASCE Figure 6-7 for domes and ASCE Figure 6-8 for arched roofs.
7. Notation:

B : Horizontal dimension of building, in feet (meter), measured normal to wind direction.
 L : Horizontal dimension of building, in feet (meter), measured parallel to wind direction.
 H : Mean roof height in feet (meters); except that eave height shall be used for $\theta \leq 10$ degrees.
 z : Height above ground, in feet (meters).
 G : Gust effect factor.
 q_z, q_h : Velocity pressure, in pounds per square foot (N/m^2), evaluated at respective height.
 θ : Angle of plane of roof from horizontal, in degrees.

8. For mansard roofs, the top horizontal surface and leeward inclined surface shall be treated as leeward surfaces from the table.
9. Except for MWFRS's at the roof consisting of moment resisting frames, the total horizontal shear shall not be less than that determined by neglecting wind forces on roof surfaces.

For roof slopes greater than 80° , use $C_p = 0.8$



Main Wind Force Res. Sys. / Comp and Clad. – Method 2		All Heights		
Figure 3.3.7	External Pressure Coefficients, C_p	Arched Roofs		
Figure 3.3.7	Partially Enclosed Buildings and Structures			

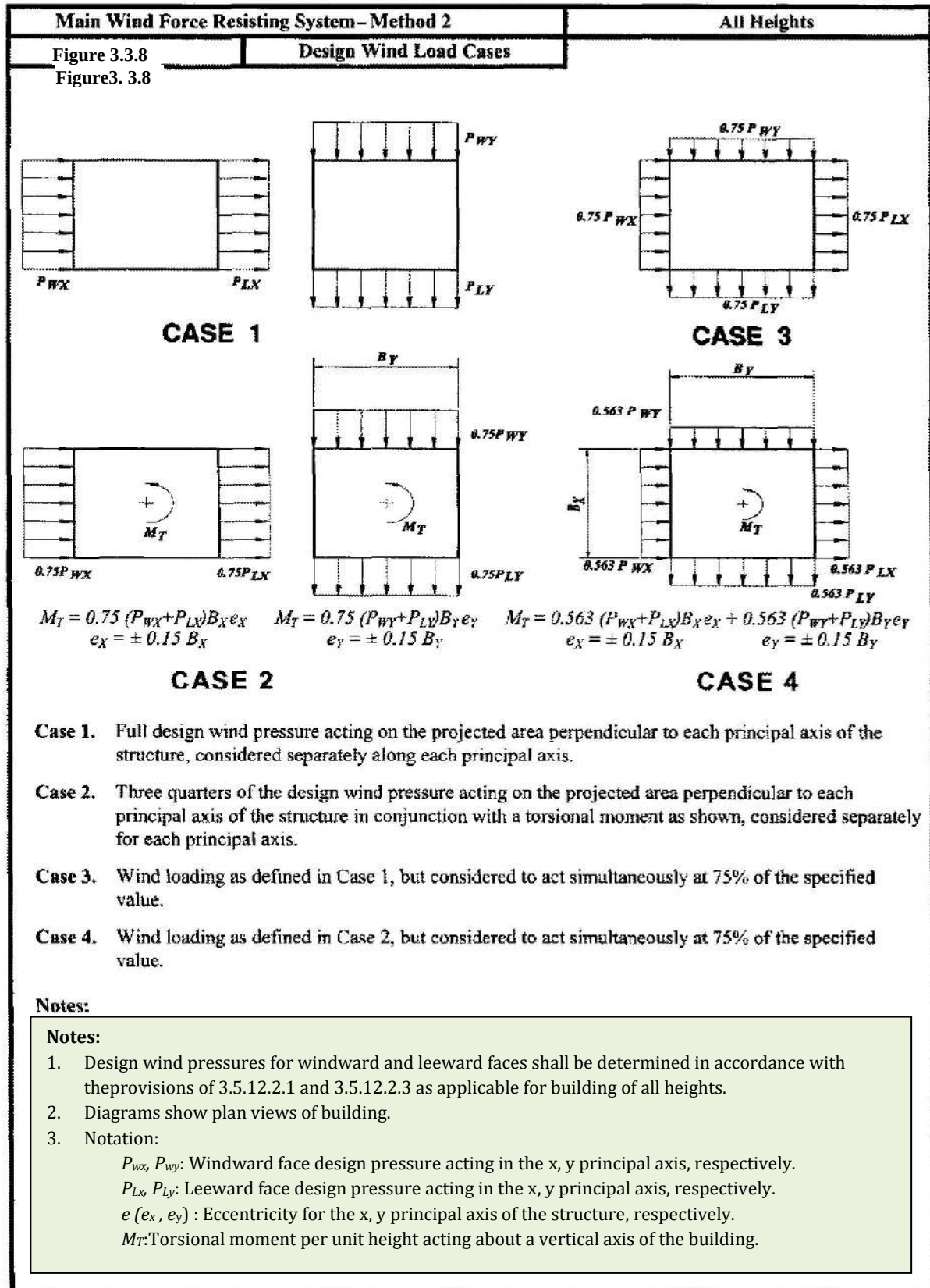
Conditions	Rise-to-span ratio, r	C_p		
		Windward quarter	Center half	Leeward quarter
Roof on elevated structure	$0 < r < 0.2$	-0.9	$-0.7 - r$	-0.5
	$0.2 \leq r < 0.3^*$	$1.5r - 0.3$	$-0.7 - r$	-0.5
	$0.3 \leq r \leq 0.6$	$2.75r - 0.7$	$-0.7 - r$	-0.5
Roof springing from ground level	$0 < r \leq 0.6$	$1.4r$	$-0.7 - r$	-0.5

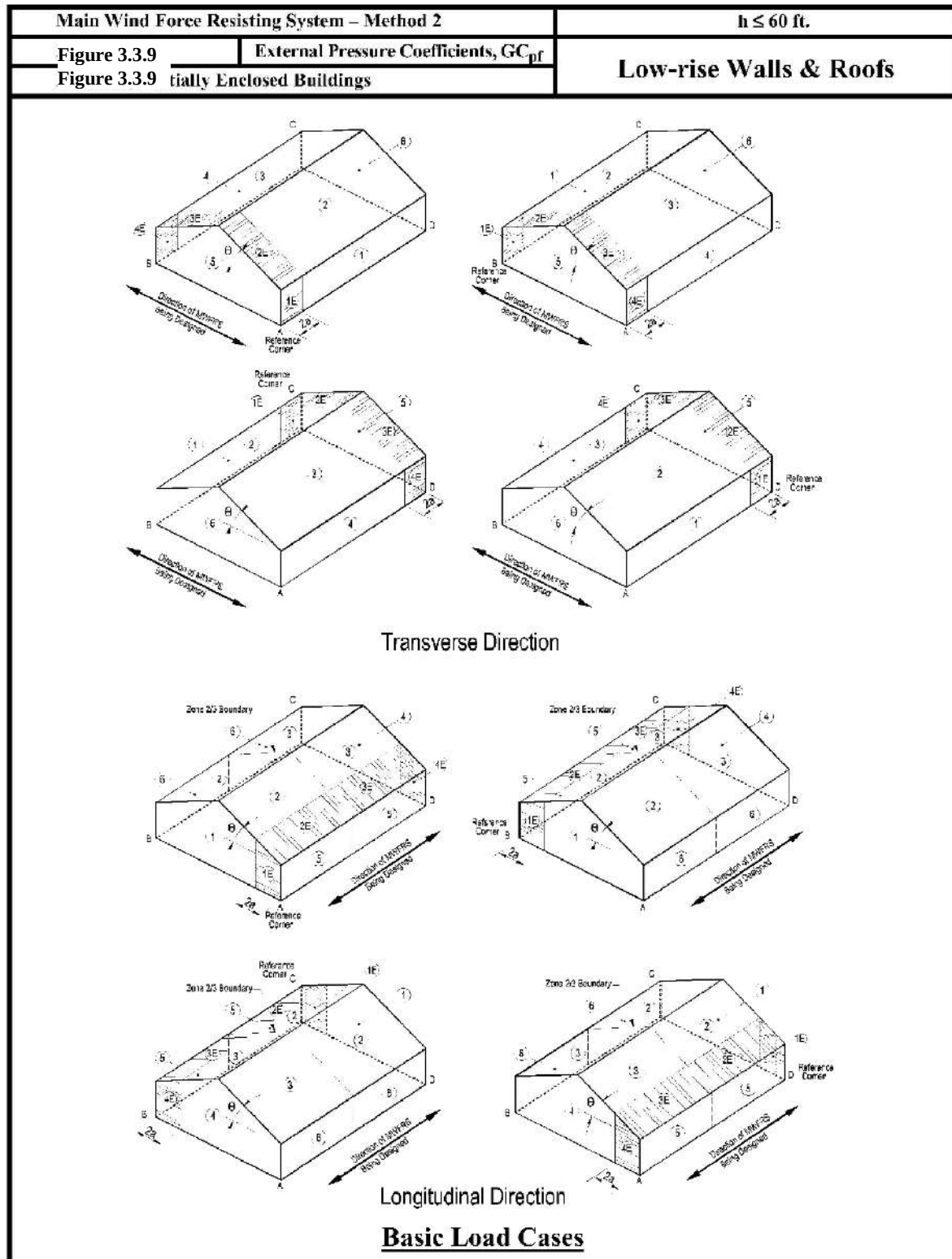
*When the rise-to-span ratio is $0.2 \leq r \leq 0.3$, alternate coefficients given by $6r - 2.1$ shall also be used for

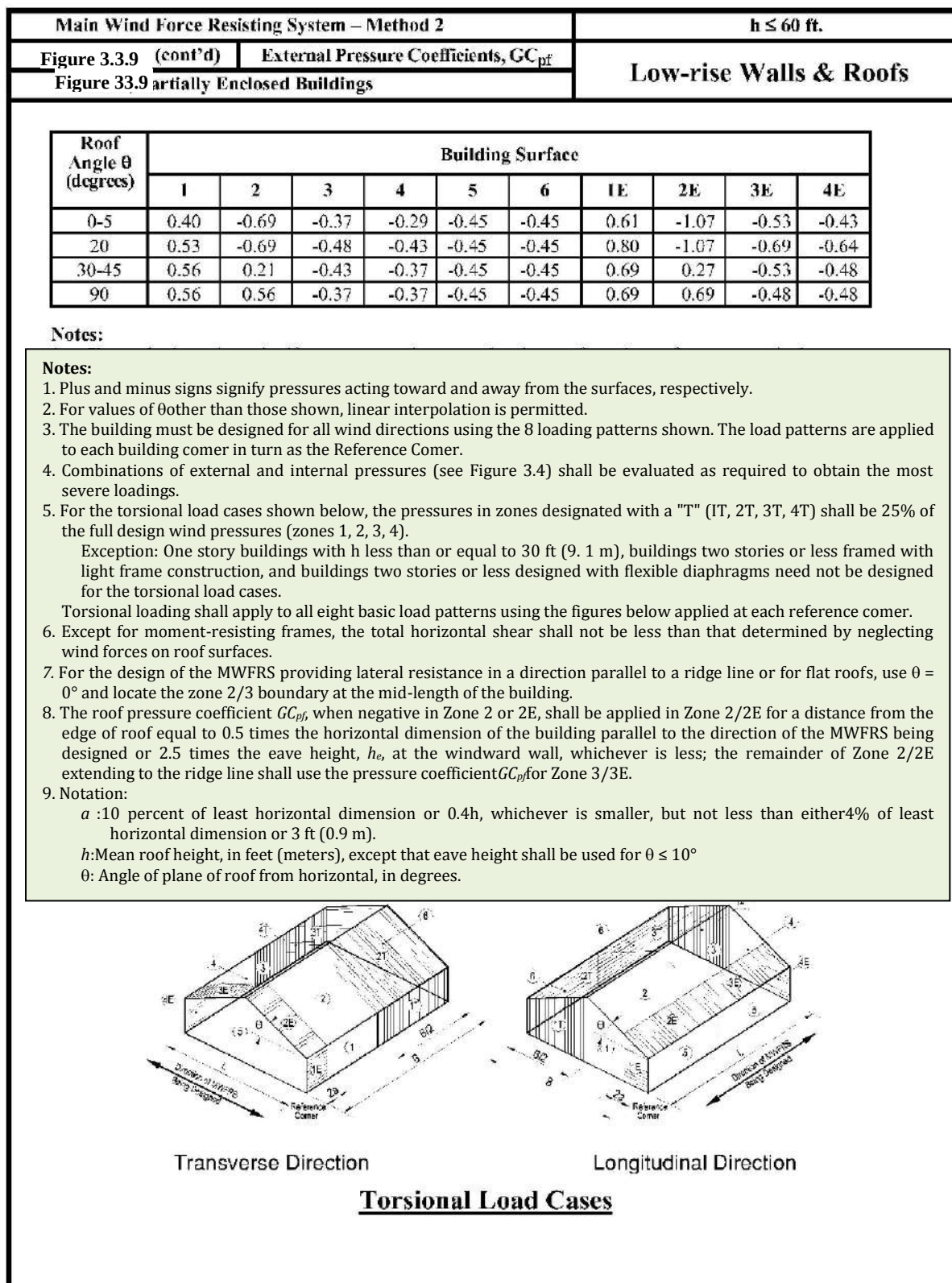
*When the rise-to-span ratio is $0.2 \leq r \leq 0.3$, alternate coefficients given by $6r - 2.1$ shall also be used for the windward quarter.

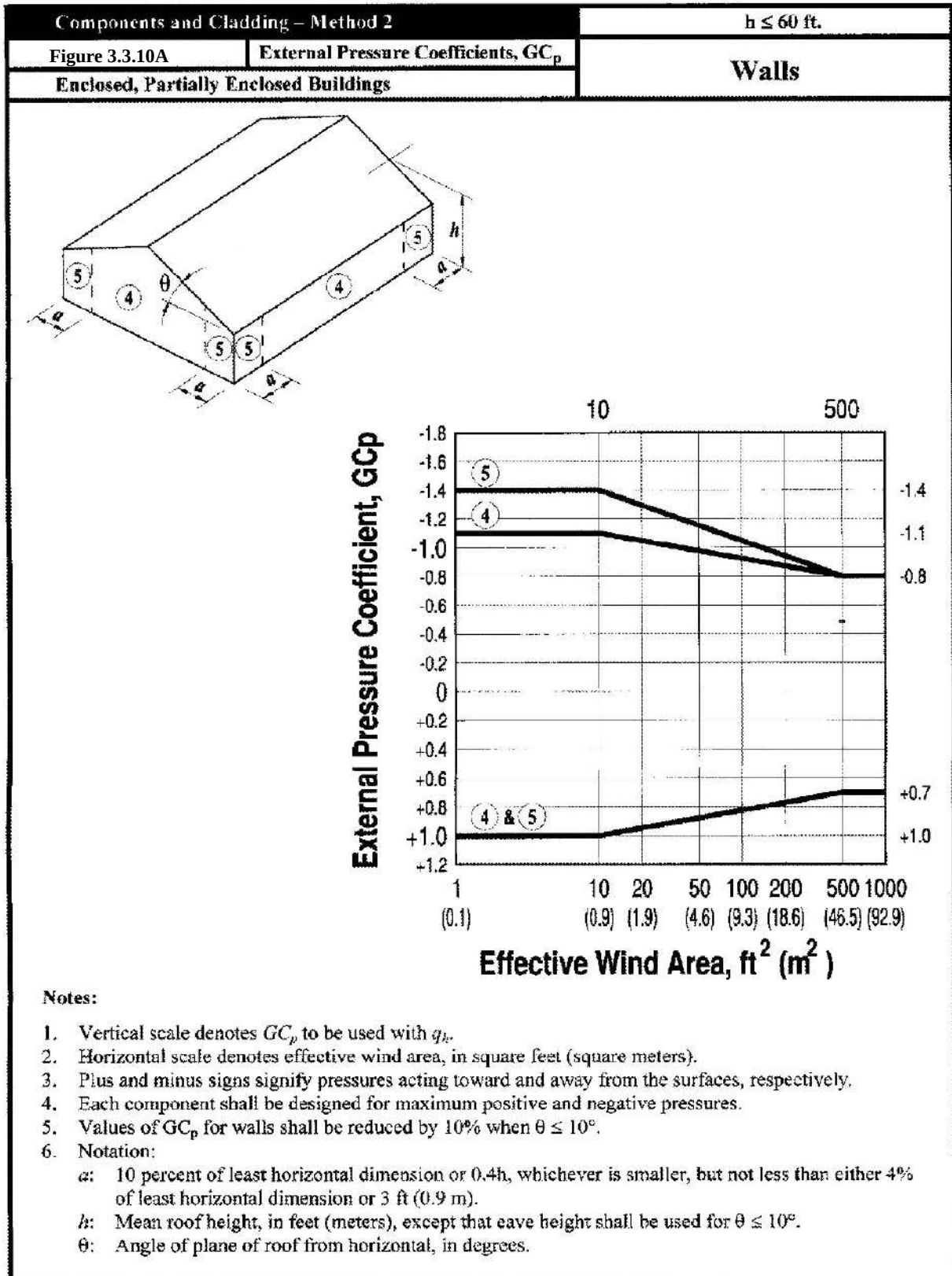
Notes:

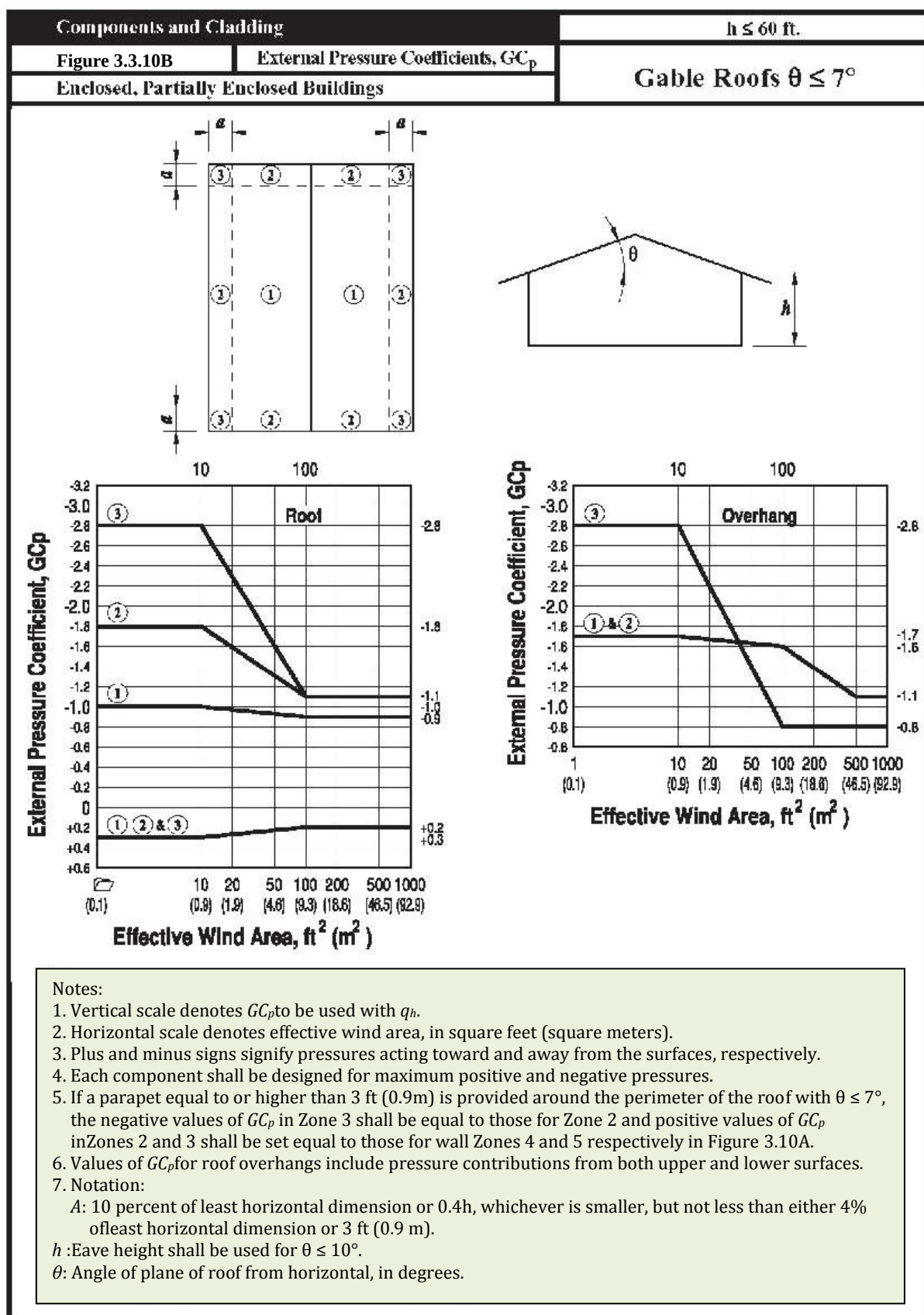
- Values listed are for the determination of average loads on main wind force resisting systems.
- Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
- For wind directed parallel to the axis of the arch, use pressure coefficients from Fig. 3.5 with wind directed parallel to ridge.
- For components and cladding: (1) At roof perimeter, use the external pressure coefficients in Fig. 3.10 with θ based on spring-line slope and (2) for remaining roof areas, use external pressure coefficients of this table multiplied by 0.87.

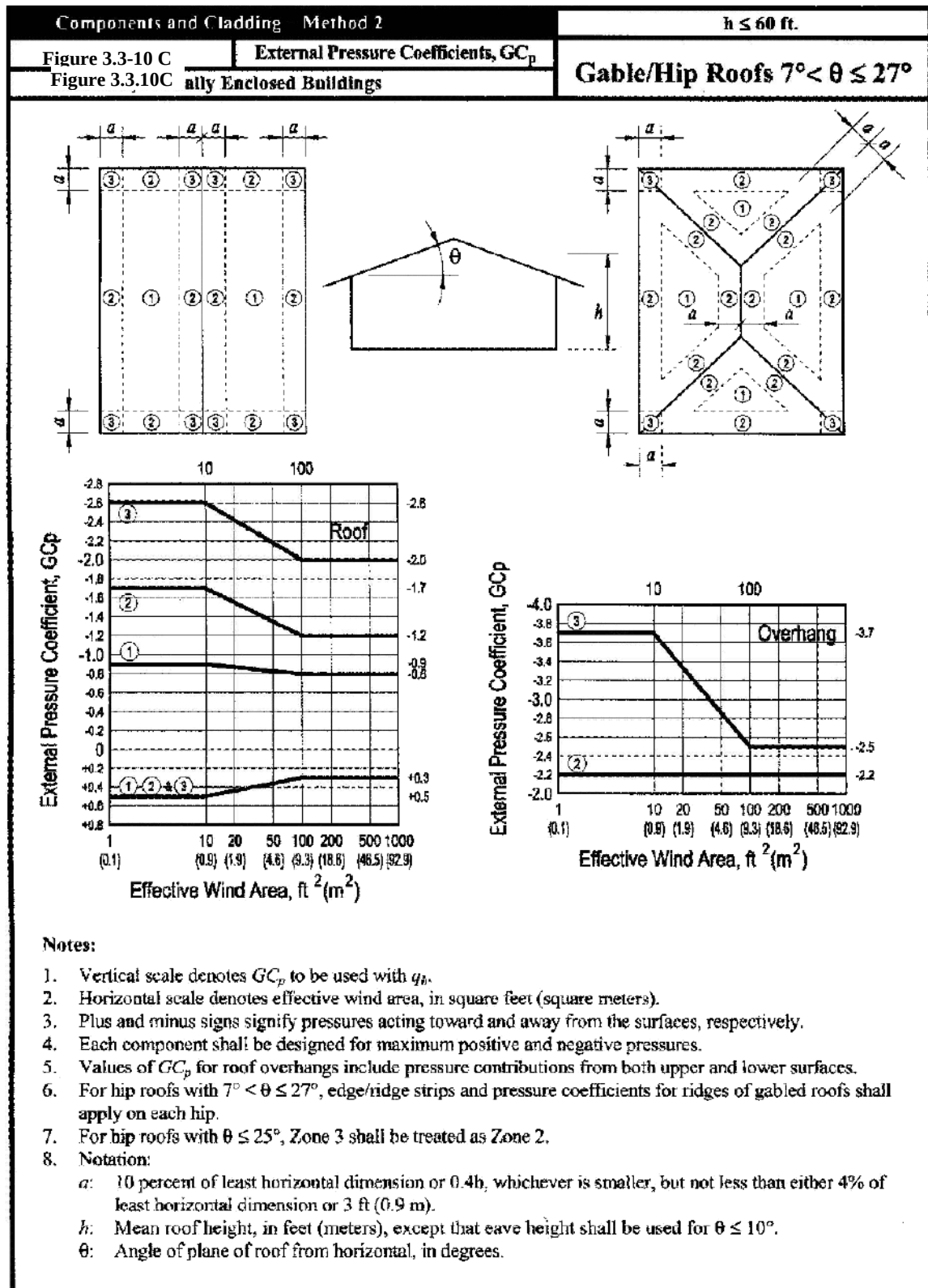


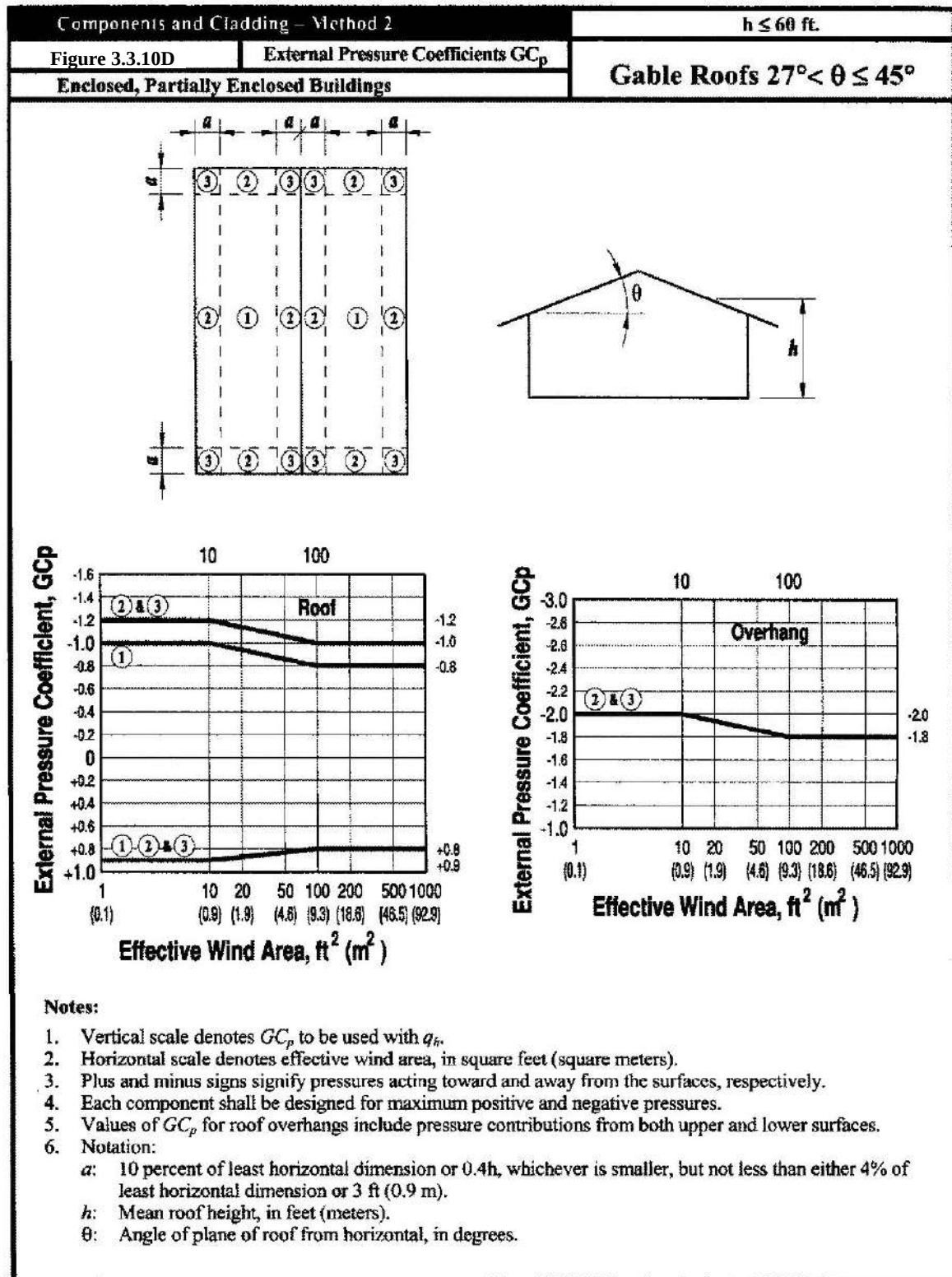




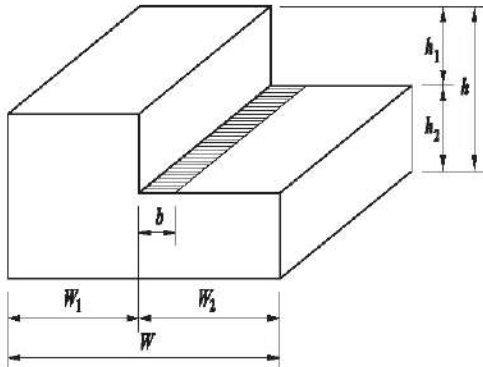








Components and Cladding - Method 2		$h \leq 60$ ft.
Figure 3.11	External Pressure Coefficients, GC_p	Stepped Roofs
Enclosed, Partially Enclosed Buildings		



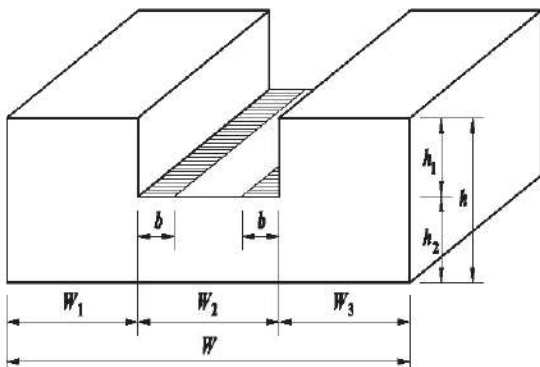
$h_1 \geq 10$ ft. (3 m)

$b = 1.5 h_1$

$b < 100$ ft. (30.5 m)

$\frac{h_i}{h} = 0.3$ to 0.7

$\frac{W_i}{W} = 0.25$ to 0.75



$h_1 \geq 10$ ft. (3 m)

$b = 1.5 h_1$

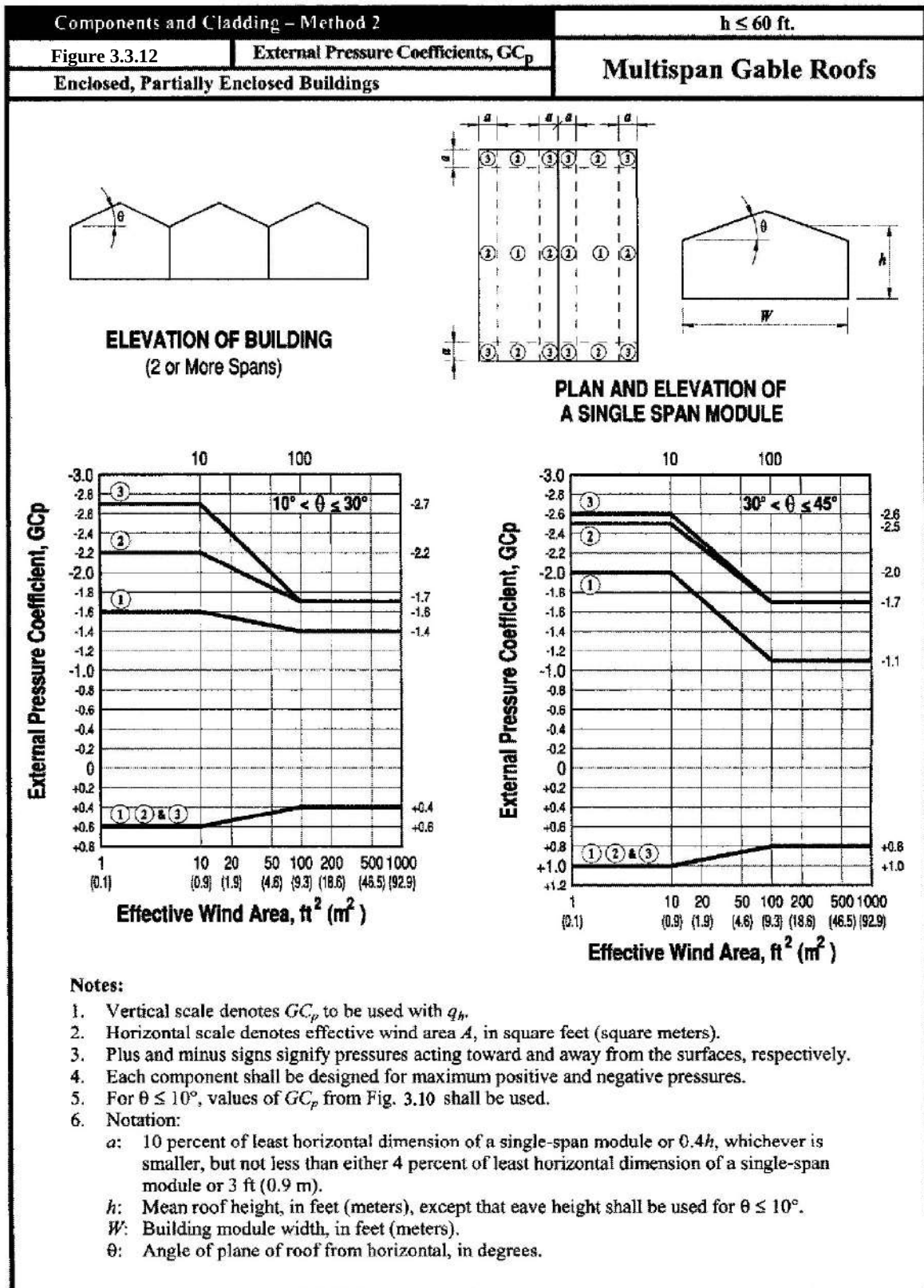
$b < 100$ ft. (30.5 m)

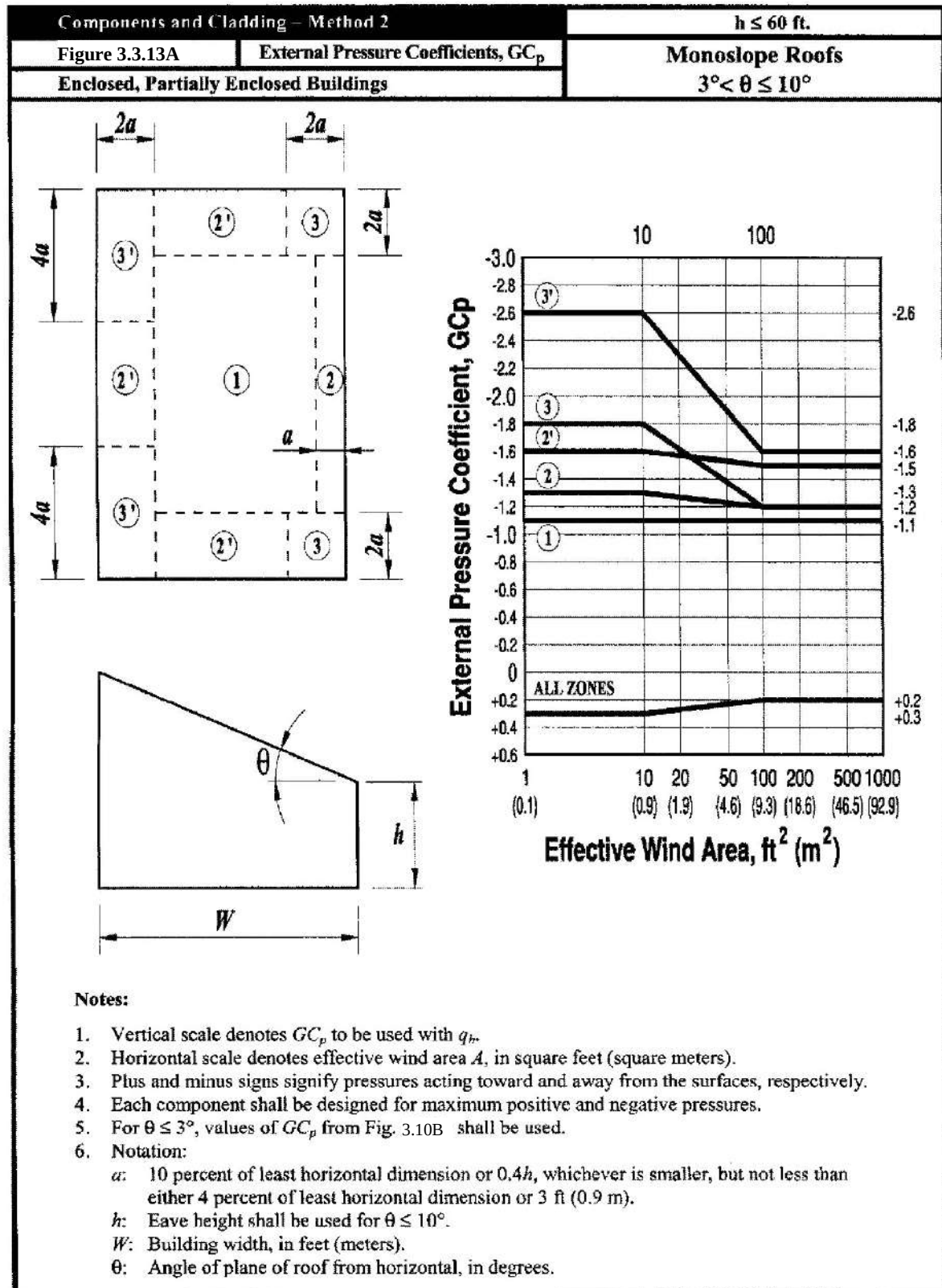
$\frac{h_i}{h} = 0.3$ to 0.7

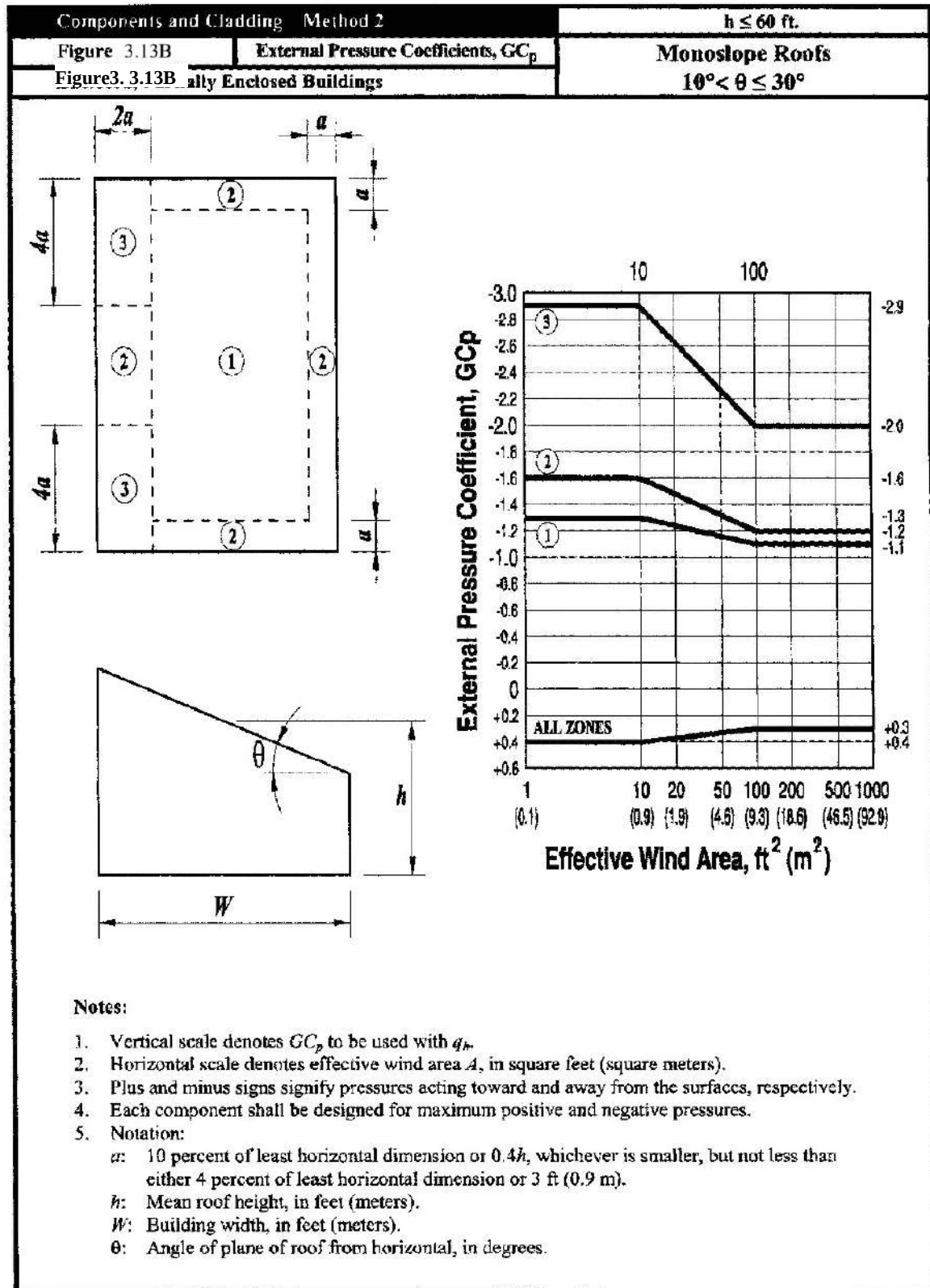
$\frac{W_i}{W} = 0.25$ to 0.75

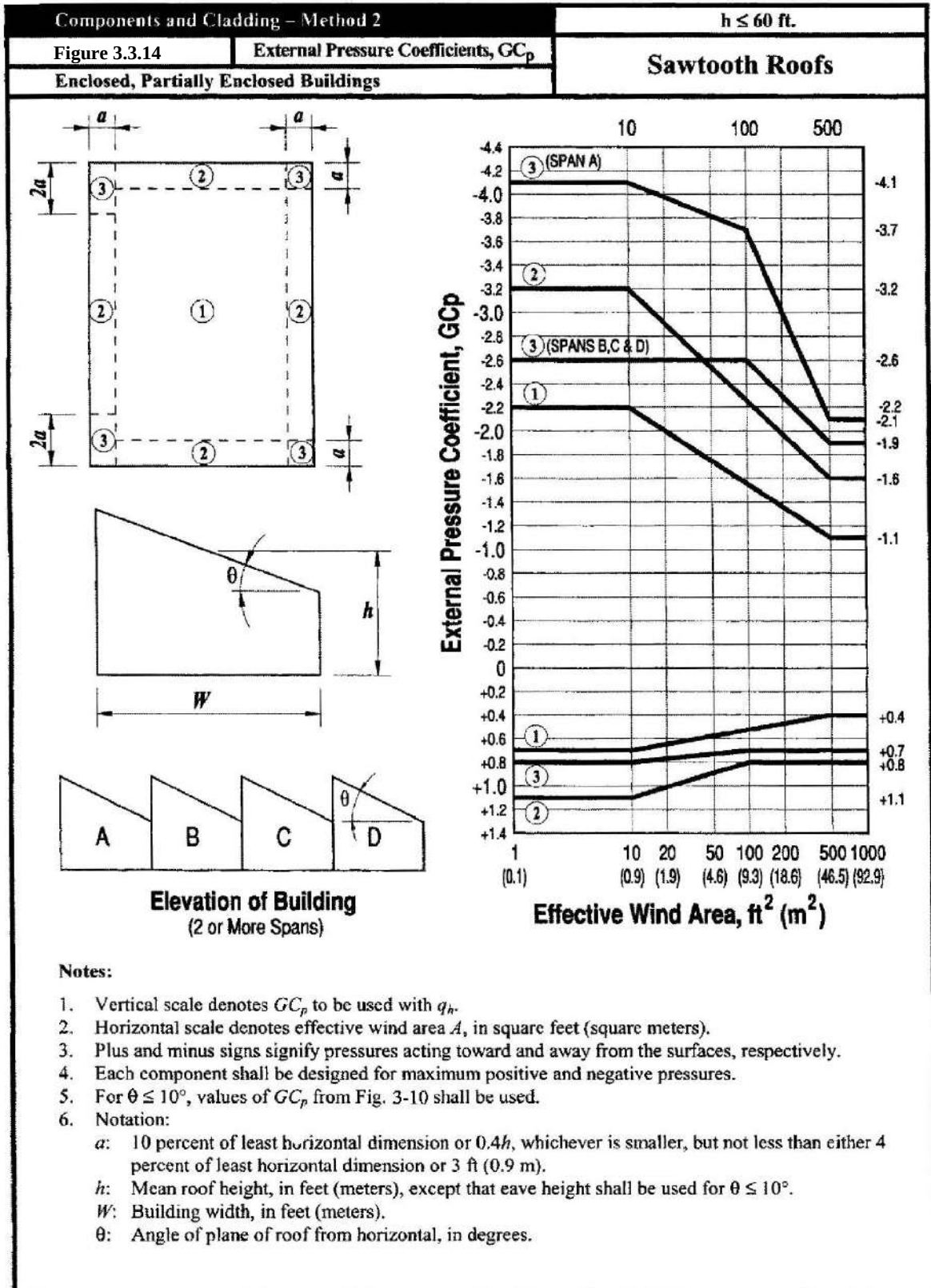
Notes:

- On the lower level of flat, stepped roofs shown in Fig. 3.11, the zone designations and pressure coefficients shown in Fig. 3.10B shall apply, except that at the roof-upper wall intersection(s), Zone 3 shall be treated as Zone 2 and Zone 2 shall be treated as Zone 1. Positive values of GC_p equal to those for walls in Fig. 3.10A shall apply on the cross-hatched areas shown in Fig. 3.11.
- Notation:
 - b : $1.5h_1$ in Fig. 3.11, but not greater than 100 ft (30.5 m).
 - h : Mean roof height, in feet (meters).
 - h_i : h_1 or h_2 in Fig. 3.11; $h = h_1 + h_2$; $h_1 \geq 10$ ft (3.1 m); $h_i/h = 0.3$ to 0.7.
 - W : Building width in Fig. 3.11.
 - W_i : W_1 or W_2 or W_3 in Fig. 3.11. $W = W_1 + W_2$ or $W_1 + W_2 + W_3$; $W_i/W = 0.25$ to 0.75.
 - θ : Angle of plane of roof from horizontal, in degrees.









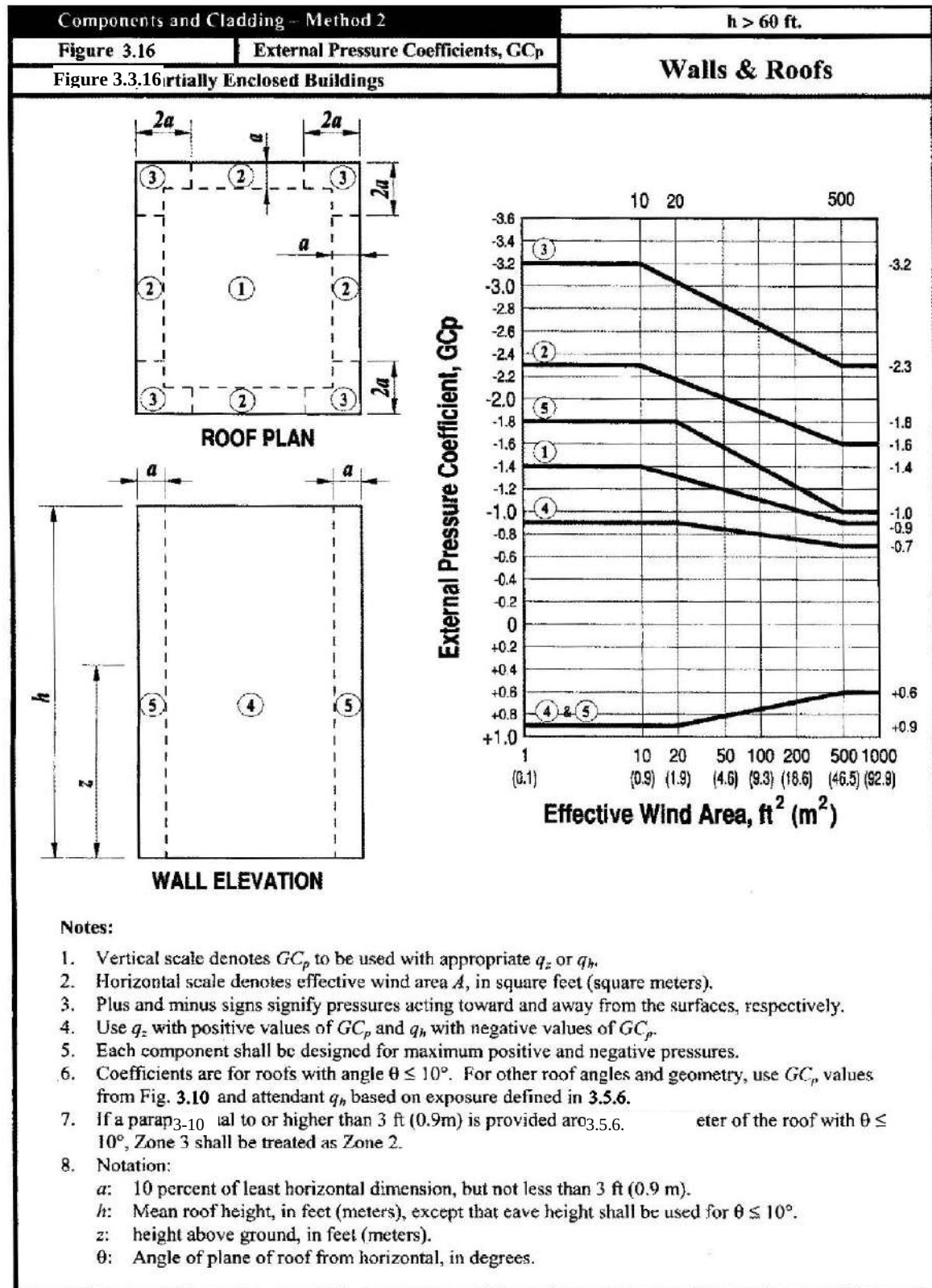
Components and Cladding – Method 2		All Heights
Figure 3.3.15	External Pressure Coefficients, GC_p	Domed Roofs
Enclosed, Partially Enclosed Buildings and Structures		

The diagram illustrates a dome structure with a circular base. The side view shows a dome with a base diameter D , a base height h_D , and a dome height f . An angle θ is defined from the springline to the top of the dome. The top view shows a circle with diameter D . Wind direction is indicated by arrows pointing towards the dome.

External Pressure Coefficients for Domes with a Circular Base			
	Negative Pressures	Positive Pressures	Positive Pressures
θ , degrees	0 – 90	0 – 60	61 – 90
GC_p	-0.9	+0.9	+0.5

Notes:

1. Values denote GC_p to be used with $q_{(h_D+f)}$ where $h_D + f$ is the height at the top of the dome.
2. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
3. Each component shall be designed for the maximum positive and negative pressures.
4. Values apply to $0 \leq h_D/D \leq 0.5$, $0.2 \leq f/D \leq 0.5$.
5. $\theta = 0$ degrees on dome springline, $\theta = 90$ degrees at dome center top point. f is measured from springline to top.



Main Wind Force Resisting System – Part I					$0.25 \leq h/L \leq 1.0$				
Figure 3.18A		Net Pressure Coefficient, C_N			Monoslope Free Roofs				
3.3.17A		Open Buildings			$\theta \leq 45^\circ, \gamma = 0^\circ, 180^\circ$				

Wind Direction
 $\gamma = 0^\circ$

Wind Direction
 $\gamma = 180^\circ$

Roof Angle θ	Load Case	Wind Direction, $\gamma = 0^\circ$				Wind Direction, $\gamma = 180^\circ$			
		Clear Wind Flow		Obstructed Wind Flow		Clear Wind Flow		Obstructed Wind Flow	
		C_{NW}	C_{NL}	C_{NW}	C_{NL}	C_{NW}	C_{NL}	C_{NW}	C_{NL}
0°	A	1.2	0.3	-0.5	-1.2	1.2	0.3	-0.5	-1.2
	B	-1.1	-0.1	-1.1	-0.6	-1.1	-0.1	-1.1	-0.6
7.5°	A	-0.6	-1	-1	-1.5	0.9	1.5	-0.2	-1.2
	B	-1.4	0	-1.7	-0.8	1.6	0.3	0.8	-0.3
15°	A	-0.9	-1.3	-1.1	-1.5	1.3	1.6	0.4	-1.1
	B	-1.9	0	-2.1	-0.6	1.8	0.6	1.2	-0.3
22.5°	A	-1.5	-1.6	-1.5	-1.7	1.7	1.8	0.5	-1
	B	-2.4	-0.3	-2.3	-0.9	2.2	0.7	1.3	0
30°	A	-1.8	-1.8	-1.5	-1.8	2.1	2.1	0.6	-1
	B	-2.5	-0.5	-2.3	-1.1	2.6	1	1.6	0.1
37.5°	A	-1.8	-1.8	-1.5	-1.8	2.1	2.2	0.7	-0.9
	B	-2.4	-0.6	-2.2	-1.1	2.7	1.1	1.9	0.3
45°	A	-1.6	-1.8	-1.3	-1.8	2.2	2.5	0.8	-0.9
	B	-2.3	-0.7	-1.9	-1.2	2.6	1.4	2.1	0.4

Notes:

- C_{NW} and C_{NL} denote net pressures (contributions from top and bottom surfaces) for windward and leeward half of roof surfaces, respectively.
- Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).
- For values of θ between 7.5° and 45° , linear interpolation is permitted. For values of θ less than 7.5° , use load coefficients for 0° .
- Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
- All load cases shown for each roof angle shall be investigated.
- Notation:
 - L : horizontal dimension of roof, measured in the along wind direction, ft. (m)
 - h : mean roof height, ft. (m)
 - γ : direction of wind, degrees
 - θ : angle of plane of roof from horizontal, degrees

Main Wind Force Resisting System		$0.25 \leq h/L \leq 1.0$
Figure 3.18B	Net Pressure Coefficient, C_N	Pitched Free Roofs $\theta \leq 45^\circ, \gamma = 0^\circ, 180^\circ$
3.3.17B	Open Buildings	

Roof Angle, θ	Load Case	Wind Direction, $\gamma = 0^\circ, 180^\circ$			
		Clear Wind Flow		Obstructed Wind Flow	
		C_{NW}	C_{NL}	C_{NW}	C_{NL}
7.5°	A	1.1	-0.3	-1.6	-1
	B	0.2	-1.2	-0.9	-1.7
15°	A	1.1	-0.4	-1.2	-1
	B	0.1	-1.1	-0.6	-1.6
22.5°	A	1.1	0.1	-1.2	-1.2
	B	-0.1	-0.8	-0.8	-1.7
30°	A	1.3	0.3	-0.7	-0.7
	B	-0.1	-0.9	-0.2	-1.1
37.5°	A	1.3	0.6	-0.6	-0.6
	B	-0.2	-0.6	-0.3	-0.9
45°	A	1.1	0.9	-0.5	-0.5
	B	-0.3	-0.5	-0.3	-0.7

Notes:

- C_{NW} and C_{NL} denote net pressures (contributions from top and bottom surfaces) for windward and leeward half of roof surfaces, respectively.
- Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow ($>50\%$ blockage).
- For values of θ between 7.5° and 45° , linear interpolation is permitted. For values of θ less than 7.5° , use monoslope roof load coefficients.
- Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
- All load cases shown for each roof angle shall be investigated.
- Notation:
 - L : horizontal dimension of roof, measured in the along wind direction, ft. (m)
 - h : mean roof height, ft. (m)
 - γ : direction of wind, degrees
 - θ : angle of plane of roof from horizontal, degrees

Main Wind Force Resisting System		0.25 ≤ h/L ≤ 1.0	
Figure 3.3.17C	Net Pressure Coefficient, C _N	Troughed Free Roofs θ ≤ 45°, γ = 0°, 180°	
Open Buildings			

Roof Angle θ	Load Case	Wind Direction, γ = 0°, 180°			
		Clear Wind Flow		Obstructed Wind Flow	
		C _{NW}	C _{NL}	C _{NW}	C _{NL}
7.5°	A	-1.1	0.3	-1.6	-0.5
	B	-0.2	1.2	-0.9	-0.8
15°	A	-1.1	0.4	-1.2	-0.5
	B	0.1	1.1	-0.6	-0.8
22.5°	A	-1.1	-0.1	-1.2	-0.6
	B	-0.1	0.8	-0.8	-0.8
30°	A	-1.3	-0.3	-1.4	-0.4
	B	-0.1	0.9	-0.2	-0.5
37.5°	A	-1.3	-0.6	-1.4	-0.3
	B	0.2	0.6	-0.3	-0.4
45°	A	-1.1	-0.9	-1.2	-0.3
	B	0.3	0.5	-0.3	-0.4

Notes:

1.

C_{NW} and C_{NL} denote net pressures (contributions from top and bottom surfaces) for windward and leeward half of roof surfaces, respectively.

2.

Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).

3.

For values of θ between 7.5° and 45°, linear interpolation is permitted. For values of θ less than 7.5°, use monoslope roof load coefficients.

4.

Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.

5.

All load cases shown for each roof angle shall be investigated.

6.

Notation:

L

: horizontal dimension of roof, measured in the along wind direction, ft. (m)

h

: mean roof height, ft. (m)

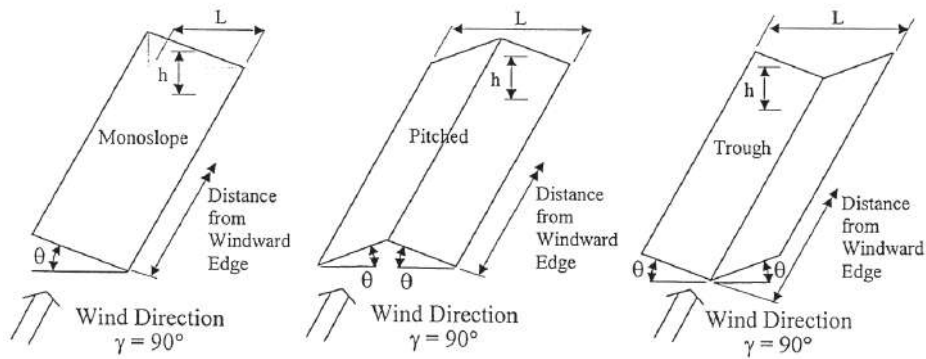
γ

: direction of wind, degrees

θ

: angle of plane of roof from horizontal, degrees

Main Wind Force Resisting System		$0.25 \leq h/L \leq 1.0$
Fig. 3.3.17D	Net Pressure Coefficient, C_N	Troughed Free Roofs $\theta \leq 45^\circ, \gamma = 0^\circ, 180^\circ$
Open Buildings		



Horizontal Distance from Windward Edge	Roof Angle θ	Load Case	Clear Wind Flow	Obstructed Wind Flow
			C_N	C_N
$\leq h$	All Shapes	A	-0.8	-1.2
	$\theta \leq 45^\circ$	B	0.8	0.5
$> h, \leq 2h$	All Shapes	A	-0.6	-0.9
	$\theta \leq 45^\circ$	B	0.5	0.5
$> 2h$	All Shapes	A	-0.3	-0.6
	$\theta \leq 45^\circ$	B	0.3	0.3

Notes:

1. C_N denotes net pressures (contributions from top and bottom surfaces).
2. Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%.
Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).
3. Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
4. All load cases shown for each roof angle shall be investigated.
5. For monoslope roofs with θ less than 5 degrees, C_N values shown apply also for cases where $\gamma = 0$ degrees and 0.05 less than or equal to h/L less than or equal to 0.25. See Figure 3.17A for other h/L values.
6. Notation:
 L : horizontal dimension of roof, measured in the along wind direction, ft. (m)
 h : mean roof height, ft. (m).
 γ : direction of wind, degrees
 θ : angle of plane of roof from horizontal, degrees

Components and Cladding		$0.25 \leq h/L \leq 1.0$
Figure 3.3.18A	Net Pressure Coefficient, C_N	Monoslope Free Roofs $\theta \leq 1.0$
Open Buildings		

Roof Angle θ	Effective Wind Area	C_N											
		Clear Wind Flow						Obstructed Wind Flow					
		Zone 3		Zone 2		Zone 1		Zone 3		Zone 2		Zone 1	
0°	$\leq a^2$	2.4	-3.3	1.8	-1.7	1.2	-1.1	1	-3.6	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	1.8	-1.7	1.8	-1.7	1.2	-1.1	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	1.2	-1.1	1.2	-1.1	1.2	-1.1	0.5	-1.2	0.5	-1.2	0.5	-1.2
7.5°	$\leq a^2$	3.2	-4.2	2.4	-2.1	1.6	-1.4	1.6	-5.1	1.2	-2.6	0.8	-1.7
	$> a^2, \leq 4.0a^2$	2.4	-2.1	2.4	-2.1	1.6	-1.4	1.2	-2.6	1.2	-2.6	0.8	-1.7
	$> 4.0a^2$	1.6	-1.4	1.6	-1.4	1.6	-1.4	0.8	-1.7	0.8	-1.7	0.8	-1.7
15°	$\leq a^2$	3.6	-3.8	2.7	-2.9	1.8	-1.9	2.4	-4.2	1.8	-3.2	1.2	-2.1
	$> a^2, \leq 4.0a^2$	2.7	-2.9	2.7	-2.9	1.8	-1.9	1.8	-3.2	1.8	-3.2	1.2	-2.1
	$> 4.0a^2$	1.8	-1.9	1.8	-1.9	1.8	-1.9	1.2	-2.1	1.2	-2.1	1.2	-2.1
30°	$\leq a^2$	5.2	-5	3.9	-3.8	2.6	-2.5	3.2	-4.6	2.4	-3.5	1.6	-2.3
	$> a^2, \leq 4.0a^2$	3.9	-3.8	3.9	-3.8	2.6	-2.5	2.4	-3.5	2.4	-3.5	1.6	-2.3
	$> 4.0a^2$	2.6	-2.5	2.6	-2.5	2.6	-2.5	1.6	-2.3	1.6	-2.3	1.6	-2.3
45°	$\leq a^2$	5.2	-4.6	3.9	-3.5	2.6	-2.3	4.2	-3.8	3.2	-2.9	2.1	-1.9
	$> a^2, \leq 4.0a^2$	3.9	-3.5	3.9	-3.5	2.6	-2.3	3.2	-2.9	3.2	-2.9	2.1	-1.9
	$> 4.0a^2$	2.6	-2.3	2.6	-2.3	2.6	-2.3	2.1	-1.9	2.1	-1.9	2.1	-1.9

Notes:

- C_N denotes net pressures (contributions from top and bottom surfaces).
- Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).
- For values of θ other than those shown, linear interpolation is permitted.
- Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
- Components and cladding elements shall be designed for positive and negative pressure coefficients shown.
- Notation:
 - a : 10% of least horizontal dimension or $0.4h$, whichever is smaller but not less than 4% of least horizontal dimension or 3 ft. (0.9 m)
 - h : mean roof height, ft. (m)
 - L : horizontal dimension of building, measured in along wind direction, ft. (m)
 - θ : angle of plane of roof from horizontal, degrees

Components and Cladding

$0.25 \leq h/L \leq 1.0$

Fig. 3.3.18B

Net Pressure Coefficient, C_N

Monoslope Free Roofs

$\theta \leq 45^\circ$

Open Buildings

$\theta < 10^\circ$

$\theta \geq 10^\circ$

Roof Angle θ	Effective Wind Area	C_N											
		Clear Wind Flow						Obstructed Wind Flow					
		Zone 3		Zone 2		Zone 1		Zone 3		Zone 2		Zone 1	
0°	$\leq a^2$	2.4	-3.3	1.8	-1.7	1.2	-1.1	1	-3.6	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	1.8	-1.7	1.8	-1.7	1.2	-1.1	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	1.2	-1.1	1.2	-1.1	1.2	-1.1	0.5	-1.2	0.5	-1.2	0.5	-1.2
7.5°	$\leq a^2$	2.2	-3.6	1.7	-1.8	1.1	-1.2	1	-5.1	0.8	-2.6	0.5	-1.7
	$> a^2, \leq 4.0a^2$	1.7	-1.8	1.7	-1.8	1.1	-1.2	0.8	-2.6	0.8	-2.6	0.5	-1.7
	$> 4.0a^2$	1.1	-1.2	1.1	-1.2	1.1	-1.2	0.5	-1.7	0.5	-1.7	0.5	-1.7
15°	$\leq a^2$	2.2	-2.2	1.7	-1.7	1.1	-1.1	1	-3.2	0.8	-2.4	0.5	-1.6
	$> a^2, \leq 4.0a^2$	1.7	-1.7	1.7	-1.7	1.1	-1.1	0.8	-2.4	0.8	-2.4	0.5	-1.6
	$> 4.0a^2$	1.1	-1.1	1.1	-1.1	1.1	-1.1	0.5	-1.6	0.5	-1.6	0.5	-1.6
30°	$\leq a^2$	2.6	-1.8	2	-1.4	1.3	-0.9	1	-2.4	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	2	-1.4	2	-1.4	1.3	-0.9	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	1.3	-0.9	1.3	-0.9	1.3	-0.9	0.5	-1.2	0.5	-1.2	0.5	-1.2
45°	$\leq a^2$	2.2	-1.6	1.7	-1.2	1.1	-0.8	1	-2.4	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	1.7	-1.2	1.7	-1.2	1.1	-0.8	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	1.1	-0.8	1.1	-0.8	1.1	-0.8	0.5	-1.2	0.5	-1.2	0.5	-1.2

Notes:

- C_N denotes net pressures (contributions from top and bottom surfaces).
- Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).
- For values of θ other than those shown, linear interpolation is permitted.
- Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
- Components and cladding elements shall be designed for positive and negative pressure coefficients shown.
- Notation:

a : 10% of least horizontal dimension or $0.4h$, whichever is smaller but not less than 4% of least horizontal dimension or 3 ft. (0.9 m).

h : mean roof height, ft. (m)

L : horizontal dimension of building, measured in along wind direction, ft. (m)

θ : angle of plane of roof from horizontal, degrees

Components and Cladding

$0.25 \leq h/L \leq 1.0$

Fig. 3.3.18C

Net Pressure Coefficient, C_N

Troughed Free Roofs

$\theta \leq 45^\circ$

Open Buildings

$\theta < 10^\circ$

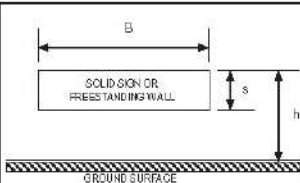
$\theta \geq 10^\circ$

Roof Angle θ	Effective Wind Area	C_N											
		Clear Wind Flow						Obstructed Wind Flow					
		Zone 3		Zone 2		Zone 1		Zone 3		Zone 2		Zone 1	
0°	$\leq a^2$	2.4	-3.3	1.8	-1.7	1.2	-1.1	1	-3.6	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	1.8	-1.7	1.8	-1.7	1.2	-1.1	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	1.2	-1.1	1.2	-1.1	1.2	-1.1	0.5	-1.2	0.5	-1.2	0.5	-1.2
7.5°	$\leq a^2$	2.4	-3.3	1.8	-1.7	1.2	-1.1	1	-4.8	0.8	-2.4	0.5	-1.6
	$> a^2, \leq 4.0a^2$	1.8	-1.7	1.8	-1.7	1.2	-1.1	0.8	-2.4	0.8	-2.4	0.5	-1.6
	$> 4.0a^2$	1.2	-1.1	1.2	-1.1	1.2	-1.1	0.5	-1.6	0.5	-1.6	0.5	-1.6
15°	$\leq a^2$	2.2	-2.2	1.7	-1.7	1.1	-1.1	1	-2.4	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	1.7	-1.7	1.7	-1.7	1.1	-1.1	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	1.1	-1.1	1.1	-1.1	1.1	-1.1	0.5	-1.2	0.5	-1.2	0.5	-1.2
30°	$\leq a^2$	1.8	-2.6	1.4	-2	0.9	-1.3	1	-2.8	0.8	-2.1	0.5	-1.4
	$> a^2, \leq 4.0a^2$	1.4	-2	1.4	-2	0.9	-1.3	0.8	-2.1	0.8	-2.1	0.5	-1.4
	$> 4.0a^2$	0.9	-1.3	0.9	-1.3	0.9	-1.3	0.5	-1.4	0.5	-1.4	0.5	-1.4
45°	$\leq a^2$	1.6	-2.2	1.2	-1.7	0.8	-1.1	1	-2.4	0.8	-1.8	0.5	-1.2
	$> a^2, \leq 4.0a^2$	1.2	-1.7	1.2	-1.7	0.8	-1.1	0.8	-1.8	0.8	-1.8	0.5	-1.2
	$> 4.0a^2$	0.8	-1.1	0.8	-1.1	0.8	-1.1	0.5	-1.2	0.5	-1.2	0.5	-1.2

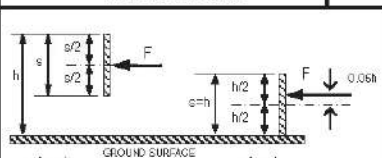
Notes:

- C_N denotes net pressures (contributions from top and bottom surfaces).
- Clear wind flow denotes relatively unobstructed wind flow with blockage less than or equal to 50%. Obstructed wind flow denotes objects below roof inhibiting wind flow (>50% blockage).
- For values of θ other than those shown, linear interpolation is permitted.
- Plus and minus signs signify pressures acting towards and away from the top roof surface, respectively.
- Components and cladding elements shall be designed for positive and negative pressure coefficients shown.
- Notation:
 - a : 10% of least horizontal dimension or 0.4h, whichever is smaller but not less than 4% of least horizontal dimension or 3 ft. (0.9 m).
 - h : mean roof height, ft. (m)
 - L : horizontal dimension of building, measured in along wind direction, ft. (m)
 - θ : angle of plane of roof from horizontal, degrees

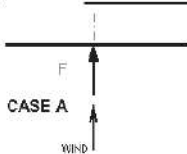
Other Structures - Method 2		All Heights	
Figure3. 1.19	Force Coefficients, C _f	Solid Freestanding Walls & Solid Freestanding Signs	
Other Structures			



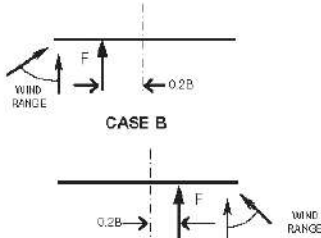
ELEVATION VIEW



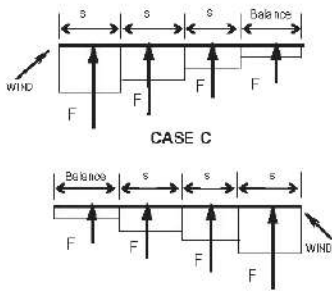
CROSS-SECTION VIEW



CASE A



CASE B



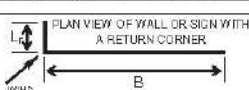
CASE C

C _f , CASE A & CASE B												
Clearance Ratio, s/h	Aspect Ratio, B/s											
	≤ 0.05	0.1	0.2	0.5	1	2	4	5	10	20	30	≥ 45
1	1.80	1.70	1.65	1.55	1.45	1.40	1.35	1.35	1.30	1.30	1.30	1.30
0.9	1.85	1.75	1.70	1.60	1.55	1.50	1.45	1.45	1.40	1.40	1.40	1.40
0.7	1.90	1.85	1.75	1.70	1.65	1.60	1.60	1.55	1.55	1.55	1.55	1.55
0.5	1.95	1.85	1.80	1.75	1.75	1.70	1.70	1.70	1.70	1.70	1.70	1.75
0.3	1.95	1.90	1.85	1.80	1.80	1.80	1.80	1.80	1.80	1.85	1.85	1.85
0.2	1.95	1.90	1.85	1.80	1.80	1.80	1.80	1.80	1.85	1.90	1.90	1.95
≤ 0.16	1.95	1.90	1.85	1.85	1.80	1.80	1.85	1.85	1.85	1.90	1.90	1.95

C _f , CASE C													
Region (horizontal distance from windward edge)	Aspect Ratio, B/s										Region (horizontal distance from windward edge)	Aspect Ratio, B/s	
	2	3	4	5	6	7	8	9	10	13		≥ 45	
0 to s	2.25	2.60	2.90	3.10*	3.30*	3.40*	3.55*	3.65*	3.75*	0 to s	4.00*	4.30*	
s to 2s	1.50	1.70	1.90	2.00	2.15	2.25	2.30	2.35	2.45	s to 2s	2.60	2.55	
2s to 3s		1.15	1.30	1.45	1.55	1.65	1.70	1.75	1.85	2s to 3s	2.00	1.95	
3s to 10s			1.10	1.05	1.05	1.05	1.05	1.00	0.95	3s to 4s	1.50	1.85	
										4s to 5s	1.35	1.85	
										5s to 10s	0.90	1.10	
										>10s	0.55	0.55	

*Values shall be multiplied by the following reduction factor when a return corner is present:

L _r /s	Reduction Factor
0.3	0.90
1.0	0.75
≥ 2	0.60



PLAN VIEW OF WALL OR SIGN WITH A RETURN CORNER

Notes:

- The term "signs" in notes below also applies to "freestanding walls".
- Signs with openings comprising less than 30% of the gross area are classified as solid signs. Force coefficients for solid signs with openings shall be permitted to be multiplied by the reduction factor $(1 - (1 - \epsilon)^{1.5})$.
- To allow for both normal and oblique wind directions, the following cases shall be considered:
 For $s/h < 1$:
 CASE A: resultant force acts normal to the face of the sign through the geometric center.
 CASE B: resultant force acts normal to the face of the sign at a distance from the geometric center toward the windward edge equal to 0.2 times the average width of the sign.
 For $B/s \geq 2$, CASE C must also be considered:
 CASE C: resultant forces act normal to the face of the sign through the geometric centers of each region.
 For $s/h = 1$:
 The same cases as above except that the vertical locations of the resultant forces occur at a distance above the geometric center equal to 0.05 times the average height of the sign.
- For CASE C where $s/h > 0.8$, force coefficients shall be multiplied by the reduction factor $(1.8 - s/h)$.
- Linear interpolation is permitted for values of s/h , B/s and L_r/s other than shown.
- Notation:
 B: horizontal dimension of sign, in feet (meters);
 h: height of the sign, in feet (meters);
 s: vertical dimension of the sign, in feet (meters);
 ϵ : ratio of solid area to gross area;
 L_r : horizontal dimension of return corner, in feet (meters)

Other Structures – Method 2		All Heights		
Figure 3.3.20	Force Coefficients, C_f	Chimneys, Tanks, Rooftop Equipment, & Similar Structures		
Cross-Section	Type of Surface	h/D		
		1	7	25
Square (wind normal to face)	All	1.3	1.4	2.0
Square (wind along diagonal)	All	1.0	1.1	1.5
Hexagonal or octagonal	All	1.0	1.2	1.4
Round ($D\sqrt{q_z} > 2.5$) ($D\sqrt{q_z} > 5.3$, D in m, q_z in N/m^2)	Moderately smooth	0.5	0.6	0.7
	Rough ($D'/D = 0.02$)	0.7	0.8	0.9
	Very rough ($D'/D = 0.08$)	0.8	1.0	0.2
Round ($D\sqrt{q_z} \leq 2.5$) ($D\sqrt{q_z} \leq 5.3$, D in m, q_z in N/m^2)	All	0.7	0.8	1.2

Notes:

- The design wind force shall be calculated based on the area of the structure projected on a plane normal to the wind direction. The force shall be assumed to act parallel to the wind direction.
- Linear interpolation is permitted for h/D values other than shown.
- Notation:
 - D : diameter of circular cross-section and least horizontal dimension of square, hexagonal or octagonal cross-sections at elevation under consideration, in feet (meters);
 - D' : depth of protruding elements such as ribs and spoilers, in feet (meters); and
 - h : height of structure, in feet (meters); and
 - q_z : velocity pressure evaluated at height z above ground, in pounds per square foot (N/m^2).

Other Structures – Method 2		All Heights	
Figure 3.3.21	Force Coefficients, C_f	Open Signs & Lattice Frameworks	

ϵ	Flat-Sided Members	Rounded Members	
		$D\sqrt{q_z} \leq 2.5$ ($D\sqrt{q_z} \leq 5.3$)	$D\sqrt{q_z} > 2.5$ ($D\sqrt{q_z} > 5.3$)
< 0.1	2.0	1.2	0.8
0.1 to 0.29	1.8	1.3	0.9
0.3 to 0.7	1.6	1.5	1.1

Notes:

- Signs with openings comprising 30% or more of the gross area are classified as open signs.
- The calculation of the design wind forces shall be based on the area of all exposed members and elements projected on a plane normal to the wind direction. Forces shall be assumed to act parallel to the wind direction.
- The area A_f consistent with these force coefficients is the solid area projected normal to the wind direction.
- Notation:
 - ϵ : ratio of solid area to gross area;
 - D : diameter of a typical round member, in feet (meters);
 - q_z : velocity pressure evaluated at height z above ground in pounds per square foot (N/m^2).

Other Structures – Method 2		All Heights
Figure 3.3.22	Force Coefficients, C_f	Trussed Towers
Open Structures		

Tower Cross Section	C_f
Square	$4.0 \leq 5.9 \epsilon \div 4.0$
Triangle	$3.4 \leq 4.7 \epsilon \div 3.4$

Notes:

- For all wind directions considered, the area A_f consistent with the specified force coefficients shall be the solid area of a tower face projected on the plane of that face for the tower segment under consideration.
- The specified force coefficients are for towers with structural angles or similar flat-sided members.
- For towers containing rounded members, it is acceptable to multiply the specified force coefficients by the following factor when determining wind forces on such members:
 $0.51 \leq 0.57$, but not > 1.0
- Wind forces shall be applied in the directions resulting in maximum member forces and reactions. For towers with square cross-sections, wind forces shall be multiplied by the following factor when the wind is directed along a tower diagonal:
 $1 + 0.75 \epsilon$, but not > 1.2
- Wind forces on tower appurtenances such as ladders, conduits, lights, elevators, etc., shall be calculated using appropriate force coefficients for these elements.
- Loads due to ice accretion as described in Section 11 shall be accounted for.
- Notation:
 ϵ : ratio of solid area to gross area of one tower face for the segment under consideration.

Table 3.3.1, Basic Wind Speed (3 sec Gust Wind Speed in mph)

Sr	City/Town	Basic Wind Speed (mph)
1	Bago	80
2	Bhamo	70
3	Bogalay	100
4	Chauk	70
5	Dawei	90
6	Falam	70
7	Hakha	90
8	Henzada	90
9	Homalin	50
10	Hpa-An	70
11	Kale	70
12	Kawthaung	90
13	Kengtung	70
14	Kyaukpyu	130
15	Lashio	70
16	Loikaw	70
17	Magwe	70
18	Mandalay	80
19	Mawlamyine	90
20	Meiktila	70
21	Monywa	70
22	Muse	70
23	Myeik	90
24	Myitkyina	70
25	Nansam	70
26	Naypyitaw	70
27	Pakokku	70
28	Pathein	100
29	Putao	70
30	Pyay	70
31	Sittwe	130
32	Taungyi	70
33	Thandwe	130
34	Yangon	100
35	Ye	90
36	Yenangyaung	70

Note: For cities not included in the table, wind speed of the nearest city in the list shall be used.

Importance Factor, I (Wind Loads)		
Table 3.3.2		
Category	Non-Cyclone Prone Regions and Cyclone Prone Regions with V = 85-100 mph and Alaska	Cyclone Prone Regions with V > 100 mph
I	0.87	0.77
II	1	1
III	1.15	1.15
IV	1.15	1.15
Note: 1. The building and structure classification categories are listed in Table 1.2.		

Terrain Exposure Constants

Table 3.3.3

Exposure	α	z_g (ft)	$\hat{a}$	$\hat{b}$	$\bar{\alpha}$	$\bar{b}$	c	ℓ (ft)	$\bar{\epsilon}$	z_{min} (ft)*
B	7.0	1200	1/7	0.84	1/4.0	0.45	0.30	320	1/3.0	30
C	9.5	900	1/9.5	1.00	1/6.5	0.65	0.20	500	1/5.0	15
D	11.5	700	1/11.5	1.07	1/9.0	0.80	0.15	650	1/8.0	7

* z_{min} = minimum height used to ensure that the equivalent height $\bar{z}$ is greater of $0.6h$ or z_{min} .

For buildings with $h \leq z_{min}$, $\bar{z}$ shall be taken as z_{min} .

In metric

Exposure	α	z_g (m)	$\hat{a}$	$\hat{b}$	$\bar{\alpha}$	$\bar{b}$	c	ℓ (m)	$\bar{\epsilon}$	z_{min} (m)*
B	7.0	365.76	1/7	0.84	1/4.0	0.45	0.30	97.54	1/3.0	9.14
C	9.5	274.32	1/9.5	1.00	1/6.5	0.65	0.20	152.4	1/5.0	4.57
D	11.5	213.36	1/11.5	1.07	1/9.0	0.80	0.15	198.12	1/8.0	2.13

* z_{min} – minimum height used to ensure that the equivalent height $\bar{z}$ is greater of $0.6h$ or z_{min} .

For buildings with $h \leq z_{min}$, $\bar{z}$ shall be taken as z_{min} .

Velocity Pressure Exposure Coefficients, K_h and K_z

Table 3.3.4

Height above ground level, z		Exposure (Note 1)			
		B		C	D
ft	(m)	Case 1	Case 2	Cases 1 & 2	Cases 1 & 2
0-15	(0-4.6)	0.70	0.57	0.85	1.03
20	(6.1)	0.70	0.62	0.90	1.08
25	(7.6)	0.70	0.66	0.94	1.12
30	(9.1)	0.70	0.70	0.98	1.16
40	(12.2)	0.76	0.76	1.04	1.22
50	(15.2)	0.81	0.81	1.09	1.27
60	(18)	0.85	0.85	1.13	1.31
70	(21.3)	0.89	0.89	1.17	1.34
80	(24.4)	0.93	0.93	1.21	1.38
90	(27.4)	0.96	0.96	1.24	1.40
100	(30.5)	0.99	0.99	1.26	1.43
120	(36.6)	1.04	1.04	1.31	1.48
140	(42.7)	1.09	1.09	1.36	1.52
160	(48.8)	1.13	1.13	1.39	1.55
180	(54.9)	1.17	1.17	1.43	1.58
200	(61.0)	1.20	1.20	1.46	1.61
250	(76.2)	1.28	1.28	1.53	1.68
300	(91.4)	1.35	1.35	1.59	1.73
350	(106.7)	1.41	1.41	1.64	1.78
400	(121.9)	1.47	1.47	1.69	1.82
450	(137.2)	1.52	1.52	1.73	1.86
500	(152.4)	1.56	1.56	1.77	1.89

Notes:

- Case 1:** a. All components and cladding.
b. Main wind force resisting system in low-rise buildings designed using Figure 3-9.
- Case 2:** a. All main wind force resisting systems in buildings except those in low-rise buildings designed using Figure 3-9.
b. All main wind force resisting systems in other structures.
- The velocity pressure exposure coefficient K_z may be determined from the following formula:
For $15 \text{ ft} \leq z \leq z_g$ For $z < 15 \text{ ft}$
 $K_z = 2.01 (z/z_g)^{2/\alpha}$ $K_z = 2.01 (15/z_g)^{2/\alpha}$
Note: z shall not be taken less than 30 feet for Case 1 in exposure B.
- α and z_g are tabulated in Table 3.3.
- Linear interpolation for intermediate values of height z is acceptable.
- Exposure categories are defined in 3.5.6.

Wind Directionality factor, K_d

Table 3.3.5

Structure Type	Directionality Factor K_d^*
Buildings	
Main Wind Force Resisting System	0.85
Components and Cladding	0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures	
Square	0.90
Hexagonal	0.95
Round	0.95
Solid Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers	
Triangular, square, rectangular	0.85
All other cross sections	0.95

* Directionality Factor K_d has been calibrated with combinations of loads specified in Section 2. This factor shall only be applied when used in conjunction with load combinations specified in 2.1.2 and 2.1.3.

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PART 3 STRUCTURAL DESIGN

NO.	TITLE	PAGE
3.4:	SEISMIC DESIGN CRITERIA AND DESIGN REQUIREMENTS FOR BUILDINGS	
3.4.1	Seismic Design Criteria	
3.4.2	Seismic Design Requirements for Building Structures	
3.4.3	Seismic Response History Procedures	
3.4.4	Site-Specific Ground Motion Procedures for Seismic Design	

SECTION 3.4: SEISMIC DESIGN CRITERIA AND DESIGN REQUIREMENTS FOR BUILDINGS

3.4.1 Seismic Design Criteria

3.4.1.1 General

3.4.1.1.1 Purpose

This section presents criteria for the design and construction of buildings subject to earthquake ground motions. The specified earthquake loads are based upon post-elastic energy dissipation in the structure, and because of this fact, the requirements for design, detailing, and construction shall be satisfied even for structures and members for which load combinations that do not contain earthquake loads indicate larger demands than combinations that include earthquake loads.

3.4.1.1.2 Scope

Every building structure, and portion thereof, including nonstructural components, shall be designed and constructed to resist the effects of earthquake motions as prescribed by the seismic requirements of this standard.

1. Detached one- and two-family dwellings that are located where the short period, spectral response acceleration parameter, S_s , is less than 0.4 or where the Seismic Design Category determined in accordance with Section 3.4.1.6 is A, B, or C.
2. Detached one- and two-family wood-frame dwellings not included in Exception 1 with not more than two stories.
3. Agricultural storage structures that are intended only for incidental human occupancy.
4. Structures that require special consideration of their response characteristics and environment and for which other regulations provide seismic criteria, such as vehicular bridges, electrical transmission towers, hydraulic structures, buried utility lines and their appurtenances, and nuclear reactors.

3.4.1.1.3 Applicability

Structures and their nonstructural components shall be designed and constructed in accordance with the requirement of Section 3.4.2.

3.4.1.1.4 Alternative materials and methods of construction

Alternative materials and methods of this standard shall not be used unless approved by the authority having jurisdiction. Substantiating evidence shall be submitted demonstrating that the proposed alternative, for the purpose intended, will be at least equal in strength, durability, and seismic resistance.

3.4.1.2 Definitions

The following definitions apply only to the seismic requirements of this standard.

ACTIVE FAULT: A fault determined to be active by the authority having jurisdiction from properly substantiated data (e.g., most recent mapping of active faults by the authority Department).

ADDITION: An increase in building area, aggregate floor area, height, or number of stories of a structure.

ALTERATION: Any construction or renovation to an existing structure other than an addition.

APPENDAGE: An architectural component such as a canopy, marquee, ornamental balcony, or statuary.

APPROVAL: The written acceptance by the authority having jurisdiction of documentation that establishes the qualification of a material, system, component, procedure, or person to fulfill the requirements of this standard for the intended use.

ATTACHMENTS: Means by which components and their supports are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

BASE: The level at which the horizontal seismic ground motions are considered to be imparted to the structure.

BASEMENT: A basement is any storey below the lowest storey above grade.

BASE SHEAR: Total design lateral force or shear at the base.

BOUNDARY ELEMENTS: Diaphragm and shear wall boundary members to which the diaphragm transfers forces. Boundary members include chords and drag struts at diaphragm and shear wall perimeters, interior openings, discontinuities, and reentrant corners.

BOUNDARY MEMBERS: Portions along wall and diaphragm edges strengthened by longitudinal and transverse reinforcement. Boundary members include chords and drag struts at diaphragm and shear wall perimeters, interior openings, discontinuities, and reentrant corners.

BUILDING: Any structure whose intended use includes shelter of human occupants.

CANTILEVERED COLUMN SYSTEM: A seismic force-resisting system in which lateral forces are resisted entirely by columns acting as cantilevers from the base.

CHARACTERISTIC EARTHQUAKE: An earthquake assessed for an active fault having a magnitude equal to the best estimate of the maximum magnitude capable of occurring on the fault, but not less than the largest magnitude that has occurred historically on the fault.

COMPONENT: A part or element of an architectural, electrical, mechanical, or structural system.

Component, Equipment: A mechanical or electrical component or element that is part of a mechanical and/or electrical system within or without a building system.

Component, Flexible: Component, including its attachments, having a fundamental period greater than 0.06s.

Component, Rigid: Component, including its attachments, having a fundamental period less than or equal to 0.06s.

COMPONENT SUPPORT: Those structural members or assemblies of members, including braces, frames, struts, and attachments that transmit all loads and forces between systems, components, or elements and the structures.

CONCRETE, PLAIN: Concrete that is either unreinforced or contains less reinforcement than the minimum amount specified in ACI 318-05 for reinforced concrete.

CONCRETE, REINFORCED: Concrete reinforced with no less reinforcement than the minimum amount required by ACI 318-05 prestressed or nonprestressed, and designed on the assumption that the two materials act together in resisting forces.

COUPLING BEAM: A beam that is used to connect adjacent concrete wall elements to make them act together as a unit to resist lateral loads.

DEFORMABILITY: The ratio of the ultimate deformation to the limit deformation.

High-Deformability Element: An element whose deformability is not less than 3.5 where subjected to four fully reversed cycles at the limit deformation.

Limited-Deformability Element: An element that is neither a low-deformability or a high-deformability element.

Low-Deformability Element: An element whose deformability is 1.5 or less.

DEFORMATION:

Limit Deformation: Two times the initial deformation that occurs at a load equal to 40 percent of the maximum strength.

Ultimate Deformation: The deformation at which failure occurs and that shall be deemed to occur if the sustainable load reduces to 80 percent or less of the maximum strength.

DESIGN AND CONSTRUCTION DOCUMENTS: The written, graphic, electronic, and pictorial documents describing the design, locations, and physical characteristics of the project required to verify compliance with this standard.

DESIGNATED SEISMIC SYSTEMS: The seismic force-resisting system and those architectural, electrical, and mechanical system or their components and for which the component importance factor, I_p , is greater than 1.0.

DESIGN EARTHQUAKE: The earthquake effects that are two-thirds of the corresponding Maximum Considered Earthquake (MCE) effects.

DESIGN EARTHQUAKE GROUND MOTION: The earthquake ground motions that are two-thirds of the corresponding MCE ground motions.

DIAPHRAGM: Roof, floor, or other membrane or bracing system acting to transfer the lateral forces to the vertical resisting elements.

DIAPHRAGM BOUNDARY: A location where shear is transferred into or out of the diaphragm element. Transfer is either to a boundary element or to another force-resisting element.

DIAPHRAGM CHORD: A diaphragm boundary element perpendicular to the applied load that is assumed to take axial stresses due to the diaphragm moment.

DRAG STRUT (COLLECTOR, TIE, DIAPHRAGM STRUT): A diaphragm or shear wall boundary element parallel to the applied load that collects and transfers diaphragm shear forces to the vertical force-resisting elements or distributes forces within the diaphragm or shear wall.

ENCLOSURE: An interior space surrounded by walls.

EQUIPMENT SUPPORT: Those structural members or assemblies of members or manufactured elements, including braces, frames, legs, lugs, snuggers, hangers, or saddles that transmit gravity loads and operating loads between the equipment and the structure.

FLEXIBLE EQUIPMENT CONNECTIONS: Those connections between equipment components that permit rotational and/or translational movement without degradation of performance. Examples include universal joints, bellows expansion joints, and flexible metal hose.

FRAME:

Braced Frame: An essentially vertical truss, or its equivalent, of the concentric or eccentric type that is provided in a building frame system or dual system to resist seismic forces.

Concentrically Braced Frame (CBF): A braced frame in which the members are subjected primarily to axial forces. CBFs are categorized as ordinary concentrically braced frames (OCBF) or special concentrically braced frames (SCBF).

Eccentrically Braced Frame (EBF): A diagonally braced frame in which at least one end of each frame is connected to a beam a short distance from a beam-column or from another diagonal brace.

Moment Frame: A frame in which members and joints resist lateral forces by flexure as well as along the axis of the members. Moment frames are categorized as intermediate moment frames (IMF), ordinary moment frames (OMF), and special moment frames (SMF).

STRUCTURAL SYSTEM:

Building Frame System: A structural system with an essentially complete space frame providing support for vertical loads. Seismic force resistance is provided by shear walls or braced frames.

Dual System: A structural system with an essentially complete space frame providing support for vertical loads. Seismic force resistance is provided by

moment resisting frames and shear walls or braced frames as prescribed in Section 3.4.2.2.5.1.

Shear Wall-Frame Interactive System: A structural system that uses combinations of ordinary reinforced concrete shear walls and ordinary reinforced concrete moment frames designed to resist lateral forces in proportion to their rigidities considering interaction between shear walls and frames on all levels.

Space Frame System: A 3-D structural system composed of interconnected members, other than bearing walls, that is capable of supporting vertical loads and, where designed for such an application, is capable of providing resistance to seismic forces.

GLAZED CURTAIN WALL: A nonbearing wall that extends beyond the edges of building floor slabs, and includes a glazing material installed in the curtain wall framing.

GLAZED STOREFRONT: A nonbearing wall that is installed between floor slabs, typically including entrances, and includes a glazing material installed in the storefront framing.

GRADE PLANE: A reference plane representing the average of finished ground level adjoining the structure at all exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane shall be established by the lowest points within the area between the buildings and the lot line or, where the lot line is more than 6 ft (1,829 mm) from the structure, between the structure and a point 6 ft (1,829 mm) from the structure.

HAZARDOUS CONTENTS: A material that is highly toxic or potentially explosive and in sufficient quantity to pose a significant life- safety threat to the general public if an uncontrolled release were to occur.

IMPORTANCE FACTOR: A factor assigned to each structure according to its Occupancy Category as prescribed in Section 3.4.1.5.

INSPECTION, SPECIAL: The observation of the work by a special inspector to determine compliance with the approved construction documents and these standards in accordance with the quality assurance plan.

Continuous Special Inspection: The full-time or intermittent observation of the work by a special inspector who is present in the area where work is being performed.

Periodic Special Inspection: The part-time or intermittent observation of the work by a special inspector who is present in the area where work has been or is being performed.

INSPECTOR, SPECIAL (who shall be identified as the owner's inspector): A person approved by the authority having jurisdiction to perform special inspection.

INVERTED PENDULUM-TYPE STRUCTURES: Structures in which more than 50 percent of the structure's mass is concentrated at the top of a slender, cantilevered structure and in which stability of the mass at the top of the structure relies on rotational restraint to the top of the cantilevered element.

JOINT: The geometric volume common to intersecting members.

LIGHT-FRAME CONSTRUCTION: A method of construction where the structural assemblies (e.g., walls, floors, ceilings and roofs) are primarily formed by a system of

repetitive wood or cold- formed steel framing members of subassemblies of these members (e.g., trusses).

LONGITUDINAL REINFORCEMENT RATIO: Area of longitudinal reinforcement divided by the cross-sectional area of the concrete.

MAXIMUM CONSIDERED EARTHQUAKE (MCE) GROUND MOTION: The most severe earthquake effects considered by this standard as defined in Section 3.4.1.4.

MECHANICALLY ANCHORED TANKS OR VESSELS: Tanks or vessels provided with mechanical anchors to resist overturning moments.

NONBUILDING STRUCTURE: A structure, other than a building.

NONBUILDING STRUCTURE SIMILAR TO A BUILDING: A nonbuilding structure that is designed and constructed in a manner similar to buildings, will respond to strong ground motion in a fashion similar to buildings, and have basic lateral and vertical seismic-force-resisting-system conforming to one of the types indicated in Table 3.4.9.

ORTHOGONAL: To be in two horizontal directions, at 90° to each other.

OWNER: Any person, agent, firm, or corporation having a legal or equitable interest in the property.

PARTITION: A nonstructural interior wall that spans horizontally or vertically from support to support. The supports may be the basic building frame, subsidiary structural members, or other portions of the partition system.

P-DELTA EFFECT: The secondary effect on shears and moments of structural members due to the action of the vertical loads induced by horizontal displacement of the structure resulting from various loading conditions.

PILE: Deep foundation components including piers, caissons, and piles.

PILE CAP: Foundation elements to which piles are connected including grade beams and mats.

REGISTERED STRUCTURAL DESIGN PROFESSIONAL: An engineer, registered or licensed to practice professional engineering, as defined by the statutory requirements of the professional registrations laws of the state in which the project is to be constructed.

SEISMIC DESIGN CATEGORY: A classification assigned to a structure based on its Occupancy Category and the severity of the design earthquake ground motion at the site as defined in Section 3.4.1.4.

SEISMIC FORCE-RESISTING SYSTEM: That part of the structural system that has been considered in the design to provide the required resistance to the seismic forces prescribed herein.

SEISMIC FORCES: The assumed forces prescribed herein, related to the response of the structure to earthquake motions, to be used in the design of the structure and its components.

SELF-ANCHORED TANKS OR VESSELS: Tanks or vessels that are stable under design overturning moment without the need for mechanical anchors to resist uplift.

SHEAR PANEL: A floor, roof, or wall component sheathed to act as a shear wall or diaphragm.

SITE CLASS: A classification assigned to a site based on the types of soils present and their engineering properties.

STORAGE RACKS: Include industrial pallet racks, moveable shelf racks, and stacker racks made of cold-formed or hot-rolled structural members. Does not include other types of racks such as drive-in and drive-through racks, cantilever racks, portable racks, or racks made of materials other than steel.

STOREY: The portion of a structure between the tops of two successive finished floor surfaces and, for the topmost storey, from the top of the floor finish to the top of the roof structural element.

STOREY ABOVE GRADE: Any storey having its finished floor surface entirely above grade, except that a storey shall be considered as a storey above grade where the finished floor surface of the storey immediately above is more than 6 ft (1,829 mm) above the grade plane, more than 6 ft (1,829 mm) above the finished ground level for more than 40 percent of the total structure perimeter, or more than 12 ft (3,658 mm) above the finished ground level at any point.

STOREY DRIFT: The horizontal deflection at the top of the storey relative to the bottom of the storey as determined in Section 3.4.2.8.6.

STOREY DRIFT RATIO: The storey drift, as determined in Section 3.4.2.8.6 divided by the storey height.

STOREY SHEAR: The summation of design lateral seismic forces at levels above the storey under consideration.

STRENGTH:

Design Strength: Nominal strength multiplied by a strength reduction factor, ϕ .

Nominal Strength: Strength of a member or cross-section calculated in accordance with the requirements and assumptions of the strength design methods of this standard (or the reference documents) before application of any strength-reduction factors.

Required Strength: Strength of a member, cross-section, or connection required to resist factored loads or related internal moments and forces in such combinations as stipulated by this standard.

STRUCTURAL OBSERVATIONS: The visual observations to determine that the seismic force-resisting system is constructed in general conformance with the construction documents.

STRUCTURE: That which is built or constructed and limited to buildings and nonbuilding structures as defined herein.

SUBDIAPHRAGM: A portion of a diaphragm used to transfer wall anchorage forces to diaphragm cross ties.

SUPPORTS: Those structural members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, which transmit loads between the nonstructural components and the structure.

TESTING AGENCY: A company or corporation that provides testing and/or inspection services.

VENEERS: Facings or ornamentation of brick, concrete, stone, tile, or similar materials attached to a backing.

WALL: A component that has a slope of 60° or greater with the horizontal plane used to enclose or divide space.

Bearing Wall: Any wall meeting either of the following classifications:

1. Any metal or wood stud wall that supports more than 100 lb/linearft (1,459 N/m) of vertical load in addition to its own weight.
2. Any concrete or masonry wall that supports more than 200 lb/linear ft (2,919 N/m) of vertical load in addition to its own weight.

Light-Framed Wall: A wall with wood or steel studs.

Light-Framed Wood Shear Wall: A wall constructed with wood studs and sheathed with material rated for shear resistance.

Nonbearing Wall: Any wall that is not a bearing wall.

Nonstructural Wall: All walls other than bearing walls or shear walls.

Shear Wall (Vertical Diaphragm): A wall, bearing or non-bearing, designed to resist lateral forces acting in the plane of the wall (sometimes referred to as a “vertical diaphragm”).

Structural Wall: Walls that meet the definition for bearing walls or shear walls.

WALL SYSTEM, BEARING: A structural system with bearing walls providing support for all or major portions of the vertical loads. Shear walls or braced frames provide seismic force resistance.

WOOD STRUCTURAL PANEL: A wood-based panel product that meets the requirements of DOC PS1 or DOC PS2 and is bonded with a waterproof adhesive. Included under this designation are plywood, oriented strand board, and composite panels.

3.4.1.3 Notation

The unit dimensions used with the items covered by the symbols shall be consistent throughout except where specifically noted. Notation presented in this section applies only to the seismic requirements in this standard as indicated.

A_{ch} = cross-sectional area (in² or mm²) of a structural member measured out-to-out of transverse reinforcement

A_0 = area of the load-carrying foundation (ft² or m²)

A_{sh} = total cross-sectional area of hoop reinforcement (in² or mm²), including supplementary cross-ties, having a spacing of s_h and crossing a section with a core dimension of h_c

A_{vd} = required area of leg (in² or mm²) of diagonal reinforcement

A_x = torsional amplification factor (Section 3.4.2.8.4.3)

a_i = the acceleration at level i obtained from a modal analysis

a_p = the amplification factor related to the response of a system or component as affected by the type of seismic attachment.

b_p = the width of the rectangular glass panel

C_d = deflection amplification factor as given in Table 3.4.9.

C_s = seismic response coefficient determined in Section 3.4.2.8.1.1. (dimensionless)

C_T = building period coefficient in Section 3.4.2.8.2.1

C_{vx} = vertical distribution factor as determined in Section 3.4.2.8.3

c = distance from the neutral axis of a flexural member to the fiber of maximum compressive strain (in. or mm)

D = the effect of dead load

D_{clear} = relative horizontal (drift) displacement, measured over the height of the glass panel under consideration, which causes initial glass-to-frame contact.

d_C = The total thickness of cohesive soil layers in the top 100 ft (30 m); see Section 3.4.1.4.2 (ft or m)

d_i = The thickness of any soil or rock layer i (between 0 and 100 ft [30 m]); see Section 3.4.1.4.2 (ft or m)

d_S = The total thickness of cohesionless soil layers in the top 100 ft (30 m); see Section 3.4.1.4.2 (ft or m)

E = effect of horizontal and vertical earthquake-induced forces (Section 3.4.2.4).

F_a = short-period site coefficient (at 0.2 s-period); see Section 3.4.1.4.3

F_i, F_n, F_x = portion of the seismic base shear, V , induced at Level i , n , or x , respectively, as determined in Section 3.4.2.8.3

F_p = the seismic force acting on a component of a structure

F_v = long-period site coefficient (at 1.0 s-period); see Section 3.4.1.4.3

f'_c = specified compressive strength of concrete used in design

f'_s = ultimate tensile strength (psi or MPa) of the bolt, stud, or insert leg wires. For A307 bolts or A108 studs, it is permitted to be assumed to be 60,000 psi (415 MPa).

f_y = specified yield strength of reinforcement (psi or MPa)

f_{yh} = specified yield strength of the special lateral reinforcement (psi or kPa)

$G = \gamma v_s^2 / g$

= the average shear modulus for the soils beneath the foundation at large strain levels (psf or Pa)

$$G_0 = \gamma v_{so}^2 / g$$

= the average shear modulus for the soils beneath the foundation at small strain levels (psf or Pa)

g = acceleration due to gravity

H = thickness of soil

h = height of a shear wall measured as the maximum clear height from top of foundation to bottom of diaphragm framing above, or the maximum clear height from top of diaphragm to bottom of diaphragm framing above

h = average roof height of structure with respect to the base

h_c = core dimension of a component measured to the outside of the special lateral reinforcement (in. or mm)

h_i, h_n, h_x = the height above the base to Level i , n , or x , respectively

h_p = the height of the rectangular glass panel

h_{sx} = the storey height below Level $x = (h_x - h_{x-1})$

I = the importance factor in Section 3.4.1.5.1

I_p = the component importance factor

i = the building level referred to by the subscript i ; $i=1$

K_p = the stiffness of the component or attachment

KL/r = the lateral slenderness ratio of a compression member measured in terms of its effective length, KL , and the least radius of gyration of the member cross section, r

k = distribution exponent given in Section 3.4.2.8.3

L = overall length of the building (ft or m) at the base in the direction being analyzed

M_t = torsional moment resulting from eccentricity between the locations of centre of mass and the centre of rigidity (Section 3.4.2.8.4.1)

M_{ta} = accidental torsional moment as determined in Section 3.4.2.8.4.2

m = a subscript denoting the mode of vibration under consideration; that is, $m = 1$ for the fundamental mode

N = standard penetration resistance, ASTM 1586

N = number of storeys (Section 3.4.2.8.2.1)

$\bar{N}$ = average field standard penetration resistance for the top 100 ft (30 m); see Section 3.4.1.4.8

$\bar{N}_{ch}$ = average standard penetration resistance for cohesionless soil layers for the top 100 ft (30 m); see Section 3.4.1.4.8

N_i = standard penetration resistance of any soil or rock layer i [between 0 and 100 ft (30 m)]; see Section 3.4.1.4.2

n = designation for the level that is uppermost in the main portion of the building

P_x = total unfactored vertical design load at and above Level x , for use in Section 3.4.2.8.7

PI = plasticity index, ASTM D4318

Q_E = effect of horizontal seismic (earthquake-induced) forces

R = response modification coefficient as given in Tables 3.4.9.

R_p = component response modification factor

S_S = specified MCE, 5 percent damped, spectral response acceleration parameter at short periods as defined in Section 3.4.1.4.1

S_I = specified MCE, 5 percent damped, spectral response acceleration parameter at a period of 1 s as defined in Section 3.4.1.4.1

S_{aM} = the site-specific MCE spectral response acceleration at any period

S_{DS} = design, 5 percent damped, spectral response acceleration parameter at short periods as defined in Section 3.4.1.4.4

S_{DI} = design, 5 percent damped, spectral response acceleration parameter at a period of 1 s as defined in Section 3.4.1.4.4

S_{MS} = the MCE, 5 percent damped, spectral response acceleration at short periods adjusted for site class effects as defined in Section 3.4.1.4.3

S_{MI} = the MCE, 5 percent damped, spectral response acceleration at a period of 1 s adjusted for site class effects as defined in Section 3.4.1.4.3

s_u = undrained shear strength; see Section 3.4.1.4.2

$\bar{s}_u$ = average undrained shear strength in top 100 ft (30 m); see Sections 3.4.1.4.8, ASTM D2166 or ASTM D2850

s_{ui} = undrained shear strength of any cohesive soil layer i (between 0 and 100 ft [30 m]); see Section 3.4.1.4.8

s_h = spacing of special lateral reinforcement (in. or mm)

T = the fundamental period of the building

T_a = approximate fundamental period of the building as determined in Section 3.4.2.8.2

T_L = long-period transition period as defined in Section 3.4.1.4.5 (Table 3.4.1)

T_p = fundamental period of the component and its attachment

$T_0 = 0.2 S_{DI} / S_{DS}$

$T_S = S_{DI} / S_{DS}$

V = total design lateral force or shear at the base

V_t = design value of the seismic base shear as determined in Section 3.4.2.9.4

V_x = seismic design shear in storey x as determined in Section 3.4.2.8.4 or 3.4.2.9.4

v_s = shear wave velocity at small shear strains (equal to 10^{-3} percent strain or less); see Section 3.4.1.4.2 (ft/s or m/s)

$\bar{v}_s$ = average shear wave velocity at small shear strains in top 100 ft (30 m); see Sections 3.4.1.4.8

v_{si} = the shear wave velocity of any soil or rock layer i (between 0 and 100 ft [30 m]); see Section 3.4.1.4.2

W = effective seismic weight of the building as defined in Section 3.4.2.7.2

W_c = gravity load of a component of the building

W_p = component operating weight (lb or N)

w = moisture content (in percent), ASTM D2216

w_i, w_n, w_x = portion of W that is located at or assigned to Level i, n , or x , respectively

x = level under consideration, 1 designates the first level above the base

z = height in structure of point of attachment of component with respect to the base

β = ratio of shear demand to shear capacity for the story between Level x and $x - 1$

β_0 = foundation damping factor

γ = average unit weight of soil (lb/ft³ or N/m³)

Δ = design storey drift as determined in Section 3.4.2.8.6

Δ_{fallout} = the relative seismic displacement (drift) at which glass fallout from the curtain wall, storefront, or partition occurs

Δ_a = allowable storey drift as specified in Section 3.4.2.12.1

δ_{max} = maximum displacement at Level x , considering torsion, Section 3.4.2.8.4.3

δ_{avg} = the average of the displacements at the extreme points of the structure at Level x , Section 3.4.2.8.4.3

δ_x = deflection of Level x at the centre of the mass at and above Level x , Eq. (3.4.22).

δ_{xe} = deflection of Level x at the centre of the mass at and above Level x determined by an elastic analysis, Section 3.4.2.8.6.

θ = stability coefficient for P -delta effects as determined in Section 3.4.2.8.7

ρ = a redundancy factor based on the extent of structural redundancy present in a building as defined in Section 3.4.2.3.4.

λ = time effect factor

Ω_0 = overstrength factor as defined in Tables 3.4.9.

3.4.1.4 Seismic Ground Motion Values

3.4.1.4.1 Specified Acceleration Parameters.

The parameters S_s and S_1 shall be determined from the 0.2s and 1.0 s spectral response accelerations in Table 3.4.1. Where S_1 is less than or equal to 0.04 and S_s is less than or equal to 0.15, the structure is permitted to be assigned to Seismic Design Category A and is only required to comply with Section 3.4.1.7.

3.4.1.4.2 Site Class.

Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Table 3.4.2. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

TABLE 3.4.1
0.2s (S_s) AND 1.0s (S_1) SPECTRAL RESPONSE ACCELERATIONS

Sr. No.	City / Town	S_s	S_1	Remarks
1.	Bagan	1.55	0.62	
2.	Bago (Pegu)	1.07	0.43	
3.	Bhamo	0.66	0.26	
3.4.	Coco Islands (Great Coco Island)	1.18	0.47	
5.	Dawei (Tavoy)	0.25	0.10	
6.	Hakha	1.87	0.75	
7.	Hpa-An (Pa-An)	0.74	0.30	
8.	Kengtung	1.32	0.52	
9.	Kyaukpyu (Kyaukphyu)	0.84	0.33	
10.	Labutta	0.64	0.26	
11.	Lashio	0.48	0.19	
12.	Loikaw	1.41	0.56	
13.	Magwe	1.45	0.58	
13.4.	Mandalay	2.01	0.80	
15.	Mawlamyine (Mawlamyaing)	0.74	0.30	
16.	Meiktila	2.07	0.83	
17.	Monywa	1.72	0.69	
18.	Myitkyina	1.7	0.68	
19.	Naypyitaw	1.32	0.53	
20.	Pakokku	1.54	0.61	
21.	Patheingyi (Bassein)	0.87	0.35	
22.	Putao	2.05	0.82	
23.	Pyaw (prome)	0.80	0.32	
23.4.	Pyinmana	1.32	0.53	
25.	Sagaing	2.12	0.85	
26.	Shwebo	2.25	0.90	
27.	Sittwe (Akyab)	1.26	0.50	
28.	Taungtha	1.20	0.48	
29.	Taunggyi	1.69	0.68	
30.	Thandwe (Sandoway)	0.88	0.35	
31.	Yangon (Rangoon)	0.77	0.31	

Note: Long-period transition period T_L is to be taken as 6 sec.

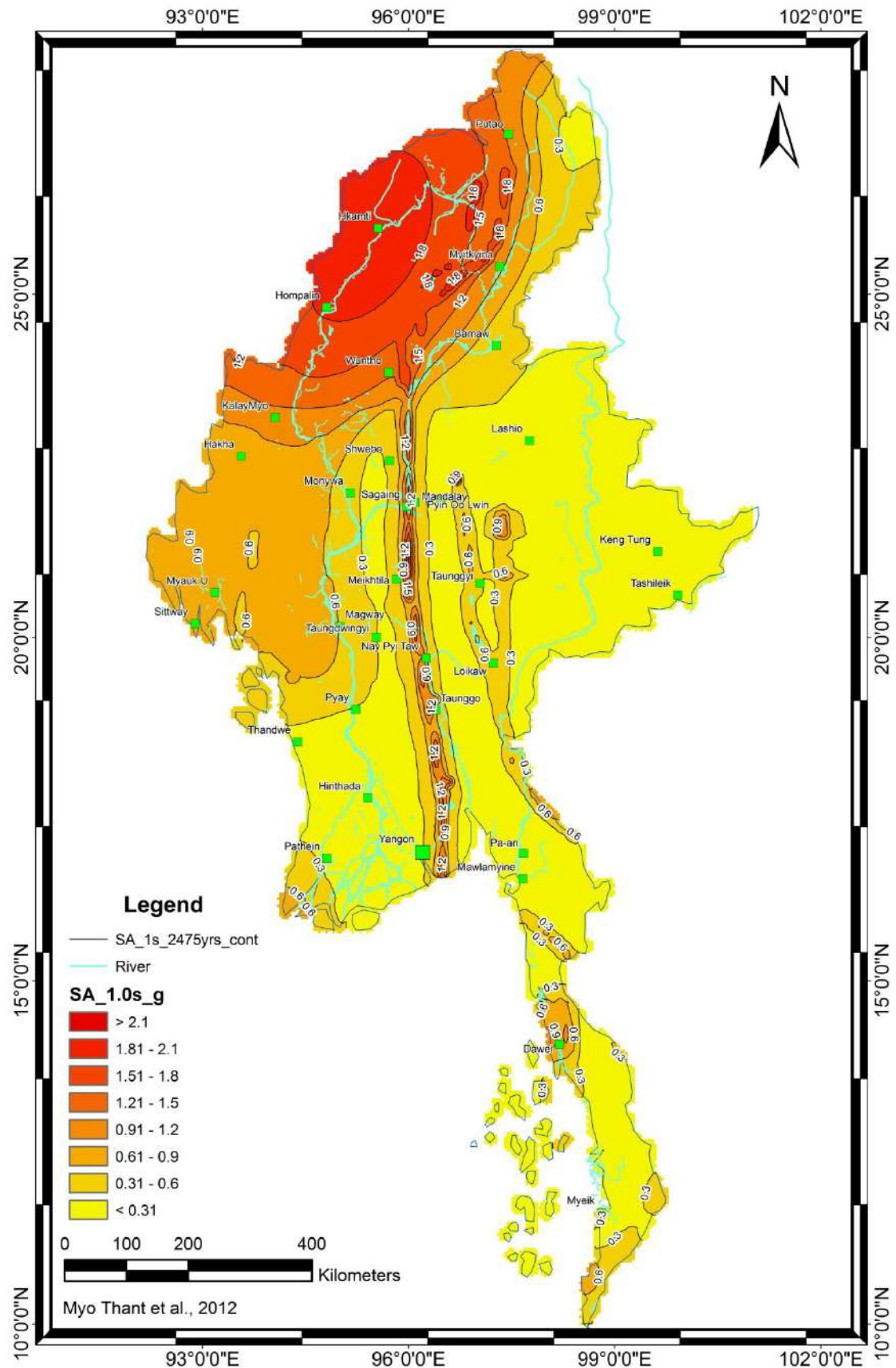


Figure 3.4.1.1: Maximum Considered Earthquake Ground Motion for 1 Sec Spectral Response Acceleration at 2% Probability in 50 Years with 5% Critical Damping, Site Class B

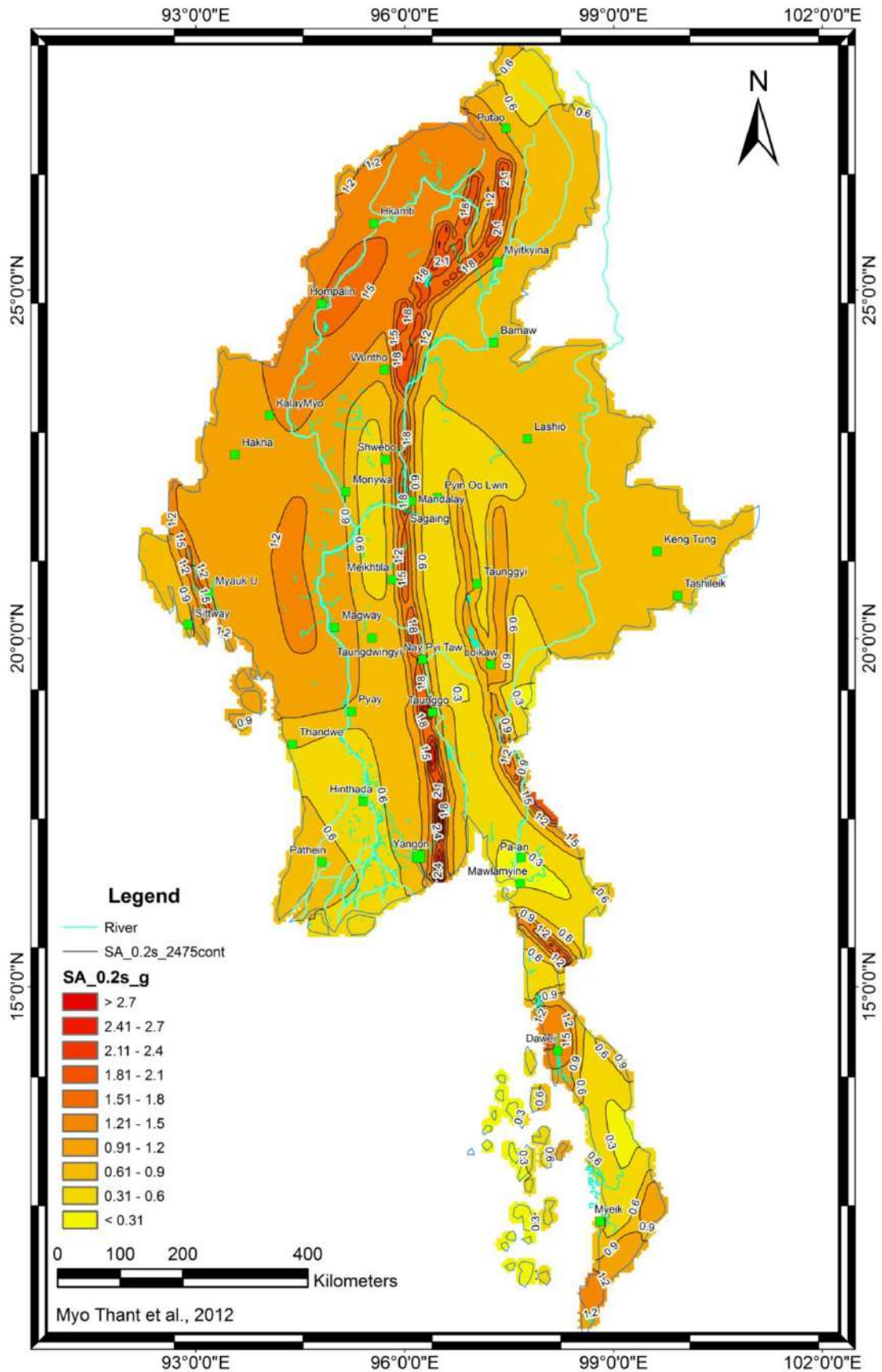


Figure 3.4.1.3: Maximum Considered Earthquake Ground Motion for 0.2 Sec Spectral Response Acceleration at 2% Probability in 50 Years with 5% Critical Damping, Site Class B

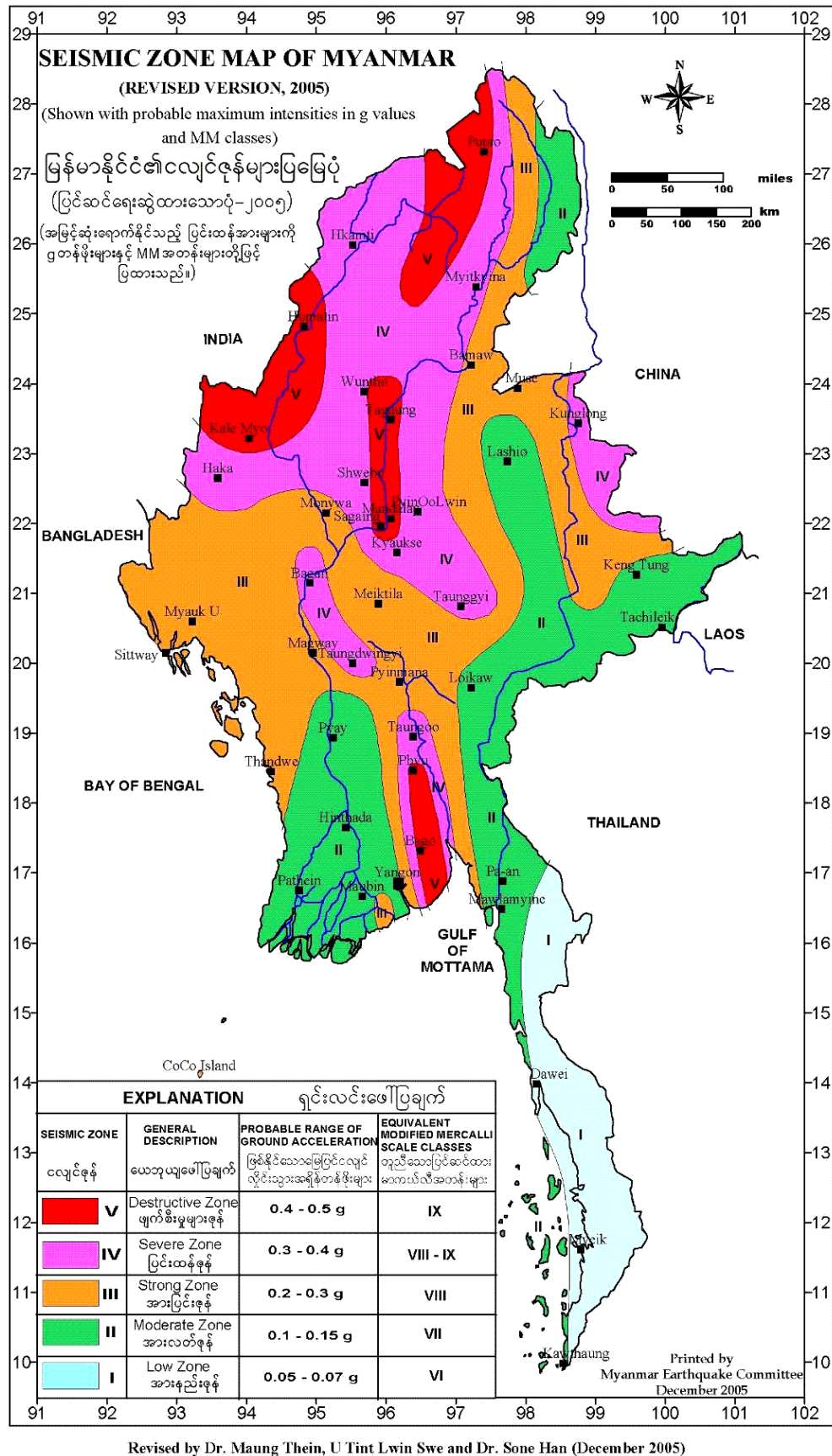


Figure 3.4.1.5: Seismic Zoning Map of Myanmar for Alternative Seismic Design Procedure according to Chapter 16 of UBC97 Code

TABLE 3.4.2 SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, SEE SECTION 3.4.1.3.4.2		
		Soil shear wave velocity, v_s (ft/s)	Standard penetration resistance, N	Soil undrained shear strength, s_u (psf)
A	Hard rock	$v_s > 5,000$	N/A	N/A
B	Rock	$2,500 < v_s \leq 5,000$	N/A	N/A
C	Very dense soil and soft rock	$1,200 < v_s \leq 2,500$	$N > 50$	$s_u \geq 2,000$
D	Stiff soil profile	$600 \leq v_s \leq 1,200$	$15 \leq N \leq 50$	$1,000 \leq s_u \leq 2,000$
E	Soft soil profile	$v_s < 600$	$N < 15$	$s_u < 1,000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $s_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 3.4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 303.48 mm, 1 square foot = 0.0929 m², 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

3.4.1.4.3 Site Coefficients and Adjusted Maximum Considered Earthquake (MCE) Spectral Response Acceleration Parameters.

The MCE spectral response acceleration for short periods (S_{MS}) and at 1 s (S_{M1}), adjusted for Site Class effects, shall be determined by Eqs.(3.4.1) and (3.4.2), respectively.

$$S_{MS} = F_a S_s \quad \text{Eq. [3.4.1]}$$

$$S_{M1} = F_v S_1 \quad \text{Eq. [3.4.2]}$$

where

S_s = the MCE spectral response acceleration at short periods as determined from Table 3.4.1

S_1 = the MCE spectral response acceleration at a period of 1 s as determined from Table 3.4.1

where site coefficients F_a and F_v are defined in Tables 3.4.3 and 3.4.4, respectively. Where the simplified design procedure of Section 3.4.2.14 is used, the value of F_a shall be determined in accordance with Section 3.4.2.14.8.1, and the values for F_v , S_{MS} , and S_{M1} need not be determined.

TABLE 3.4.3 SITE COEFFICIENT, F_a

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period				
	$S_s \leq 0.25$	$S_s = 0.5$	$S_s = 0.75$	$S_s = 1.0$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.3.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_s .

TABLE 3.4.4 SITE COEFFICIENT, F_v

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.3.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_1 .

3.4.1.4.4 Design Spectral Acceleration Parameters.

Design earthquake spectral response acceleration parameter at short period, S_{DS} , and at 1 s period, S_{D1} , shall be determined from Eqs.(3.4.3) and (3.4.4), respectively. Where the alternative simplified design procedure of Section 3.4.2.14 is used, the value of S_{DS} shall be determined in accordance with Section 3.4.2.13.4.8.1, and the value for S_{D1} need not be determined.

$$S_{DS} = 2/3 S_{MS} \quad \text{Eq.[3.4.3]}$$

$$S_{D1} = 2/3 S_{M1} \quad \text{Eq.[3.4.4]}$$

3.4.1.4.5 Design Response Spectrum

Where a design response spectrum is required by this standard and site-specific ground motion procedures are not used, the design response spectrum curve shall be developed as indicated in Fig. 3.4.1 and as follows:

1. For periods less than T_0 , the design spectral response acceleration, S_a , shall be taken as given by Eq. (3.4.5):

$$S_a = S_{DS} (0.4 + 0.6 T / T_0) \quad \text{Eq.[3.4.5]}$$

2. For periods greater than or equal to T_0 and less than or equal to T_s , the

design spectral response acceleration, S_a , shall be taken equal to S_{DS} .

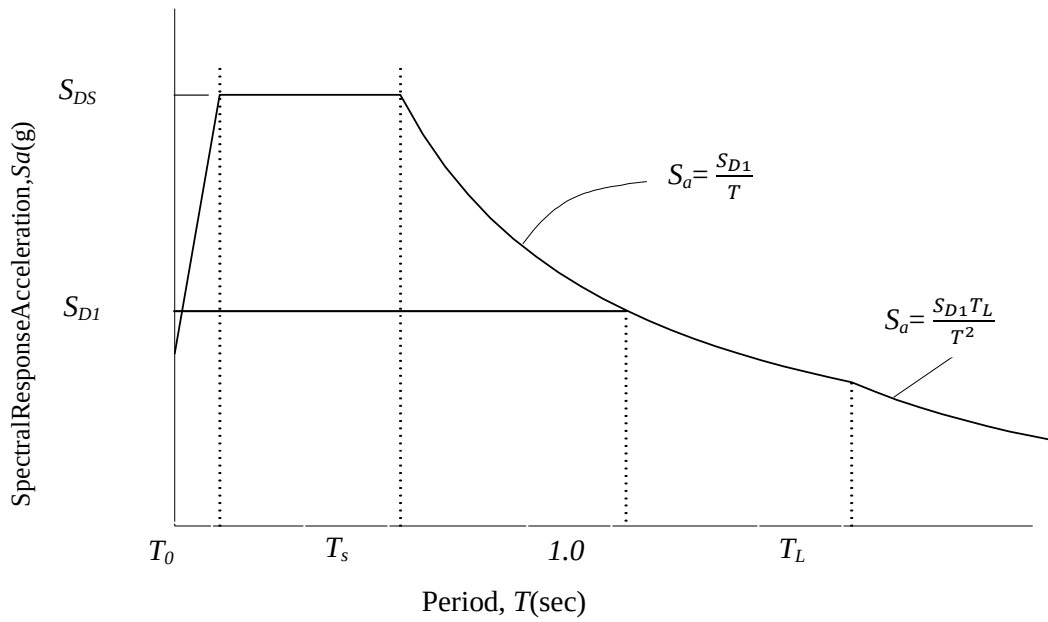


Figure 3.4.1 Design response spectrum

3. For periods greater than T_s , and less than or equal to T_L , the design spectral response acceleration, S_a , shall be taken as given by Eq. (3.4.6):

$$S_a = S_{D1}/T \quad \text{Eq.[3.4.6]}$$

4. For periods greater than T_L , S_a shall be taken as given by Eq. (3.4.7):

$$S_a = S_{D1}T_L/T^2 \quad \text{Eq.[3.4.7]}$$

where

S_{DS} = the design spectral response acceleration parameter at short periods

S_{D1} = the design spectral response acceleration parameter at 1-s period

T = the fundamental period of the structure, s

$$T_0 = 0.2 S_{D1}/S_{DS}$$

$$T_s = S_{D1}/S_{DS} \text{ and}$$

T_L = long-period transition period as specified in Table 3.4.1

3.4.1.4.6 MCE Response Spectrum

Where a MCE response spectrum is required, it shall be determined by multiplying the design response spectrum by 1.5.

3.4.1.4.7 Zoning Map and Peak Ground Acceleration

Where a MCE response spectrum is required, it shall be determined by multiplying the design response spectrum by 1.5.

As an alternative seismic design deterministic Seismic Zoning Map of Myanmar shall be used and the procedure for calculating base shear shall follow according to Chapter 16 of UBC97 Code.

3.4.1.4.7 Site-Specific Ground Motion Procedures

The site-specific ground motion procedures set forth in Chapter 21 of ASCE (see section 3.4.4) are permitted to be used to determine ground motions for any structure.

3.4.1.4.8 Site classification for seismic design

Site classification for Site Class C, D or E shall be determined from Table 3.4.5.

The notation presented below apply to the upper 100 feet (30 480 mm) of the site profile. Profiles containing distinctly different soil and/or rock layers shall be subdivided into those layers designated by a number that ranges from 1 to n at the bottom where there is a total of n distinct layers in the upper 100 feet (30 480 mm). The symbol i then refers to any one of the layers between 1 and n .

where

v_{si} = the shear wave velocity in feet per second (m/s).

d_i = the thickness of any layer between 0 and 100 feet (30 480 mm).

where

$$\bar{v}_s = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \frac{d_i}{v_{si}}} \quad \text{Eq.(3.4.8)}$$

$$\sum_{i=1}^n d_i = 100 \text{ feet (30 480 mm)}$$

N_i is the Standard Penetration Resistance (ASTM D 1586) not to exceed 100 blows/foot (305 mm) as directly measured in the field without corrections. When refusal is met for a rock layer, N_i shall be taken as 100 blows/foot (305 mm).

$$\bar{N} = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \frac{d_i}{N_i}} \quad \text{Eq.(3.4.9)}$$

where N_i and d_i in Equation (4-9) are for cohesionless soil, cohesive soil and rock layers.

$$\bar{N}_{ch} = \frac{d_s}{\sum_{i=1}^m \frac{d_i}{N_i}} \quad \text{Eq.(3.4.10)}$$

where

$$\sum_{i=1}^m d_i = d_s$$

Use d_i and N_i for cohesionless soil layers only in Equation (3.4.10)

d_s =total thickness of cohesionless soil layers in the top 100 feet (30 480 mm).

m =number of cohesionless soil layers in the top 100 feet (30 480 mm).

s_{ui} = the undrained shear strength in psf(kPa), not to exceed 5,000 psf (240 kPa), ASTM D2166 or D2850.

$$\bar{S}_u = \frac{d_c}{\sum_{i=1}^k \frac{d_i}{s_{ui}}} \quad \text{Eq.(3.4.11)}$$

where

$$\sum_{i=1}^k d_i = d_c$$

d_c =the total thickness of cohesive soil layers in the top 100 feet (30 480 mm).

k =the number of cohesive soil layers in the top 100 feet (30 480 mm).

PI =the plasticity index, ASTM D 4318

w =the moisture content in percent, ASTM D 2216

Where a site does not qualify under the criteria for Site Class F and there is a total thickness of soft clay greater than 10 feet (3048 mm) where a soft clay layer is defined by: $s_u < 500$ psf (24 kPa), $w \geq 40$ percent, and $PI > 20$, it shall be classified as Site Class E.

The shear wave velocity for rock, Site Class B, shall be either measured on site or estimated by a geotechnical engineer or engineering geologist/seismologist for competent rock with moderate fracturing and weathering. Softer and more highly fractured and weathered rock shall either be measured on site for shear wave velocity or classified as Site Class C.

The hard rock category, Site Class A, shall be supported by shear wave velocity measurements either on site or on profiles of the same rock type in the same formation with an equal or greater degree of weathering and fracturing. Where hard rock conditions are known to be continuous to a depth of 100 feet (30480 mm), surficial shear wave velocity measurements are permitted to be extrapolated to assess $\bar{v}_s$.

The rock categories, Site Classes A and B, shall not be used if there is more than 10 feet (3048 mm) of soil between the rock surface and the bottom of the spread footing or mat foundation.

TABLE 3.4.5
SITE CLASSIFICATION

SITE CLASS	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
E	< 600 ft/s	<15	<1,000 psf
D	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
C	1,200 to 2,500 ft/s	>50	>2,000

For SI: 1 foot per second = 304.8 mm per second, 1 pound per square foot = 0.0479 kN/m².

a. If the $\bar{s}_u$ method is used and the $\bar{N}_{ch}$ and $\bar{s}_u$ criteria differ, select the category with the softer soils (for example, use Site Class E instead of D).

3.4.1.4.8.1 Steps for classifying a site

1. Check for the four categories of Site Class F requiring site-specific evaluation. If the site corresponds to any of these categories, classify the site as Site Class F and conduct a site-specific evaluation.
2. Check for the existence of a total thickness of soft clay > 10 feet (3048 mm) where a soft clay layer is defined by: $s_u < 500$ psf (24kPa), $w \geq 40$ percent and $PI > 20$. If these criteria are satisfied, classify the site as Site Class E.
3. Categorize the site using one of the following three methods with $\bar{v}_s$, $\bar{N}$, and $\bar{s}_u$ and computed in all cases as specified:
 - (i) $\bar{v}_s$ for the top 100 feet (30480 mm) ($\bar{v}_s$ method)
 - (ii) $\bar{N}_{ch}$ for the top 100 feet (30480 mm) ($\bar{N}$ method)
 - (iii) $\bar{N}$ for cohesionless soil layers ($PI < 20$) in the top 100 feet (30480 mm) and average, $\bar{s}_u$ for cohesive soil layers ($PI > 20$) in the top 100 feet (30480 mm) ($\bar{s}_u$ method)

3.4.1.5 Importance Factor and Occupancy Category

3.4.1.5.1 Importance factor

An importance factor, I , shall be assigned to each structure in accordance with Table 3.4.6 based on the Occupancy Category from Table 1.2.

TABLE 3.4.6 IMPORTANCE FACTORS

OccupancyCategory	<i>I</i>
I or II	1.0
III	1.25
IV	1.5

3.4.1.5.2 Protected access for occupancy category IV

Where operational access to an Occupancy Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Occupancy Category IV structures. Where operational access is less than 10 ft from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Occupancy Category IV structure.

3.4.1.6 Seismic Design Category

Structures shall be assigned a Seismic Design Category in accordance with Section 3.4.1.6.1.

3.4.1.6.1 Assignment of Seismic Design Category

Occupancy Category I, II, or III structures located where the spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category E. Occupancy Category IV structures located where the spectral response acceleration parameter at 1-s period, S_1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category F. All other structures shall be assigned to a Seismic Design Category based on their Occupancy Category and the design spectral response acceleration parameters, S_{DS} and S_{DI} , determined in accordance with Section 3.4.1.4.4. Each building shall be assigned to the more severe Seismic Design Category in accordance with Table 3.4.7 or 3.4.8, irrespective of the fundamental period of vibration of the structure, T .

TABLE 3.4.7 SEISMIC DESIGN CATEGORY BASED ON SHORT PERIOD RESPONSE ACCELERATION PARAMETER

Value of S_{DS}	OccupancyCategory		
	I or II	III	IV
$S_{DS} < 0.167$	A	A	A
$0.167 \leq S_{DS} < 0.33$	B	B	C
$0.33 \leq S_{DS} < 0.50$	C	C	D
$0.50 \leq S_{DS}$	D	D	D

**TABLE 3.4.8 SEISMIC DESIGN CATEGORY BASED ON 1-S PERIOD RESPONSE
ACCELERATION PARAMETER**

Value of S_{D1}	Occupancy Category		
	I or II	III	IV
$S_{D1} < 0.067$	A	A	A
$0.067 \leq S_{D1} < 0.133$	B	B	C
$0.133 \leq S_{D1} < 0.20$	C	C	D
$0.20 \leq S_{D1}$	D	D	D

3.4.1.6.2 Alternative Seismic Design Category determination

Where S_I is less than 0.75, the Seismic Design Category is permitted to be determined from Table 3.4.7 alone where all of the following apply:

1. In each of the two orthogonal directions, the approximate fundamental period of the structure, T_a , determined in accordance with Section 3.4.2.8.2.1 is less than $0.8T_s$, where T_s is determined in accordance with Section 3.4.1.4.5.
2. In each of two orthogonal directions, the fundamental period of the structure used to calculate the storey drift is less than T_s .
3. Eq. (3.4.21) is used to determine the seismic response coefficient C_s .
- 3.4. The diaphragms are rigid as defined in Section 3.4.2.3.1.3 or for diaphragms that are flexible, the distance between vertical elements of the seismic force-resisting system does not exceed 40 ft.

3.4.1.6.3 Simplified design procedure

Where the alternative simplified design procedure of Section 3.4.2.14 is used, the Seismic Design Category is permitted to be determined from Table 3.4.7 alone, using the value of S_{DS} determined in Section 3.4.2.14.8.1.

3.4.1.7 Design Requirements for Seismic Design Category A

3.4.1.7.1 Applicability of seismic requirements for Seismic Design Category A structures.

Structures assigned to Seismic Design Category A need only comply with the requirements of Section 3.4.1.7. The effects on the structure and its components due to the forces prescribed in this section shall be taken as E and combined with the effects of other loads in accordance with the load combinations of Section 2.1.2 or 2.1.3.

3.4.1.7.2 Lateral forces.

Each structure shall be analyzed for the effects of static lateral forces applied independently in each of two orthogonal directions. In each direction, the static lateral forces at all levels shall be applied simultaneously. For purposes of analysis, the force at each level shall be determined using Eq. (3.4.12) as follows:

$$F_x = 0.01w_x E_q \quad (3.4.12)$$

where

F_x = the design lateral force applied at storey x , and

w_x = the portion of the total dead load of the structure, D , located or assigned to Level x

3.4.1.7.3 Load path connections

All parts of the structure between separation joints shall be interconnected to form a continuous path to the lateral force-resisting system, and the connections shall be capable of transmitting the lateral forces induced by the parts being connected. Any smaller portion of the structure shall be tied to the remainder of the structure with elements having design strength of not less than 5 percent of the portion's weight. This connection force does not apply to the overall design of the lateral force-resisting system. Connection design forces need not exceed the maximum forces that the structural system can deliver to the connection.

3.4.1.7.4 Connection to supports

A positive connection for resisting a horizontal force acting parallel to the member shall be provided for each beam, girder, or truss either directly to its supporting elements, or to slabs designed to act as diaphragms. Where the connection is through a diaphragm, then the member's supporting element must also be connected to the diaphragm. The connection shall have a minimum design strength of 5 percent of the dead plus live load reaction.

3.4.1.7.5 Anchorage of concrete or masonry walls

Concrete and masonry walls shall be anchored to the roof and all floors and members that provide lateral support for the wall or that are supported by the wall. The anchorage shall provide a direct connection between the walls and the roof or floor construction. The connections shall be capable of resisting the horizontal forces specified in Section 3.4.1.7.2, but not less than a minimum strength level horizontal force of 280 lb/ linear ft (3.4.09 kN/m) of wall substituted for E in the load combinations of Section 2.1.2 or 2.1.3.

3.4.1.8 Geologic Hazards and Geotechnical Investigation

3.4.1.8.1 Site limitation for Seismic Design Categories E and F

A structure assigned to Seismic Design Category E or F shall not be located where there is a known potential for an active fault to cause rupture of the ground surface at the structure.

3.4.1.8.2 Geotechnical investigation report for Seismic Design Categories C through F

A geotechnical investigation report shall be provided for a structure assigned to Seismic Design Category C, D, E, or F in accordance with this section. An investigation shall be conducted and a report shall be submitted that shall include an evaluation of the following potential geologic and seismic hazards:

- a. Slope instability;
- b. Liquefaction;
- c. Differential settlement;
- d. Surface displacement due to faulting or lateral spreading.

The report shall contain recommendations for appropriate foundation designs or other measures to mitigate the effects of the previously mentioned hazards. Where deemed appropriate by the authority having jurisdiction, a site-specific geotechnical report is not

required where prior evaluations of nearby sites with similar soil conditions provide sufficient direction relative to the proposed construction.

3.4.1.8.3 Additional geotechnical investigation report requirements for Seismic Design Categories D through F

The geotechnical investigation report for a structure assigned to Seismic Design Category D, E, or F shall include:

1. The determination of lateral pressures on basement and retaining walls due to earthquake motions;
2. The potential for liquefaction and soil strength loss evaluated for site peak ground accelerations, magnitudes, and source characteristics consistent with the design earthquake ground motions. Peak ground acceleration is permitted to be determined based on a site-specific study taking into account soil amplification effects or, in the absence of such a study, peak ground accelerations shall be assumed equal to $S_s / 2.5$;
3. Assessment of potential consequences of liquefaction and soil strength loss, including estimation of differential settlement, lateral movement, lateral loads on foundations, reduction in foundation soil-bearing capacity, increases in lateral pressures on retaining walls, and flotation of buried structures;
4. Discussion of mitigation measures such as, but not limited to, ground stabilization, selection of appropriate foundation type and depths, selection of appropriate structural systems to accommodate anticipated displacements and forces, or any combination of these measures and how they shall be considered in the design of the structure.

3.4.2 Seismic Design Requirements for Building Structures

3.4.2.1 Structural Design Basis

3.4.2.1.1 Basic requirements

The seismic analysis and design procedures to be used in the design of building structures and their components shall be as prescribed in this section. The building structure shall include complete lateral and vertical force-resisting systems capable of providing adequate strength, stiffness, and energy dissipation capacity to withstand the design ground motions within the prescribed limits of deformation and strength demand. The design ground motions shall be assumed to occur along any horizontal direction of a building structure. The adequacy of the structural systems shall be demonstrated through the construction of a mathematical model and evaluation of this model for the effects of design ground motions. The design seismic forces, and their distribution over the height of the building structure, shall be established in accordance with one of the applicable procedures indicated in Section 3.4.2.6 and the corresponding internal forces and deformations in the members of the structure shall be determined. An approved alternative procedure shall not be used to establish the seismic forces and their distribution unless the corresponding internal forces and deformations in the members are determined using a model consistent with the procedure adopted.

EXCEPTION: As an alternative, the simplified design procedures of Section 3.4.2.14 is permitted to be used in lieu of the requirements of Sections 3.4.2.1 through 3.4.2.12, subject to all of the limitations contained in Section 3.4.2.14

3.4.2.1.2 Member design, connection design, and deformation limit

Individual members, including those not part of the seismic force-resisting system, shall be provided with adequate strength to resist the shears, axial forces, and moments determined in accordance with this standard, and connections shall develop the strength of the connected members or the forces indicated in Section 3.4.2.1.1. The deformation of the structure shall not exceed the prescribed limits where the structure is subjected to the design seismic forces.

3.4.2.1.3 Continuous load path and interconnection

A continuous load path, or load paths, with adequate strength and stiffness shall be provided to transfer all forces from the point of application to the final point of resistance. All parts of the structure between separation joints shall be interconnected to form a continuous path to the seismic force-resisting system, and the connections shall be capable of transmitting the seismic force (F_p) induced by the parts being connected. Any smaller portion of the structure shall be tied to the remainder of the structure with elements having a design strength capable of transmitting a seismic force of 0.133 times the short period design spectral response acceleration parameter, S_{DS} , times the weight of the smaller portion or 5 percent of the portion's weight, whichever is greater. This connection force does not apply to the overall design of the seismic force-resisting system. Connection design forces need not exceed the maximum forces that the structural system can deliver to the connection.

3.4.2.1.4 Connection to supports

A positive connection for resisting a horizontal force acting parallel to the member shall

be provided for each beam, girder, or truss either directly to its supporting elements, or to slabs designed to act as diaphragms. Where the connection is through a diaphragm, then the member's supporting element must also be connected to the diaphragm. The connection shall have a minimum design strength of 5 percent of the dead plus live load reaction.

3.4.2.1.5 Foundation design

The foundation shall be designed to resist the forces developed and accommodate the movements imparted to the structure by the design ground motions. The dynamic nature of the forces, the expected ground motion, the design basis for strength and energy dissipation capacity of the structure, and the dynamic properties of the soil shall be included in the determination of the foundation design criteria. The design and construction of foundations shall comply with Section 3.4.2.13

3.4.2.1.6 Material design and detailing requirements

Structural elements including foundation elements shall conform to the material design and detailing requirements set forth in later sections on material design standards.

3.4.2.2 Structural System Selection

3.4.2.2.1 Selection and limitations

The basic lateral and vertical seismic force-resisting system shall conform to one of the types indicated in Table 3.4.9 or a combination of systems as permitted in Sections 3.4.2.2.2, 3.4.2.2.3, and 3.4.2.2.4. Each type is subdivided by the types of vertical elements used to resist lateral seismic forces. The structural system used shall be in accordance with the Seismic Design Category and height limitations indicated in Table 3.4.9. The appropriate response modification coefficient, R , system overstrength factor, Ω_0 , and the deflection amplification factor, C_d , indicated in Table 3.4.9 shall be used in determining the base shear, element design forces, and design storey drift.

Seismic force-resisting systems that are not contained in Table 3.4.9 are permitted if analytical and test data are submitted that establish the dynamic characteristics and demonstrate the lateral force resistance and energy dissipation capacity to be equivalent to the structural systems listed in Table 3.4.9 for equivalent response modification coefficient, R , system overstrength coefficient, Ω_0 , and deflection amplification factor, C_d , values.

The selected seismic force-resisting system shall be designed and detailed in accordance with the specific requirements for the system per the applicable reference document and the additional requirements set forth in later sections on material design standards.

3.4.2.2.2 Combinations of framing systems in different directions

Different seismic force-resisting systems are permitted to be used to resist seismic forces along each of the two orthogonal axes of the structure. Where different systems are used, the respective R , C_d , and Ω_0 coefficients shall apply to each system, including the limitations on system use contained in Table 3.4.9.

3.4.2.2.3 Combinations of framing systems in the same direction

Where different seismic force-resisting systems are used in combination to resist seismic forces in the same direction of structural response, other than those

combinations considered as dual systems, the more stringent system limitation contained in Table 3.4.9 shall apply and the design shall comply with the requirements of this section.

TABLE 3.4.9 DESIGN COEFFICIENTS AND FACTORS FOR SEISMIC FORCE-RESISTING SYSTEMS

Seismic Force-Resisting System	ASCE 7 Section where Detailing Requirements are Specified	Response Modification Coefficient, R_a	System Overstrength Factor, Ω_0	Deflection Amplification Factor, C_{db}	Structural System Limitations and Building Height (ft) Limits				
					Seismic Design Category				
					B	C	Dd	Ed	Fe
A. BEARING WALL SYSTEMS									
1. Special reinforced concrete shear walls	13.4.2 and 13.4.2.3.6	5	2½	5	NL	NL	160	160	100
2. Ordinary reinforced concrete shear walls	13.4.2 and 13.4.2.3.4	4	2½	4	NL	NL	NP	NP	NP
3. Detailed plain concrete shear walls	13.4.2 and 13.4.2.3.2	2	2½	2	NL	NP	NP	NP	NP
3.4. Ordinary plain concrete shear walls	13.4.2 and 13.4.2.3.1	1½	2½	1½	NL	NP	NP	NP	NP
5. Intermediate precast shear walls	13.4.2 and 13.4.2.3.5	4	2½	4	NL	NL	40k	40k	40k
6. Ordinary precast shear walls	13.4.2 and 13.4.2.3.3	3	2½	3	NL	NP	NP	NP	NP
7. Special reinforced masonry shear walls	13.4.4 and 13.4.3.4.3	5	2½	3½	NL	NL	160	160	100
8. Intermediate reinforced masonry shear walls	13.4.4 and 13.4.3.4.3	3½	2½	2¼	NL	NL	NP	NP	NP
9. Ordinary reinforced masonry shear walls	13.4.4	2	2½	1¾	NL	160	NP	NP	NP
10. Detailed plain masonry shear walls	13.4.4	2	2½	1¾	NL	NP	NP	NP	NP
11. Ordinary plain masonry shear walls	13.4.4	1½	2½	1¼	NL	NP	NP	NP	NP
12. Prestressed masonry shear walls	13.4.4	1½	2½	1¾	NL	NP	NP	NP	NP
13. Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets	13.4.1 and 13.4.1.3.4.2, and 13.4.5	6½	3	4	NL	NL	65	65	65
14. Light-framed walls with shear panels of all other materials	13.4.1 and 13.4.1.3.4.2, and 13.4.5	2	2½	2	NL	NL	35	NP	NP
15. Light-framed wall systems using flat strap bracing	13.4.1 and 13.4.1.3.4.2, and 13.4.5	4	2	3½	NL	NL	65	65	65
B. BUILDING FRAME SYSTEMS									
1. Steel eccentrically braced frames, moment resisting connections at columns away from links	13.4.1	8	2	4	NL	NL	160	160	100
2. Steel eccentrically braced frames, non-moment-resisting, connections at columns away from links	13.4.1	7	2	4	NL	NL	160	160	100
3. Special steel concentrically braced frames	13.4.1	6	2	5	NL	NL	160	160	100
3.4. Ordinary steel concentrically braced frames	13.4.1	3¼	2	2½	NL	NL	35j	35j	NPj
5. Special reinforced concrete shear walls	13.4.2 and 13.4.2.3.6	6	2½	5	NL	NL	160	160	100
6. Ordinary reinforced concrete shear walls	13.4.2 and 13.4.2.3.4	5	2½	4½	NL	NL	NP	NP	NP

**TABLE 3.4.9 DESIGN COEFFICIENTS AND FACTORS FOR SEISMIC FORCE-RESISTING SYSTEMS
(CONTINUED)**

Seismic Force-Resisting System	ASCE 7 Section where Detailing Requirements are Specified	Response Modification Coefficient, R^a	System Overstrength Factor, Ω_0^g	Deflection Amplification Factor, C_d^b	Structural System Limitations and Building Seismic Design Category				
					B	C	D ^d	E ^d	F ^e
7. Detailed plain concrete shear walls	13.4.2 and 13.4.2.3.2	2	2½	2	NL	NP	NP	NP	NP
8. Ordinary plain concrete shear walls	13.4.2 and 13.4.2.3.1	1½	2½	1½	NL	NP	NP	NP	NP
9. Intermediate precast shear walls	13.4.2 and 13.4.2.3.5	5	2½	4½	NL	NL	40 ^k	40 ^k	40 ^k
10. Ordinary precast shear walls	13.4.2 and 13.4.2.3.3	4	2½	4	NL	NP	NP	NP	NP
11. Composite steel and concrete eccentrically braced frames	13.4.3	8	2	4	NL	NL	160	160	100
12. Composite steel and concrete concentrically braced frames	13.4.3	5	2	4½	NL	NL	160	160	100
13. Ordinary composite steel and concrete braced frames	13.4.3	3	2	3	NL	NL	NP	NP	NP
13.4. Composite steel plate shear walls	13.4.3	6½	2½	5½	NL	NL	160	160	100
15. Special composite reinforced concrete shear walls with steel elements	13.4.3	6	2½	5	NL	NL	160	160	100
16. Ordinary composite reinforced concrete shear walls with steel elements	13.4.3	5	2½	4½	NL	NL	NP	NP	NP
17. Special reinforced masonry shear walls	13.4.4	5½	2½	4	NL	NL	160	160	100
18. Intermediate reinforced masonry shear walls	13.4.4	4	2½	4	NL	NL	NP	NP	NP
19. Ordinary reinforced masonry shear walls	13.4.4	2	2½	2	NL	160	NP	NP	NP
20. Detailed plain masonry shear walls	14	2	2½	2	NL	NP	NP	NP	NP
21. Ordinary plain masonry shear walls	14	1½	2½	1¼	NL	NP	NP	NP	NP
22. Prestressed masonry shear walls	13.4.4	1½	2½	1¾	NL	NP	NP	NP	NP
23. Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets	13.4.1, 13.4.1.3.4.2, and 13.4.5	7	2½	4½	NL	NL	65	65	65
23.4. Light-framed walls with shear panels of all other materials	13.4.1, 13.4.1.3.4.2, and 13.4.5	2½	2½	2½	NL	NL	35	NP	NP
25. Buckling-restrained braced frames, non-moment-resisting beam-column connections	13.4.1	7	2	5½	NL	NL	160	160	100
26. Buckling-restrained braced frames, moment-resisting beam-column connections	13.4.1	8	2½	5	NL	NL	160	160	100
27. Special steel plate shear	13.4.1	7	2	6	NL	NL	160	160	100
C. MOMENT-RESISTING FRAME SYSTEMS									
1. Special steel moment frames	13.4.1 and	8	3	5½	NL	NL	NL	NL	NL
2. Special steel truss moment frames	13.4.1	7	3	5½	NL	NL	160	100	NP

TABLE 3.4.9 DESIGN COEFFICIENTS AND FACTORS FOR SEISMIC FORCE-RESISTING SYSTEMS (CONTINUED)

Seismic Force-Resisting System	ASCE 7 Section where Detailing Requirements are Specified	Response Modification Coefficient, R^a	System Overstrength Factor, Ω_0^g	Deflection Amplification Factor, C_d^b	Structural System Limitations and Building Seismic Design Category				
					B	C	D ^d	E ^d	F ^e
3. Intermediate steel moment frames	12.2.5.6, 12.2.5.7, 12.2.5.8, 12.2.5.9.	3.4.5	3	4	NL	NL	35 ^{h,i}	NP ^h	NP ⁱ
3.4. Ordinary steel moment frames	12.2.5.6, 12.2.5.7, 12.2.5.8 and 12.2.5.9.	3.5	3	3	NL	NL	NP ^h	NP ^h	NP ⁱ
5. Special reinforced concrete moment frames	12.2.5.5 and 13.4.2	8	3	5½	NL	NL	NL	NL	NL
6. Intermediate reinforced concrete moment frames	13.4.2	5	3	4½	NL	NL	NP	NP	NP
7. Ordinary reinforced concrete moment frames	13.4.2	3	3	2½	NL	NP	NP	NP	NP
8. Special composite steel and concrete moment frames	12.2.5.5 and 13.4.3	8	3	5½	NL	NL	NL	NL	NL
9. Intermediate composite moment frames	13.4.3	5	3	4½	NL	NL	NP	NP	NP
10. Composite partially restrained moment frames	13.4.3	6	3	5½	160	160	100	NP	NP
11. Ordinary composite moment frames	13.4.3	3	3	5½	NL	NP	NP	NP	NP
D. DUAL SYSTEMS WITH SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1. Steel eccentrically braced	13.4.1	8	2½	4	NL	NL	NL	NL	NL
2. Special steel concentrically braced frames	13.4.1	7	2½	5½	NL	NL	NL	NL	NL
3. Special reinforced concrete shear walls	13.4.2	7	2½	5½	NL	NL	NL	NL	NL
3.4. Ordinary reinforced concrete shear walls	13.4.2	6	2½	5	NL	NL	NP	NP	NP
5. Composite steel and concrete eccentrically braced	13.4.3	8	2½	4	NL	NL	NL	NL	NL
6. Composite steel and concrete concentrically braced	13.4.3	6	2½	5	NL	NL	NL	NL	NL
7. Composite steel plate shear walls	13.4.3	7½	2½	6	NL	NL	NL	NL	NL
8. Special composite reinforced concrete shear walls with steel elements	13.4.3	7	2½	6	NL	NL	NL	NL	NL
9. Ordinary composite reinforced concrete shear walls with steel elements	13.4.3	6	2½	5	NL	NL	NP	NP	NP
10. Special reinforced masonry shear walls	13.4.4	5½	3	5	NL	NL	NL	NL	NL
11. Intermediate reinforced masonry shear walls	13.4.4	4	3	3½	NL	NL	NP	NP	NP
12. Buckling-restrained braced frame	13.4.1	8	2½	5	NL	NL	NL	NL	NL

TABLE 3.4.9 DESIGN COEFFICIENTS AND FACTORS FOR SEISMIC FORCE-RESISTING SYSTEMS (CONTINUED)

Seismic Force-Resisting System	ASCE 7 Section where Detailing Requirements are Specified	Response Modification Coefficient, R^a	System Overstrength Factor, Ω_0^g	Deflection Amplification Factor, C_d^b	Structural System Limitations and Building Height (ft) Limit ^c				
					Seismic Design Category				
					B	C	D ^d	E ^d	F ^e
13.Special steel plate shear walls	13.4.1	8	2½	6½	NL	NL	NL	NL	NL
E.DUAL SYSTEMS WITH INTERMEDIATE MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1.Special steel concentrically braced frames ^f	13.4.1	6	2½	5	NL	NL	35	NP	NP ^{h, k}
2.Special reinforced concrete shear walls	13.4.2	6½	2½	5	NL	NL	160	100	100
3.Ordinary reinforced masonry shear walls	13.4.4	3	3	2½	NL	160	NP	NP	NP
3.4.Intermediate reinforced masonry shear walls	13.4.4	3½	3	3	NL	NL	NP	NP	NP
5.Composite steel and concrete concentrically braced frames	13.4.3	5½	2½	4½	NL	NL	160	100	NP
6.Ordinary composite braced frames	13.4.3	3½	2½	3	NL	NL	NP	NP	NP
7.Ordinary composite reinforced concrete shear walls with steel elements	13.4.3	5	3	4½	NL	NL	NP	NP	NP
8.Ordinary reinforced concrete shear walls	13.4.2	5½	2½	4½	NL	NL	NP	NP	NP
F.SHEAR WALL-FRAME INTERACTIVE SYSTEM WITH ORDINARY REINFORCED CONCRETE MOMENT FRAMES AND ORDINARY REINFORCED CONCRETE SHEAR WALLS	12.2.5.10 and 13.4.2	4½	2½	4	NL	NP	NP	NP	NP
G.CANTILEVERED COLUMN SYSTEMS DETAILED TO CONFORM TO THE REQUIREMENTS FOR	12.2.5.2								
1.Special steel moment frames	12.2.5.5 and 13.4.1	2½	1¼	2½	35	35	35	35	35
2.Intermediate steel moment frames	13.4.1	1½	1¼	1½	35	35	35h	NPh, i	NPh, i
3.Ordinary steel moment frames	13.4.1	1¼	1¼	1¼	35	35	NP	NPh,	NPh,
3.4.Special reinforced concrete moment frames	12.2.5.5 and 13.4.2	2½	1¼	2½	35	35	35	35	35
5.Intermediate concrete moment frames	13.4.2	1½	1¼	1½	35	35	NP	NP	NP
6.Ordinary concrete moment frames	13.4.2	1	1¼	1	35	NP	NP	NP	NP
7.Timber frames	13.4.5	1½	1½	1½	35	35	35	NP	NP
H.STEEL SYSTEMS NOT SPECIFICALLY DETAILED FOR SEISMIC RESISTANCE, EXCLUDING CANTILEVER COLUMN SYSTEMS	13.4.1	3	3	3	NL	NL	NP	NP	NP

- a. Response modification coefficient, R , for use throughout the standard. Note R reduces forces to a strength level, not an allowable stress level.
- b. Reflection amplification factor, C_d , for use in Sections 3.4.2.8.6 and 3.4.2.8.7
- c. NL = Not Limited and NP = Not Permitted. For metric units use 30.5 m for 100 ft and use 48.8 m for 160 ft. Heights are measured from the base of the structure as defined in Section 3.4.1.2.
- d. See Section 3.4.2.2.5.4 for a description of building systems limited to buildings with a height of 240 ft (73.2 m) or less.
- e. See Section 3.4.2.2.5.4 for building systems limited to buildings with a height of 160 ft (48.8m) or less.
- f. Ordinary moment frame is permitted to be used in lieu of intermediate moment frame for Seismic Design Categories B or C.
- g. The tabulated value of the overstrength factor, ϕ , is permitted to be reduced by subtracting one-half for structures with flexible diaphragms, but shall not be taken as less than 2.0 for any structure.
- h. See Sections 3.4.2.2.5.6 and 3.4.2.2.5.7 for limitations for steel OMFs and IMFs in structures assigned to Seismic Design Category D or E.
- i. See Sections 3.4.2.2.5.8 and 3.4.2.2.5.9 for limitations for steel OMFs and IMFs in structures assigned to Seismic Design Category F.
- j. Steel ordinary concentrically braced frames are permitted in single-storey buildings up to a height of 60 ft (18.3 m) where the dead load of the roof does not exceed 20 psf (0.96 kN/m²) and in penthouse structures.
- k. Increase in height to 45 ft (13.7 m) is permitted for single storey storage warehouse facilities.

3.4.2.2.3.1 R , C_d , and Ω_0 values for vertical combinations.

The value of the response modification coefficient, R , used for design at any storey shall not exceed the lowest value of R that is used in the same direction at any storey above that storey. Likewise, the deflection amplification factor, C_d , and the system overstrength factor, Ω_0 , used for the design at any storey shall not be less than the largest value of this factor that is used in the same direction at any storey above that storey.

EXCEPTIONS:

1. Rooftop structures not exceeding two storeys in height and 10 percent of the total structure weight.
2. Other supported structural systems with a weight equal to or less than 10 percent of the weight of the structure.
3. Detached one- and two-family dwellings of light-frame construction.

A two-stage equivalent lateral force procedure is permitted to be used for structures having a flexible upper portion above a rigid lower

portion, provided that the design of the structure complies with the following:

- a. The stiffness of the lower portion must be at least 10 times the stiffness of the upper portion.
- b. The period of the entire structure shall not be greater than 1.1 times the period of the upper portion considered as a separate structure fixed at the base.
- c. The flexible upper portion shall be designed as a separate structure using the appropriate values of R and ρ .
- d. The rigid lower portion shall be designed as a separate structure using the appropriate values of R and ρ . The reactions from the upper portion shall be those determined from the analysis of the upper portion amplified by the ratio of the R/ρ of the upper portion over R/ρ of the lower portion. This ratio shall not be less than 1.0.

3.4.2.2.3.2 R , C_d , and Ω_0 values for horizontal combinations

Where a combination of different structural systems is utilized to resist lateral forces in the same direction, the value of R used for design in that direction shall not be greater than the least value of R for any of the systems utilized in that direction. Resisting elements are permitted to be designed using the least value of R for the different structural systems found in each independent line of resistance if the following three conditions are met: (1) Occupancy Category I or II building, (2) two storeys or less in height, and (3) use of light-frame construction or flexible diaphragms. The value of R used for design of diaphragms in such structures shall not be greater than the least value for any of the systems utilized in the same direction.

The deflection amplification factor, C_d , and the system over strength factor, Ω_0 , in the direction under consideration at any storey shall not be less than the largest value of this factor for the R factor used in the same direction being considered.

3.4.2.2.4 Combination framing detailing requirements

Structural components common to different framing systems used to resist seismic motions in any direction shall be designed using the detailing requirements of Section 3.4.2 required by the highest response modification coefficient, R , of the connected framing systems.

3.4.2.2.5 System specific requirements

The structural framing system shall also comply with the following system specific requirements of this section.

3.4.2.2.5.1 Dual system

For a dual system, the moment frames shall be capable of resisting at least 25 percent of the design seismic forces. The total seismic force resistance is to be provided by the combination of the moment frames and

the shear walls or braced frames in proportion to their rigidities.

3.4.2.2.5.2 Cantilever column systems

Cantilever column systems are permitted as indicated in Table 3.4.9 and as follows. The axial load on individual cantilever column elements calculated in accordance with the load combinations of Section 2.1.2 shall not exceed 15 percent of the design strength of the column to resist axial loads alone, or for allowable stress design, the axial load stress on individual cantilever column elements, calculated in accordance with the load combinations of Section 2.1.3 shall not exceed 15 percent of the permissible axial stress.

Foundation and other elements used to provide overturning resistance at the base of cantilever column elements shall have the strength to resist the load combinations with overstrength factor of Section 3.4.2.4.3.2.

3.4.2.2.5.3 Inverted pendulum-type structures

Regardless of the structural system selected, inverted pendulums as defined in Section 3.4.1.2, shall comply with this section. Supporting columns or piers of inverted pendulum-type structures shall be designed for the bending moment calculated at the base determined using the procedures given in Section 3.4.2.8 and varying uniformly to a moment at the top equal to one-half the calculated bending moment at the base.

3.4.2.2.5.4 Increased building height limit for steel braced frames and special reinforced concrete shear walls

The height limits in Table 3.4.9 are permitted to be increased from 160 ft (50 m) to 240 ft (75 m) for structures assigned to Seismic Design Categories D or E and from 100 ft (30 m) to 160 ft (50 m) for structures assigned to Seismic Design Category F that have steel braced frames or special reinforced concrete cast-in-place shear walls and that meet both of the following requirements:

1. The structure shall not have an extreme torsional irregularity as defined in Table 3.4.9 (horizontal structural irregularity Type 1b).
2. The braced frames or shear walls in any one plane shall resist no more than 60 percent of the total seismic forces in each direction, neglecting accidental torsional effects.

3.4.2.2.5.5 Special moment frames in structures assigned to Seismic Design Categories D through F

For structures assigned to Seismic Design Categories D, E, or F, a special moment frame that is used but not required by Table 3.4.9 shall not be discontinued and supported by a more rigid system with a lower response modification coefficient, R , unless the requirements of Sections 3.4.2.3.3.2 and 3.4.2.3.3.4 are met. Where a special moment frame is required by Table 3.4.9, the frame shall be continuous to the foundation.

3.4.2.2.5.6 Single-storey steel ordinary and intermediate moment frames in structures assigned to Seismic Design Category D or E

Single-storey steel ordinary moment frames and intermediate moment frames in structures assigned to Seismic Design Category D or E are permitted up to a height of 65 ft (20 m) where the dead load supported by and tributary to the roof does not exceed 20 psf (0.96 kN/m²). In addition, the dead loads tributary to the moment frame, of the exterior wall more than 35 ft above the base shall not exceed 20 psf (0.96 kN/m²).

3.4.2.2.5.7 Other steel ordinary and intermediate moment frames in structures assigned to Seismic Design Category D or E

Steel ordinary moment frames in structures assigned to Seismic Design Category D or E not meeting the limitations set forth in Section 3.4.2.2.5.6 are permitted within light-frame construction up to a height of 35 ft (10.6 m) where neither the roof nor the floor dead load supported by and tributary to the moment frames exceeds 35 psf (1.68 kN/m²). In addition, the dead load of the exterior walls tributary to the moment frame shall not exceed 20 psf (0.96 kN/m²). Steel intermediate moment frames in structures assigned to Seismic Design Category D or E not meeting the limitations set forth in Section 3.4.2.2.5.6 permitted as follows:

1. In Seismic Design Category D, intermediate moment frames are permitted to a height of 35 ft (10.6 m).
2. In Seismic Design Category E, intermediate moment frames are permitted to a height of 35 ft (10.6 m) provided neither the roof nor the floor dead load supported by and tributary to the moment frames exceeds 35 psf (1.68 kN/m²). In addition, the dead load of the exterior walls tributary to the moment frame shall not exceed 20 psf (0.96 kN/m²).

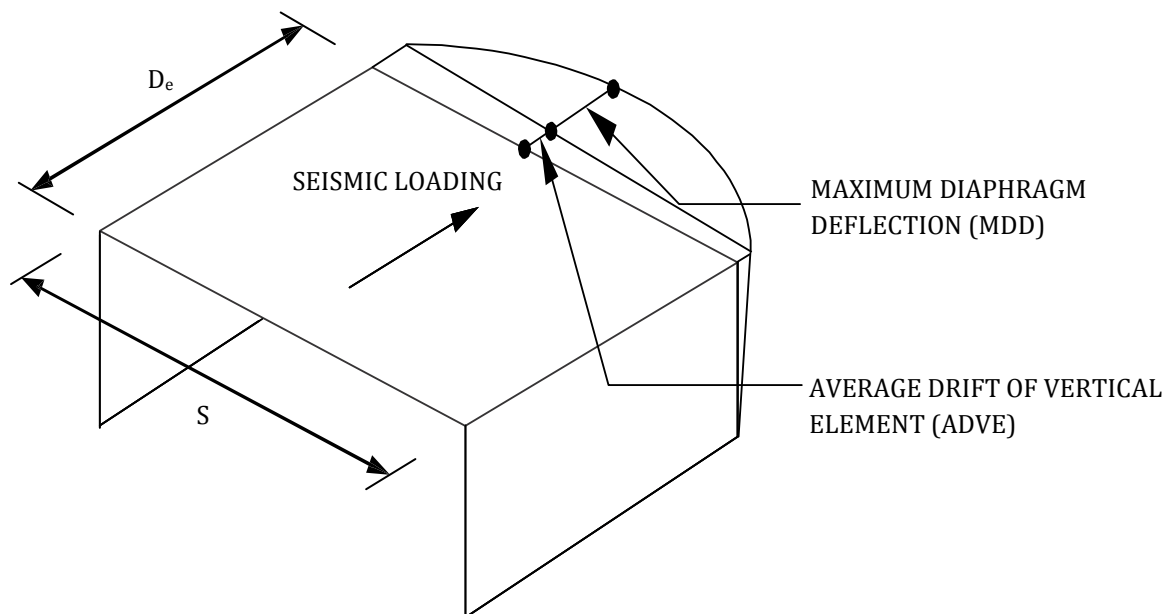


Figure 3.4.2 Flexible diaphragm

3.4.2.2.5.8 Single-storey steel ordinary and intermediate moment frames in structures assigned to Seismic Design Category F

Single-storey steel ordinary moment frames and intermediate moment frames in structures assigned to Seismic Design Category F are permitted up to a height of 65 ft (20m) where the dead load supported by and tributary to the roof does not exceed 20 psf (0.96 kN/m²). In addition, the dead loads of the exterior walls tributary to the moment frame shall not exceed 20 psf (0.96 kN/m²).

3.4.2.2.5.9 Other steel intermediate moment frame limitations in structures assigned to Seismic Design Category F

In addition to the limitations for steel intermediate moment frames in structures assigned to Seismic Design Category E as set forth in Section 3.4.2.2.5.7, steel intermediate moment frames in structures assigned to Seismic Design Category F are permitted in light-frame construction.

3.4.2.2.5.10 Shear wall-frame interactive systems

The shear strength of the shear walls of the shear wall-frame interactive system shall be at least 75 percent of the design storey shear at each storey. The frames of the shear wall-frame interactive system shall be capable of resisting at least 25 percent of the design storey shear in every storey.

3.4.2.3 Diaphragm Flexibility, Configuration Irregularities, and Redundancy

3.4.2.3.1 Diaphragm flexibility

The structural analysis shall consider the relative stiffnesses of diaphragms and the vertical elements of the seismic force-resisting system. Unless a diaphragm can be idealized as either flexible or rigid in accordance with Sections 3.4.2.3.1.1, 3.4.2.3.1.2, or 3.4.2.3.1.3, the structural analysis shall explicitly include consideration of the stiffness of the diaphragm (i.e., semirigid modeling assumption).

3.4.2.3.1.1 Flexible diaphragm condition

Diaphragms constructed of untopped steel decking or wood structural panels are permitted to be idealized as flexible in structures in which the vertical elements are steel or composite steel and concrete braced frames, or concrete, masonry, steel, or composite shear walls. Diaphragms of wood structural panels or untopped steel decks in one- and two-family residential buildings of light-frame construction shall also be permitted to be idealized as flexible.

3.4.2.3.1.2 Alternatives to ASCE 7

The following provisions shall be permitted as alternatives to the relevant provisions of ASCE 7. Diaphragms constructed of wood structural panels or untopped steel decking shall also be permitted to be idealized as flexible, provided all of the following conditions are met:

1. Toppings of concrete or similar materials are not placed over wood structural panel diaphragms except for nonstructural toppings no greater than 1½ inches (38 mm) thick.
2. Each line of vertical elements of the lateral-force-resisting system complies with the allowable storey drift of Table 3.4.8.

3. Vertical elements of the lateral-force-resisting system are light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets.

4. Portions of wood structural panel diaphragms that cantilever beyond the vertical elements of the lateral-force-resisting system are designed in accordance with Section 2305.2.5 of the International Building Code.

3.4.2.3.1.3 Rigid diaphragm condition

Diaphragms of concrete slabs or concrete-filled metal deck with span-to-depth ratios of 3 or less in structures that have no horizontal irregularities are permitted to be idealized as rigid.

3.4.2.3.1.4 Calculated flexible diaphragm condition

Diaphragms not satisfying the conditions of Sections 3.4.2.3.1.1 or 3.4.2.3.1.2 are permitted to be idealized as flexible where the computed maximum in-plane deflection of the diaphragm under lateral load is more than two times the average storey drift of adjoining vertical elements of the seismic force-resisting system of the associated storey under equivalent tributary lateral load as shown in Fig. 3.4.2. The loadings used for this calculation shall be those prescribed by Section 3.4.2.8.

3.4.2.3.2 Irregular and regular classification

Structures shall be classified as regular or irregular based upon the criteria in this section. Such classification shall be based on horizontal and vertical configurations.

3.4.2.3.2.1 Horizontal irregularity

Structures having one or more of the irregularity types listed in Table 3.4.10 shall be designated as having horizontal structural irregularity.

Such structures assigned to the seismic design categories listed in Table 3.4.10 shall comply with the requirements in the sections referenced in that table.

3.4.2.3.2.2 Vertical irregularity

Structures having one or more of the irregularity types listed in Table 3.4.11 shall be designated as having vertical irregularity. Such structures assigned to the Seismic Design Categories listed in Table 3.4.11 shall comply with the requirements in the sections referenced in that table.

EXCEPTIONS:

1. Vertical structural irregularities of Types 1a, 1b, or 2 in Table 3.4.11 do not apply where no storey drift ratio under design lateral seismic force is greater than 130 percent of the storey drift ratio of the next storey above. Torsional effects need not be considered in the calculation of storey drifts. The storey drift ratio relationship for the top two storeys of the structure are not required to be evaluated.

2. Irregularities of Types 1a, 1b, and 2 in Table 3.4.11 are not required to be considered for one-storey buildings in any Seismic Design Category or for two-storey buildings assigned to Seismic Design Categories B, C, or D.

3.4.2.3.3 Limitations and additional requirements for systems with structural irregularities

3.4.2.3.3.1 Prohibited horizontal and vertical irregularities for Seismic Design Categories D through F

Structures assigned to Seismic Design Category E or F having horizontal irregularity Type 1b of Table 3.4.10 or vertical irregularities Type 1b, 5a, or 5b of Table 3.4.11 shall not be permitted. Structures assigned to Seismic Design Category D having vertical irregularity Type 5b of Table 3.4.11 shall not be permitted.

TABLE 3.4.10 HORIZONTAL STRUCTURAL IRREGULARITIES

	Irregularity Type and Description	Reference Section	Seismic Design Category Application
1a.	Torsional Irregularity is defined to exist where the maximum storey drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure. Torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.	3.4.2.3.3.4 3.4.2.8.3.4.3 3.4.2.7.3 3.4.2.12.1 Table 3.4.13 3.4.3.2.2	D, E, and F C, D, E, and F B, C, D, E, and F C, D, E, and F D, E, and F B, C, D, E, and F
1b.	Extreme Torsional Irregularity is defined to exist where the maximum storey drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.4 times the average of the storey drifts at the two ends of the structure. Extreme torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.	3.4.2.3.3.1 3.4.2.3.3.4 3.4.2.7.3 3.4.2.8.3.4.3 3.4.2.12.1 Table 3.4.13 3.4.3.2.2	E and F D B, C, and D C and D C and D D B, C, and D
2.	Reentrant Corner Irregularity is defined to exist where both plan projections of the structure beyond a reentrant corner are greater than 15% of the plan dimension of the structure in the given direction.	3.4.2.3.3.4 Table 3.4.13	D, E, and F D, E, and F
3.	Diaphragm Discontinuity Irregularity is defined to exist where there are diaphragms with abrupt discontinuities or variations in stiffness, including those having cutout or open areas greater than 50% of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50% from one storey to the next.	3.4.2.3.3.4 Table 3.4.13	D, E, and F D, E, and F
3.4.	Out-of-Plane Offsets Irregularity is defined to exist where there are discontinuities in a lateral force-resistance path, such as out-of-plane offsets of the vertical elements.	3.4.2.3.3.4 3.4.2.3.3.3 3.4.2.7.3 Table 3.4.13 3.4.3.2.2	D, E, and F B, C, D, E, and F B, C, D, E, and F D, E, and F B, C, D, E, and F
5.	Nonparallel Systems-Irregularity is defined to exist where the vertical lateral force-resisting elements are not parallel to or symmetric about the major orthogonal axes of the seismic force-resisting system.	3.4.2.5.3 3.4.2.7.3 Table 3.4.13 3.4.3.2.2	C, D, E, and F B, C, D, E, and F D, E, and F B, C, D, E, and F

3.4.2.3.3.2 Extreme weak storeys

Structures with a vertical irregularity Type 5b as defined in Table 3.4.11, shall not be over two storeys or 30 ft (9 m) in height.

EXCEPTION: The limit does not apply where the “weak” storey is capable of resisting a total seismic force equal to Q_0 times the design force prescribed in Section 3.4.2.8

3.4.2.3.3.3 Elements supporting discontinuous walls or frames

Columns, beams, trusses, or slabs supporting discontinuous walls or frames of structures having horizontal irregularity Type 4 of Table 3.4.10 or vertical irregularity Type 4 of Table 3.4.11 shall have the design strength to resist the maximum axial force that can develop in accordance with the load combinations with overstrength factor of Section 3.4.2.4.3.2. The connections of such discontinuous elements to the supporting members shall be adequate to transmit the forces for which the discontinuous elements were required to be designed.

3.4.2.3.3.4 Increase in forces due to irregularities for Seismic Design Categories D through F

For structures assigned to Seismic Design Category D, E, or F and having a horizontal structural irregularity of Type 1a, 1b, 2, 3, or 4 in Table 3.4.10 or a vertical structural irregularity of Type 4 in Table 3.4.11, the design forces determined from Section 3.4.2.8.1 shall be increased 25 percent for connections of diaphragms to vertical elements and to collectors and for connections of collectors to the vertical elements. Collectors and their connections also shall be designed for these increased forces unless they are designed for the load combinations with overstrength factor of Section 3.4.2.4.3.2, in accordance with Section 3.4.2.10.2.1.

3.4.2.3.4 Redundancy

A redundancy factor, ρ , shall be assigned to the seismic force-resisting system in each of two orthogonal directions for all structures in accordance with this section.

TABLE 3.4.11 VERTICAL STRUCTURAL IRREGULARITIES

	Irregularity Type and Description	Reference Section	Seismic Design Category Application
1a.	Stiffness-Soft Storey Irregularity is defined to exist where there is a storey in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average stiffness of the three	Table 3.4.13	D, E, and F
1b.	Stiffness-Extreme Soft Storey Irregularity is defined to exist where there is a storey in which the lateral stiffness is less than 60% of that in the storey above or less than 70% of the average stiffness of	3.4.2.3.3.1 Table 3.4.13	E and F D, E, and F
2.	Weight (Mass) Irregularity is defined to exist where the effective mass of any storey is more than 150% of the effective mass of an adjacent storey. A roof that is lighter than the floor below need not be considered	Table 3.4.13	D, E, and F

3.	Vertical Geometric Irregularity is defined to exist where the horizontal dimension of the seismic force-resisting system in any storey is more than 130% of that in an adjacent storey.	Table 3.4.13	B, D, E, and F
4.	In-Plane Discontinuity in Vertical Lateral Force-Resisting Element Irregularity is defined to exist where an in-plane offset of the lateral force-resisting elements is greater than the length of those elements or there exists a reduction in stiffness of the resisting	3.4.2.3.3.3 3.4.2.3.3.4 Table 3.4.13	B, C, D, E, and F D, E, and F D, E, and F
5a.	Discontinuity in Lateral Strength–Weak Storey Irregularity is defined to exist where the storey lateral strength is less than 80% of that in the storey above. The storey lateral strength is the total lateral strength of all seismic-resisting elements sharing the storey shear for the direction under consideration.	3.4.2.3.3.1 Table 3.4.13	E and F D, E, and F
5b.	Discontinuity in Lateral Strength–Extreme Weak Storey Irregularity is defined to exist where the storey lateral strength is less than 65% of that in the storey above. The storey strength is the total strength of all seismic-resisting elements sharing the storey shear for the direction under consideration.	3.4.2.3.3.1 3.4.2.3.3.2 Table 4.13	D, E, and F B and C D, E, and F

3.4.2.3.4.1 Conditions where value of ρ is 1.0

The value of ρ is permitted to equal 1.0 for the following:

1. Structures assigned to Seismic Design Category B or C.
2. Drift calculation and P-delta effects.
3. Design of nonstructural components.
4. Design of nonbuilding structures that are not similar to buildings.
5. Design of collector elements, splices, and their connections for which the load combinations with overstrength factor of Section 3.4.2.4.3.2 are used.
6. Design of members or connections where the load combinations with overstrength of Section 3.4.2.4.3.2 are required for design.
7. Diaphragm loads determined using Eq. (3.4.37).
8. Structures with damping systems

3.4.2.3.4.2 Redundancy factor, ρ , for Seismic Design Categories D through F

For structures assigned to Seismic Design Category D, E, or F, ρ shall equal 1.3 unless one of the following two conditions is met, whereby ρ is permitted to be taken as 1.0:

- a. Each storey resisting more than 35 percent of the base shear in the direction of interest shall comply with Table 3.4.12.
- b. Structures that are regular in plan at all levels provided that the seismic force-resisting systems consist of at least two bays of seismic force-resisting perimeter framing on each side of the structure in each orthogonal direction at each storey resisting more than 35 percent of the base shear. The number of bays for a shear wall shall be calculated as the

length of shear wall divided by the storey height or two times the length of shear wall divided by the storey height for light-framed construction.

3.4.2.4 Seismic Load Effects and Combinations

3.4.2.4.1 Applicability

All members of the structure, including those not part of the seismic force-resisting system, shall be designed using the seismic load effects of Section 3.4.2.4 unless otherwise exempted by this standard. Seismic load effects are the axial, shear, and flexural member forces resulting from application of horizontal and vertical seismic forces as set forth in Section 3.4.2.4.2. Where specifically required, seismic load effects shall be modified to account for system overstrength, as set forth in Section 3.4.2.4.3.

TABLE 3.4.12 REQUIREMENTS FOR EACH STOREY RESISTING MORE THAN 35% OF THE BASE SHEAR

Lateral Force-Resisting Element	Requirement
Braced Frames	Removal of an individual brace, or connection thereto, would not result in more than a 33% reduction in storey strength, nor does the resulting system have an extreme torsional irregularity (horizontal structural irregularity Type 1b).
Moment Frames	Loss of moment resistance at the beam-to-column connections at both ends of a single beam would not result in more than a 33% reduction in storey strength, nor does the resulting system have an extreme torsional irregularity (horizontal structural irregularity Type 1b).
Shear Walls or Wall Pier with a height-to-length ratio of greater than 1.0	Removal of a shear wall or wall pier with a height-to-length ratio greater than 1.0 within any storey, or collector connections thereto, would not result in more than a 33% reduction in storey strength, nor does the resulting system have an extreme torsional irregularity (horizontal structural irregularity Type 1b).
Cantilever Columns	Loss of moment resistance at the base connections of any single cantilever column would not result in more than a 33% reduction in storey strength, nor does the resulting system have an extreme torsional irregularity (horizontal structural irregularity Type 1b).
Other	No requirements

3.4.2.4.2 Seismic load effect

The seismic load effect, E , shall be determined in accordance with the following:

1. For use in load combination 5 in Section 2.1.2.2 or load combinations 5 and 6 in Section 2.1.3.1, E shall be determined in accordance with Eq. (3.4.13) as follows:

$$E = E_h + E_v \text{ Eq. (3.4.13)}$$

2. For use in load combination 7 in Section 2.1.2.2 or load combination 8 in Section 2.1.3.1, E shall be determined in accordance with Eq. (3.4.14) as follows:

$$E = E_h - E_v \text{ Eq. (3.4.14)}$$

where

E = seismic load effect

E_h = effect of horizontal seismic forces as defined in Section 3.4.2.4.2.1

E_v = effect of vertical seismic forces as defined in Section 3.4.2.4.2.2

3.4.2.4.2.1 Horizontal seismic load effect

The horizontal seismic load effect, E_h , shall be determined in accordance with Eq.(3.4.15) as follows:

$$E_h = \rho Q_E \quad \text{Eq. (3.4.15)}$$

where

Q_E = effects of horizontal seismic forces from V or F_p . Where required in Sections 3.4.2.5.3 and 3.4.2.5.4, such effects shall result from application of horizontal forces simultaneously in two directions at right angles to each other.

ρ = redundancy factor, as defined in Section 3.4.2.3.4

3.4.2.4.2.2 Vertical seismic load effect

The vertical seismic load effect, E_v , shall be determined in accordance with Eq. (3.4.16) as follows:

$$E_v = 0.2 S_{DS} D \quad \text{Eq. (3.4.16)}$$

where

S_{DS} = design spectral response acceleration parameter at short periods obtained from Section 3.4.1.4.4

D = effect of dead load

EXCEPTIONS: The vertical seismic load effect, E_v , is permitted to be taken as zero for either of the following conditions:

1. In Eqs. (3.4.13), (3.4.14), (3.4.17), and (3.4.18) where S_{DS} is equal to or less than 0.125.
2. In Eq. (3.4.14) where determining demands on the soil-structure interface of foundations.

3.4.2.4.2.3 Seismic load combinations

Where the prescribed seismic load effect, E , defined in Section 3.4.2.4.2 is combined with the effects of other loads as set forth in Section 2, the following seismic load combinations for structures not subject to flood or atmospheric ice loads shall be used in lieu of the seismic load combinations in either Section 2.1.2.2 or 2.1.3.1.

Basic combinations for strength design (see Sections 2.1.2.2 and 1.1.2 for notation)

$$5. (1.2 + 0.2 S_{DS}) D + \rho Q_E + L$$

$$7. (0.9 - 0.2 S_{DS}) D + \rho Q_E + 1.6 H$$

NOTES:

1. The load factor on L in combination 5 is permitted to equal 0.5 for all occupancies in which L_0 in Table 2.2 is less than or equal to 100 psf (3.4.79 kN/m²), with the exception of garages or areas occupied as places of public assembly.
2. The load factor on H shall be set equal to zero in combination 7 if the structural action due to H counteracts that due to E. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Basic combinations for allowable stress design (see Sections 2.1.3.1 and 1.1.2 for notation).

$$5. (1.0 + 0.14 S_{DS}) D + H + F + 0.7\rho Q_E$$

$$6. (1.0 + 0.105 S_{DS}) D + H + F + 0.525\rho Q_E + 0.75L + 0.75(L_r \text{ or } R)$$

$$8. (0.6 - 0.14 S_{DS}) D + 0.7\rho Q_E + H$$

3.4.2.4.3 Seismic load effect including overstrength factor

Where specifically required, conditions requiring overstrength factor applications shall be determined in accordance with the following:

1. For use in load combination 5 in Section 2.1.2.2 or load combinations 5 and 6 in Section 2.1.3.1, E shall be taken equal to E_m as determined in accordance with Eq. (3.4.17) as follows:

$$E_m = E_{mh} + E_v \text{ Eq. (3.4.17)}$$

2. For use in load combination 7 in Section 2.1.2.2 or load combination 8 in Section 2.1.3.1, E shall be taken equal to E_m as determined in accordance with Eq. (3.4.18) as follows:

$$E_m = E_{mh} - E_v \text{ Eq. (3.4.18)}$$

where

E_m = seismic load effect including overstrength factor

E_{mh} = effect of horizontal seismic forces including structural overstrength as defined in Section 3.4.2.4.3.1

E_v = vertical seismic load effect as defined in Section 3.4.2.4.2.2

3.4.2.4.3.1 Horizontal seismic load effect with overstrength factor

The horizontal seismic load effect with overstrength factor, E_{mh} , shall be determined in accordance with Eq. (3.4.19) as follows:

$$E_{mh} = \Omega_o Q_E \text{ Eq. (3.4.19)}$$

where

Q_E = effects of horizontal seismic forces from V as specified in Sections 3.4.2.8.1 . Where required in Sections 3.4.2.5.3 and 3.4.2.5.4, such effects shall result from application of horizontal forces simultaneously in two directions at right angles to each other.

Ω_o = overstrength factor

EXCEPTION: The value of E_{mh} need not exceed the maximum force that can develop in the element as determined by a rational, plastic mechanism analysis or nonlinear response analysis utilizing realistic expected values of material strengths.

3.4.2.4.3.2 Load combinations with overstrength factor

Where the seismic load effect with overstrength, E_m , defined in Section 3.4.2.4.3 is combined with the effects of other loads as set forth in Section 2, the following seismic load combination for structures not subject to flood or atmospheric ice loads shall be used in lieu of the seismic load combinations in either Section 2.1.2.2 or 2.1.3.1:

Basic combinations for strength design with overstrength factor (see Sections 2.1.2.2 and 1.1.2 for notation)

$$5. (1.2 + 0.2S_{DS}) D + \Omega_o Q_E + L$$

$$7. (0.9 - 0.2S_{DS}) D + \Omega_o Q_E + 1.6 H$$

NOTES:

1. The load factor on L in combination 5 is permitted to equal 0.5 for all occupancies in which L_0 in Table 2.2 is less than or equal to 100 psf (3.4.79 kN/m²), with the exception of garages or areas occupied as places of public assembly.
2. The load factor on H shall be set equal to zero in combination 7 if the structural action due to H counteracts that due to E . Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Basic combinations for allowable stress design with overstrength factor (see Sections 2.1.3.1 and 1.1.2 for notation).

$$5. (1.0 + 0.14S_{DS}) D + H + F + 0.7\Omega_o Q_E$$

$$6. (1.0 + 0.105S_{DS}) D + H + F + 0.525 \Omega_o Q_E + 0.75L + 0.75(L_r \text{ or } R)$$

$$8. (0.6 - 0.14S_{DS}) D + 0.7\Omega_o Q_E + H$$

3.4.2.4.3.3 Allowable stress increase for load combinations with overstrength.

Where allowable stress design methodologies are used with the seismic load effect defined in Section 3.4.2.4.3 applied in load combinations 5, 6, or 8 of Section 2.1.3.1, allowable stresses are permitted to be determined using an allowable stress increase of 1.2. This increase shall not be combined with increases in allowable stresses or load combination reductions otherwise

permitted by this standard or the material reference document except that combination with the duration of load increases permitted in AF&PANDS is permitted.

3.4.2.4.4 Minimum upward force for horizontal cantilevers for Seismic Design Categories D through F

In structures assigned to SeismicDesign Category D, E, or F, horizontal cantilever structural components shall be designed for a minimum net upward force of 0.2 times the dead load in addition to the applicable load combinations of Section 3.4.2.4.

3.4.2.5 Direction of Loading

3.4.2.5.1 Direction of loading criteria

The directions of application of seismic forces used in the design shall be those which will produce the most critical load effects. It is permitted to satisfy this requirement using the procedures of Section 3.4.2.5.2 for SeismicDesign Category B, Section 3.4.2.5.3 for SeismicDesign Category C, and Section 3.4.2.5.4 for Seismic Design Categories D, E, and F.

3.4.2.5.2 Seismic Design Category B

For structures assigned to SeismicDesign Category B, the design seismic forces are permitted to be applied independently in each of two orthogonal directions and orthogonal interaction effects are permitted to be neglected.

3.4.2.5.3 Seismic Design Category C

Loading applied to structures assigned to Seismic Design Category C shall, as a minimum, conform to the requirements of Section 3.4.2.5.2 for Seismic Design Category B and the requirements of this section. Structures that have horizontal structural irregularity Type 5 in Table 3.4.10 shall use one of the following procedures:

a. Orthogonal combination procedure

The structure shall be analyzed using the equivalent lateral force analysis procedure of Section 3.4.2.8, the modal response spectrum analysis procedure of Section 3.4.2.9, or the linear response history procedure of Section 3.4.3.1, as permitted under Section 3.4.2.6, with the loading applied independently in any two orthogonal directions and the most critical load effect due to direction of application of seismic forces on the structure is permitted to be assumed to be satisfied if components and their foundations are designed for the following combination of prescribed loads: 100 percent of the forces for one direction plus 30 percent of the forces for the perpendicular direction; the combination requiring the maximum component strength shall be used.

b. Simultaneous application of orthogonal ground motion

The structure shall be analyzed using the linear response history procedure of Section 3.4.3.1 or the nonlinear response history procedure of Section 3.4.3.2, as permitted by Section 3.4.2.6, with orthogonal pairs of ground motion acceleration histories applied simultaneously.

3.4.2.5.4 Seismic Design Categories D through F

Structures assigned to Seismic Design Category D, E, or F shall, as a minimum, conform to the requirements of Section 3.4.2.5.3. In addition, any column or wall that forms part of two or more intersecting seismic force-resisting systems and is subjected to axial load due to seismic forces acting along either principal plan axis equaling or exceeding 20 percent of the axial design strength of the column or wall

shall be designed for the most critical load effect due to application of seismic forces in any direction. Either of the procedures of Section 3.4.2.5.3 a or b are permitted to be used to satisfy this requirement. Except as required by Section 3.4.2.7.3, 2-D analyses are permitted for structures with flexible diaphragms.

3.4.2.6 Analysis Procedure Selection

The structural analysis required by Section 3.4.2 shall consist of one of the types permitted in Table 3.4.13, based on the structure's Seismic Design Category, structural system, dynamic properties, and regularity, or with the approval of the authority having jurisdiction, an alternative generally accepted procedure is permitted to be used. The analysis procedure selected shall be completed in accordance with the requirements of the corresponding section referenced in Table 3.4.13.

3.4.2.7 Modeling Criteria

3.4.2.7.1 Foundation modeling

For purposes of determining seismic loads, it is permitted to consider the structure to be fixed at the base.

3.4.2.7.2 Effective seismic weight

The effective seismic weight, W , of a structure shall include the total dead load and other loads listed below:

1. In areas used for storage, a minimum of 25 percent of the floor live load (floor live load in public garages and open parking structures need not be included).
2. Where provision for partitions is required by Section 2.3.2.2 in the floor load design, the actual partition weight or a minimum weight of 10 psf (0.48 kN/m^2) of floor area, whichever is greater.
3. Total operating weight of permanent equipment.

TABLE 3.4.13 PERMITTED ANALYTICAL PROCEDURES

Seismic Design Category	Structural Characteristics	Equivalent Lateral Force Analysis Section 3.4.2.8	Modal Response Spectrum Analysis Section 3.4.2.9	Seismic Response History Procedures Section 3.4.3.4.2
B, C	Occupancy Category I or II buildings of light-framed construction not exceeding 3 storeys in height	P	P	P
	Other Occupancy Category I or II buildings not exceeding 2 storeys in height	P	P	P
	All other structures	P	P	P
D, E, F	Occupancy Category I or II buildings of light-framed construction not exceeding 3 storeys in height	P	P	P
	Other Occupancy Category I or II buildings not exceeding 2 storeys in height	P	P	P
	Regular structures with $T < 3.5T_s$ and all structures of light frame construction	P	P	P
	Irregular structures with $T < 3.5T_s$ and having only horizontal irregularities Type 2, 3, 4, or 5 of Table 12.2-1 or vertical irregularities Type 4, 5a, or 5b of Table 3.4.10	P	P	P
	All other structures	NP	P	P

NOTE: P: Permitted; NP: Not Permitted

3.4.2.7.3 Structural modeling

A mathematical model of the structure shall be constructed for the purpose of determining member forces and structure displacements resulting from applied loads and any imposed displacements or P-Delta effects. The model shall include the stiffness and strength of elements that are significant to the distribution of forces and deformations in the structure and represent the spatial distribution of mass and stiffness throughout the structure.

Structures that have horizontal structural irregularity Type 1a, 1b, 4, or 5 of Table 3.4.10 shall be analyzed using a 3-D representation. Where a 3-D model is used, a minimum of three dynamic degrees of freedom consisting of translation in two orthogonal plan directions and torsional rotation about the vertical axis shall be included at each level of the structure. Where the diaphragms have not been classified as rigid or flexible in accordance with Section 3.4.2.3.1, the model shall include representation of the diaphragm's stiffness characteristics and such additional dynamic degrees of freedom as are required to account for the participation of the diaphragm in the structure's dynamic response. In addition, the model shall comply with the following:

- Stiffness properties of concrete and masonry elements shall consider the effects of cracked sections.
- For steel moment frame systems, the contribution of panel zone deformations to overall storey drift shall be included.

3.4.2.7.4 Interaction effects

Moment-resisting frames that are enclosed or adjoined by elements that are more rigid and not considered to be part of the seismic force-resisting system shall be designed so that the action or failure of those elements will not impair the vertical load and seismic force-resisting capability of the frame. The design shall provide for

the effect of these rigid elements on the structural system at structural deformations corresponding to the design storey drift (Δ) as determined in Section 3.4.2.8.6. In addition, the effects of these elements shall be considered where determining whether a structure has one or more of the irregularities defined in Section 3.4.2.3.2.

3.4.2.8 Equivalent Lateral Force Procedure

3.4.2.8.1 Seismic base shear

The seismic base shear, V , in a given direction shall be determined in accordance with the following equation:

$$V = C_s W \quad \text{Eq. (3.4.20)}$$

where

C_s = the seismic response coefficient determined in accordance with Section 3.4.2.8.1.1

W = the effective seismic weight per Section 3.4.2.7.2.

3.4.2.8.1.1 Calculation of seismic response coefficient

The seismic response coefficient, C_s , shall be determined in accordance with Eq. (3.4.21).

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I}\right)} \quad \text{Eq. (3.4.21)}$$

where

S_{DS} = the design spectral response acceleration parameter in the short period range as determined from Section 3.4.1.3.4.3.4.

R = the response modification factor in Table 3.4.9

I = the occupancy importance factor determined in accordance with Section 3.4.1.5.1

The value of C_s computed in accordance with Eq. (3.4.21) need not exceed the following:

$$C_s = \frac{S_{D1}}{T\left(\frac{R}{I}\right)} \text{ for } T \leq T_L \quad \text{Eq. (3.4.22)}$$

$$C_s = \frac{S_{D1}T_L}{T^2\left(\frac{R}{I}\right)} \text{ for } T > T_L \quad \text{Eq. (3.4.23)}$$

C_s shall not be less than

$$C_s = 0.01 \quad \text{Eq. (3.4.24)}$$

In addition, for structures located where S_1 is equal to or greater than $0.6g$,

C_s shall not be less than

$$C_s = \frac{0.5S_1}{\left(\frac{R}{I}\right)} \quad \text{Eq. (3.4.25)}$$

TABLE 3.4.14 COEFFICIENT FOR UPPER LIMIT ON CALCULATED PERIOD

Design Spectral Response Acceleration Parameter at 1 s, S_{D1}	Coefficient C_u
≥ 0.4	1.4
0.3	1.4
0.2	1.5
0.15	1.6
≤ 0.1	1.7

where I and R are as defined in Section 3.4.2.8.1.1 and

S_{D1} = the design spectral response acceleration parameter at a period of 1.0 s, as determined from Section 3.4.1.4.4

T = the fundamental period of the structure (s) determined in Section 3.4.2.8.2

T_L = long-period transition period (s) determined in Section 3.4.1.4.5

S_I = the mapped maximum considered earthquake spectral response acceleration parameter determined in accordance with Section 3.4.1.4.1.

3.4.2.8.1.2 Soil structure interaction reduction

A soil structure interaction reduction is permitted where determined using generally accepted procedures approved by the authority having jurisdiction.

3.4.2.8.1.3 Maximum S_s value in determination of C_s

For regular structures five storeys or less in height and having a period, T , of 0.5 s or less, C_s is permitted to be calculated using a value of 1.5 for S_s

3.4.2.8.2 Period determination

The fundamental period of the structure, T , in the direction under consideration shall be established using the structural properties and deformational characteristics of the resisting elements in a properly substantiated analysis. The fundamental period, T , shall not exceed the product of the coefficient for upper limit on calculated period (C_u) from Table 3.4.14 and the approximate fundamental period, T_a , determined from Eq. (3.4.26). As an alternative to performing an analysis to determine the fundamental

period, T , it is permitted to use the approximate building period, T_a , calculated in accordance with Section 3.4.2.8.2.1, directly.

3.4.2.8.2.1 Approximate fundamental period

The approximate fundamental period (T_a), in s, shall be determined from the following equation:

$$T_a = C_t h_n^x \quad \text{Eq. (3.4.26)}$$

where h_n is the height in ft above the base to the highest level of the structure and

the coefficients C_t and x are determined from Table 3.4.15.

TABLE 3.4.15 VALUES OF APPROXIMATE PERIOD PARAMETERS C_t AND x

Structure Type	C	x
Moment-resisting frame systems in which the frames resist 100% of the required seismic force and are not enclosed or adjoined by components that are more rigid and will prevent the frames from deflecting where		
Steel moment-resisting frames	0.028(0.0724) ^a	0.8
Concrete moment-resisting frames	0.016(0.0466) ^a	0.9
Eccentrically braced steel frames	0.03 (0.0731) ^a	0.75
All other structural systems	0.02 (0.0488) ^a	0.75

^a Metric equivalents are shown in parentheses.

Alternatively, it is permitted to determine the approximate fundamental period (T_a), in s, from the following equation for structures not exceeding 12 storeys in height in which the seismic force-resisting system consists entirely of concrete or steel moment resisting frames and the storey height is at least 10 ft (3 m):

$$T_a = 0.1 N \quad \text{Eq. (3.4.27)}$$

where N = number of storeys.

The approximate fundamental period, T_a , in s for masonry or concrete shear wall structures is permitted to be determined from Eq. (3.4.28) as follows:

$$T_a = \frac{0.0019}{\sqrt{C_w}} h_n \quad \text{Eq. (3.4.28)}$$

where h_n is as defined in the preceding text and C_w is calculated from Eq. (3.4.29) as follows:

$$C_w = \frac{100}{A_B} \sum_{i=1}^x \left(\frac{h_n}{h_i} \right)^2 \frac{A_i}{\left[1 + 0.83 \left(\frac{h_i}{D_i} \right)^2 \right]} \quad \text{Eq. (3.4.29)}$$

where A_B = area of base of structure, ft²

A_i = web area of shear wall “i” in ft²

D_i = length of shear wall “i” in ft

h_i = height of shear wall “i” in ft

x = number of shear walls in the building effective in resisting lateral forces in the direction under consideration.

3.4.2.8.3 Vertical distribution of seismic forces

The lateral seismic force (F_x) (kip or kN) induced at any level shall be determined from the following equations:

$$F_x = C_{vx} V \quad \text{Eq. (3.4.30)}$$

and

$$C_{vx} = \frac{w_x h_x^k}{\sum_{i=1}^n w_i h_i^k} \quad \text{Eq.(3.4.31)}$$

Where C_{vx} = vertical distribution factor,

V = total design lateral force or shear at the base of the structure (kip or kN)

w_i and w_x = the portion of the total effective seismic weight of the structure (W) located or assigned to Level i or x

h_i and h_x = the height (ft or m) from the base to Level i or x

k = an exponent related to the structure period as follows:

for structures having a period of 0.5 s or less, $k = 1$

for structures having a period of 2.5 s or more, $k = 2$

for structures having a period between 0.5 and 2.5s, k shall be 2 or shall be determined by linear interpolation between 1 and 2

3.4.2.8.4 Horizontal distribution of forces

The seismic design storey shear in any storey (V_x) (kip or kN) shall be determined from the following equation:

$$V_x = \sum_{i=x}^n F_i \quad \text{Eq. (3.4.20)}$$

Where F_i = the portion of the seismic base shear (V_x) (kip or kN) induced at Level i .

The seismic design storey shear (V_x) (kip or kN) shall be distributed to the various vertical elements of the seismic force-resisting system in the storey under consideration based on the relative lateral stiffness of the vertical resisting elements and the diaphragm.

3.4.2.8.4.1 Inherent torsion

For diaphragms that are not flexible, the distribution of lateral forces at each level shall consider the effect of the inherent torsional moment, M_t , resulting from eccentricity between the locations of the centre of mass and the centre of rigidity. For flexible diaphragms, the distribution of forces to the vertical elements shall account for the position and distribution of the masses supported.

3.4.2.8.4.2 Accidental torsion

Where diaphragms are not flexible, the design shall include the inherent torsional moment (M_t) (kip or kN) resulting from the location of the structure masses plus the accidental torsional moments (M_{ta}) (kip or kN) caused by assumed displacement of the centre of mass each way from its actual location by a distance equal to 5 percent of the dimension of the structure perpendicular to the direction of the applied forces.

Where earthquake forces are applied concurrently in two orthogonal directions, the required 5 percent displacement of the centre of mass need not be applied in both of the orthogonal directions at the same time, but shall be applied in the direction that produces the greater effect.

3.4.2.8.4.3 Amplification of accidental torsional moment

Structures assigned to Seismic Design Category C, D, E, or F, where Type 1a or 1b torsional irregularity exists as defined in Table 3.4.10 shall have the effects accounted for by multiplying M_{ta} at each level by a torsional amplification factor (A_x) as illustrated in Fig. 3.4.3 and determined from the following equation:

$$A_x = \left(\frac{\delta_{max}}{1.2\delta_{avg}} \right)^2 \quad \text{Eq. (3.4.33)}$$

where

δ_{max} = the maximum displacement at Level x (in. or mm) computed assuming $A_x=1$

δ_{avg} = the average of the displacements at the extreme points of the structure at Level x computed assuming $A_x= 1$ (in. or mm)

EXCEPTION: The accidental torsional moment need not be amplified for structures of light-frame construction.

The torsional amplification factor (A_x) is not required to exceed 3.0. The more severe loading for each element shall be considered for design.

3.4.2.8.5 Overturning

The structure shall be designed to resist overturning effects caused by the seismic forces determined in Section 3.4.2.8.3.

3.4.2.8.6 Storey drift determination

The design storey drift (Δ) shall be computed as the difference of the deflections at the centres of mass at the top and bottom of the storey under consideration. See Fig.3.4.4. Where allowable stress design is used, Δ shall be computed using the strength level seismic forces specified in Section 3.4.2.8 without reduction for allowable stress design.

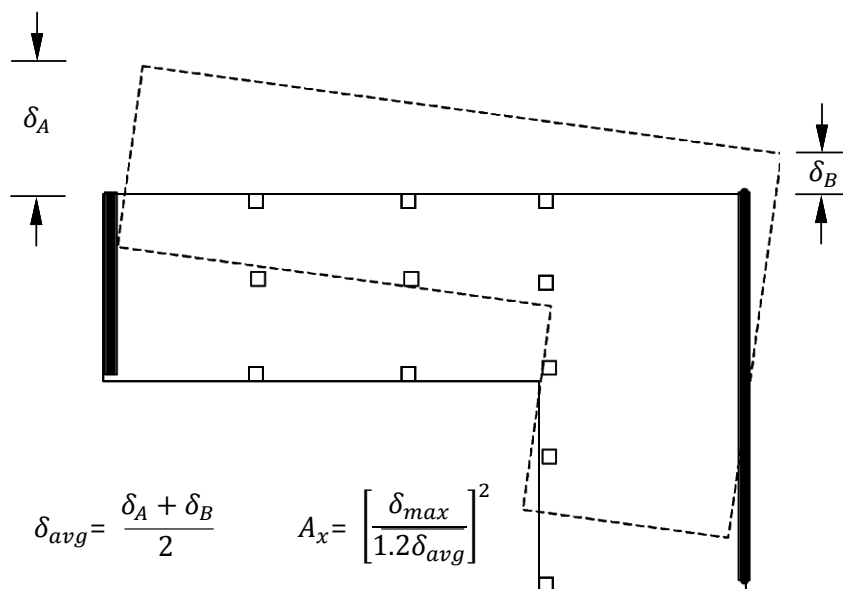


Fig. 3.4.3 Torsional amplification factor, A_x

The deflections of Level x at the centre of the mass (δ_x) (in. or mm) shall be determined in accordance with the following equation:

$$\delta_x = \frac{C_d \delta_{xe}}{I} \quad \text{Eq. (3.4.34)}$$

where C_d = the deflection amplification factor in Table 3.4.9

δ_{xe} = the deflections determined by an elastic analysis

I = the importance factor determined in accordance with Section 3.4.1.5.1

3.4.2.8.6.1 Minimum base shear for computing drift

The elastic analysis of the seismic force-resisting system shall be made using the prescribed seismic design forces of Section 3.4.2.8.

3.4.2.8.6.2 Period for computing drift

For determining compliance with the story drift limits of Section 3.4.2.12.1, it is permitted to determine the elastic drifts, (δ_{xe}), using seismic design forces based on the computed fundamental period of the structure without the upper limit ($C_u T_a$) specified in Section 3.4.2.8.2.

3.4.2.8.7 P-Delta effects

P-delta effects on storey shears and moments, the resulting member forces and moments, and the storey drifts induced by these effects are not required to be considered where the stability coefficient (θ) as determined by the following equation is equal to or less than 0.10:

$$\theta = \frac{P_x \Delta}{V_x h_{sx} C_d} \quad \text{Eq. (3.4.35)}$$

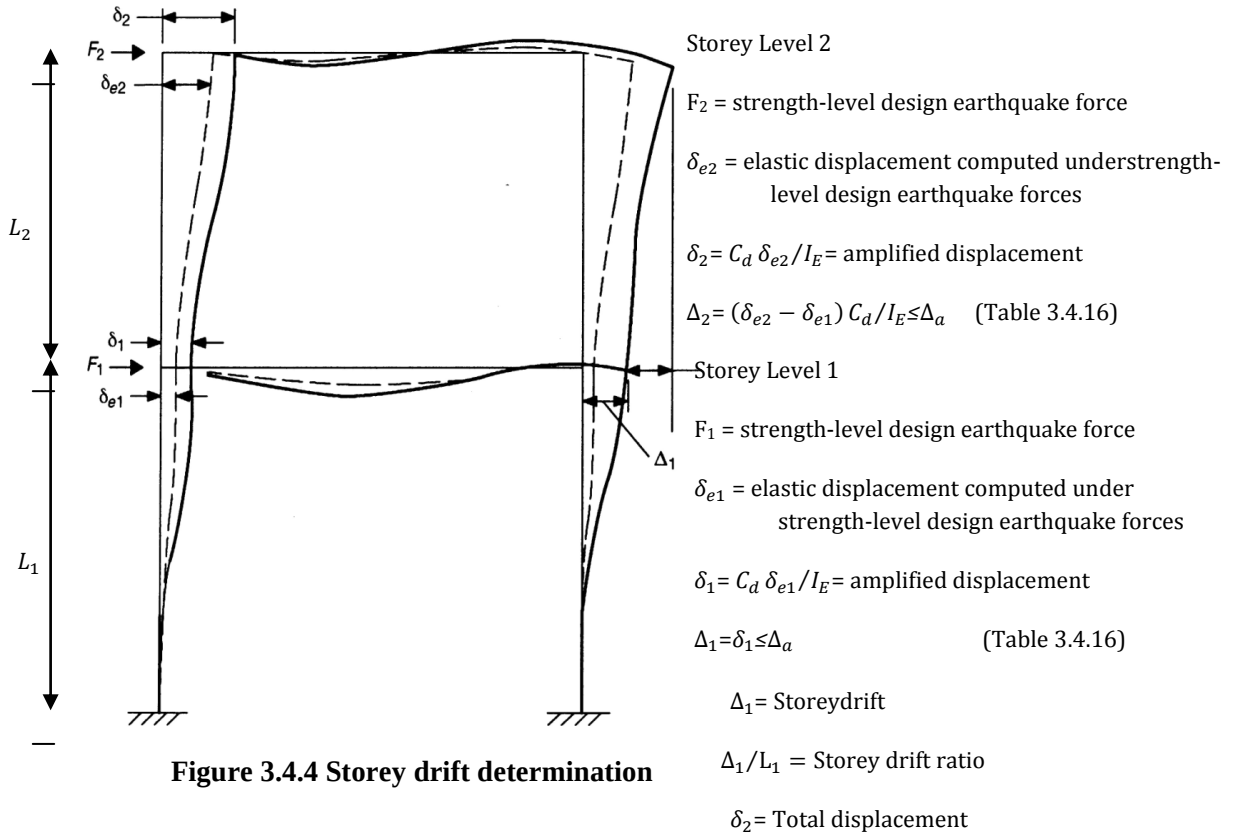


Figure 3.4.4 Storey drift determination

where

P_x = the total vertical design load at and above Level x (kip or kN); where computing P_x , no individual load factor need exceed 1.0

Δ = the design storey drift as defined in Section 3.4.2.8.6 occurring simultaneously with V_x (in. or mm)

V_x = the seismic shear force acting between Levels x and $x - 1$ (kip or kN)

h_{sx} = the storey height below Level x (in. or mm)

C_d = the deflection amplification factor in Table 3.4.9.

The stability coefficient (θ) shall not exceed θ_{max} determined as follows:

$$\theta_{max} = \frac{0.5}{\beta C_d} \leq 0.25 \quad \text{Eq. (3.4.36)}$$

where β is the ratio of shear demand to shear capacity for the storey between Levels x and $x - 1$. This ratio is permitted to be conservatively taken as 1.0.

Where the stability coefficient (θ) is greater than 0.10 but less than or equal to θ_{max} , the incremental factor related to P-delta effects on displacements and member forces shall be determined by rational analysis. Alternatively, it is permitted to multiply displacements and member forces by $1.0/(1-\theta)$.

Where θ is greater than θ_{max} , the structure is potentially unstable and shall be redesigned.

Where the P-delta effect is included in an automated analysis, Eq. (3.4.36) shall still be satisfied, however, the value of θ computed from Eq. (3.4.35) using the results of the P-delta analysis is permitted to be divided by $(1 + \theta)$ before checking Eq. (3.4.36).

3.4.2.9 Modal Response Spectrum Analysis

3.4.2.9.1 Number of modes

An analysis shall be conducted to determine the natural modes of vibration for the structure. The analysis shall include a sufficient number of modes to obtain a combined modal mass participation of at least 90 percent of the actual mass in each of the orthogonal horizontal directions of response considered by the model.

3.4.2.9.2 Modal response parameters

The value for each force- related design parameter of interest, including storey drifts, support forces, and individual member forces for each mode of response shall be computed using the properties of each mode and the response spectra defined in either Section 3.4.1.4.5 divided by the quantity $\frac{R}{I}$. The value for displacement and drift quantities shall be multiplied by the quantity $\frac{C_d}{I}$.

3.4.2.9.3 Combined response parameters

The value for each parameter of interest calculated for the various modes shall be combined using either the square root of the sum of the squares method (SRSS) or the complete quadratic combination method (CQC), in accordance with ASCE 3.4. The CQC method shall be used for each of the modal values or where closely spaced modes that

have significant cross-correlation of translational and torsional response.

3.4.2.9.4 Scaling design values of combined response

A base shear (V) shall be calculated in each of the two orthogonal horizontal directions using the calculated fundamental period of the structure T in each direction and the procedures of Section 3.4.2.8, except where the calculated fundamental period exceeds $(C_u)(T_a)$, then $(C_u)(T_a)$ shall be used in lieu of T in that direction. Where the combined response for the modal base shear (V_t) is less than 85 percent of the calculated base shear (V) using the equivalent lateral force procedure, the forces, but not the drifts, shall be multiplied by $0.85 \frac{V}{V_t}$:

where

V = the equivalent lateral force procedure base shear, calculated in accordance with this section and Section 3.4.2.8.

V_t = the base shear from the required modal combination

3.4.2.9.5 Horizontal shear distribution

The distribution of horizontal shear shall be in accordance with the requirements of Section 3.4.2.8.4.3 except that amplification of torsion per Section 3.4.2.8.4 is not required where accidental torsional effects are included in the dynamic analysis model.

3.4.2.9.6 P-Delta effects

The P-delta effects shall be determined in accordance with Section 3.4.2.8.7. The base shear used to determine the storey shears and the storey drifts shall be determined in accordance with Section 3.4.2.8.6.

3.4.2.9.7 Soil structure interaction reduction

A soil structure interaction reduction is permitted where determined using generally accepted procedures approved by the authority having jurisdiction.

3.4.2.10 Diaphragms, Chords, and Collectors

3.4.2.10.1 Diaphragm design

Diaphragms shall be designed for both the shear and bending stresses resulting from design forces. At diaphragm discontinuities, such as openings and reentrant corners, the design shall assure that the dissipation or transfer of edge (chord) forces combined with other forces in the diaphragm is within shear and tension capacity of the diaphragm.

3.4.2.10.1.1 Diaphragm design forces

Floor and roof diaphragms shall be designed to resist design seismic forces from the structural analysis, but shall not be less than that determined in accordance with Eq. (3.4.37) as follows:

$$F_{px} = \frac{\sum_{i=1}^n F_i}{\sum_{i=1}^n w_i} w_{px} \quad \text{Eq. (3.4.37)}$$

where

F_{px} = the diaphragm design force

F_i = the design force applied to Level i

w_i = the weight tributary to Level i

w_{px} = the weight tributary to the diaphragm at Level x

The force determined from Eq. (3.4.37) need not exceed $0.4S_{DS} I w_{px}$, but shall not be less than $0.2S_{DS} I w_{px}$. Where the diaphragm is required to transfer design seismic force from the vertical resisting elements above the diaphragm to other vertical resisting elements below the diaphragm due to offsets in the placement of the elements or to changes in relative lateral stiffness in the vertical elements, these forces shall be added to those determined from Eq. (3.4.37). The redundancy factor, ρ , applies to the design of diaphragms in structures assigned to Seismic Design Category D, E, or F. For inertial forces calculated in accordance with Eq. (3.4.37), the redundancy factor shall equal 1.0. For transfer forces, the redundancy factor, ρ , shall be the same as that used for the structure. For structures having horizontal or vertical structural irregularities of the types indicated in Section 3.4.2.3.3.4, the requirements of that section shall also apply.

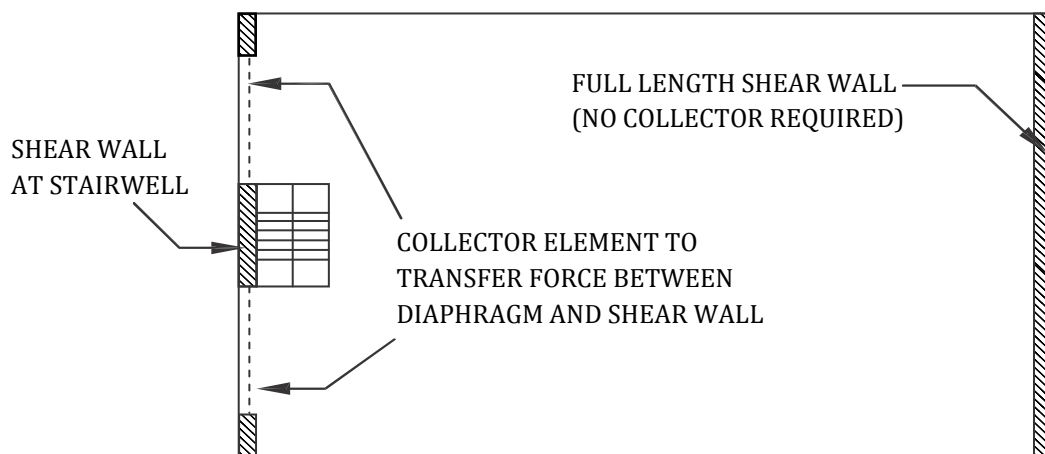


Figure 3.4.5 Collectors

3.4.2.10.2 Collector elements

Collector elements shall be provided that are capable of transferring the seismic forces originating in other portions of the structure to the element providing the resistance to those forces.

3.4.2.10.2.1 Collector elements requiring load combinations with overstrength factor for Seismic Design Categories C through F

In structures assigned to Seismic Design Category C, D, E, or F, collector elements (see Fig. 3.4.5), splices, and their connections to resisting elements shall resist the load combinations with overstrength of Section 3.4.2.4.3.2.

EXCEPTION: In structures or portions thereof braced entirely by light-frame shear walls, collector elements, splices, and connections to resisting elements need only be designed to resist forces in accordance with Section 3.4.2.10.1.1.

3.4.2.11 Structural Walls and Their Anchorage

3.4.2.11.1 Design for out-of-plane forces

Structural walls and their anchorage shall be designed for a force normal to the surface equal to $0.4S_{DS}I$ times the weight of the structural wall with a minimum force of 10 percent of the weight of the structural wall. Interconnection of structural wall elements and connections to supporting framing systems shall have sufficient ductility, rotational capacity, or sufficient strength to resist shrinkage, thermal changes, and differential foundation settlement when combined with seismic forces.

3.4.2.11.2 Anchorage of concrete or masonry structural walls

The anchorage of concrete or masonry structural walls to supporting construction shall provide a direct connection capable of resisting the greater of the following:

- a. The force set forth in Section 3.4.2.11.1.
- b. A force of $400 S_{DS}$ lb/linear ft ($5.84 S_{DS}$ kN/m) of wall
- c. 280 lb/linear ft (3.4.09 kN/m) of wall

Structural walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 ft (1,219 mm).

3.4.2.11.2.1 Anchorage of concrete or masonry structural walls to flexible diaphragms

In addition to the requirements set forth in Section 3.4.2.11.2, anchorage of concrete or masonry structural walls to flexible diaphragms in structures assigned to Seismic Design Category C, D, E, or F shall have the strength to develop the out-of-plane force given by Eq. (3.4.38):

$$F_p = 0.8 S_{DS} I W_p \quad \text{Eq. (3.4.38)}$$

where

F_p = the design force in the individual anchors

S_{DS} = the design spectral response acceleration parameter at short periods per Section 3.4.1.4.4

I = the occupancy importance factor per Section 3.4.1.5.1

W_p = the weight of the wall tributary to the anchor

3.4.2.11.2.2 Additional requirements for diaphragms in structures assigned to Seismic Design Categories C through F

3.4.2.11.2.2.1 Transfer of anchorage forces into diaphragm

Diaphragms shall be provided with continuous ties or struts between diaphragm chords to distribute these anchorage forces into the diaphragms. Diaphragm connections shall be positive, mechanical, or welded. Added chords are permitted to be used to form subdiaphragms to transmit the anchorage forces to the main continuous cross-ties. The maximum length-to-width ratio of the structural subdiaphragm shall be 2.5 to 1. Connections and anchorages capable of resisting the prescribed forces shall be provided between the diaphragm and the attached

components. Connections shall extend into the diaphragm a sufficient distance to develop the force transferred into the diaphragm.

3.4.2.11.2.2.2 Steel elements of structural wall anchorage system

The strength design forces for steel elements of the structural wall anchorage system, with the exception of anchor bolts and reinforcing steel, shall be increased by 1.4 times the forces otherwise required by this section.

3.4.2.11.2.2.3 Wood diaphragms

In wood diaphragms, the continuous ties shall be in addition to the diaphragm sheathing. Anchorage shall not be accomplished by use of toenails or nails subject to withdrawal nor shall wood ledgers or framing be used in cross-grain bending or cross-grain tension. The diaphragm sheathing shall not be considered effective as providing the ties or struts required by this section.

3.4.2.11.2.2.4 Metal deck diaphragms

In metal deck diaphragms, the metal deck shall not be used as the continuous ties required by this section in the direction perpendicular to the deck span.

3.4.2.11.2.2.5 Embedded straps

Diaphragm to structural wall anchorage using embedded straps shall be attached to, or hooked around, the reinforcing steel or otherwise terminated so as to effectively transfer forces to the reinforcing steel.

3.4.2.11.2.2.6 Eccentrically loaded anchorage system

Where elements of the wall anchorage system are loaded eccentrically or are not perpendicular to the wall, the system shall be designed to resist all components of the forces induced by the eccentricity.

TABLE 3.4.16 ALLOWABLE STOREY DRIFT, $\Delta_a^{a,b}$

Structure	Occupancy Category		
	I or II	III	IV
Structures, other than masonry shear wall structures, 4 storeys or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the storey drifts.	$0.025h_{sx}^c$	$0.020h_{sx}$	$0.015h_{sx}$
Masonry cantilever shear wall structures ^d	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.020h_{sx}$	$0.020h_{sx}$

a h_{sx} is the storey height below Level x .

- b *For seismic force-resisting systems comprised solely of moment frames in Seismic Design Categories D, E, and F, the allowable storey drift shall comply with the requirements of Section 3.4.2.12.1.1.*
- c *There shall be no drift limit for single-storey structures with interior walls, partitions, ceilings, and exterior wall systems that have been designed to accommodate the storey drifts. The structure separation requirement of Section 3.4.2.12.3 is not waived.*
- d *Structures in which the basic structural system consists of masonry shear walls designed as vertical elements cantilevered from their base or foundation support which are so constructed that moment transfer between shear walls (coupling) is negligible.*

3.4.2.11.2.2.7 Walls with pilasters

Where pilasters are present in the wall, the anchorage force at the pilasters shall be calculated considering the additional load transferred from the wall panels to the pilasters. However, the minimum anchorage force at a floor or roof shall not be reduced.

3.4.2.12 Drift and Deformation

3.4.2.12.1 Storey drift limit

The design storey drift (Δ) as determined in Sections 3.4.2.8.6, 3.4.2.9.2, or 3.4.3.1 shall not exceed the allowable story drift (Δ_a) as obtained from Table 3.4.16 for any storey. For structures with significant torsional deflections, the maximum drift shall include torsional effects. For structures assigned to Seismic Design Category C, D, E, or F having horizontal irregularity Types 1a or 1b of Table 3.4.10, the design storey drift, Δ , shall be computed as the largest difference of the deflections along any of the edges of the structure at the top and bottom of the storey under consideration.

3.4.2.12.1.1 Moment frames in structures assigned to Seismic Design Categories D through F

For seismic force-resisting systems comprised solely of moment frames in structures assigned to Seismic Design Categories D, E, or F, the design storey drift (Δ) shall not exceed Δ_a / ρ for any storey. ρ shall be determined in accordance with Section 3.4.2.3.4.2.

3.4.2.12.2 Diaphragm deflection

The deflection in the plane of the diaphragm, as determined by engineering analysis, shall not exceed the permissible deflection of the attached elements. Permissible deflection shall be that deflection that will permit the attached element to maintain its structural integrity under the individual loading and continue to support the prescribed loads.

3.4.2.12.3 Building separation

All portions of the structure shall be designed and constructed to act as an integral unit in resisting seismic forces unless separated structurally by a distance sufficient to avoid damaging contact under total deflection (δ_x) as determined in Section 3.4.2.8.6.

3.4.2.12.4 Deformation compatibility for Seismic Design Categories D through F

For structures assigned to Seismic Design Category D, E, or F, every structural component not included in the seismic force-resisting system in the direction under

consideration shall be designed to be adequate for the gravity load effects and the seismic forces resulting from displacement to the design storey drift (Δ) as determined in accordance with Section 3.4.2.8.6 (see also Section 3.4.2.12.1).

EXCEPTION: Reinforced concrete frame members not designed as part of the seismic force-resisting system shall comply with Section 21.9 of ACI 318-05.

Where determining the moments and shears induced in components that are not included in the seismic force-resisting system in the direction under consideration, the stiffening effects of adjoining rigid structural and nonstructural elements shall be considered and a rational value of member and restraint stiffness shall be used.

3.4.2.13 Foundation Design

3.4.2.13.1 Design basis

The design basis for foundations shall be as set forth in Section 3.4.2.1.5.

3.4.2.13.2 Materials of construction

Materials used for the design and construction of foundations shall comply with the requirements of material sections. Design and detailing of concrete piles shall comply with PART 4 of this Code.

3.4.2.13.3 Foundation load-deformation characteristics

Where foundation flexibility is included for the linear analysis procedures in Section 3.4.2, the load-deformation characteristics of the foundation-soil system (foundation stiffness) shall be modeled in accordance with the requirements of this section. The linear load-deformation behaviour of foundations shall be represented by an equivalent linear stiffness using soil properties that are compatible with the soil strain levels associated with the design earthquake motion. The strain-compatible shear modulus, G , and the associated strain-compatible shear wave velocity, v_s , needed for the evaluation of equivalent linear stiffness shall be determined based on soil structure interaction for seismic design or a site-specific study. A 50 percent increase and decrease in stiffness shall be incorporated in dynamic analyses unless smaller variations can be justified based on field measurements of dynamic soil properties or direct measurements of dynamic foundation stiffness. The largest values of response shall be used in design.

3.4.2.13.4 Reduction of foundation overturning

Overturning effects at the soil-foundation interface are permitted to be reduced by 25 percent for foundations of structures that satisfy both of the following conditions:

- a. The structure is designed in accordance with the Equivalent Lateral Force Analysis as set forth in Section 3.4.2.8.
- b. The structure is not an inverted pendulum or cantilevered column type structure.

Overturning effects at the soil-foundation interface are permitted to be reduced by 10 percent for foundations of structures designed in accordance with the modal analysis requirements of Section 3.4.2.9.

3.4.2.13.5 Requirements for structures assigned to Seismic Design Category C

In addition to the requirements of Section 3.4.1.8.2, the following foundation design requirements shall apply to structures assigned to Seismic Design Category C.

3.4.2.13.5.1 Pole-type structures

Where construction employing posts or poles as columns embedded in earth or embedded in concrete footings in the earth is used to resist lateral loads, the depth of embedment required for posts or poles to resist seismic forces shall be determined by means of the design criteria established in the foundation investigation report.

3.4.2.13.5.2 Foundation ties

Individual pile caps, drilled piers, or caissons shall be interconnected by ties. All ties shall have a design strength in tension or compression at least equal to a force equal to 10 percent of S_D times the larger pile cap or column factored dead plus factored live load unless it is demonstrated that equivalent restraint will be provided by reinforced concrete beams within slabs on grade or reinforced concrete slabs on grade or confinement by competent rock, hard cohesive soils, very dense granular soils, or other approved means.

3.4.2.13.5.3 Pile anchorage requirements

In addition to the requirements of Section 3.4.2.2.3.1, anchorage of piles shall comply with this section. Where required for resistance to uplift forces, anchorage of steel pipe (round HSS sections), concrete-filled steel pipe or H piles to the pile cap shall be made by means other than concrete bond to the bare steel section.

EXCEPTION: Anchorage of concrete-filled steel pipe piles is permitted to be accomplished using deformed bars developed into the concrete portion of the pile.

3.4.2.13.6 Requirements for structures assigned to Seismic Design Categories D through F

In addition to the requirements of Sections 3.4.1.8.2, and 3.4.1.8.3, the following foundation design requirements shall apply to structures assigned to Seismic Design Category D, E, or F. Design and construction of concrete foundation components shall conform to the requirements of ACI 318-05, Section 21.8, except as modified by the requirements of this section.

EXCEPTION: Detached one- and two-family dwellings of light-frame construction not exceeding two storeys in height above grade need only comply with the requirements for Sections 3.4.1.8.2, 3.4.1.8.3 (Items 2 through 4), 3.4.2.13.2, and 3.4.2.13.5.

3.4.2.13.6.1 Pole-type structures

Where construction employing posts or poles as columns embedded in earth or embedded in concrete footings in the earth is used to resist lateral loads, the depth of embedment required for posts or poles to resist seismic forces shall be determined by means of the design criteria established in the foundation

investigation report.

3.4.2.13.6.2 Foundation ties

Individual pile caps, drilled piers, or caissons shall be interconnected by ties. In addition, individual spread footings founded on Site Class E or F shall be interconnected by ties. All ties shall have a design strength in tension or compression

at least equal to a force equal to 10 percent of S_D times the larger pile cap or column factored dead plus factored live load unless it is demonstrated that equivalent restraint will be provided by reinforced concrete beams within slabs on grade or reinforced concrete slabs on grade or confinement by competent rock, hard cohesive soils, very dense granular soils, or other approved means.

3.4.2.13.6.3 General pile design requirement

Piling shall be designed and constructed to withstand deformations from earthquake ground motions and structure response. Deformations shall include both free-field soil strains (without the structure) and deformations induced by lateral pile resistance to structure seismic forces, all as modified by soil-pile interaction.

3.4.2.13.6.4 Batter piles

Batter piles and their connections shall be capable of resisting forces and moments from the load combinations with overstrength factor of Section 3.4.2.4.3.2 or 3.4.2.14.3.2.2. Where vertical and batter piles act jointly to resist foundation forces as a group, these forces shall be distributed to the individual piles in accordance with their relative horizontal and vertical rigidities and the geometric distribution of the piles within the group.

3.4.2.13.6.5 Pile anchorage requirements

In addition to the requirements of Section 3.4.2.3.5.3, anchorage of piles shall comply with this section. Design of anchorage of piles into the pile cap shall consider the combined effect of axial forces due to uplift and bending moments due to fixity to the pile cap. For piles required to resist uplift forces or provide rotational restraint, anchorage into the pile cap shall be capable of developing the following:

1. In the case of uplift, the lesser of the nominal tensile strength of the longitudinal reinforcement in a concrete pile, or the nominal tensile strength of a steel pile, or 1.3 times the pile pullout resistance, or the axial tension force resulting from the load combinations with overstrength factor of Section 3.4.2.4.3.2 or 3.4.2.14.3.2.2. The pile pullout resistance shall be taken as the ultimate frictional or adhesive force that can be developed between the soil and the pile plus the pile weight.
2. In the case of rotational restraint, the lesser of the axial and shear forces and moments resulting from the load

combinations with overstrength factor of Section 3.4.2.4.3.2 or 3.4.2.14.3.2.2 or development of the full axial, bending, and shear nominal strength of the pile.

3.4.2.13.6.6 Splices of pile segments

Splices of pile segments shall develop the nominal strength of the pile section, but the splice need not develop the nominal strength of the pile in tension, shear, and bending where it has been designed to resist axial and shear forces and moments from the load combinations with overstrength factor of Section 3.4.2.4.3.2 or 3.4.2.14.3.2.2.

3.4.2.13.6.7 Pile soil interaction

Pile moments, shears, and lateral deflections used for design shall be established considering the interaction of the shaft and soil. Where the ratio of the depth of embedment of the pile to the pile diameter or width is less than or equal to 6, the pile is permitted to be assumed to be flexurally rigid with respect to the soil.

3.4.2.13.6.8 Pile group effects

Pile group effects from soil on lateral pile nominal strength shall be included where pile centre-to-centre spacing in the direction of lateral force is less than eight pile diameters or widths. Pile group effects on vertical nominal strength shall be included where pile centre-to-centre spacing is less than three pile diameters or widths.

3.4.2.14 Alternative Simplified Structural Design Criteria For Simple Bearing Wall or Building Frame Systems

3.4.2.14.1 General

3.4.2.14.1.1 Simplified design procedure

The procedures of this section are permitted to be used in lieu of other analytical procedures in Section 3.4.2 for the analysis and design of simple buildings with bearing wall or building frame systems, subject to all of the limitations listed in Section 3.4.2.14.1.1. Where these procedures are used, the Seismic Design Category shall be determined from Table 3.4.15 using the value of S_{DS} from Section 3.4.2.14.8.1.

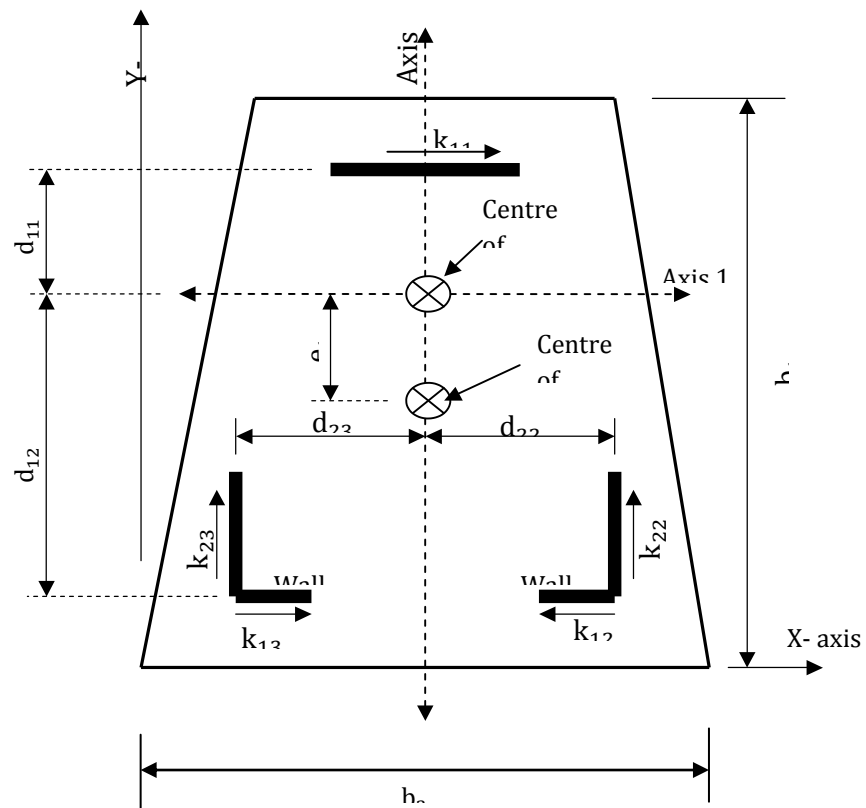


Figure 3.4.6 Notation used in torsion check for nonflexible diaphragms

TABLE 3.4.17 DESIGN COEFFICIENTS AND FACTORS FOR SEISMIC FORCE-RESISTING SYSTEMS FOR SIMPLIFIED DESIGN PROCEDURE

Seismic Force-Resisting System	ASCE 7 Section where Detailing Requirements are Specified	Response Modification Coefficient, R_a	Limitations ^b		
			Seismic Design Category		
			B	C	D,E
A. BEARING WALL SYSTEMS					
1. Special reinforced concrete shear walls	13.4.2 and 13.4.2.3.6	5	P	P	P
2. Ordinary reinforced concrete shear walls	13.4.2 and 13.4.2.3.4	4	P	P	NP
3. Detailed plain concrete shear walls	13.4.2 and 13.4.2.3.2	2	P	NP	NP
4. Ordinary plain concrete shear walls	13.4.2 and 13.4.2.3.1	1½	P	NP	NP
5. Intermediate precast shear walls	13.4.2 and 13.4.2.3.5	4	P	P	40 ^c
6. Ordinary precast shear walls	13.4.2 and 13.4.2.3.3	3	P	NP	NP
7. Special reinforced masonry shear walls	13.4.4 and 13.4.3.4.3	5	P	P	P
8. Intermediate reinforced masonry shear walls	13.4.4 and 13.4.3.4.3	3½	P	P	NP
9. Ordinary reinforced masonry shear walls	13.4.4	2	P	NP	NP
10. Detailed plain masonry shear walls	13.4.4	2	P	NP	NP
11. Ordinary plain masonry shear walls	13.4.4	1½	P	NP	NP
12. Prestressed masonry shear walls	13.4.	1½	P	NP	NP
13. Light-frame walls sheathed with wood structural panels	13.4.1, 13.4.1.3.4.2, and 13.4.5	6½	P	P	P
13.4. Light-frame walls sheathed with wood structural panels	13.4.1, 13.4.1.3.4.2, and 13.4.5	2	P	P	NP ^d
15. Light-frame wall systems using flat strap bracing	13.4.1, 13.4.1.3.4.2, and 13.4.5	4	P	P	P
B. BUILDING FRAME SYSTEMS					
1. Steel eccentrically braced frames, moment-resisting connections at columns away from links	13.4.1	8	P	P	P
2. Steel eccentrically braced frames, non-moment-resisting connections at columns away from links	13.4.1	7	P	P	P
3. Special steel concentrically braced frames	13.4.	6	P	P	P
3.4. Ordinary steel concentrically braced frames	13.4.	3¼	P	P	P
5. Special reinforced concrete shear walls	13.4.2 and 13.4.2.3.6	6	P	P	P
6. Ordinary reinforced concrete shear walls	13.4.2 and 13.4.2.3.4	5	P	P	NP
7. Detailed plain concrete shear walls	13.4.2 and 13.4.2.3.2	2	P	NP	NP
8. Ordinary plain concrete shear walls	13.4.2 and 13.4.2.3.1	1½	P	NP	NP
9. Intermediate precast shear walls	13.4.2 and 13.4.2.3.5	5	P	P	40 ^c
10. Ordinary precast shear walls	13.4.2 and 13.4.2.3.3	4	P	NP	NP
11. Composite steel and concrete eccentrically braced frames	13.4.	8	P	P	P
12. Composite steel and concrete concentrically braced frames	13.4.	5	P	P	P
13. Ordinary composite steel and concrete braced frames	13.4.	3	P	P	NP
13.4. Composite steel plate shear walls	13.4.	6½	P	P	P
15. Special composite reinforced concrete shear walls with steel elements	13.4.3	6	P	P	P
16. Ordinary composite reinforced concrete shear walls with steel elements	13.4.3	5	P	P	NP
17. Special reinforced masonry shear walls	13.4.	5½	P	P	P
18. Intermediate reinforced masonry shear walls	13.4.	4	P	P	NP
19. Ordinary reinforced masonry shear walls	13.4.	2	P	NP	NP
20. Detailed plain masonry shear walls	13.4.	2	P	NP	NP
21. Ordinary plain masonry shear walls	13.4.	1½	P	NP	NP
22. Prestressed masonry shear walls	13.4.	1½	P	NP	NP
23. Light-frame walls sheathed with wood structural panels	13.4.1, 13.4.1.3.4.2, and 13.4.5	7	P	P	P
23.4. Light-frame walls sheathed with wood structural panels	13.4.1, 13.4.1.3.4.2, and 13.4.5	2½	P	P	NP ^d
25. Buckling-restrained braced frames, non-moment-resisting beam-	13.4.1	7	P	P	P

26. Buckling-restrained braced frames, moment-resisting beam-column connections	13.4.1	8	P	P	P
27. Special steel plate shear wall	13.4.	7	P	P	P

a Response modification coefficient, *R*, for use throughout the standard.

b P = permitted; NP = not permitted.

c Light-framed walls with shear panels of all other materials not permitted in Seismic Design Category E.

d Light-framed walls with shear panels of all other materials permitted up to 35 ft in height in Seismic Design Category D and not permitted in Seismic Design Category E.

The simplified design procedure is permitted to be used if the following limitations are met:

1. The structure shall qualify for Occupancy Category I or II in accordance with Table 1.2.
2. The site class shall not be class E or F.
3. The structure shall not exceed three storeys in height above grade.
4. The seismic-force resisting system shall be either a bearing wall system or building frame system, as indicated in Table 3.4.17.
5. The structure shall have at least two lines of lateral resistance in each of two major axis directions.
6. At least one line of resistance shall be provided on each side of the centre of mass in each direction.
7. For structures with flexible diaphragms, overhangs beyond the outside line of shear walls or braced frames shall satisfy the following:

$$a \leq d/5 \quad \text{Eq.(3.4.39)}$$

where

a = the distance perpendicular to the forces being considered from the extreme edge of the diaphragm to the line of vertical resistance closest to that edge

d = the depth of the diaphragm parallel to the forces being considered at the line of vertical resistance closest to the edge

8. For buildings with a diaphragm that is not flexible, the distance between the centre of rigidity and the centre of mass parallel to each major axis shall not exceed 15 percent of the greatest width of the diaphragm parallel to that axis. In addition, the following shall be satisfied for each major axis direction:

$$\sum_{i=1}^m k_{1i} d_i^2 + \sum_{j=1}^n k_{2j} d_j^2 \geq 2.5 \left(0.05 + \frac{e_1}{b}\right) b^2 \sum_{i=1}^m k_{1i} \quad \text{Eq. (3.4.40)}$$

where (see Fig. 3.4.6):

k_{1i} = the lateral load stiffness of wall “i” or braced frame “i” parallel to major axis1

k_{2j} = the lateral load stiffness of wall “j” or braced frame “j” parallel to major axis2

d_{1i} = the distance from the wall "i" or braced frame "i" to the centre of rigidity, perpendicular to major axis 1

d_{2j} = the distance from the wall "j" or braced frame "j" to the centre of rigidity, perpendicular to major axis 2

b_i = the width of the diaphragm perpendicular to major axis 1

m = the number of walls and braced frames resisting lateral force in direction 1

n = the number of walls and braced frames resisting lateral force in direction 2

Eq. (3.4.40) need not be checked where a structure fulfills all the following limitations:

1. The arrangement of walls or braced frames is symmetric about each major axis direction.
 2. The distance between the two most separated lines of walls or braced frames is at least 90 percent of the dimension of the structure perpendicular to that axis direction.
 3. The stiffness along each of the lines considered for item 2 above is at least 33 percent of the total stiffness in that axis direction.
9. Lines of resistance of the lateral force-resisting system shall be oriented at angles of no more than 15° from alignment with the major orthogonal horizontal axes of the building.
10. The simplified design procedure shall be used for each major orthogonal horizontal axis direction of the building.
11. System irregularities caused by in-plane or out-of-plane offsets of lateral force-resisting elements shall not be permitted.
- EXCEPTION: Out-of-plane and in-plane offsets of shear walls are permitted in two-storey buildings of light-frame construction provided that the framing supporting the upper wall is designed for seismic force effects from overturning of the wall amplified by a factor of 2.5.
12. The lateral-load-resistance of any storey shall not be less than 80 percent of the storey above.

3.4.2.14.1.2 Definitions

The definitions listed in Section 3.4.1.2 shall be used in addition to the following:

PRINCIPAL ORTHOGONAL HORIZONTAL DIRECTIONS: The orthogonal directions that overlay the majority of lateral force resisting elements.

3.4.2.14.1.3 Notation

D = The effect of dead load

E = The effect of horizontal and vertical earthquake-induced forces

F_a = Acceleration-based site coefficient, see Section 3.4.2.14.8.1.

F_i = The portion of the seismic base shear, V , induced at Level i

F_p = The seismic design force applicable to a particular structural component

F_x = See Section 3.4.2.14.8.2

h_i = The height above the base to Level i

h_x = The height above the base to Level x

Level i = The building level referred to by the subscript i ;

$i = 1$ designates the first level above the base

Level n = The level that is uppermost in the main portion of the building

Level x = See “Level i ”

Q_E = The effect of horizontal seismic forces

R = The response modification coefficient as given in Table 3.4.17

S_{DS} = See Section 3.4.2.14.8.1

S_S = See Section 3.4.14.1

V = The total design shear at the base of the structure in the direction of interest, as determined using the procedure of 3.4.2.14.8.1

V_x = The seismic design shear in Storey x .See Section 3.4.2.14.8.3

W = See Section 3.4.2.14.8.1

W_c = Weight of wall

W_p = Weight of structural component

w_i = The portion of the effective seismic weight, W , located at or assigned to Level i

w_x = See Section 3.4.2.14.8.2

3.4.2.14.2 Design basis

The structure shall include complete lateral and vertical-force-resisting systems with adequate strength to resist the design seismic forces, specified in this section, in combination with other loads. Design seismic forces shall be distributed to the various elements of the structure and their connections using a linear elastic analysis in accordance with the procedures of Section 3.4.2.14.8. The members of the seismic

force-resisting system and their connections shall be detailed to conform with the applicable requirements for the selected structural system as indicated in Section 3.4.2.13.4.3.4.1. A continuous load path, or load paths, with adequate strength and stiffness shall be provided to transfer all forces from the point of application to the final point of resistance. The foundation shall be designed to accommodate the forces developed.

3.4.2.14.3 Seismic load effects and combinations

All members of the structure, including those not part of the seismic force-resisting system, shall be designed using the seismic load effects of Section 3.4.2.14.3 unless otherwise exempted by this standard. Seismic load effects are the axial, shear, and flexural member forces resulting from application of horizontal and vertical seismic forces as set forth in Section 3.4.2.14.3.1. Where specifically required, seismic load effects shall be modified to account for system

overstrength, as set forth in Section 3.4.2.14.3.1.3.

3.4.2.13.4.3.1 Seismic load effect

The seismic load effect, E , shall be determined in accordance with the following:

1. For use in load combination 5 in Section 2.1.2.2 or load combination 5 and 6 in Section 2.1.3.1, E shall be determined in accordance with Eq. (3.4.41) as follows:

$$E = E_h + E_v \quad \text{Eq. (3.4.41)}$$

2. For use in load combination 7 in Section 2.1.2.2 or load combination 8 in Section 2.1.3.1, E shall be determined in accordance with Eq. (3.4.42) as follows:

$$E = E_h - E_v \quad \text{Eq. (3.4.42)}$$

where

E = seismic load effect

E_h = effect of horizontal seismic forces as defined in Section 3.4.2.14.3.1.1.

E_v = effect of vertical seismic forces as defined in Section 3.4.2.14.3.1.2.

3.4.2.14.3.1.1 Horizontal seismic load effect

The horizontal seismic load effect, E_h , shall be determined in accordance with Eq. (3.4.43) as follows:

$$E_h = Q_E \quad \text{Eq. (3.4.43)}$$

where

Q_E = effects of horizontal seismic forces from V or F_p as specified in Sections 3.4.2.14.7.5, and 3.4.2.14.8.1.

3.4.2.14.3.1.2 Vertical seismic load effect

The vertical seismic load effect, E_v , shall be determined in accordance with Eq. (3.4.44) as follows:

$$E_v = 0.2S_{DS}D \quad \text{Eq. (3.4.44)}$$

where

S_{DS} = design spectral response acceleration parameter at short periods obtained from Section 3.4.1.4.4

D = effect of dead load

EXCEPTION: The vertical seismic load effect, E_v , is permitted to be taken as zero for either of the following conditions:

1. In Eqs. (3.4.3), (3.4.4), (3.4.7), and (3.4.46) where S_{DS} is equal to or less than 0.125.
2. In Eq. (3.4.42) where determining demands on the soil-structure interface of foundations.

3.4.2.14.3.1.3 Seismic load combinations

Where the prescribed seismic load effect, E , defined in Section 3.4.2.14.3.1 is combined with the effects of other loads as set forth in Chapter 2, the following seismic load combinations for structures not subject to flood or atmospheric ice loads shall be used in lieu of the seismic load combinations in Sections 2.1.2.2 or 2.1.3.1.

Basic combinations for strength design (see Sections 2.1.2 and 1.1.2 for notation).

$$5. (1.2 + 0.2S_{DS}) D + Q_E + L$$

$$7. (0.9 - 0.2S_{DS}) D + Q_E + 1.6 H$$

NOTES:

1. The load factor on L in combination 5 is permitted to equal 0.5 for all occupancies in which L_o in Table 2.2 is less than or equal to 100 psf (3.4.79 kN/m²), with the exception of garages or areas occupied as places of public assembly.

2. The load factor on H shall be set equal to zero in combination 7

if the structural action due to H counteracts that due to E . Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Basic combinations for allowable stress design (see Sections 2.1.3 and 1.1.2 for notation).

$$5. (1.0 + 0.14S_{DS}) D + H + F + 0.7 Q_E$$

$$6. (1.0 + 0.105S_{DS}) D + H + F + 0.525 Q_E + 0.75L + 0.75(L_r \text{ or } R)$$

$$8. (0.6 - 0.14S_{DS}) D + 0.7 Q_E + H$$

3.4.2.14.3.2 Seismic load effect including a 2.5 overstrength factor

Where specifically required, conditions requiring overstrength factor applications shall be determined in accordance with the following:

1. For use in load combination 5 in Section 2.1.2.2 or load combinations 5 and 6 in Section 2.1.3.1, E shall be taken equal to E_m as determined in accordance with Eq. (3.4.45) as follows:

$$E_m = E_{mh} + E_v \quad \text{Eq. (3.4.45)}$$

2. For use in load combination 7 in Section 2.1.2.2 or load combination 8 in Section 2.1.3.1, E shall be taken equal to E_m as determined in accordance with Eq. 3.4.46 as follows:

$$E_m = E_{mh} - E_v \quad \text{Eq. (3.4.46)}$$

where

E_m = seismic load effect including overstrength factor

E_{mh} = effect of horizontal seismic forces including structural overstrength as defined in Section 3.4.2.14.3.2.1

E_v = vertical seismic load effect as defined in Section 3.4.2.14.3.1.2

3.4.2.14.3.2.1 Horizontal seismic load effect with a 2.5 overstrength factor

The horizontal seismic load effect with overstrength factor, E_{mh} , shall be determined in accordance with Eq.(3.4.47) as follows:

$$E_{mh} = 2.5 Q_E \quad \text{Eq. (3.4.47)}$$

where

Q_E = effects of horizontal seismic forces from V or F_p as specified in Sections 3.4.2.14.8.1 and 3.4.2.14.7.5.

EXCEPTION: The value of E_{mh} need not exceed the maximum force that can develop in the element as determined by a rational, plastic mechanism analysis or nonlinear response analysis utilizing realistic expected values of material strengths.

3.4.2.14.3.2.2 Load combinations with overstrength factor

Where the seismic load effect with overstrength, E_m , defined in Section 3.4.2.14.3.2 is combined with the effects of other loads as set forth in Section 2, the following seismic load combinations for structures not subject to flood or atmospheric ice loads shall be used in lieu of the seismic load combinations in Section 2.1.2.2 or 2.1.3.1:

Basic combinations for strength design with overstrength factor (see Sections 2.1.2.2 and 1.1.2 for notation)

$$5. (1.2 + 0.2S_{DS}) D + 2.5 Q_E + L$$

$$7. (0.9 - 0.2S_{DS}) D + 2.5 Q_E + 1.6 H$$

NOTES:

1. The load factor on L in combination 5 is permitted to equal 0.5 for all occupancies in which L_0 in Table 2.2 is less than or equal to 100 psf (3.4.79 kN/m²), with the exception of garages or areas occupied as places of public assembly.
2. The load factor on H shall be set equal to zero in combination 7 if the structural action due to H counteracts that due to E . Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Basic combinations for allowable stress design with overstrength factor (see Sections 2.1.3.1 and 1.1.2 for notation)

$$5. (1.0 + 0.14S_{DS}) D + H + F + 0.7 Q_E$$

$$6. (1.0 + 0.105S_{DS}) D + H + F + 0.525 Q_E + 0.75L + 0.75(L_r \text{ or } R)$$

$$8. (0.6 - 0.14S_{DS}) D + 0.7 Q_E + H$$

3.4.2.14.3.2.3 Allowable stress increase for load combinations with overstrength

Where allowable stress design methodologies are used with the seismic load effect defined in Section 3.4.2.14.3.2 applied in load combinations 5, 6, or 8 of Section 2.1.3.1, allowable stresses are permitted to be determined using an allowable stress increase of 1.2. This increase shall not be combined with increases in allowable stresses or load combination reductions otherwise permitted by this standard or the material reference document except that combination with the duration of load increases permitted in AF&PA NDS (American Forest and Paper Association, Natural Design Specification for Wood Construction, AF&PA NDS-05, 2005) is permitted.

3.4.2.14.4 Seismic force-resisting system

3.4.2.14.4.1 Selection and limitations

The basic lateral and vertical seismic force-resisting system shall conform to one of the types indicated in Table 3.4.17 and shall conform to all of the detailing requirements referenced in the table. The appropriate response modification coefficient, R , indicated in Table 3.4.17 shall be used in determining the base shear and element design forces as set forth in the seismic requirements of this standard.

Special framing and detailing requirements are indicated in Section 3.4.2.14.7 and in sections on material design standards.

3.4.2.14.4.2 Combinations of framing systems

3.4.2.14.4.2.1 Horizontal combinations

Different seismic force-resisting systems are permitted to be used in each of the two principal orthogonal building directions. Where a combination of different structural systems is utilized to resist lateral forces in the same direction, the value of R used for design in that direction shall not be greater than the least value of R for any of the systems utilized in that direction.

EXCEPTION: For buildings of light-frame construction or have flexible diaphragms and that are two stories or less in height, resisting elements are permitted to be designed using the least value of R of the different seismic force-resisting systems found in each independent line of framing. The value of R used for design of diaphragms in such structures shall not be greater than the least value for any of the systems utilized in that same direction.

3.4.2.14.4.2.2 Vertical combinations

Different seismic force-resisting systems are permitted to be used in different storeys. The value of R used in a given direction shall not be greater than the least value of any of the systems used in that direction.

3.4.2.14.4.2.3 Combination framing detailing requirements

The detailing requirements of Section 3.4.2.14.7 required by the higher response modification coefficient, R , shall be used for structural components common to systems having different response modification coefficients.

3.4.2.14.5 Diaphragm flexibility

Diaphragms constructed of steel decking, (untopped), wood structural panels, or similar panelized construction are permitted to be considered flexible.

3.4.2.14.6 Application of loading

The effects of the combination of loads shall be considered as prescribed in Section 3.4.2.14.3. The design seismic forces are permitted to be applied separately in each orthogonal direction and the combination of effects from the two directions need not be considered. Reversal of load shall be considered.

3.4.2.14.7 Design and detailing requirements

The design and detailing of the components of the seismic force-resisting system shall comply with the requirements of this section. The foundation shall be designed to resist the forces developed and accommodate the movements imparted to the structure by the design ground motions. The dynamic nature of the forces, the expected ground motion, the design basis for strength and energy dissipation capacity of the structure, and the dynamic properties of the soil shall be included in the determination of the foundation design criteria. The design and construction of foundations shall comply with Section 3.4.2.13. Structural elements including foundation elements shall conform to the material design and detailing requirements.

3.4.2.14.7.1 Connections

All parts of the structure between separation joints shall be interconnected, and the connection shall be capable of transmitting the seismic force, F_p , induced by the parts being connected. Any smaller portion of the structure shall be tied to the remainder of the structure with elements having a strength of 0.20 times the short period design spectral response acceleration coefficient, S_{DS} , times the weight of the smaller portion or 5 percent of the portion's weight, whichever is greater.

A positive connection for resisting a horizontal force acting parallel to the member shall be provided for each beam, girder, or truss either directly to its supporting

elements, or to slabs designed to act as diaphragms. Where the connection is through a diaphragm, then the member's supporting element must also be connected to the diaphragm. The connection shall have minimum design strength of 5 percent of the dead plus live load reaction.

3.4.2.14.7.2 Openings or reentrant building corners

Except where as otherwise specifically provided for in this standard, openings in shear walls, diaphragms, or other plate-type elements, shall be provided with

reinforcement at the edges of the openings or reentrant corners designed to transfer the stresses into the structure. The edge reinforcement shall extend into the body of the wall or diaphragm a distance sufficient to develop the force in the reinforcement.

EXCEPTION: Perforated shear walls of wood structural panels are permitted where designed in accordance with AF&PA SDPWS.

3.4.2.14.7.3 Collector elements

Collector elements shall be provided with adequate strength to transfer the seismic forces originating in other portions of the structure to the element providing the resistance to those forces (see Fig. 3.4.4). Collector elements, splices, and their connections to resisting elements shall be designed to resist the forces defined in Section 3.4.2.14.3.2.

EXCEPTION: In structures, or portions thereof, braced entirely by light-frame shear walls, collector elements, splices, and connections to resisting elements are permitted to be designed to resist forces in accordance with Section 3.4.2.14.7.4.

3.4.2.14.7.4 Diaphragms

Floor and roof diaphragms shall be designed to resist the design seismic forces at each level, F_x , calculated in accordance with Section 3.4.2.14.8.2. Where the diaphragm is required to transfer design seismic forces from the vertical-resisting elements above the diaphragm to other vertical-resisting elements below the diaphragm due to changes in relative lateral stiffness in the vertical elements, the transferred portion of the seismic shear force at that level, V_x , shall be added to the diaphragm design force. Diaphragms shall provide for both the shear and bending stresses resulting from these forces. Diaphragms shall have ties or struts to distribute the wall anchorage forces into the diaphragm. Diaphragm connections shall be positive, mechanical, or welded type connections.

3.4.2.14.7.5 Anchorage of concrete or masonry structural walls

Concrete or masonry structural walls shall be anchored to all floors, roofs, and members that provide out-of-plane lateral support for the wall or that are supported by the wall. The anchorage shall provide a positive direct connection between the wall and floor, roof, or supporting member with the strength to resist horizontal forces specified in this section for structures with flexible diaphragms.

Anchorage of structural walls to flexible diaphragms shall have the strength to develop the out-of-plane force given by Eq. (3.4.48):

$$F_p = 0.8 S_{DS} W_p \quad \text{Eq. (3.4.48)}$$

where

F_p = the design force in the individual anchors

S_{DS} = the design spectral response acceleration at short periods per Section 3.4.2.14.8.1

W_p = the weight of the wall tributary to the anchor

EXCEPTION: For Seismic Design Category B, the coefficient 0.8 shall be 0.4, with a minimum force of 10 percent of the tributary weight of the wall or 400 SDS in pounds per foot, whichever is greater.

3.4.2.14.7.5 Transfer of anchorage forces into diaphragms

Diaphragms shall be provided with continuous ties or struts between diaphragm chords to distribute these anchorage forces into the diaphragms. Added chords are permitted to be used to form subdiaphragms to transmit the anchorage forces to the main continuous cross-ties. The maximum length-to-width ratio of the structural subdiaphragm shall be 2.5 to 1. Connections and anchorages capable of resisting the prescribed forces shall be provided between the diaphragm and the attached components. Connections shall extend into the diaphragm a sufficient distance to develop the force transferred into the diaphragm.

3.4.2.14.7.5.1 Wood diaphragms

In wood diaphragms, the continuous ties shall be in addition to the diaphragm sheathing. Anchorage shall not be accomplished by use of toenails or nails subject to withdrawal nor shall wood ledgers or framing be used in cross-grain bending or cross-grain tension. The diaphragm sheathing shall not

be considered effective as providing the ties or struts required by this section.

3.4.2.14.7.5.2 Metal deck diaphragms

In metal deck diaphragms, the metal deck shall not be used as the continuous ties required by this section in the direction perpendicular to the deck span.

3.4.2.14.7.5.3 Embedded straps

Diaphragm to wall anchorage using embedded straps shall be attached to or hooked around the reinforcing steel or otherwise terminated so as to effectively transfer forces to the reinforcing steel.

3.4.2.14.7.6 Bearing walls and shear walls

Exterior and interior bearing walls and shear walls and their anchorage shall be designed for a force equal to 40 percent of the short period design spectral response acceleration S_{DS} times the weight of wall, W_c , normal to the surface, with a minimum force of 10 percent of the weight of the wall. Interconnection of wall elements and connections to supporting framing systems shall have sufficient ductility, rotational capacity, or sufficient strength to resist shrinkage, thermal changes, and differential foundation settlement where combined with seismic forces.

3.4.2.14.8 Simplified lateral force analysis procedure

An equivalent lateral force analysis shall consist of the application of equivalent static lateral forces to a linear mathematical model of the structure. The lateral forces applied in each direction shall sum to a total seismic base shear given by Section 3.4.2.14.8.1 and shall be distributed vertically in accordance with Section 3.4.2.14.8.2. For purposes of

analysis, the structure shall be considered fixed at the base.

3.4.2.14.8.1 Seismic base shear

The seismic base shear, V , in a given direction shall be determined in accordance with Eq. (3.4.49):

$$V = \frac{F S_{DS}}{R} W \quad \text{Eq. (3.4.49)}$$

where

$$S_{DS} = \frac{2}{3} F_a S_s$$

where F_a is permitted to be taken as 1.0 for rock sites, 1.4 for soil sites, or determined in accordance with Section 3.4.1.4.3. For the purpose of this section, sites are

permitted to be considered to be rock if there is no more than 10 ft (3 m) of soil between the rock surface and the bottom of spread footing or mat foundation. In calculating S_{DS} , S_s shall be in accordance with Section 3.4.1.4.1, but need not be taken larger than 1.5.

$F = 1.0$ for one-storey buildings

$F = 1.1$ for two-storey buildings

$F = 1.2$ for three-storey buildings

R = the response modification factor from Table 3.4.17

W = effective seismic weight of structure that shall include the total dead load and other loads listed in the following text

1. In areas used for storage, a minimum of 25 percent of the floor live load (floor live load in public garages and open parking structures need not be included).
2. Where provision for partitions is required by Section 3.4.2.2 in the floor load design, the actual partition weight, or a minimum weight of 10 psf (0.48 kN/m²) of floor area, whichever is greater.
3. Total operating weight of permanent equipment.
4. Where the flat roof snow load, P_f , exceeds 30 psf (1.44 kN/m²), 20 percent of the uniform design snow load, regardless of actual roof slope.

3.4.2.14.8.2 Vertical distribution

The forces at each level shall be calculated using the following equation:

$$F_x = \frac{w_x}{W} V \quad \text{Eq. (3.4.50)}$$

where

w_x = the portion of the effective seismic weight of the structure, W , at

level x .

3.4.2.14.8.3 Horizontal shear distribution

The seismic design storey shear in any storey, V_x (kip or kN), shall be determined from the following equation:

$$V_x = \sum_{i=x}^n F_i \quad \text{Eq.(3.4.51)}$$

where F_i = the portion of the seismic base shear, V (kip or kN) induced at Level, i

3.4.2.14.8.3.1 Flexible diaphragm structures

The seismic design storey shear in stories of structures with flexible diaphragms, as defined in Section 3.4.2.14.5, shall be distributed to the vertical elements of the lateral force resisting system using tributary area rules. Two-dimensional analysis is permitted where diaphragms are flexible.

3.4.2.14.8.3.2 Structures with diaphragms that are not flexible

For structures with diaphragms that are not flexible, as defined in Section 3.4.2.14.5, the seismic design storey shear, V_x , (kip or kN) shall be distributed to the various vertical elements of the seismic force-resisting system in the storey under consideration based on the relative lateral stiffnesses of the vertical elements and the diaphragm.

3.4.2.14.8.3.2.1 Torsion

The design of structures with diaphragms that are not flexible shall include the torsional moment, M_t (kip-ft or KN-m) resulting from eccentricity between the locations of centre of mass and the centre of rigidity.

3.4.2.14.8.4 Overturning

The structure shall be designed to resist overturning effects caused by the seismic forces determined in Section 3.4.2.14.8.2. The foundations of structures shall be designed for not less than 75 percent of the foundation overturning design moment, M_f (kip-ft or kN-m) at the foundation-soil interface.

3.4.2.14.8.5 Drift limits and building separation

Structural drift need not be calculated. Where a drift value is needed for use in material standards, to determine structural separations between buildings, for design of cladding, or for other design requirements, it shall be taken as 1 percent of building height unless computed to be less. All portions of the structure shall be designed to act as an integral unit in resisting seismic forces unless separated structurally by a distance sufficient to avoid damaging contact under the total deflection.

SECTION 3.4: SEISMIC DESIGN CRITERIA AND DESIGN REQUIREMENTS FOR BUILDINGS (CONTINUED)

3.4.3 Seismic Response History Procedures

3.4.3.1 Linear Response History Procedure

Where linear response history procedure is performed the requirements of this section shall be satisfied.

3.4.3.1.1 Analysis requirements

A linear response history analysis shall consist of an analysis of a linear mathematical model of the structure to determine its response, through methods of numerical integration, to suites of ground motion acceleration histories compatible with the design response spectrum for the site. The analysis shall be performed in accordance with the requirements of this section.

3.4.3.1.2 Modeling

Mathematical models shall conform to the requirements of Section 3.4.2.7.

3.4.3.1.3 Ground motion

A suite of not less than three appropriate ground motions shall be used in the analysis. Ground motion shall conform to the requirements of this section.

3.4.3.1.3.1 Two-dimensional analysis

Where 2-D analyses are performed, each ground motion shall consist of a horizontal acceleration history, selected from an actual recorded event. Appropriate acceleration histories shall be obtained from records of events having magnitudes, fault distance, and source mechanisms that are consistent with those that control the maximum considered earthquake. Where the required number of appropriate recorded ground motion records are not available, appropriate simulated ground motion records shall be used to make up the total number required. The ground motions shall be scaled such that the average value of the 5 percent damped response spectra for the suite of motions is not less than the design response spectrum for the site for periods ranging from $0.2T$ to $1.5T$ where T is the natural period of the structure in the fundamental mode for the direction of response being analyzed.

3.4.3.1.3.2 Three-dimensional analysis

Where 3-D analysis is performed, ground motions shall consist of pairs of appropriate horizontal ground motion acceleration components that shall be selected and scaled from individual recorded events. Appropriate ground motions shall be selected from events having magnitudes, fault distance, and source mechanisms that are consistent with those that control the maximum considered earthquake. Where the required number of recorded ground motion pairs are not available, appropriate simulated ground motion pairs

shall be used to make up the total number required. For each pair of horizontal ground motion components, a square root of the sum of the squares (SRSS)

spectrum shall be constructed by taking the SRSS of the 5 percent-damped responsespectrafor the scaled components (where an identical scale factor is applied to both components of a pair).Eachpair of motions shall be scaled such that for each period between $0.2T$ and $1.5T$, the average of the SRSS spectra from all horizontal component pairs does not fall below 1.3times the corresponding ordinate of the design response spectrum, determined in accordance with Section3.4.1.4.5 or 3.4.4.2, by more than 10 percent.

3.4.3.1.4 Response parameters

For each ground motion analyzed, the individual response parameters shall be multiplied by the scalar quantity I/R where I is the importance factor determined in accordance with Section 3.4.1.5.1 and R is the response modification coefficient selected in accordance with Section 3.4.2.2.1. For each ground motion i , where i is the designation assigned to each ground motion, the maximum value of the base shear, V_i , member forces, Q_{Ei} , and storey drifts, Δ_i at each storey, scaled as indicated in the preceding text shall be determined. Where the maximum scaled base shear predicted by the analysis, V_i , is less than the value of V determined using the minimum value of C_s set forth in Eq. (3.4.24) or when located where S_i is equal to or greater than $0.6g$, the minimum value of C_s set forth in Eq. (3.4.25), the scaled member forces, Q_{Ei} , shall be additionally multiplied by V where V is the minimum base shear that has been determined using the minimum value of C_s set forth in Eq. (3.4.24), or when located where S_i is equal to or greater than $0.6g$, the minimum value of C_s set forth in Eq. (3.4.25).

If at least seven ground motions are analyzed, the design member forces used in the load combinations of Section 3.4.2.4.2.1, and the design story drift used in the evaluation of drift in accordance with Section 3.4.2.12.1 is permitted to be taken respectively as the average of the scaled Q_{Ei} and Δ_i values determined from the analyses and scaled as indicated in the preceding text. If fewer than seven ground motions are analyzed, the design member forces and the design story drift shall be taken as the maximum value of the scaled Q_{Ei} and Δ_i values determined from the analyses.

Where this standard requires the consideration of the load combinations with overstrength factor of Section 3.4.2.4.3.2, the value of $\Omega_0 Q_E$ need not be taken larger than the maximum of the unscaled value, Q_{Ei} , obtained from the analyses.

3.4.3.2 Nonlinear Response History Procedure

Where nonlinear response history procedure is performed the requirements of Section 3.4.3.2 shall be satisfied.

3.4.3.2.1 Analysis requirements

A nonlinear response history analysis shall consist of an analysis of a mathematical model of the structure that directly accounts for the nonlinear hysteretic behaviour of the structure's components to determine its response through methods of numerical integration to suites of ground motion acceleration histories compatible with the design response spectrum for the site. The analysis shall be performed in accordance with this section. See Section 3.4.2.1.1 for limitations on the use of this procedure.

3.4.3.2.2 Modeling

A mathematical model of the structure shall be constructed that represents the

spatial distribution of mass throughout the structure. The hysteretic behaviour of elements shall be modeled consistent with suitable laboratory test data and shall account for all significant yielding, strength degradation, stiffness degradation, and hysteretic pinching indicated by such test data. Strength of elements shall be based on expected values considering material overstrength, strain hardening, and hysteretic strength degradation. Linear properties, consistent with the requirements of Section 3.4.2.7.3, are permitted to be used for those elements demonstrated by the analysis to remain within their linear range of response. The structure shall be assumed to have a fixed-base, or alternatively, it is permitted to use realistic assumptions with regard to the stiffness and load-carrying characteristics of the foundations consistent with site-specific soils data and rational principles of engineering mechanics.

For regular structures with independent orthogonal seismic force-resisting systems, independent 2-D models are permitted to be constructed to represent each system. For structures having plan irregularities Types 1a, 1b, 4, or 5 of Table 3.4.10 or structures without independent orthogonal systems, a 3-D model incorporating a minimum of three dynamic degrees of freedom consisting of translation in two orthogonal plan directions and torsional rotation about the vertical axis at each level of the structure shall be used. Where the diaphragms are not rigid compared to the vertical elements of the seismic force-resisting system, the model should include representation of the diaphragm's flexibility and such additional dynamic degrees of freedom as are required to account for the participation of the diaphragm in the structure's dynamic response.

3.4.3.2.3 Ground motion and other loading

Ground motion shall conform to the requirements of Section 3.4.3.1.3. The structure shall be analyzed for the effects of these ground motions simultaneously with the effects of dead load in combination with not less than 25 percent of the required live loads.

3.4.3.2.4 Response parameters

For each ground motion analyzed, individual response parameters consisting of the maximum value of the individual member forces, Q_{Ei} , member inelastic deformations, ψ_i , and storey drifts, Δ_i , at each storey shall be determined, where i is the designation assigned to each ground motion.

If at least seven ground motions are analyzed, the design values of member forces, Q_E , member inelastic deformations, ψ , and storey drift, Δ_i , are permitted to be taken as the average of the Q_{Ei} , ψ_i , and Δ_i values determined from the analyses. If fewer than seven ground motions are analyzed, the design member forces, Q_E , design member inelastic deformations, ψ , and the design storey drift, Δ_i , shall be taken as the maximum value of the Q_{Ei} , ψ_i and Δ_i values determined from the analyses.

3.4.3.2.4.1 Member strength

The adequacy of members to resist the combination of load effects of Section 3.4.2.4 need not be evaluated.

EXCEPTION: Where this standard requires the consideration of the load combinations with overstrength factor of Section 3.4.2.4.3.2, the maximum value of Q_{Ei} obtained from the suite of analyses shall be taken in place of the quantity $\Omega_0 Q_E$.

3.4.3.2.4.2 Member deformation

The adequacy of individual members and their connections to withstand the estimated design deformation values, ψ_i , as predicted by the analyses shall be evaluated based on laboratory test data for similar components. The effects of gravity and other loads on member deformation capacity shall be considered in these evaluations. Member deformation shall not exceed two-thirds of a value that results in loss of ability to carry gravity loads, or that results in deterioration of member strength to less than the 67 percent of the peak value.

3.4.3.2.3.4.3 Storey drift

The design storey drift, Δ_I , obtained from the analyses shall not exceed 125 percent of the drift limit specified in Section 3.4.2.12.1.

3.4.3.2.5 Design review

A design review of the seismic force-resisting system and the structural analysis shall be performed by an independent team of registered design professionals in the appropriate disciplines and others experienced in seismic analysis methods and the theory and application of nonlinear seismic analysis and structural behaviour under extreme cyclic loads. The design review shall include, but need not be limited to, the following:

Review of any site-specific seismic criteria employed in the analysis including the development of site-specific spectra and ground motion time histories.

1. Review of acceptance criteria used to demonstrate the adequacy of structural elements and systems to withstand the calculated force and deformation demands, together with that laboratory and other data used to substantiate these criteria.
2. Review of the preliminary design including the selection of structural system and the configuration of structural elements.
3. Review of the final design of the entire structural system and all supporting analyses.

SECTION 3.4: SEISMIC DESIGN CRITERIA AND DESIGN REQUIREMENTS FOR BUILDINGS (continued)

3.4.4- Site-Specific Ground Motion Procedures for Seismic Design

3.4.4.1 Site Response Analysis

The requirements of Section 3.4.3.4.1 shall be satisfied where site response analysis is performed or required by Section 3.4.1.3.4.7. The analysis shall be documented in a report.

3.4.4.1.1 Base Ground Motions

A maximum considered earthquake (MCE) response spectrum shall be developed for bedrock, using the procedure of Sections 3.4.1.4.6 or 3.4.4.2. Unless a site-specific ground motion hazard analysis described in Section 3.4.4.2 is carried out, the MCE rock response spectrum shall be developed using the procedure of Section 3.4.1.4.6 assuming Site Class B. If bedrock consists of Site Class A, the spectrum shall be adjusted using the site coefficients in Section 3.4.1.4.3 unless other site coefficients can be justified. At least five recorded or simulated horizontal ground motion acceleration time histories shall be selected from events having magnitudes and fault distances that are consistent with those that control the MCE. Each selected time history shall be scaled so that its response spectrum is, on average, approximately at the level of the MCE rock response spectrum over the period range of significance to structural response.

3.4.4.1.2 Site condition modeling

A site response model based on low-strain shear wave velocities, nonlinear or equivalent linear shear stress-strain relationships, and unit weights shall be developed. Low-strain shear wave velocities shall be determined from field measurements at the site or from measurements from similar soils in the site vicinity. Nonlinear or equivalent linear shear stress-strain relationships and unit weights shall be selected on the basis of laboratory tests or published relationships for similar soils. The uncertainties in soil properties shall be estimated. Where very deep soil profiles make the development of a soil model to bedrock impractical, the model is permitted to be terminated where the soil stiffness is at least as great as the values used to define Site Class D . In such cases, the MCE response spectrum and acceleration time histories of the base motion developed in Section 3.4.4.1.1 shall be adjusted upward using site coefficients in Section 3.4.1.4.3 consistent with the classification of the soils at the profile base.

3.4.4.1.3 Site response analysis and computed results

Base ground motion time histories shall be input to the soil profile as outcropping motions. Using appropriate computational techniques that treat nonlinear soil properties in a nonlinear or equivalent-linear manner, the response of the soil profile shall be determined and surface ground motion time histories shall be calculated. Ratios of 5 percent damped response spectra of surface ground motions to input base ground motions shall be calculated. The recommended surface MCE ground motion response spectrum shall not be lower than the MCE response spectrum of the base

motion multiplied by the average surface-to-base response spectral ratios (calculated period by period) obtained from the site response analyses. The recommended surface

ground motions that result from the analysis shall reflect consideration of sensitivity of response to uncertainty in soil properties, depth of soil model, and input motions

3.4.4.2 Ground Motion Hazard Analysis

The requirements of Section 3.4.4.2 shall be satisfied where a ground motion hazard analysis is performed or required by Section 3.4.1.4.7. The ground motion hazard analysis shall account for the regional tectonic setting, geology, and seismicity, the expected recurrence rates and maximum magnitudes of earthquakes on known faults and source zones, the characteristics of ground motion attenuation, near source effects, if any, on ground motions, and the effects of subsurface site conditions on ground motions. The characteristics of subsurface site conditions shall be considered either using attenuation relations that represent regional and local geology or in accordance with Section 3.4.4.1. The analysis shall incorporate current seismic interpretations, including uncertainties for models and parameter values for seismic sources and ground motions. The analysis shall be documented in a report.

3.4.4.2.1 Probabilistic MCE

The probabilistic MCE spectral response accelerations shall be taken as the spectral response accelerations represented by a 5 percent damped acceleration response spectrum having a 2 percent probability of exceedance within a 50-yr. period.

3.4.4.2.2 Deterministic MCE

The deterministic MCE response acceleration at each period shall be calculated as 150 percent of the largest median 5 percent damped spectral response acceleration computed at that period for characteristic earthquakes on all known active faults within the region. For the purposes of this standard, the ordinates of the deterministic MCE ground motion response spectrum shall not be taken lower than the corresponding ordinates of the response spectrum determined in accordance with Fig. 3.4.7, where F_a and F_v are determined using Tables 3.4.3 and 3.4.4, respectively, with the value of S_s taken as 1.5 and the value of S_1 taken as 0.6.

3.4.4.2.3 Site-specific MCE

The site-specific MCE spectral response acceleration at any period, S_{aM} , shall be taken as the lesser of the spectral response accelerations from the probabilistic MCE of Section 3.4.4.2.1 and the deterministic MCE of Section 3.4.4.2.2.

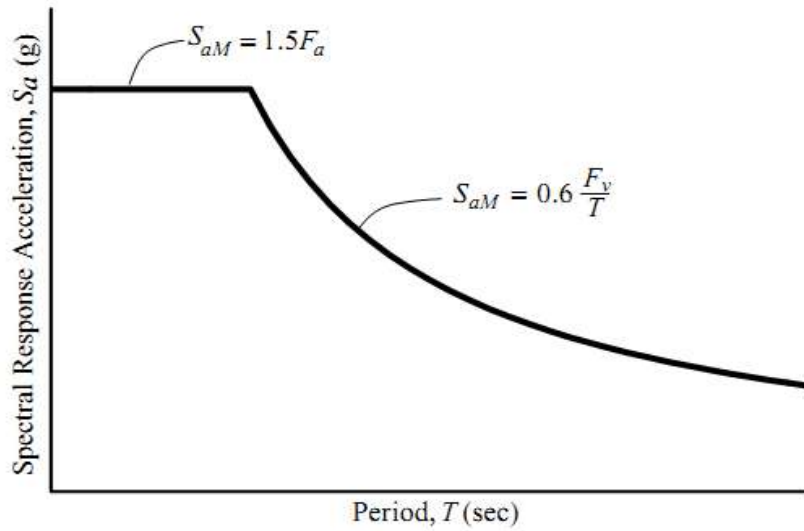


Figure 3.4.7 Deterministic lower limit on MCE response spectrum

3.4.4.3 Design Response Spectrum

The design spectral response acceleration at any period shall be determined from Eq. (3.4.52):

$$S_d = \frac{2}{3} S_{aM} \quad \text{Eq. (3.4.52)}$$

where S_{aM} is the MCE spectral response acceleration obtained from Section 3.4.4.1 or 3.4.4.2. The design spectral response acceleration at any period shall not be taken less than 80 percent of S_d determined in accordance with Section 3.4.1.4.5. For sites classified as Site Class F requiring site response analysis in accordance with Section 3.4.1.4.7, the design spectral response acceleration at any period shall not be taken less than 80 percent of S_d determined for Site Class E in accordance with Section 3.4.1.4.5.

3.4.4.4 Design Acceleration Parameters

Where the site-specific procedure is used to determine the design ground motion in accordance with Section 3.4.4.3, the parameter S_{DS} shall be taken as the spectral acceleration, S_a , obtained from the site-specific spectra at a period of 0.2 s, except that it shall not be taken less than 90 percent of the peak spectral acceleration, S_a , at any period larger than 0.2 s. The parameter S_{D1} shall be taken as the greater of the spectral acceleration, S_a , at a period of 1s or two times the spectral acceleration, S_a , at a period of 2 sec. The parameters S_{MS} and S_{M1} shall be taken as 1.5 times S_{DS} and S_{D1} , respectively. The values so obtained shall not be less than 80 percent of the values determined in accordance with Section 3.4.1.4.3 for S_{MS} and S_{M1} and Section 3.4.1.4.4 for S_{DS} and S_{D1} .

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PART 3 STRUCTURAL DESIGN

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3.5: CONCRETE

Italics are used for text within Sections 3.5.3 through 3.5.8 of this PART to indicate provisions that differ from ACI 318-05.

3.5.1 General

3.5.1.1 Scope

The provisions of this section shall govern the materials, quality control, design and construction of concrete used in structures.

3.5.1.2 Plain and Reinforced Concrete

Structural concrete shall be designed and constructed in accordance with the requirements of this SECTION and ACI 318-05 as amended in Section 5.8. Except for the provisions of Sections 5.4 and 5.10, the design and construction of slabs on grade shall not be governed by this SECTION unless they transmit vertical loads or lateral forces from other parts of the structure to the soil.

3.5.1.3 Source and Applicability

The format and subject matter of Sections 5.2 through 5.4 and 5.6 of this section are patterned after, and in general conformity with, the provisions for structural concrete in ACI 318-05. Sections 5.5, 5.7 and 5.8 are reproduced from chapters 5, 7 and 9 of the ACI Code.

3.5.1.4 Design and Construction Documents

The design and construction documents for structural concrete construction shall include:

1. The specified compressive strength of concrete at the stated ages or stages of construction for which each concrete element is designed.
2. The specified strength or grade of reinforcement.
3. The size and location of structural elements, reinforcement, and anchors.
4. Provision for dimensional changes resulting from creep, shrinkage and temperature.
5. Details and location of contraction or isolation joints specified for plain concrete.
6. Anchorage length of reinforcement and location and length of lap splices.
7. Type and location of mechanical and welded splices of reinforcement.
8. The magnitude and location of prestressing forces.
9. Minimum concrete compressive strength at time of posttensioning.
10. Stressing sequence for posttensioning tendons.
11. For structures assigned to Seismic Design Category D, E or F, a statement if slab on grade is designed as a structural diaphragm (see Section 21.10.3.4 of ACI 318).
12. Structural specifications
13. Soil data used in design

3.5.2 Definitions

3.5.2.1 General

The words and terms defined in ACI 318 shall, for the purposes of this SECTION and as used elsewhere in this PART for concrete construction, have the meanings shown in ACI 318-05.

3.5.3 Specifications for Tests and Materials

3.5.3.1 General

Materials used to produce concrete, concrete itself and testing thereof shall comply with the applicable standards listed in ACI 318.

3.5.3.2 Glass Fiber Reinforced Concrete

Glass fiber reinforced concrete (GFRC) and the materials used in such concrete shall be in accordance with the PCI MNL 128 standard.

3.5.4 Durability Requirements

3.5.4.1 Water-Cementitious Materials Ratio

Where maximum water-cementitious materials ratios are specified in ACI 318, they shall be calculated in accordance with ACI 318, Section 4.1.

3.5.4.2 Freezing and Thawing Exposures

Concrete that will be exposed to freezing and thawing, deicing chemicals or other exposure conditions as defined below shall comply with Sections 3.5.4.2.1 through 3.5.4.2.3.

3.5.4.2.1 Air entrainment

Concrete exposed to freezing and thawing or deicing chemicals shall be air entrained in accordance with ACI 318, Section 4.2.1.

3.5.4.2.2 Concrete properties

Concrete that will be subject to the following exposures shall conform to the corresponding maximum water-cementitious materials ratios and minimum specified concrete compressive strength requirements of ACI 318, Section 4.2.2.

1. Concrete intended to have lower permeability where exposed to water;
2. Concrete exposed to freezing and thawing in a moist condition or deicer chemicals; or
3. Concrete with reinforcement where the concrete is exposed to chlorides from deicing chemicals, salt, salt water, brackish water, seawater or spray from these sources.

3.5.4.3 Sulfate Exposures

Concrete that will be exposed to sulfate-containing solutions or soils shall comply with the maximum water-cementitious materials ratios, minimum specified compressive strength and be made with the appropriate type of cement in accordance with the provisions of ACI 318, Section 4.3.

3.5.4.4 Corrosion Protection of Reinforcement

Reinforcement in concrete shall be protected from corrosion and exposure to chlorides in accordance with ACI 318, Section 4.4.

3.5.5 Concrete Quality, Mixing and Placing

3.5.5.1 General

The required strength and durability of concrete shall be determined by compliance with the proportioning, testing, mixing and placing provisions of Sections 3.5.5.1.1 through 3.5.5.13.

- 3.5.5.1.1** Concrete shall be proportioned to provide an average compressive strength, f'_{cr} , as prescribed in Section 3.5.5.3.2 and shall satisfy the durability criteria of Section 5.4. Concrete shall be produced to minimize the frequency of strength tests below f'_c , as prescribed in 3.5.5.6.3.3. For concrete designed and constructed in accordance with the code, f'_c shall not be less than 2500 psi. However, for design of earthquake-resistant structures, specified compressive strength of concrete, f'_c , shall not be less than 3000 psi (see also Section 21.1.3 of the ACI Code).
- 3.5.5.1.2** Requirements for f'_c shall be based on tests of specimens made and tested as prescribed in 3.5.5.6.3.
- 3.5.5.1.3** Unless otherwise specified, f'_c shall be based on 28-day tests. If other than 28 days, test age for f'_c shall be as indicated in design drawings or specifications.
- 3.5.5.1.4** Where design criteria in ACI Sections 9.5.2.3, 11.2, and 12.2.4 provide for use of splitting tensile strength value of concrete, laboratory tests shall be made in accordance with "Standard Specification for Lightweight Aggregates for Structural Concrete" (ASTM C 330) to establish a value of f_{ct} corresponding to f'_c .
- 3.5.5.1.5** Splitting tensile strength tests shall not be used as a basis for field acceptance of concrete.

3.5.5.2 Selection of Concrete Proportions

- 3.5.5.2.1** Proportions of materials for concrete shall be established to provide:
- (a) Workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding;
 - (b) Resistance to special exposures as required by Section 3.5.4.
 - (c) Conformance with strength test requirements of Section 3.5.5.6.
- 3.5.5.2.2** Where different materials are to be used for different portions of proposed work, each combination shall be evaluated.
- 3.5.5.2.3** Concrete proportions shall be established in accordance with Section 3.5.5.3 or, alternatively Section 3.5.5.4, and shall meet applicable requirements of Section 3.5.4.

3.5.5.3 Proportioning on the Basis of Field Experience or Trial Mixtures, or Both

3.5.5.3.1 Sample standard deviation

3.5.5.3.1.1 Where a concrete production facility has test records, a sample standard deviation, s_s , shall be established. Test records from which s_s is calculated:

- (a) Shall represent materials, quality control procedures, and conditions similar to those expected and changes in materials and proportions within the test records shall not have been more restricted than those for proposed work;
- (b) Shall represent concrete produced to meet a specified compressive strength or strengths within 1000s psi of f'_c ;

- (c) Shall consist of at least 30 consecutive tests or two groups of consecutive tests totaling at least 30 tests as defined in Section 3.5.5.6.2.4 except as provided in Section 3.5.5.3.1.2.

3.5.5.3.1.2 Where a concrete production facility does not have test records meeting requirements of Section 3.5.5.3.1.1, but does have a record based on 15 to 29 consecutive tests, a sample standard deviation s_s shall be established as the product of the calculated sample standard deviation and modification factor of Table 3.5.1. To be acceptable, test records shall meet requirements (a) and (b) of Section 3.5.5.3.1.1, and represent only a single record of consecutive tests that span a period of not less than 45 calendar days.

TABLE 3.5.1 MODIFICATION FACTOR FOR SAMPLE STANDARD DEVIATION WHEN LESS THAN 30 TESTS ARE AVAILABLE

No. of tests*	Modification factor for sample standard deviation†
Less than 15	Use Table 3.5.2
15	1.16
20	1.08
25	1.03
30 or more	1.00

**Interpolate for intermediate numbers of tests.

†Modified sample standard deviation, s_s , to be used to determine required average strength, f'_{cr} , from Section 3.5.5.3.2.1.

3.5.5.3.2 Required average strength

3.5.5.3.2.1 Required average compressive strength f'_{cr} used as the basis for selection of concrete proportions shall be determined from Table 3.5.2 using the sample standard deviation, s_s , calculated in accordance with Section 3.5.5.3.1.1 or Section 3.5.5.3.1.2.

TABLE 3.5.2 REQUIRED AVERAGE COMPRESSIVE STRENGTH WHEN DATA ARE AVAILABLE TO ESTABLISH A SAMPLE STANDARD DEVIATION

Specified compressive strength, psi	Required average compressive strength, psi
$f'_c \leq 5000$	Use the larger value computed from Eq. (5-1) and (5-2) $f'_{cr} = f'_c + 1.34s_s(5-1)$ $f'_{cr} = f'_c + 2.33s_s(5-2)$
$f'_c > 5000$	Use the larger value computed from Eq. (5-1) and (5-3) $f'_{cr} = f'_c + 1.34s_s(5-1)$ $f'_{cr} = 0.90f'_c + 2.33s_s(5-3)$

3.5.5.3.2.2 When a concrete production facility does not have field strength test records for calculation of s_s meeting requirements of Section 3.5.5.3.1.1 or

Section 3.5.5.3.1.2, f'_{cr} shall be determined from Table 3.5.3 and documentation of average strength shall be in accordance with requirements of Section 3.5.5.3.3.

TABLE 3.5.3 REQUIRED AVERAGE COMPRESSIVE STRENGTH WHEN DATA ARE NOT AVAILABLE TO ESTABLISH A SAMPLE STANDARD DEVIATION

Specified compressive strength, psi	Required average compressive strength, psi
$f'_c < 3000$	$f'_{cr} = f'_c + 1000$
$3000 \leq f'_c \leq 5000$	$f'_{cr} = f'_c + 1200$
$f'_c > 5000$	$f'_{cr} = 1.1f'_c + 700$

3.5.5.3.3 Documentation of average compressive strength

Documentation that proposed concrete proportions will produce an average compressive strength equal to or greater than required average compressive strength f'_{cr} (see Section 3.5.5.3.2) shall consist of a field strength test record, several strength test records, or trial mixtures.

3.5.5.3.3.1 When test records are used to demonstrate that proposed concrete proportions will produce f'_{cr} (see Section 3.5.5.3.2), such records shall represent materials and conditions similar to those expected. Changes in materials, conditions, and proportions within the test records shall not have been more restricted than those for proposed work. For the purpose of documenting average strength potential, test records consisting of less than 30 but not less than 10 consecutive tests are acceptable provided test records encompass a period of time not less than 45 days. Required concrete proportions shall be permitted to be established by interpolation between the strengths and proportions of two or more test records, each of which meets other requirements of this section.

3.5.5.3.3.2 When an acceptable record of field test results is not available, concrete proportions established from trial mixtures meeting the following restrictions shall be permitted:

- Materials shall be those for proposed work;
- Trial mixtures having proportions and consistencies required for proposed work shall be made using at least three different water-cementitious materials ratios or cementitious materials contents that will produce a range of strengths encompassing f'_{cr} ;
- Trial mixtures shall be designed to produce a slump within ± 0.75 in. of maximum permitted, and for air-entrained concrete, within ± 0.5 percent of maximum allowable air content;
- For each water-cementitious materials ratio or cementitious materials content, at least three test specimens for each test age shall be made and cured in accordance with "Method of Making and Curing Concrete Test Specimens in the Laboratory" (ASTM C 192) or the corresponding British Standard practice (BS 1881-108) for cube specimens. Specimens shall be tested at 28 days or at test age designated for determination of f'_c ;
- From results of tests, a curve shall be plotted showing the relationship between water-cementitious

materials ratio or cementitious materials content and compressive strength at designated test age;

- (f) Maximum water-cementitious material ratio or minimum cementitious materials content for concrete to be used in proposed work shall be that shown by the curve to produce f'_{cr} required by Section 3.5.5.3.2, unless a lower water-cementitious materials ratio or higher strength is required by Section 3.5.4.

3.5.5.4 Proportioning without Field Experience or Trial Mixtures

3.5.5.4.1 If data required by Section 3.5.5.3 are not available, concrete proportions shall be based upon other experience or information, if approved by the registered design professional. The required average compressive strength f'_{cr} of concrete produced with materials similar to those proposed for use shall be at least 1200 psi greater than f'_c . This alternative shall not be used if f'_c is greater than 5000 psi.

3.5.5.4.2 Concrete proportioned by this section shall conform to the durability requirements of Section 3.5.4 and to compressive strength test criteria of Section 3.5.5.6.

3.5.5.5 Average Compressive Strength Reduction

As data become available during construction, it shall be permitted to reduce the amount by which the required average concrete strength, f'_{cr} , must exceed f'_c , provided:

- (a) Thirty or more test results are available and average of test results exceeds that required by Section 3.5.5.3.2.1, using a sample standard deviation calculated in accordance with Section 3.5.5.3.1.1; or
- (b) Fifteen to 29 test results are available and average of test results exceeds that required by Section 3.5.5.3.2.1 using a sample standard deviation calculated in accordance with Section 3.5.5.3.1.2; and
- (c) Special exposure requirements of Section 3.5.4 are met.

3.5.5.6 Evaluation and Acceptance of Concrete

3.5.5.6.1 Concrete shall be tested in accordance with the requirements of Sections 3.5.5.6.2 through 3.5.5.6.5. Qualified field testing technicians shall perform tests on fresh concrete at the jobsite, prepare specimens required for curing under field conditions, prepare specimens required for testing in the laboratory, and record the temperature of the fresh concrete when preparing specimens for strength tests. Qualified laboratory technicians shall perform all required laboratory tests.

3.5.5.6.2 Frequency of testing

3.5.5.6.2.1 Samples for strength tests of each class of concrete placed each day shall be taken not less than once a day, nor less than once for each 150 yd³ of concrete, nor less than once for each 5000 ft² of surface area for slabs or walls.

3.5.5.6.2.2 On a given project, if total volume of concrete is such that frequency of

testing required by Section 3.5.5.6.2.1 would provide less than five strength tests for a given class of concrete, tests shall be made from at least five randomly selected batches or from each batch if fewer than five batches are used.

3.5.5.6.2.3 When total quantity of a given class of concrete is less than 50 yd³, strength tests are not required when evidence of satisfactory strength is submitted to and approved by the building official.

3.5.5.6.2.4 A strength test shall be the average of the strengths of two specimens made from the same sample of concrete and tested at 28 days or at test age designated for determination of f'_c .

3.5.5.6.3 Laboratory-cured specimens

3.5.5.6.3.1 Samples for strength tests shall be taken in accordance with “Method of Sampling Freshly Mixed Concrete” (ASTM C 172) or the corresponding British Standard practice (BS 1881-125) for cube specimens.

3.5.5.6.3.2 Specimens for strength tests shall be molded and laboratory-cured in accordance with “Practice for Making and Curing Concrete Test Specimens in the laboratory” (ASTM C192) (or BS 1881-108 for cube specimens) and tested in accordance with “Test Method for Compressive Strength of Cylindrical Concrete Specimens” (ASTM C39) or the corresponding British Standard practice for cube specimens (BS 1881-116).

3.5.5.6.3.3 Strength level of an individual class of concrete shall be considered satisfactory if both of the following requirements are met:

- (a) Every arithmetic average of any three consecutive strength tests equals or exceeds f'_c ;
- (b) No individual strength test (average of two cylinders) falls below f'_c by more than 500 psi when f'_c is 5000 psi or less; or by more than $0.10f'_c$ when f'_c is more than 5000 psi.

3.5.5.6.3.4 If either of the requirements of Section 3.5.5.6.3.3 is not met, steps shall be taken to increase the average of subsequent strength test results. Requirements of Section 3.5.5.6.5 shall be observed if requirement of Section 3.5.5.6.3.3(b) is not met.

3.5.5.6.3.5 For conversion of cube strength to cylinder strengths and vice versa, the following relationships shall be used, where f'_c is the cylinder strength.

- (a) $f'_{c, cube} \cong f'_c \div 0.78$ ($f'_c \leq 3500$ psi)
- (b) $f'_{c, cube} \cong f'_c \div 0.80$ ($3500 < f'_c \leq 5000$ psi)
- (c) $f'_{c, cube} \cong f'_c \div 0.81$ ($5000 < f'_c \leq 6000$ psi)
- (d) $f'_{c, cube} \cong f'_c \div 0.83$ ($6000 < f'_c \leq 7500$ psi)

3.5.5.6.4 Field-cured specimens

3.5.5.6.4.1 If required by the building official, results of strength tests of specimens cured under field conditions shall be provided.

3.5.5.6.4.2 Field-cured specimens shall be cured under field conditions in accordance with “Practice for Making and Curing Concrete Test Specimens in the Field” (ASTM C31) or the corresponding British Standard practice (BS 1881-108) for cube specimens.

3.5.5.6.4.3 Field-cured test cylinders shall be molded at the same time and from the same samples as laboratory-cured test specimens.

3.5.5.6.4.4 Procedures for protecting and curing concrete shall be improved when strength of field-cured specimens at test age designated for determination of f'_c is less than 85 percent of that of companion laboratory-cured specimens. The 85 percent limitation shall not apply if field-cured cylinder strength exceeds f'_c by more than 500 psi.

3.5.5.6.5 Investigation of flow-strength test results

3.5.5.6.5.1 If any strength test (see Section 3.5.5.6.2.4) of laboratory-cured cylinders falls below f'_c by more than the values given in Section 3.5.5.6.3.3(b) or if tests of field-cured cylinders indicate deficiencies in protection and curing (see Section 3.5.5.6.4.4), steps shall be taken to assure that load-carrying capacity of the structure is not jeopardized.

3.5.5.6.5.2 If the likelihood of low-strength concrete is confirmed and calculations indicate that load-carrying capacity is significantly reduced, tests of cores drilled from the area in question in accordance with “Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete” (ASTM C42) shall be permitted. In such cases, three cores shall be taken for each strength test that falls below the values given in Section 3.5.5.6.3.3(b).

3.5.5.6.5.3 Cores shall be prepared for transport and storage by wiping drilling water from their surfaces and placing the cores in watertight bags or containers immediately after drilling. Cores shall be tested no earlier than 48 hours and not later than 7 days after coring unless approved by the registered design professional.

3.5.5.6.5.4 Concrete in an area represented by core tests shall be considered structurally adequate if the average of three cores is equal to at least 85 percent of f'_c and if no single core is less than 75 percent of f'_c . Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted.

3.5.5.6.5.5 If criteria of Section 3.5.5.6.5.4 are not met and if the structural adequacy remains in doubt, the responsible authority shall be permitted to order a strength evaluation in accordance with Chapter 20 of ACI Code for the questionable portion of the structure, or take other appropriate action.

3.5.5.7 Preparation of Equipment and Place of Deposit

3.5.5.7.1 Preparation before concrete placement shall include the following:

- (a) All equipment for mixing and transporting concrete shall be clean;
- (b) All debris shall be removed from spaces to be occupied by concrete;
- (c) Forms shall be properly coated;
- (d) Masonry filler units that will be in contact with concrete shall be well drenched;
- (e) Reinforcement shall be thoroughly clean of deleterious coatings;
- (f) Water shall be removed from place of deposit before concrete is placed unless a tremie is to be used or unless otherwise permitted by the building official;

(g) All laitance and other unsound material shall be removed before additional concrete is placed against hardened concrete.

3.5.5.8 Mixing

3.5.5.8.1 All concrete shall be mixed until there is a uniform distribution of materials and shall be discharged completely before mixer is recharged.

3.5.5.8.2 Ready-mixed concrete shall be mixed and delivered in accordance with requirements of "Specification for Ready-Mixed Concrete" (ASTM C94) or "Specification for Concrete Made by Volumetric Batching and Continuous Mixing" (ASTM C685).

3.5.5.8.3 Job-mixed concrete shall be mixed in accordance with the following:

- (a) Mixing shall be done in a batch mixer of approved type;
- (b) Mixer shall be rotated at a speed recommended by the manufacturer;
- (c) Mixing shall be continued for at least 1½ minutes after all materials are in the drum, unless a shorter time is shown to be satisfactory by the mixing uniformity tests of "Specification for Ready-Mixed Concrete" (ASTM C 94);
- (d) Materials handling, batching, and mixing shall conform to applicable provisions of "Specification for Ready-Mixed Concrete" (ASTM C94);
- (e) A detailed record shall be kept to identify:
 - (1) number of batches produced;
 - (2) proportions of materials used;
 - (3) approximate location of final deposit in structure;
 - (4) time and date of mixing and placing.

3.5.5.9 Conveying

3.5.5.9.1 Concrete shall be conveyed from mixer to place of final deposit by methods that will prevent separation or loss of materials.

3.5.5.9.2 Conveying equipment shall be capable of providing a supply of concrete at site of placement without separation of ingredients and without interruptions sufficient to permit loss of plasticity between successive increments.

3.5.5.10 Depositing

3.5.5.10.1 Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to rehandling or flowing.

3.5.5.10.2 Concreting shall be carried on at such a rate that concrete is at all times plastic and flows readily into spaces between reinforcement.

3.5.5.10.3 Concrete that has partially hardened or been contaminated by foreign materials shall not be deposited in the structure.

3.5.5.10.4 Retempered concrete or concrete that has been remixed after initial set shall not be used unless approved by the engineer.

3.5.5.10.5 After concreting is started, it shall be carried on as a continuous operation until placing of a panel or section, as defined by its boundaries or predetermined joints, is completed except as permitted or prohibited by Section 3.6.4 of ACI Code.

3.5.5.10.6 Top surfaces of vertically formed lifts shall be generally level.

3.5.5.10.7 When construction joints are required, joints shall be made in accordance with Section 3.6.4 of ACI Code.

3.5.5.10.8 All concrete shall be thoroughly consolidated by suitable means during placement and shall be thoroughly worked around reinforcement and embedded fixtures and into corners of forms.

3.5.5.11 Curing

3.5.5.11.1 Concrete (other than high-early-strength) shall be maintained above 50 F and in a moist condition for at least the first 7 days after placement, except when cured in accordance with Section 3.5.5.11.3.

3.5.5.11.2 High-early-strength concrete shall be maintained above 50 F and in a moist condition for at least the first 3 days, except when cured in accordance with Section 3.5.5.11.3.

3.5.5.11.3 Accelerated curing

3.5.5.11.3.1 Curing by high-pressure steam, steam at atmospheric pressure, heat and moisture, or other accepted processes, shall be permitted to accelerate strength gain and reduce time of curing.

3.5.5.11.3.2 Accelerated curing shall provide a compressive strength of the concrete at the load stage considered at least equal to required design strength at that load stage.

3.5.5.11.3.3 Curing process shall be such as to produce concrete with a durability at least equivalent to the curing method of Section 3.5.5.11.1 or Section 3.5.5.11.2.

3.5.5.11.4 When required by the engineer or architect, supplementary strength tests in accordance with Section 3.5.5.6.4 shall be performed to assure that curing is satisfactory.

3.5.5.12 Cold Weather Requirements

3.5.5.12.1 Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather.

3.5.5.12.2 All concrete materials and all reinforcement, forms, fillers, and ground with which concrete is to come in contact shall be free from frost.

3.5.5.12.3 Frozen materials or materials containing ice shall not be used.

3.5.5.13 Hot Weather Requirements

During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure.

3.5.6 Formwork, Embedded Pipes and Construction Joints

3.5.6.1 Formwork

The design, fabrication and erection of forms shall comply with ACI 318, Section 3.6.1.

3.5.6.2 Removal of Forms, Shores and Reshores

The removal of forms and shores, including from slabs and beams (except where cast on the ground), and the installation of reshores shall comply with ACI 318, Section 3.6.2.

3.5.6.3 Conduits and Pipes Embedded in Concrete

Conduits, pipes and sleeves of any material not harmful to concrete and within the limitations of ACI 318, Section 3.6.3, are permitted to be embedded in concrete with approval of the registered design professional.

3.5.6.4 Construction Joints.

Construction joints, including their location, shall comply with the provisions of ACI 318, Section 3.6.4.

3.5.7 Details of Reinforcement

3.5.7.1 Standard Hooks

The term standard hook as used in this PART shall mean one of the following:

3.5.7.1.1 180-deg bend plus 4db extension, but not less than 2½ in. at free end of bar.

3.5.7.1.2 90-deg bend plus 12db extension at free end of bar.

3.5.7.1.3 For stirrup and tie hooks

(a) No. 5 bar and smaller, 90-deg bend plus 6db extension at free end of bar; or

(b) No. 6, No. 7, and No. 8 bar, 90-deg bend plus 12db extension at free end of bar; or

(c) No. 8 bar and smaller, 135-deg bend plus 6db extension at free end of bar.

3.5.7.1.4 Seismic hooks as defined in Section 21.1 of ACI Code.

3.5.7.2 Minimum Bend Diameters

3.5.7.2.1 Diameter of bend measured on the inside of the bar, other than for stirrups and ties in sizes No. 3 through No. 5, shall not be less than the values in Table 3.5.4.

3.5.7.2.2 Inside diameter of bend for stirrups and ties shall not be less than 4db for No. 5 bar and smaller. For bars larger than No. 5, diameter of bend shall be in accordance with Table 3.5.4.

3.5.7.2.3 Inside diameter of bend in welded wire reinforcement for stirrups and ties shall not be less than 4db for deformed wire larger than D6 and 2db for all other wires. Bends with inside diameter of less than 8db shall not be less than 4db from nearest welded intersection.

TABLE 3.5.4 MINIMUM DIAMETERS OF BEND

Bar size	Minimum diameter
No. 3 through No. 8	6d _b
No. 9, No. 10, and No. 11	8d _b
No. 14 and No. 18	10d _b

3.5.7.3 Bending

3.5.7.3.1 All reinforcement shall be bent cold, unless otherwise permitted by the engineer.

3.5.7.3.2 Reinforcement partially embedded in concrete shall not be field bent, except as shown on the design drawings or permitted by the engineer.

3.5.7.4 Surface Conditions of Reinforcement

3.5.7.4.1 At the time concrete is placed, reinforcement shall be free from mud, oil, or other nonmetallic coatings that decrease bond. Epoxy-coating of steel reinforcement in accordance with standards referenced in Section 3.5.3.7 and Section 3.5.3.8 of ACI Code shall be permitted.

3.5.7.4.2 Except for prestressing steel, steel reinforcement with rust, mill scale, or a combination of both shall be considered satisfactory, provided the minimum dimensions (including height of deformations) and weight of a hand-wire-brushed test specimen comply with applicable ASTM specifications referenced in Section 3.5 of ACI Code.

3.5.7.4.3 Prestressing steel shall be clean and free of oil, dirt, scale, pitting and excessive rust. A light coating of rust shall be permitted.

3.5.7.5 Placing Reinforcement

3.5.7.5.1 Reinforcement, including tendons, and post-tensioning ducts shall be accurately placed and adequately supported before concrete is placed, and shall be secured against displacement within tolerances permitted in Section 7.5.2 of ACI Code.

3.5.7.5.2 Unless otherwise specified by the registered design professional, reinforcement, including tendons, and post-tensioning ducts shall be placed within the tolerances in Section 7.5.2.1 and Section 7.5.2.2 of ACI Code.

3.5.7.5.2.1 Tolerance for d and minimum concrete cover in flexural members, walls, and compression members shall be as follows:

	Tolerance on d	Tolerance on minimum concrete cover
$d \leq 8$ in.	$\pm 3/8$ in.	$-3/8$ in.
$d > 8$ in.	$\pm 1/2$ in.	$-1/2$ in.

except that tolerance for the clear distance to formed soffits shall be minus $1/4$ in. and tolerance for cover shall not exceed minus $1/3$ the minimum concrete cover required in the design drawings and specifications.

3.5.7.5.2.2 Tolerance for longitudinal location of bends and ends of reinforcement shall be ± 2 in., except the tolerance shall be $\pm 1/2$ in. at the discontinuous ends of brackets and corbels, and ± 1 in. at the discontinuous ends of other members. The tolerance for minimum concrete cover of Section 7.5.2.1 of ACI Code shall also apply at discontinuous ends of members.

3.5.7.5.3 Welded wire reinforcement (with wire size not greater than W5 or D5) used in slabs not exceeding 10 ft in span shall be permitted to be curved from a point near the top of slab over the support to a point near the bottom of slab at mid-span, provided such reinforcement is either continuous over, or securely anchored at support.

3.5.7.5.4 Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by the engineer.

3.5.7.6 Spacing Limits for Reinforcement

3.5.7.6.1 The minimum clear spacing between parallel bars in a layer shall be d_b , but not less than 1 in. See also Section 3.3.2 of ACI Code.

3.5.7.6.2 Where parallel reinforcement is placed in two or more layers, bars in the upper layers shall be placed directly above bars in the bottom layer with clear distance between layers not less than 1 in.

3.5.7.6.3 In spirally reinforced or tied reinforced compression members, clear distance between longitudinal bars shall be not less than $1.5d_b$ nor less than $1\frac{1}{2}$ in. See also Section 3.3.2 of ACI Code.

3.5.7.6.4 Clear distance limitation between bars shall apply also to the clear distance between a contact lap splice and adjacent splices or bars.

3.5.7.6.5 In walls and slabs other than concrete joist construction, primary flexural reinforcement shall not be spaced farther apart than three times the wall or slab thickness, nor farther apart than 18 in.

3.5.7.6.6 Bundled bars

3.5.7.6.6.1 Groups of parallel reinforcing bars bundled in contact to act as a unit shall be limited to four in any one bundle.

3.5.7.6.6.2 Bundled bars shall be enclosed within stirrups or ties.

3.5.7.6.6.3 Bars larger than No. 11 shall not be bundled in beams.

3.5.7.6.6.4 Individual bars within a bundle terminated within the span of flexural members shall terminate at different points with at least $40d_b$ stagger.

3.5.7.6.6.5 Where spacing limitations and minimum concrete cover are based on bar diameter, d_b , a unit of bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area.

3.5.7.6.7 Tendons and ducts

3.5.7.6.7.1 Centre-to-centre spacing of pretensioning tendons at each end of a member shall be not less than $4d_b$ for strands, or $5d_b$ for wire, except that if specified compressive strength of concrete at time of initial prestress, f'_{ci} is 4000 psi or more, minimum centre-to-centre spacing of strands shall be $1\frac{3}{4}$ in. for strands of $\frac{1}{2}$ in. nominal diameter or smaller and 2 in. for strands of 0.6 in. nominal diameter. See also Section 3.3.2. Closer vertical spacing and bundling of tendons shall be permitted in the middle portion of a span.

3.5.7.6.7.2 Bundling of post-tensioning ducts shall be permitted if shown that concrete can be satisfactorily placed and if provision is made to prevent the prestressing steel, when tensioned, from breaking through the duct.

3.5.7.7 Concrete Protection for Reinforcement

3.5.7.7.1 Cast-in-place concrete (nonprestressed)

The following minimum concrete covers shall be provided for reinforcement, but shall not be less than required by Section 7.7.5 and Section 7.7.7 of ACI Code:

Minimum cover, in.

(a) Concrete cast against and permanently exposed to earth	3
(b) Concrete exposed to earth or weather:	
No. 6 through No. 18 bars.....	2
No. 5 bar, W31 or D31 wire,	

and smaller	1½
(c) Concrete not exposed to weather or in contact with ground:	
Slabs, walls, joists:	
No. 14 and No. 18 bars	1½
No. 11 bar and smaller	¾
Beams, columns:	
Primary reinforcement, ties, stirrups, spirals	1½
Shells, folded plate members:	
No. 6 bar and larger.....	¾
No. 5 bar, W31 or D31 wire, and smaller	½

3.5.7.7.2 Cast-In-place concrete (prestressed)

The following minimum concrete cover shall be provided for prestressed and nonprestressed reinforcement, ducts, and end fitting, but shall not be less than required by Section 7.7.5, Section 7.7.5.1, and Section 7.7.7 of ACI Code.

Minimum cover, in.

(a) Concrete cast against and permanently exposed to earth	3
(b) Concrete exposed to earth or weather:	
Wall panels, slabs, joists.....	1
Other members.....	1½
(c) Concrete not exposed to weather or in contact with ground:	
Slabs, walls, joists	¾
Beams, columns	
Primary reinforcement,.....	1½
Ties, stirrups, spirals	1
Shells, folded plate members:	
No. 5 bar, W31 or D31 wire and smaller,.....	3/8
Other reinforcement.....	d_b but not less than ¾

3.5.7.7.3 Precast concrete (manufactured under plant control conditions)

The following minimum concrete cover shall be provided for prestressed and nonprestressed reinforcement, ducts, and end fittings, but shall not be less than required by Section 7.7.5, Section 7.7.5.1, and Section 7.7.7 of ACI Code:

Minimum cover, in.

(a) Concrete exposed to earth or weather:	
Wall panels:	
No. 14 and No. 18 bars, prestressing tendons larger than 1½ in. diameter.....	1½
No. 11 bar and smaller, prestressing tendons 1½ in. diameter and smaller, W31 and D31 wire and smaller.....	¾
Other members:	

No. 14 and No. 18 bars, prestressing tendons larger than 1½ in. diameter	2
No. 6 through No. 11 bars, prestressing tendons larger than 5/8 in. diameter through 1½ in. diameter	1½
No. 5 bar and smaller, prestressing tendons 5/8 in. diameter and smaller, W31 and D31 wire, and smaller	1¼
(b) Concrete not exposed to weather or in contact with ground:	
Slabs, walls, joists:	
No. 14 and No. 18 bars, prestressing tendons larger than 1½ in. diameter	1¼
Prestressing tendons 1½ in. diameter and smaller	¾
No. 11 bar and smaller, W31 or D31 wire, and smaller	5/8
Beams, columns:	
Primary reinforcement.....d _b but not less than 5/8 and need not exceed 1½	
Ties, stirrups, spirals	3/8
Shells, folded plate members:	
Prestressing tendons	¾
No. 6 bar and larger	5/8
No. 5 bar and smaller, W31 or D31 wire, and smaller	3/8

3.5.7.7.4 Bundled bars

For bundled bars, minimum concrete cover shall be equal to the equivalent diameter of the bundle, but need not be greater than 2 in.; except for concrete cast against and permanently exposed to earth, where minimum cover shall be 3 in.

3.5.7.7.5 Corrosive environments

In corrosive environments or other severe exposure conditions, amount of concrete protection shall be suitably increased, and denseness and non-porosity of protecting concrete shall be considered, or other protection shall be provided.

3.5.7.7.5.1 For prestressed concrete members exposed to corrosive environments or other severe exposure conditions, and which are classified as Class T or C in Section 18.3.3 of ACI Code, minimum cover to the prestressed reinforcement shall be increased 50 percent. This requirement shall be permitted to be waived if the pre-compressed tensile zone is not in tension under sustained loads.

3.5.7.7.6 Future extensions

Exposed reinforcement, inserts, and plates intended for bonding with future extensions shall be protected from corrosion.

3.5.7.7 Fire protection

Thickness of cover for fire protection greater than the minimum concrete cover specified in Section 7.7 of ACI Code shall be permitted to be used if required by the authority having jurisdiction.

3.5.7.8 Special Reinforcement Details for Columns

3.5.7.8.1 Offset bars

Offset bent longitudinal bars shall conform to the following:

3.5.7.8.1.1 Slope of inclined portion of an offset bar with axis of column shall not exceed 1 in 6.

3.5.7.8.1.2 Portions of bar above and below an offset shall be parallel to axis of column.

3.5.7.8.1.3 Horizontal support at offset bends shall be provided by lateral ties, spirals, or parts of the floor construction. Horizontal support provided shall be designed to resist $1\frac{1}{2}$ times the horizontal component of the computed force in the inclined portion of an offset bar. Lateral ties or spirals, if used, shall be placed not more than 6 in. from points of bend.

3.5.7.8.1.4 Offset bars shall be bent before placement in the forms. See Section 5.7.3.

3.5.7.8.1.5 Where a column face is offset 3 in. or greater, longitudinal bars shall not be offset bent. Separate dowels, lap spliced with the longitudinal bars adjacent to the offset column faces, shall be provided. Lap splices shall conform to Section 12.17 of ACI Code.

3.5.7.8.2 Steel cores

Load transfer in structural steel cores of composite compression members shall be provided by the following:

3.5.7.8.2.1 Ends of structural steel cores shall be accurately finished to bear at end bearing splices, with positive provision for alignment of one core above the other in concentric contact.

3.5.7.8.2.2 At end bearing splices, bearing shall be considered effective to transfer not more than 50 per- cent of the total compressive stress in the steel core.

3.5.7.8.2.3 Transfer of stress between column base and footing shall be designed in accordance with Section 15.8 of ACI Code.

3.5.7.8.2.4 Base of structural steel section shall be designed to transfer the total load from the entire composite member to the footing; or, the base shall be designed to transfer the load from the steel core only, provided ample concrete section is available for transfer of the portion of the total load carried by the reinforced concrete section to the footing by compression in the concrete and by reinforcement.

3.5.7.9 Connections

3.5.7.9.1 At connections of principal framing elements (such as beams and columns), enclosure shall be provided for splices of continuing reinforcement and for anchorage of reinforcement terminating in such connections.

3.5.7.9.2 Enclosure at connections shall consist of external concrete or internal closed ties, spirals, or stirrups.

3.5.7.10 Lateral Reinforcement for Compression Members

3.5.7.10.1 Lateral reinforcement for compression members shall conform to the provisions of Section 5.7.10.4 and Section 5.7.10.5 and, where shear or torsion reinforcement is required, shall also conform to provisions of Chapter 11 of ACI Code.

3.5.7.10.2 Lateral reinforcement requirements for composite compression members shall conform to Section 10.16 of ACI Code. Lateral reinforcement requirements for tendons shall conform to Section 18.11 of ACI Code.

3.5.7.10.3 It shall be permitted to waive the lateral reinforcement requirements of Section 7.10, Section 10.16, and Section 18.11 of ACI Code where tests and structural analysis show adequate strength and feasibility of construction.

3.5.7.10.4 Spirals

Spiral reinforcement for compression members shall conform to Section 10.9.3 of ACI Code and to the following:

3.5.7.10.4.1 Spirals shall consist of evenly spaced continuous bar or wire of such size and so assembled to permit handling and placing without distortion from designed dimensions.

3.5.7.10.4.2 For cast-in-place construction, size of spirals shall not be less than 3/8 in. diameter.

3.5.7.10.4.3 Clear spacing between spirals shall not exceed 3 in., nor be less than 1 in. See also Section 3.3.2 of ACI Code.

3.5.7.10.4.4 Anchorage of spiral reinforcement shall be provided by 1½ extra turns of spiral bar or wire at each end of a spiral unit.

3.5.7.10.4.5 Spiral reinforcement shall be spliced, if needed, by any one of the following methods:

(a) Laps splices not less than the larger of 12 in.

and the length indicated in one of (1) through (5) below:

(1) deformed uncoated bar or wire.....**48d_b**

(2) plain uncoated bar or wire.....**72d_b**

(3) epoxy-coated deformed bar or wire...**72d_b**

(4) plain uncoated bar or wire with a standard stirrup or tie hook in accordance with Section 5.7.1.3 at ends of lapped spiral reinforcement. The hooks shall be embedded within the core confined by the spiral reinforcement.....**48d_b**

(5) epoxy-coated deformed bar or wire with a standard stirrup or tie hook in accordance with Section 5.7.1.3 at ends of lapped spiral reinforcement. The hooks shall be embedded within the core confined by the spiral reinforcement.....**48d_b**

(b) Full mechanical or welded splices in accordance with Section 12.14.3 of ACI Code.

3.5.7.10.4.6 Spirals shall extend from top of footing or slab in any storey to level of lowest horizontal reinforcement in members supported above.

3.5.7.10.4.7 Where beams or brackets do not frame into all sides of a column, ties shall extend above termination of spiral to bottom of slab or drop panel.

3.5.7.10.4.8 In columns with capitals, spirals shall extend to a level at which the diameter or width of capital is two times that of the column.

3.5.7.10.4.9 Spirals shall be held firmly in place and true to line.

3.5.7.10.5 Ties

Tie reinforcement for compression members shall conform to the following:

3.5.7.10.5.1 All nonprestressed bars shall be enclosed by lateral ties, at least No. 3 in size for longitudinal bars No. 10 or smaller, and at least No. 4 in size for No. 11, No. 14, No. 18, and bundled longitudinal bars. Deformed wire or welded wire reinforcement of equivalent area shall be permitted.

3.5.7.10.5.2 Vertical spacing of ties shall not exceed 16 longitudinal bar diameters, 48 tie bar or wire diameters, or least dimension of the compression member.

3.5.7.10.5.3 Ties shall be arranged such that every corner and alternate longitudinal bar shall have lateral support provided by the corner of a tie with an included angle of not more than 135 degree and no bar shall be farther than 6 in. clear on each side along the tie from such a laterally supported bar. Where longitudinal bars are located around the perimeter of a circle, a complete circular tie shall be permitted.

3.5.7.10.5.4 Ties shall be located vertically not more than one-half a tie spacing above the top of footing or slab in any story, and shall be spaced as provided herein to not more than one-half a tie spacing below the lowest horizontal reinforcement in slab or drop panel above.

3.5.7.10.5.5 Where beams or brackets frame from four directions into a column, termination of ties not more than 3 in. below lowest reinforcement in shallowest of such beams or brackets shall be permitted.

3.5.7.10.5.6 Where anchor bolts are placed in the top of columns or pedestals, the bolts shall be enclosed by lateral reinforcement that also surrounds at least four vertical bars of the column or pedestal. The lateral reinforcement shall be distributed within 5 in. of the top of the column or pedestal, and shall consist of at least two No. 4 or three No. 3 bars.

3.5.7.11 Lateral Reinforcement for Flexural Members

3.5.7.11.1 Compression reinforcement in beams shall be enclosed by ties or stirrups satisfying the size and spacing limitations in Section 5.7.10.5 or by welded wire reinforcement of equivalent area. Such ties or stirrups shall be provided throughout the distance where compression reinforcement is required.

3.5.7.11.2 Lateral reinforcement for flexural framing members subject to stress reversal or torsion at supports shall consist of closed ties, closed stirrups, or spirals extending around the flexural reinforcement.

3.5.7.11.3 Closed ties or stirrups shall be formed in one piece by overlapping standard stirrup or tie end hooks around a longitudinal bar, or formed in one or two pieces lap spliced with a Class B splice (lap of $1.3l_d$) or anchored in accordance with Section 12.13 of ACI Code.

3.5.7.12 Shrinkage and Temperature Reinforcement

3.5.7.12.1 Reinforcement for shrinkage and temperature stresses normal to flexural reinforcement shall be provided in structural slabs where the flexural reinforcement extends in one direction only.

3.5.7.12.1.1 Shrinkage and temperature reinforcement shall be provided in accordance with either Section 5.7.12.2 or Section 5.7.12.3.

3.5.7.12.1.2 Where shrinkage and temperature movements are significantly restrained, the requirements of Section 8.2.4 and Section 9.2.3 of ACI Code shall be considered.

3.5.7.12.2 Deformed reinforcement conforming to Section 3.5.3 of ACI Code used for shrinkage and temperature reinforcement shall be provided in accordance with the following:

3.5.7.12.2.1 Area of shrinkage and temperature reinforcement shall provide at least the following ratios of reinforcement area to gross concrete area, but not less than 0.0014:

(a) Slabs where Grade 40 or 50 deformed bars are used.....
0.0020

(b) Slabs where Grade 60
deformed bars or welded wire reinforcement are used.....
0.0018

(c) Slabs where reinforcement with yield stress exceeding 60,000
psi measured at a yield strain of 0.35 percent is used... $0.0018 \times \frac{f_y}{60,000}$

3.5.7.12.2.2 Shrinkage and temperature reinforcement shall be spaced not farther apart than five times the slab thickness, nor farther apart than 18 in.

3.5.7.12.2.3 At all sections where required, reinforcement to resist shrinkage and temperature stresses shall develop f_y in tension in accordance with Chapter 12 of ACI Code.

3.5.7.12.3 Prestressing steel conforming to Section 3.5.5 of ACI Code used for shrinkage and temperature reinforcement shall be provided in accordance with the following:

3.5.7.12.3.1 Tendons shall be proportioned to provide a minimum average compressive stress of 100 psi on gross concrete area using effective prestress, after losses, in accordance with Section 18.6 of ACI Code.

3.5.7.12.3.2 Spacing of tendons shall not exceed 6 ft.

3.5.7.12.3.3 When spacing of tendons exceeds 54 in., additional bonded shrinkage and temperature reinforcement conforming to Section 5.7.12.2 shall be provided between the tendons at slab edges extending from the slab edge for a distance equal to the tendon spacing.

3.5.7.13 Requirements for Structural Integrity

3.5.7.13.1 In the detailing of reinforcement and connections, members of a structure shall be effectively tied together to improve integrity of the overall structure.

3.5.7.13.2 For cast-in-place construction, the following shall constitute minimum requirements:

3.5.7.13.2.1 In joist construction, at least one bottom bar shall be continuous or shall be spliced with a Class A tension splice or a mechanical or welded splice satisfying Section 12.14.3 of ACI Code and at non-continuous supports shall be terminated with a standard hook.

3.5.7.13.2.2 Beams along the perimeter of the structure shall have continuous reinforcement consisting of:

- (a) at least one-sixth of the tension reinforcement required for negative moment at the support, but not less than two bars; and
- (b) at least one-quarter of the tension reinforcement required for positive moment at midspan, but not less than two bars.

3.5.7.13.2.3 Where splices are needed to provide the required continuity, the top reinforcement shall be spliced at or near midspan and bottom reinforcement shall be spliced at or near the support. Splices shall be Class A tension splices or mechanical or welded splices satisfying Section 12.14.3. The continuous reinforcement required in Section 5.7.13.2.2 (a) and Section 5.7.13.2.2 (b) shall be enclosed by the corners of U-stirrups having not less than 135-deg hooks around the continuous top bars, or by one-piece closed stirrups with not less than 135-degree hooks around one of the continuous top bars. Stirrups need not be extended through any joints.

3.5.7.13.2.4 In other than perimeter beams, when stirrups as defined in Section 5.7.13.2.3 are not provided, at least one-quarter of the positive moment reinforcement required at midspan, but not less than two bars, shall be continuous or shall be spliced over or near the support with a Class A tension splice or a mechanical or welded splice satisfying Section 12.14.3 of ACI Code, and at noncontinuous supports shall be terminated with a standard hook.

3.5.7.13.2.5 For two-way slab construction, see Section 13.3.8.5 of ACI Code.

3.5.7.13.3 For precast concrete construction, tension ties shall be provided in the transverse, longitudinal, and vertical directions and around the perimeter of the structure to effectively tie elements together. The provisions of Section 16.5 of ACI Code shall apply.

3.5.7.13.4 For lift-slab construction, see Section 13.3.8.6 and Section 18.12.6 of ACI Code.

3.5.8 Modifications to ACI 318-05

3.5.8.1 General

The text of ACI 318-05 shall be modified as indicated in Sections 5.8.1.1 through 5.8.1.20.

3.5.8.1.1 ACI 318, Section 1.3

Modify ACI 318, Section 1.3, by amending Section 1.3.3 to read as follows:

1.3.3- When the ambient temperature falls below 40°F or rises above 95°F, a record shall be kept of the protection given to concrete during placement and curing.

3.5.8.1.2 ACI 318, Section 3.5

Modify ACI 318, Section 3.5, by adding to Section 3.5.3.2 the following:

Deformed reinforcement resisting earthquake-induced flexural and axial forces in frame members, structural walls, and coupling beams, shall comply with ASTM A706. ASTM A615 Grades 40 and 60 reinforcement shall be permitted in these members if:

- (a) The actual yield strength based on mill tests does not exceed f_y by more than 18,000 psi; and
- (b) The ratio of the actual tensile strength to the actual yield strength is not less than 1.25 (see also ACI 318 Section 21.1.5.2).

3.5.8.1.3. ACI 318, Section 8.1

Modify ACI 318, Section 8.1, by renumbering Section 8.1.3 as Section 8.1.4 and adding new Section 8.1.3 to read as follows:

8.1.3 Design of reinforced concrete using the Allowable Stress Design method as given in APPENDIX A- ALTERNATIVE DESIGN METHOD of ACI 318-99 and reprinted as APPENDIX A in this SECTION shall be permitted. Limitations for the use of this method shall be specified by the local authority department.

3.5.8.1.4 ACI 318, Section 9.3

Modify ACI 318, Section 9.3, by changing the ϕ values in Section 9.3.2.1 to 9.3.2.7 to read as follows:

- 9.3.2.1- *Tension-controlled sections, as defined in Section 10.3.4 (see also Section 9.3.2.7) of ACI Code 0.80*
- 9.3.2.2- *Compression-controlled sections, as defined in Section 10.3.3 of ACI Code:*
- (a) *Members with spiral reinforcement conforming to Section 10.9.3 of ACI Code 0.67*
 - (b) *Other reinforced members 0.62*
- For sections in which the net tensile strain in the extreme tension steel at normal strength, ϵ_t , is between the limits for compression-controlled and tension-controlled sections, ϕ shall be permitted to be linearly increased from that for compression-controlled sections to 0.80 as ϵ_t increases from the compression-controlled strain limit to 0.005.*
- Alternatively, when Appendix B is used, for members in which f_y does not exceed 60,000 psi, with symmetric reinforcement, and with $(d-d')/h$ not less than 0.70, ϕ shall be permitted to be increased linearly to 0.80 as ϕP_n decreases from 0.10 $f'_c A_g$ to zero. For other reinforced members, ϕ shall be permitted to be increased linearly to 0.80 as ϕP_n decreases from 0.10 $f'_c A_g$ or ϕP_b , whichever is smaller, to zero.*
- 9.3.2.3- *Shear and torsion 0.75*
- 9.3.2.4- *Bearing on concrete (except for post-tensioned anchorage zones and strut-and-tie models) 0.60*
- 9.3.2.5- *Post-tensioned anchorage zones 0.80*
- 9.3.2.6- *Strut-and -tie models (Appendix A), and struts, ties, nodal zones, and bearing*

areas in such models.....0.70

9.3.2.7- Flexural sections in pretensioned members where strand embedment is less than the development length as provided in Section 12.9.1.1 of ACI Code:

(a) From the end of the member to the end of the transfer length..... 0.70

(b) From the end of the transfer length to the end of the development length
 ϕ shall be permitted to be linearly increased from
 0.90 to 0.85

Where bonding of a strand does not extend to the end of the member, strand embedment shall be assumed to begin at the end of the debonded length. See also Section 12.9.3 of ACI Code.

3.5.8.1.5 ACI 318, Section 10.5

Modify ACI 318, Section 10.5, by adding new Section 10.5.5 to read as follows:

10.5.5 In structures assigned to Seismic Design Category B, beams in ordinary moment frames forming part of the seismic-force-resisting system shall have at least two main flexural reinforcing bars continuously top and bottom throughout the beam and continuous through or developed within exterior columns or boundary elements.

3.5.8.1.6 ACI 318, Section 11.11

Modify ACI 318, Section 11.11, by changing its title to read as shown below and by adding new Section 11.11.3 to read as follows:

11.11– Special provisions for columns.

11.11.3 –In structures assigned to Seismic Design Category B, columns of ordinary moment frames having a clear height-to-maximum-plan-dimension ratio of five or less shall be designed for shear in accordance with Section 21.12.3.

3.5.8.1.7 ACI 318, Section 21.1

Modify existing definitions and add the following definitions to ACI 318, Section 21.1.

DESIGN DISPLACEMENT. Total lateral displacement expected for the design-basis earthquake, as specified by Section 12.8.6 of ASCE 7.

DETAILED PLAIN CONCRETE STRUCTURAL WALL. A wall complying with the requirements of Chapter 22 of ACI Code, including Section 22.6.7.

ORDINARY PRECAST STRUCTURAL WALL. A precast wall complying with the requirements of Chapters 1 through 18.

ORDINARY REINFORCED CONCRETE STRUCTURAL WALL. A cast-in-place wall complying with the requirements of Chapters 1 through 18 of ACI Code.

ORDINARY STRUCTURAL PLAIN CONCRETE WALL. A wall complying with the requirements of Chapter 22 of ACI Code, excluding 22.6.7.

WALL PIER. A wall segment with a horizontal length-to-thickness ratio of at least 2.5, but not exceeding 6, whose clear height is at least two times its horizontal length.

3.5.8.1.8 ACI 318, Section 21.2.1

Modify ACI 318 Sections 21.2.1.2, 21.2.1.3 and 21.2.1.4, to read as follows:

21.2.1.2 For structures assigned to Seismic Design Category A or B, provisions of Chapters 1 through 18 and 22 of ACI Code shall apply except as modified by the provisions of this SECTION. Where the seismic design loads are computed using provisions for intermediate or special concrete systems, the requirements of Chapter 21 of ACI Code for intermediate or special systems, as applicable, shall be satisfied.

21.2.1.3 For structures assigned to Seismic Design Category C, intermediate or special moment frames, intermediate precast structural walls or ordinary or special reinforced concrete structural walls shall be used to resist seismic forces induced by earthquake motions. Where the design seismic loads are computed using provisions for special concrete systems, the requirements of Chapter 21 of ACI Code for special systems, as applicable, shall be satisfied.

21.2.1.4 For structures assigned to Seismic Design Category D, E or F, special moment frames, special reinforced concrete structural walls, diaphragms and trusses and foundations complying with Sections 21.2 through 21.10 or intermediate precast structural walls complying with Section 21.13 shall be used to resist forces induced by earthquake motions. Members not proportioned to resist earthquake forces shall comply with Section 21.11.

3.5.8.1.9 ACI 318, Section 21.2.5

Modify ACI 318, Section 21.2.5, by renumbering as Section 21.2.5.1 and adding new Section 21.2.5.2 to read as follows:

21.2.5 Reinforcement in members resisting earthquake-induced forces.

21.2.5.1 Except as permitted in Section 21.2.5.2, reinforcement resisting earthquake-induced flexural and axial forces in frame members and in structural wall boundary elements shall comply with ASTM A 706. ASTM 615, Grades 40 and 60 reinforcement, shall be permitted in these members if (a) the actual yield strength based on mill tests does not exceed the specified yield, f_y , strength by more than 18,000 psi (124 MPa) [retests shall not exceed this value by more than an additional 3,000 psi (21 MPa)], and (b) the ratio of the actual tensile strength to the actual yield strength is not less than 1.25. For computing shear strength, the value of f_y for transverse reinforcement, including spiral reinforcement, shall not exceed 60,000 psi (414 MPa).

21.2.5.2 Prestressing steel shall be permitted in flexural members of frames, provided the average prestress, f_{po} , calculated for an area equal to the member's shortest cross-sectional dimension multiplied by the perpendicular dimension shall be the lesser of 700 psi (4.83 MPa) or $f_c / 6$ at locations of nonlinear action where prestressing steel is used in members of frames.

3.5.8.1.10 ACI 318, Section 21.2

Modify ACI 318, Section 21.2, by adding new Section 21.2.9 to read as follows:

21.2.9 Anchorages for unbonded post-tensioning tendons resisting earthquake induced forces in structures assigned to Seismic Design Category C, D, E or F shall withstand, without failure, 50 cycles of loading ranging between 40 and 85 percent of the specified tensile strength of the prestressing steel.

3.5.8.1.11 ACI 318, Section 21.3

Modify ACI 318, Section 21.3, by adding new Section 21.3.2.5 to read as follows:

21.3.2.5 Unless the special moment frame is qualified for use through structural testing as required by Section 21.6.3, for flexural members prestressing steel shall not provide more than one-quarter of the strength for either positive or negative moment at the critical section in a plastic hinge location and shall be anchored at or beyond the exterior face of a joint.

3.5.8.1.12 ACI 318, Section 21.7

Modify ACI 318, Section 21.7, by adding new Section 21.7.10 to read as follows:

21.7.10 Wall piers and wall segments.

21.7.10.1 Wall piers not designed as a part of a special moment frame shall have transverse reinforcement designed to satisfy the requirements in Section 21.7.10.2.

EXCEPTIONS:

1. Wall piers that satisfy Section 21.11.

2. Wall piers along a wall line within a story where other shear wall segments provide lateral support to the wall piers and such segments have a total stiffness of at least six times the sum of the stiffness of all the wall piers.

21.7.10.2 Transverse reinforcement with seismic hooks at both ends shall be designed to resist the shear forces determined from Section 21.4.5.1. Spacing of transverse reinforcement shall not exceed 6 inches (152 mm). Transverse reinforcement shall be extended beyond the pier clear height for at least 12 inches (305 mm).

21.7.10.3 Wall segments with a horizontal length-to-thickness ratio less than 2.5 shall be designed as columns.

3.5.8.1.13 ACI 318, Section 21.8

Modify Section 21.8.1 to read as follows:

21.8.1 Special structural walls constructed using precast concrete shall satisfy all the requirements of Section 21.7 for cast-in-place special structural walls in addition to Sections 21.13.2 through 21.13.4.

3.5.8.1.14 ACI 318, Section 21.10.1.1

Modify ACI 318, Section 21.10.1.1, to read as follows:

21.10.1.1 Foundations resisting earthquake-induced forces or transferring earthquake-induced forces between a structure and the ground shall comply with the requirements of Section 21.10 and other applicable provisions of ACI 318 unless modified by PART 4 of the Code on soil and foundations.

3.5.8.1.15 ACI 318, Section 21.11

Modify ACI 318, Section 21.11.2.2 to read as follows:

21.11.2.2 Members with factored gravity axial forces exceeding $(A_g f'_c / 10)$ shall satisfy Sections 21.4.3, 21.4.4.1(c), 21.4.4.3 and 21.4.5. The maximum longitudinal spacing of ties shall be s_o for the full column height. Spacing, s_o , shall not exceed the smaller of six diameters of the smallest longitudinal bar enclosed and 6 inches (152 mm). Lap splices of longitudinal reinforcement in such members need not satisfy Section 21.4.3.2 in structures where the seismic-force-resisting system does not include special moment frames.

3.5.8.1.16 ACI 318, Section 21.12.5

Modify ACI 318, Section 21.12.5, by adding new Section 21.12.5.6 to read as follows:

21.12.5.6 Columns supporting reactions from discontinuous stiff members, such as walls, shall be designed for the special load combinations in Section 2.1.5 of this PART and shall be provided with transverse reinforcement at the spacing, s_o , as defined in Section 21.12.5.2 over their full height beneath the level at which the discontinuity

occurs. This transverse reinforcement shall be extended above and below the column as required in Section 21.4.4.5.

3.5.8.1.17 ACI 318, Section 21.13

Modify ACI 318, Section 21.13, by renumbering Section 21.13.3 to become 21.13.4 and adding new Sections 21.13.3, 21.13.5 and 21.13.6 to read as follows:

21.13.3 Except for Type 2 mechanical splices, connection elements that are designed to yield shall be capable of maintaining 80 percent of their design strength at the deformation induced by the design displacement.

21.13.4 –Elements of the connection that are not designed to yield shall develop at least $1.5 S_y$.

21.13.5 Wall piers not designed as part of a moment frame shall have transverse reinforcement designed to resist the shear forces determined from Section 21.12.3. Spacing of transverse reinforcement shall not exceed 8 inches (203 mm). Transverse reinforcement shall be extended beyond the pier clear height for at least 12 inches (305 mm).

EXCEPTIONS:

- 1. Wall piers that satisfy Section 21.11.*
- 2. Wall piers along a wall line within a story where other shear wall segments provide lateral support to the wall piers and such segments have a total stiffness of at least six times the sum of the stiffnesses of all the wall piers.*

21.13.6 –Wall segments with a horizontal length-to-thickness ratio less than 2.5 shall be designed as columns.

3.5.8.1.18 ACI 318, Section 22.6

Modify ACI 318, Section 22.6, by adding new Section 22.6.7 to read:

22.6.7 Detailed plain concrete structural walls.

22.6.7.1 Detailed plain concrete structural walls are walls conforming to the requirements of ordinary structural plain concrete walls and Section 22.6.7.2.

22.6.7.2 - Reinforcement shall be provided as follows:

- (a) Vertical reinforcement of at least 0.20 square inch (129 mm²) in cross-sectional area shall be provided continuously from support to support at each corner, at each side of each opening and at the ends of walls. The continuous vertical bar required beside an opening is permitted to substitute for one of the two No.5 bars required by Section 22.6.6.5.*
- (b) Horizontal reinforcement at least 0.20 square inch (129 mm²) in cross-sectional area shall be provided:*
 - 1. Continuously at structurally connected roof and floor levels and at the top of walls;*
 - 2. At the bottom of load-bearing walls or in the top of foundations where doweled to the wall; and*
 - 3. At a maximum spacing of 120 inches (3048 mm).*

Reinforcement at the top and bottom of openings, where used in determining the maximum spacing specified in Item 3 above, shall be continuous in the wall.

3.5.8.1.19 ACI 318, Section 22.10

Delete ACI 318, Section 22.10, and replace with the following:

22.10 Plain concrete in structures assigned to Seismic Design Category C, D, E or F.

22.10.1—Structures assigned to Seismic Design Category C, D, E or F shall not have elements of structural plain concrete, except as follows:

(a) Structural plain concrete basement, foundation or other walls below the base are permitted in detached one- and two-family dwellings three stories or less in height constructed with stud-bearing walls. In dwellings assigned to Seismic Design Category D or E, the height of the wall shall not exceed 8 feet (2438 mm), the thickness shall not be less than 7½ inches (190 mm), and the wall shall retain no more than 4 feet (1219 mm) of unbalanced fill. Walls shall have reinforcement in accordance with Section 22.6.6.5.

(b) Isolated footings of plain concrete supporting pedestals or columns are permitted, provided the projection of the footing beyond the face of the supported member does not exceed the footing thickness.

EXCEPTION: In detached one- and two-family dwellings three stories or less in height, the projection of the footing beyond the face of the supported member is permitted to exceed the footing thickness.

(c) Plain concrete footings supporting walls are permitted, provided the footings have at least two continuous longitudinal reinforcing bars. Bars shall not be smaller than No. 4 and shall have a total area of not less than 0.002 times the gross cross-sectional area of the footing. For footings that exceed 8 inches (203 mm) in thickness, a minimum of one bar shall be provided at the top and bottom of the footing. Continuity of reinforcement shall be provided at corners and intersections.

EXCEPTIONS:

1. In detached one- and two-family dwellings three stories or less in height and constructed with stud-bearing walls, plain concrete footings without longitudinal reinforcement supporting walls are permitted.
2. For foundation systems consisting of a plain concrete footing and a plain concrete stem wall, a minimum of one bar shall be provided at the top of the stem wall and at the bottom of the footing.
3. Where a slab on ground is cast monolithically with the footing, one No. 5 bar is permitted to be located at either the top of the slab or bottom of the footing.

3.5.8.1.20 ACI 318, Section D.3.3

Modify ACI 318, Sections D.3.3.2 through D.3.3.5, to read as follows:

D.3.3.2 In structures assigned to Seismic Design Category C, D, E or F, post-installed anchors for use under D.2.3 shall have passed the Simulated Seismic Tests of ACI 355.2.

D.3.3.3 In structures assigned to Seismic Design Category C, D, E or F, the design strength of anchors shall be taken as $0.75\phi N_n$ and $0.75\phi V_n$, where ϕ is given in D.4.4 or D.4.5, and N_n and V_n are determined in accordance with D.4.1.

D.3.3.4 In structures assigned to Seismic Design Category C, D, E or F, anchors shall be designed to be governed by tensile or shear strength of a ductile steel element, unless D.3.3.5 is satisfied.

D.3.3.5 Instead of D.3.3.4, the attachment that the anchor is connecting to the structure shall be designed so that the attachment will undergo ductile yielding at a load level corresponding to anchor forces no greater than the design strength of anchors specified in D.3.3.3, or the minimum design strength of the anchors shall be at least 2.5 times the factored forces transmitted by the attachment.

3.5.9 Structural Plain Concrete

3.5.9.1 Scope

The design and construction of structural plain concrete, both cast-in-place and precast, shall comply with the minimum requirements of Section 3.5.9 and Chapter 22 of ACI 318, as modified in Section 3.5.8.

3.5.9.1.1 Special structures

For special structures, such as arches, underground utility structures, gravity walls and shielding walls, the provisions of this section shall govern where applicable.

3.5.9.2 Limitations

The use of structural plain concrete shall be limited to:

1. Members that are continuously supported by soil, such as walls and footings, or by other structural members capable of providing continuous vertical support.
2. Members for which arch action provides compression under all conditions of loading.
3. Walls and pedestals.

The use of structural plain concrete columns and structural plain concrete footings on piles is not permitted. See Section 3.5.8.1.15 for additional limitations on the use of structural plain concrete.

3.5.9.3 Joints

Contraction or isolation joints shall be provided to divide structural plain concrete members into flexurally discontinuous elements in accordance with ACI 318, Section 22.3.

3.5.9.4 Design

Structural plain concrete walls, footings and pedestals shall be designed for adequate strength in accordance with ACI 318, Sections 22.4 through 22.8.

EXCEPTION: For Group R-3 occupancies and buildings of other occupancies less than two stories in height of light-frame construction, the required edge thickness of ACI 318 is permitted to be reduced to 6 inches (152 mm), provided that the footing does not extend more than 4 inches (102 mm) on either side of the supported wall.

3.5.9.5 Precast Members

The design, fabrication, transportation and erection of precast, structural plain concrete elements shall be in accordance with ACI 318, Section 22.9.

3.5.9.6 Walls

In addition to the requirements of this section, structural plain concrete walls shall comply with the applicable requirements of ACI 318, Chapter 22.

3.5.9.6.1 Basement walls

The thickness of exterior basement walls and foundation walls shall be not less than 7½ inches (191 mm). Structural plain concrete exterior basement walls shall be exempt from the requirements for special exposure conditions of Section 1904.2.2.

3.5.9.6.2 Other walls

Except as provided for in Section 1909.6.1, the thickness of bearing walls shall be not less than 1/24 the unsupported height or length, whichever is shorter, but not less than 5½ inches (140 mm).

3.5.9.6.3 Openings in walls

Not less than two No. 5 bars shall be provided around window and door openings. Such bars shall extend at least 24 inches (610 mm) beyond the corners of openings.

3.5.10 Minimum Slab Provisions

3.5.10.1 General

The thickness of concrete floor slabs supported directly on the ground shall not be less than 3½ inches (89 mm). A 6-mil (0.006 inch; 0.15 mm) polyethylene vapor retarder with joints lapped not less than 6 inches (152 mm) shall be placed between the base course or subgrade and the concrete floor slab, or other approved equivalent methods or materials shall be used to retard vapor transmission through the floor slab.

EXCEPTION: A vapor retarder is not required:

1. For detached structures accessory to occupancies in Group R-3 (permanent residential group), such as garages, utility buildings or other unheated facilities.
2. For unheated storage rooms having an area of less than 70 square feet (6.5 m²) and carports attached to occupancies in Group R-3.
3. For buildings of other occupancies where migration of moisture through the slab from below will not be detrimental to the intended occupancy of the building.
4. For driveways, walks, patios and other flatwork which will not be enclosed at a later date.
5. Where approved based on local site conditions.

3.5.11 Anchorage to Concrete — Allowable Stress Design

3.5.11.1 Scope

The provisions of this section shall govern the allowable stress design of headed bolts and headed stud anchors cast in normal-weight concrete for purposes of transmitting structural loads from one connected element to the other. These provisions do not apply to anchors installed in hardened concrete or where load combinations include earthquake loads or effects. The bearing area of headed anchors shall be not less than one and one-half times the shank area. Where strength design is used, or where load combinations include earthquake loads or effects, the design strength of anchors shall be determined in accordance with Section 3.5.12. Bolts shall conform to ASTM A 307 or an approved equivalent.

3.5.11.2 Allowable Service Load

The allowable service load for headed anchors in shear or tension shall be as indicated in Table 3.5.1. Where anchors are subject to combined shear and tension, the following relationship shall be satisfied:

$$(P_s/P_t)^{5/3} + (V_s/V_t)^{5/3} \leq 1 \quad \text{Eq. (3.5.1)}$$

where:

P_s = Applied tension service load, pounds (N).

P_t = Allowable tension service load from Table 3.5.1, pounds (N).

V_s = Applied shear service load, pounds (N).

V_t = Allowable shear service load from Table 3.5.1, pounds (N).

TABLE 3.5.1
ALLOWABLE SERVICE LOAD ON EMBEDDED BOLTS (Pounds)

BOLT DIAMETER (inches)	MINIMUM EMBEDMENT (inches)	EDGE DISTANCE (inches)	SPACING (inches)	MINIMUM CONCRETE STRENGTH (psi)					
				$f_c = 2,500$		$f_c = 3,000$		$f_c = 4,000$	
				Tension	Shear	Tension	Shear	Tension	Shear
$1/4$	$2 1/2$	$1 1/2$	3	200	500	200	500	200	500
$3/8$	3	$2 1/4$	$4 1/2$	500	1,100	500	1,100	500	1,100
$1/2$	4 4	3 5	6 5	950 1,450	1,250 1,600	950 1,500	1,250 1,650	950 1,550	1,250 1,750
$5/8$	1 $4 1/2$	3 $6 1/4$	1 $7 1/2$	1,500 2,125	2,750 2,950	1,500 2,200	2,750 3,000	1,500 2,400	2,750 3,050
$3/4$	5 5	1 $7 1/2$	9 9	2,250 2,825	3,250 4,275	2,250 2,950	3,560 4,300	2,250 3,200	3,560 4,400
$7/8$	6	$5 1/4$	$10 1/2$	2,550	3,700	2,550	4,050	2,550	4,050
1	7	6	12	3,050	4,125	3,250	4,500	3,650	5,300
$1 1/8$	8	$6 3/4$	$13 1/2$	3,400	4,750	3,400	4,750	3,400	4,750
$1 1/4$	9	$7 1/2$	15	4,000	5,800	4,000	5,800	4,000	5,800

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 0.00689 MPa, 1 pound = 4.45 N.

3.5.11.3 Required Edge Distance and Spacing

The allowable service loads in tension and shear specified in Table 3.5.1 are for the edge distance and spacing specified. The edge distance and spacing are permitted to be reduced to 50 percent of the values specified with an equal reduction in allowable service load. Where edge distance and spacing are reduced less than 50 percent, the allowable service load shall be determined by linear interpolation.

3.5.11.4 Increase for Special Inspection

Where special inspection is provided for the installation of anchors, a 100-percent increase in the allowable tension values of Table 3.5.1 is permitted. No increase in shear value is permitted.

3.5.12 Anchorage to Concrete — Strength Design

3.5.12.1 Scope

The provisions of this section shall govern the strength design of anchors installed in concrete for purposes of transmitting structural loads from one connected element to the

other. Headed bolts, headed studs and hooked (J- or L-) bolts cast in concrete and expansion anchors and undercut anchors installed in hardened concrete shall be designed in accordance with Appendix D of ACI 318 as modified by Section 9.8.1.16, provided they are within the scope of Appendix D of ACI Code.

EXCEPTION: Where the basic concrete breakout strength in tension of a single anchor, N_b , is determined in accordance with Equation (D-7), the concrete breakout strength requirements of Section D.4.2.2 of ACI Code shall be considered satisfied by the design procedures of Sections D.5.2 and D.6.2 of ACI Code for anchors exceeding 2 inches (51 mm) in diameter or 25 inches (635 mm) tensile embedment depth.

The strength design of anchors that are not within the scope of Appendix D of ACI 318, and as amended above, shall be in accordance with an approved procedure.

3.5.13 Shotcrete

3.5.13.1 General

Shotcrete is mortar or concrete that is pneumatically projected at high velocity onto a surface. Except as specified in this section, shotcrete shall conform to the requirements of this section for plain or reinforced concrete.

3.5.13.2 Proportions and materials

Shotcrete proportions shall be selected that allows suitable placement procedures using the delivery equipment selected and shall result in finished in-place hardened shotcrete meeting the strength requirements of this code.

3.5.13.3 Aggregate

Coarse aggregate, if used, shall not exceed 3/4 inch (19.1 mm).

3.5.13.4 Reinforcement

Reinforcement used in shotcrete construction shall comply with the provisions of Sections 3.5.13.4.1 through 3.5.13.4.4.

3.5.13.4.1 Size

The maximum size of reinforcement shall be No. 5 bars unless it is demonstrated by preconstruction tests that adequate encasement of larger bars will be achieved.

3.5.13.4.2 Clearance

When No. 5 or smaller bars are used, there shall be a minimum clearance between parallel reinforcement bars of 2½ inches (64 mm). When bars larger than No. 5 are permitted, there shall be a minimum clearance between parallel bars equal to six diameters of the bars used. When two curtains of steel are provided, the curtain nearer the nozzle shall have a minimum spacing equal to 12 bar diameters and the remaining curtain shall have a minimum spacing of six bar diameters.

EXCEPTION: Subject to the approval of the building official, required clearances shall be reduced where it is demonstrated by preconstruction tests that adequate encasement of the bars used in the design will be achieved.

3.5.13.4.3 Splices

Lap splices of reinforcing bars shall utilize the noncontact lap splice method with a minimum clearance of 2 inches (51 mm) between bars. The use of contact lap splices necessary for support of the reinforcing is permitted when approved by the building

official, based on satisfactory preconstruction tests that show that adequate encasement of the bars will be achieved, and provided that the splice is oriented so that a plane through the centre of the spliced bars is perpendicular to the surface of the shotcrete.

3.5.13.4.4 Spirally tied columns

Shotcrete shall not be applied to spirally tied columns.

3.5.13.5 Preconstruction Tests

When required by the building official, a test panel shall be shot, cured, cored or sawn, examined and tested prior to commencement of the project. The sample panel shall be representative of the project and simulate job conditions as closely as possible. The panel thickness and reinforcing shall reproduce the thickest and most congested area specified in the structural design. It shall be shot at the same angle, using the same nozzleman and with the same concrete mix design that will be used on the project. The equipment used in preconstruction testing shall be the same equipment used in the work requiring such testing, unless substitute equipment is approved by the building official.

3.5.13.6 Rebound

Any rebound or accumulated loose aggregate shall be removed from the surfaces to be covered prior to placing the initial or any succeeding layers of shotcrete. Rebound shall not be used as aggregate.

3.5.13.7 Joints

Except where permitted herein, unfinished work shall not be allowed to stand for more than 30 minutes unless edges are sloped to a thin edge. For structural elements that will be under compression and for construction joints shown on the approved construction documents, square joints are permitted. Before placing additional material adjacent to previously applied work, sloping and square edges shall be cleaned and wetted.

3.5.13.8 Damage

In-place shotcrete that exhibits sags, sloughs, segregation, honeycombing, sand pockets or other obvious defects shall be removed and replaced. Shotcrete above sags and sloughs shall be removed and replaced while still plastic.

3.5.13.9 Curing

During the curing periods specified herein, shotcrete shall be maintained above 40°F (4°C) and in moist condition.

3.5.13.9.1 Initial curing

Shotcrete shall be kept continuously moist for 24 hours after shotcreting is complete or shall be sealed with an approved curing compound.

3.5.13.9.2 Final curing

Final curing shall continue for seven days after shotcreting, or for three days if high-early-strength cement is used, or until the specified strength is obtained. Final curing shall consist of the initial curing process or the shotcrete shall be covered with an approved moisture-retaining cover.

3.5.13.9.3 Natural curing

Natural curing shall not be used in lieu of that specified in this section unless the relative humidity remains at or above 85 percent, and is authorized by the registered design professional and approved by the building official.

3.5.13.10 Strength Tests

Strength tests for shotcrete shall be made by an approved agency on specimens that are representative of the work and which have been water soaked for at least 24 hours prior to

testing. When the maximum-size aggregate is larger than 3/8 inch (9.5 mm), specimens shall consist of not less than three 3-inch-diameter (76 mm) cores or 3-inch (76 mm) cubes. When the maximum-size aggregate is 3/8 inch (9.5 mm) or smaller, specimens shall consist of not less than 2-inch-diameter (51 mm) cores or 2-inch (51 mm) cubes.

3.5.13.10.1 Sampling

Specimens shall be taken from the in-place work or from test panels, and shall be taken at least once each shift, but not less than one for each 50 cubic yards (38.2 m³) of shotcrete.

3.5.13.10.2 Panel criteria

When the maximum-size aggregate is larger than 3/8 inch (9.5 mm), the test panels shall have minimum dimensions of 18 inches by 18 inches (457 mm by 457 mm). When the maximum size aggregate is 3/8 inch (9.5 mm) or smaller, the test panels shall have minimum dimensions of 12 inches by 12 inches (305 mm by 305 mm). Panels shall be shot in the same position as the work, during the course of the work and by the nozzlemen doing the work. The conditions under which the panels are cured shall be the same as the work.

3.5.13.10.3 Acceptance criteria

The average compressive strength of three cores from the in-place work or a single test panel shall equal or exceed $0.85f'_c$ with no single core less than $0.75f'_c$. The average compressive strength of three cubes taken from the in-place work or a single test panel shall equal or exceed f'_c with no individual cube less than $0.88f'_c$. To check accuracy, locations represented by erratic core or cube strengths shall be retested.

3.5.14 Concrete- Filled Pipe Columns

3.5.14.1 General

Concrete-filled pipe columns shall be manufactured from standard, extra-strong or double-extra-strong steel pipe or tubing that is filled with concrete so placed and manipulated as to secure maximum density and to ensure complete filling of the pipe without voids.

3.5.14.2 Design

The safe supporting capacity of concrete-filled pipe columns shall be computed in accordance with the approved rules or as determined by a test.

3.5.14.3 Connections

Caps, base plates and connections shall be of approved types and shall be positively attached to the shell and anchored to the concrete core. Welding of brackets without mechanical anchorage shall be prohibited. Where the pipe is slotted to accommodate webs of brackets or other connections, the integrity of the shell shall be restored by welding to ensure hooping action of the composite section.

3.5.14.4 Reinforcement

To increase the safe load-supporting capacity of concrete-filled pipe columns, the steel reinforcement shall be in the form of rods, structural shapes or pipe embedded in the concrete core with sufficient clearance to ensure the composite action of the section, but not nearer than 1 inch (25 mm) to the exterior steel shell. Structural shapes used as reinforcement shall be milled to ensure bearing on cap and base plates.

3.5.14.5 Fire-Resistance-Rating Protection

Pipe columns shall be of such size or so protected as to develop the required fire-resistance ratings specified in this Code. Where an outer steel shell is used to enclose the fire-resistant covering, the shell shall not be included in the calculations for strength of the column section. The minimum diameter of pipe columns shall be 4 inches (102 mm) except that in structures of Type V construction not exceeding three stories or 40 feet (12192 mm) in height, pipe columns used in the basement and as secondary steel members shall have a minimum diameter of 3 inches (76 mm).

3.5.14.6 Approvals

Details of column connections and splices shall be shop fabricated by approved methods and shall be approved only after tests in accordance with the approved rules. Shop-fabricated concrete-filled pipe columns shall be inspected by the building official or by an approved representative of the manufacturer at the plant.

APPENDIX A

ALTERNATIVE DESIGN METHOD

A.0 Notation

Some notation definitions are modified from those in the main body of the SECTION for specific use in the application of Appendix A.

A_g = gross area of section, in²

A_v = area of shear reinforcement within a distance s , in²

A_1 = loaded area

A_2 = maximum area of the portion of the supporting surface that is geometrically similar to and concentric with the loaded area

b_o = perimeter of critical section for slabs and footings, in.

b_w = web width, or diameter of circular section, in.

d = distance from extreme compression fiber to centroid of tension reinforcement, in.

E_c = modulus of elasticity of concrete, psi

E_s = modulus of elasticity of reinforcement, psi

f'_c = specified compressive strength of concrete, psi

$\sqrt{f'_c}$ = square root of specified compressive strength of concrete, psi

f_{ct} = average splitting tensile strength of light-weight aggregate concrete, psi

f_s = permissible tensile stress in reinforcement, psi

f_y = specified yield strength of reinforcement, psi

M = design moment

n = modular ratio of elasticity

$= E_s / E_c$

N = design axial load normal to cross section occurring simultaneously with V ; to be taken as positive for compression, negative for tension, and to include effects of tension due to creep and shrinkage

s = spacing of shear reinforcement in direction parallel to longitudinal reinforcement, in.

v = design shear stress

v_c = permissible shear stress carried by concrete, psi

v_h = permissible horizontal shear stress, psi

V = design shear force at section

α = angle between inclined stirrups and longitudinal axis of member

β_c = ratio of long side to short side of concentrated load or reaction area

ρ_w = ratio of tension reinforcement

$= A_s / b_w d$

ϕ = strength reduction factor

A.1 Scope

A.1.1

Nonprestressed reinforced concrete members shall be permitted to be designed using service loads (without load factors) and permissible service load stresses in accordance with provisions of Appendix A. Limitations, if any, for the use of this method shall be specified by the authority department.

A.1.2 For design of members not covered by Appendix A, appropriate provisions of ACI Codes shall apply.

A.1.3 All applicable provisions of ACI Code for nonprestressed concrete, except Section 8.4, shall apply to members designed by the Alternative Design Method.

A.1.4 Flexural members shall meet requirements for deflection control in Section 9.5, and requirements of Sections 10.4 through 10.7 of ACI Code.

A.2 General

A.2.1 Load factors and strength reduction factors ϕ shall be taken as unity for members designed by the Alternative Design Method.

A.2.2 It shall be permitted to proportion members for 75 percent of capacities required by other parts of Appendix A when considering wind or earthquake forces combined with other loads, provided the resulting section is not less than that required for the combination of dead and live load.

A.2.3 When dead load reduces effects of other loads, members shall be designed for 85 percent of dead load in combination with the other loads.

A.3 Permissible Service Load Stresses

A.3.1 Stresses in concrete shall not exceed the following:

(a) Flexure

Extreme fiber stress in compression..... $0.45f'_c$

(b) Shear*

Beams and one-way slabs and footings:

Shear carried by concrete, v_c $1.1\sqrt{f'_c}$

Maximum shear carried by concrete plus

Shear reinforcement..... $v_c + 4.4\sqrt{f'_c}$

Joists:**

Shear carried by concrete, v_c $1.2\sqrt{f'_c}$

Two-way slabs and footings:

Footnote: *Formore detailed calculation of shear stress carried by concrete V_c and shear values for lightweight aggregate concrete, see Section A.7.4.

**Designed in accordance with Section 8.11 of ACI Code.

Shear carried by concrete, $v_c^\dagger$ $(1 + \frac{2}{\beta_c})\sqrt{f'_c}$ but not greater than $2\sqrt{f'_c}$

(c) Bearing on loaded area[‡]..... $0.3f'_c$

A.3.2 Tensile stress in reinforcement f_s shall not exceed the following:

(a) Grade 40 or Grade 50 reinforcement..... 20,000 psi

(b) Grade 60 reinforcement or greater and welded wire fabric (plain or deformed)..... 24,000 psi

(c) For flexural reinforcement, 3/8 in. or less in diameter, in one-way slabs of not more than 12 ft span..... $0.50f_y$ but not greater than 30,000 psi

A.4 Development and Splices of Reinforcement

A.4.1 Development and splices of reinforcement shall be as required in Chapter 12 of ACI Code.

A.4.2 In satisfying requirements of Section 12.11.3, M_n shall be taken as computed moment capacity assuming all positive moment tension reinforcement at the section to

bestressed to the permissible tensile stress f_s , and V_u shall be taken as unfactored shear force at the section.

A.5 Flexure

For investigation of stresses at service loads, straight-line theory (for flexure) shall be used with the following assumptions.

A.5.1 Strains vary linearly as the distance from the neutral axis, except for deep flexural members with overall depth-span ratios greater than 2/5 for continuous spans and 4/5 for simple spans, a nonlinear distribution of strain shall be considered, See Section 10.7 of ACI Code.

A.5.2 Stress-strain relationship of concrete is a straight line under service loads within permissible service load stresses.

A.5.3 In reinforced concrete members, concrete resists not tension.

A.5.4 It shall be permitted to take the modular ratio, $n = E_s/E_c$, as the nearest whole number (but not less than 6). Except in calculations for deflections, value of n for lightweight concrete shall be assumed to be the same as for normal weight concrete of the same strength.

Footnote: † If shear reinforcement is provided, see Section A.7.7.4 and A.7.7.5.

‡ When the supporting surface is wider on all sides than the loaded area, permissible bearing stress on the loaded area shall be permitted to be multiplied by $\sqrt{A_2/A_1}$ but not more than 2. When the supporting surface is sloped or stepped, A_2 shall be permitted to be taken as the area of the lower base of the largest frustum of a right pyramid or cone contained wholly within the support and having for its upper base the loaded area, and having side slopes of 1 vertical to 2 horizontal.

A.5.5 In doubly reinforced flexural members, an effective modular ratio of $2E_s/E_c$ shall be used to transform compression reinforcement for stress computations. Compressive stress in such reinforcement shall not exceed permissible tensile stress.

A.6 Compression Members with or without Flexure

A.6.1 Combined flexure and axial load capacity of compression members shall be taken as 40 percent of that computed in accordance with provisions in Chapter 10 of ACI Code.

A.6.2 Slenderness effects shall be included according to requirements of Sections 10.10 through 10.13. In Eq. (10.9) and (10.18) the term P_u shall be replaced by 2.5 times the design axial load, and the factor 0.75 shall be taken equal to 1.0.

A.6.3 Wall shall be designed in accordance with Chapter 14 of this ACI Code with flexure and axial load capacities taken as 40 percent of that computed using Chapter 14. In Eq. (14-1), ϕ shall be taken equal to 1.0.

A.7 Shear and Torsion

A.7.1 Design shear stress v shall be computed by

$$v = \frac{V}{b_w d} \quad (A-1)$$

where V is design shear force at section considered.

A.7.2 When the reaction, in direction of applied

shear, introduces compression into the end regions of a member, sections located less than a distance d from face of support shall be permitted to be designed for the same shear v as that computed at a distance d .

A.7.3 Whenever applicable, effects of torsion, in accordance with provisions of Chapter 11 of ACI Code, shall be added. Shear and torsional moment strengths provided by concrete and limiting maximum strengths for torsion shall be taken as 55 percent of the values given in Chapter 11.

A.7.4 Shear Stress Carried by Concrete

A.7.4.1 For members subject to shear and flexure only, shear stress carried by concrete v_c shall not exceed $1.1\sqrt{f'_c}$ unless a more detailed calculation is made in accordance with Section A.7.4.4.

A.7.4.2 For members subject to axial compression, shear stress carried by concrete v_c shall not exceed $1.1\sqrt{f'_c}$ unless a more detailed calculation is made in accordance with Section A.7.4.5.

A.7.4.3 For members subject to significant axial tension, shear reinforcement shall be designed to carry total shear, unless a more detailed calculation is made using

$$v_c = 1.1(1 + 0.004 \frac{N}{A_g}) \sqrt{f'_c} \quad (\text{A-2})$$

where N is negative for tension. Quantity N/A_g shall be expressed in psi.

A.7.4.4 For members subject to shear and flexure only, it shall be permitted to compute v_c by

$$v_c = \sqrt{f'_c} + 1300 \rho_w \frac{V_d}{M} \quad (\text{A-3})$$

but v_c shall not exceed $1.9\sqrt{f'_c}$. Quantity V_d/M shall not be taken greater than 1.0, where M is design moment occurring simultaneously with V at section considered.

A.7.4.5 For members subject to axial compression, it shall be permitted to compute v_c by

$$v_c = 1.1(1 + 0.0006 \frac{N}{A_g}) \sqrt{f'_c} \quad (\text{A-4})$$

Quantity N/A_g shall be expressed in psi.

A.7.4.6 Shear stresses carried by concrete v_c apply to normal weight concrete. When lightweight aggregate concrete is used, one of the following modifications shall apply:

- When f_{ct} is specified and concrete is proportioned in accordance with Section 5.2, $f_{ct}/6.7$ shall be substituted for $\sqrt{f'_c}$ but the value of $f_{ct}/6.7$ shall not exceed $\sqrt{f'_c}$;
- When f_{ct} is not specified, the value of $\sqrt{f'_c}$ shall be multiplied by 0.75 for "all-lightweight" concrete and by 0.85 for "sand-lightweight" concrete. Linear interpolation shall be permitted when partial sand replacement is used.

A.7.4.7 In determining shear stress carried by concrete v_c , whenever applicable, effects of axial tension due to creep and shrinkage in restrained members shall be included and it shall be permitted to include effects of inclined flexural compression in variable-depth members.

A.7.5 Shear Stress Carried by Shear Reinforcement

A.7.5.1 Types of Shear Reinforcement

Shear reinforcement shall consist of one of the following:

- Stirrups perpendicular to axis of member;
- Welded wire fabric with wires located perpendicular to axis of member making an angle

- of 45 deg or more with longitudinal tension reinforcement;
- (c) Longitudinal reinforcement with bent portion making an angle of 30 deg or more with longitudinal tension reinforcement;
- (d) Combination of stirrups and bent longitudinal reinforcement;
- (e) Spirals.

A.7.5.2 Design yield strength of shear reinforcement shall not exceed 60,000 psi.

A.7.5.3 Stirrups and other bars or wires used as shear reinforcement shall extend to a distance d from extreme compression fiber and shall be anchored at both ends according to Section 12.13 of ACI Code to develop design yield strength of reinforcement.

A.7.5.4 Spacing Limits for Shear Reinforcement

A.7.5.4.1 Spacing of shear reinforcement placed perpendicular to axis of member shall not exceed $d/2$, nor 24 in.

A.7.5.4.2 Inclined stirrups and bent longitudinal reinforcements shall be spaced that every 45-deg line, extending toward the reaction from mid-depth of member ($d/2$) to longitudinal tension reinforcement, shall be crossed by at least one line of shear reinforcement.

A.7.5.4.3 When $(v - v_c)$ exceeds $2\sqrt{f'_c}$, maximum spacing given in Sections A.7.5.4.1 and A.7.5.4.2 shall be reduced by one-half.

A.7.5.5 Minimum Shear Reinforcement

A.7.5.5.1 A minimum area of shear reinforcement shall be provided in all reinforced concrete flexural members where design shear stress is greater than one-half the permissible shear stress v_c carried by concrete, except:

- (a) Slabs and footings;
- (b) Concrete joist construction defined by Section 8.11 of ACI Code;
- (c) Beams with total depth not greater than 10 in., 2.5 times thickness of flange, or one-half the width of web, whichever is greatest.

A.7.5.5.2 Minimum shear reinforcement requirements of Section A.7.5.5.1 shall be permitted to be waived if shown by test that required ultimate flexural and shear strength can be developed when shear reinforcement is omitted.

A.7.5.5.3 Where shear reinforcement is required by Section A.7.5.5.1 or by analysis, minimum area of shear reinforcement shall be computed by

$$A_v = 50 \frac{b_w s}{f_y} \quad (A-5)$$

where b_w and s are in inches.

A.7.5.6 Design of Shear Reinforcement

A.7.5.6.1 Where design shear stress v exceeds shear stress carried by concrete v_c , shear reinforcements shall be provided in accordance with Sections A.7.5.6.2 through A.7.5.6.8.

A.7.5.6.2 When shear reinforcement perpendicular to axis of member is used,

$$A_v = \frac{(v - v_c) b_w s}{f_s} \quad (A-6)$$

A.7.5.6.3 When inclined stirrups are used as shear reinforcement,

$$A_v = \frac{(v - v_c) b_w s}{f_s (\sin \alpha + \cos \alpha)} \quad (A-7)$$

A.7.5.6.4 When shear reinforcement consists of a single bar or a single group of parallel bars, all bent up at the same distance from the support,

$$A_v = \frac{(v - v_c)b_w d}{f_s \sin \alpha} \quad (A-8)$$

where $(v - v_c)$ shall not exceed $1.6 \sqrt{f'_c}$.

A.7.5.6.5 When shear reinforcement consists of a series of parallel bent-up bars or groups of parallel bent-up bars at different distances from the support, required area shall be computed by Eq. (A-7).

A.7.5.6.6 Only the centre three-quarters of the inclined portion of any longitudinal bent bar shall be considered effective for shear reinforcement.

A.7.5.6.7 When more than one type of shear reinforcement is used to reinforce the same portion of a member, required area shall be computed as the sum of the various types separately. In such computations, v_c shall be included only once.

A.7.5.6.8 Value of $(v - v_c)$ shall not exceed $4.4 \sqrt{f'_c}$.

A.7.6 Shear Friction

Where it is appropriate to consider shear transfer across a given plane, such as an existing or potential crack, an interface between dissimilar materials, or an interface between two concrete cast at different times, shear-friction provisions of Section 11.7 of ACI Code shall be permitted to be applied, with limiting maximum stress for shear taken as 55 percent of that given in Section 11.7.5. Permissible stress in shear-friction reinforcement shall be that given in Section A.3.2.

A.7.7 Special Provisions for Slabs and Footings

A.7.7.1 Shear capacity of slabs and footings in the vicinity of concentrated loads or reactions is governed by the more severe of two conditions:

A.7.7.1.1 Beam action for slab or footing, with a critical section extending in a plane across the entire width and located at a distance d from face of concentrated load or reaction area. For this condition, the slab or footing shall be designed in accordance with Sections A.7.1 through A.7.5.

A.7.7.1.2 Two-way action for slab or footing, with a critical section perpendicular to plane of slab and located so that its perimeter is a minimum, but need not approach closer than $d/2$ to perimeter of concentrated load or reaction area. For this condition, the slab or footing shall be designed in accordance with Section A.7.7.2 and A.7.7.3.

A.7.7.2 Design shear stress v shall be computed by

$$v = \frac{V}{b_o d} \quad (A-9)$$

where v and b_o shall be taken at the critical section defined in Section A.7.7.1.2.

A.7.7.3 Design shear stress v shall not exceed v_c given by Eq. (A-10) unless shear reinforcement is provided

$$v_c = \left(1 + \frac{2}{\beta_c}\right) \sqrt{f'_c} \quad (A-10)$$

But v_c shall not exceed $2\sqrt{f'_c}$. β_c is the ratio of long side to short side of concentrated load or reaction area. When lightweight aggregate concrete is used, the modifications of Section A.7.4.6 shall apply.

A.7.7.4 If shear reinforcement consisting of bars or wires is provided in accordance with Section 11.12.3 of ACI Code, v_c shall not exceed $\sqrt{f'_c}$, and v shall not exceed $3\sqrt{f'_c}$.

A.7.7.5 If shear reinforcement consisting of steel I- or channel-shaped sections (shearheads)

is provided in accordance with Section 11.12.4 of ACI Code, v on the critical section defined in Section A.7.7.1.2 shall not exceed $3.5\sqrt{f'_c}$, and v on the critical section defined in Section 11.12.4.7 shall not exceed $2\sqrt{f'_c}$. In Eq. (11.37) and Eq. (11.38), design shear force V shall be multiplied by 2 and substituted for V_u .

A.7.8 Special Provisions for Other Members

For design of deep flexural members, brackets and corbels, and walls, the special provisions of Chapter 11 of ACI Code shall be used, with shear strengths provided by concrete and limiting maximum strengths for shear taken as 55 percent of the values given in Chapter 11 of ACI Code. In Section 11.10.6, the design axial load shall be multiplied by 1.2 if compression and 2.0 if tension, and substituted for N_u .

A.7.9 Composite Concrete Flexural Members

For design of composite concrete flexural members, permissible horizontal shear stress v_h shall not exceed 55 percent of the horizontal shear strength given in Section 17.5.3 of ACI Code.

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PART 3 STRUCTURAL DESIGN

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SECTION 3.6: STEEL

3.6.1 General

3.6.1.1 Scope.

The provisions of this section govern the quality, design, fabrication and erection of steel used structurally in buildings.

3.6.2 Definitions

The following terms as used in this Section have the following meanings.

AASHTO: American Association of State Highway and Transportation Officials.

ADJUSTABLE ITEMS: See Section 3.6.6.7.13.1.3.

AESS: See Architecturally Exposed Structural Steel.

AISC: American Institute of Steel Construction, Inc.

The AISC CODE: The AISC Code of Standard Practice for Steel Buildings and Bridges, 2005, as adopted by the American Institute of Steel Construction, Inc.

The AISC SPECIFICATION: The AISC Specification for Structural Steel Buildings, 2005, as adopted by the American Institute of Steel Construction, Inc.

ANCHOR BOLT: See Anchor Rod.

ANCHOR ROD: A mechanical device that is either cast or drilled and chemically adhered, grouted or wedged into concrete and/or masonry for the purpose of the subsequent attachment of Structural Steel.

ANCHOR- ROD GROUP: A set of Anchor Rods that receives a single fabricated Structural Steel shipping piece.

ANSI: American National Standards Institute.

ARCHITECT: The entity that is professionally qualified and duly licensed to perform architectural services.

ARCHITECTURALLY EXPOSED STRUCTURAL STEEL: See Section 3.6.6.9.

AREMA: American Railway Engineering and Maintenance of Way Association.

ASME: American Society of Mechanical Engineers.

ASTM: American Society for Testing and Materials.

AWS: American Welding Society.

BEARING DEVICES: Shop-attached base and bearing plates, loose base and bearing plates and leveling devices, such as leveling plates, leveling nuts and washers and leveling screws.



CLARIFICATION: An interpretation, of the Design Drawings or Specification that have been Released for Construction, made in response to an RFI or a note on an approval drawing and providing an explanation that neither revises the information that has been Released for Construction nor alters the cost or schedule of performance of the work.

COLUMN LINE: The grid line of column centers set in the field based on the dimensions shown on the structural design drawings and using the building layout provided by the Owners Designated Representative for Construction. Column offsets are taken from the column line. The column line may be straight or curved as shown in the structural design drawings.

CONNECTION: An assembly of one or more joints that is used to transmit forces between two or more members and/or connection elements.

CONTRACT

DOCUMENTS: The documents that define the responsibilities of the parties that are involved in bidding, fabricating and erecting Structural Steel. These documents normally include the Design Drawings, the Specifications and the contract.

DESIGN DRAWINGS: The graphic and pictorial portions of the Contract Documents showing the design, location and dimensions of the work. These documents generally include plans, elevations, sections, details, schedules, diagrams and notes.

EMBEDMENT

DRAWINGS: Drawings that show the location and placement of items that are installed to receive Structural Steel.

EOR: See Structural Engineer of Record.

ENGINEER: See Structural Engineer of Record.

ENGINEER OF RECORD: See Structural Engineer of Record.

ERECTION

BRACING

DRAWINGS: Drawings that are prepared by the Erector to illustrate the sequence of erection, any requirements for temporary supports and the requirements for raising, bolting and/or welding. These drawings are in addition to the Erection Drawings.

ERECTION

DRAWINGS: Field-installation or member-placement drawings that are prepared by the Fabricator to show the location and attachment of the individual shipping pieces.

ERECTOR: The entity that is responsible for the erection of the Structural Steel.

ESTABLISHED

COLUMN

LINE: The actual field line that is most representative of the erected column centers along a line of columns placed using the dimensions shown in the structural Design Drawings and the lines and benchmarks.

established by the

Owner's Designated Representative for Construction, to be used in applying the erection tolerances given in this SECTION for column shipping pieces.

FABRICATOR: The entity that is responsible for fabricating the Structural Steel.

HAZARDOUS

MATERIALS: Components, compounds or devices that are either encountered during the performance of the contract work or incorporated into it containing substances that, notwithstanding the application of reasonable care, present a threat of harm to persons and/or the environment.

INSPECTOR: The Owner's testing and inspection agency.

MBMA: Metal Building Manufacturers Association.

MILL MATERIAL: Steel mill products that are ordered expressly for the requirements of a specific project.

OWNER: The entity that is identified as such in the Contract Documents.

OWNER'S DESIGNATED REPRESENTATIVE FOR CONSTRUCTION: The Owner or the entity that is responsible to the Owner for the overall construction of the project, including its planning, quality and completion. This is usually the general contractor, the construction manager or similar authority at the jobsite.

OWNER'S DESIGNATED REPRESENTATIVE FOR DESIGN: The Owner or the entity that is responsible to the Owner for the overall structural design of the project, including the Structural Steel frame. This is usually the Structural Engineer of Record.

PLANS: See Design Drawings.

RCSC: Research Council on Structural Connections.

RELEASED FOR CONSTRUCTION: The term that describes the status of Contract Documents that are in such a condition that the Fabricator and the Erector can rely upon them for the performance of their work, including the ordering of material and the preparation of Shop and Erection Drawings.

REVISION: An instruction or directive providing information that differs from information that has been Released for Construction. A Revision may, but does not always, impact the cost or schedule of performance of the work.

RFI: A written request for information or clarification generated during the construction phase of the project.

SER: See Structural Engineer of Record.

SHOP

DRAWINGS: Drawings of the individual Structural Steel shipping pieces that are to be produced in the fabrication shop.

SJI: Steel Joist Institute.

SPECIFICATIONS: The portion of the Contract Documents that consists of the written requirements for materials, standards and workmanship.

SSPC: The Society for Protective Coatings, which was formerly known as the Steel Structures Painting Council.

STANDARD STRUCTURAL SHAPES: Hot-rolled W-, S-, M- and HP-shapes, channels and angles listed in ASTM A6/A6M; structural tees split from the hot-rolled W-, S- and M-shapes listed in ASTM A6/A6M; hollow structural sections produced to ASTM A500, A501, A618 or A847; and, steel pipe produced to ASTM A53/A53M.

STEEL DETAILER: The entity that produces the Shop and Erection Drawings.

STRUCTURAL ENGINEER OF RECORD: The licensed professional who is responsible for sealing the Contract Documents, which indicates that he or she has performed or supervised the analysis, design and document preparation for the structure and has knowledge of the load-carrying structural system.

STRUCTURAL STEEL: The elements of the structural frame as given in Section 6.6.2.1.

TIER: The Structural Steel framing defined by a column shipping piece.

WELD SHOW-THROUGH: In Architecturally Exposed Structural Steel, visual indication of the presence of a weld or welds on the side of the member opposite the weld.

3.6.3 Identification and Protection of Steel for Structural Purposes

3.6.3.1 Identification

Steel furnished for structural load-carrying purposes shall be properly identified for conformity to the ordered grade in accordance with the specified ASTM standard or other specification and the provisions of this section. Steel that is not readily identifiable as to grade from marking and test records shall be tested to determine conformity to such standards.

3.6.3.2 Protection

Painting of structural steel shall comply with the requirements contained in AISC 360. Individual structural members and assembled panels of cold-formed steel construction, except where fabricated of approved corrosion-resistant steel or of steel having a corrosion-resistant or other approved coating, shall be protected against corrosion with an approved coat of paint, enamel or other approved protection.

3.6.4 Connections

3.6.4.1 Welding

The details of design, workmanship and technique for welding, inspection of welding and qualification of welding operators shall conform to the requirements of the specifications.

listed in Sections 3.6.5, 3.6.6, 3.6.7, 3.6.8, 3.6.10 and 3.6.11. Special inspection of welding shall be provided where required by the authority having jurisdiction.

3.6.4.2 Bolting

The design, installation and inspection of bolts shall be in accordance with the requirements of the specifications listed in Sections 3.6.5, 3.6.6, 3.6.7, 3.6.8, and 3.6.10, 3.6.11. Special inspection of the installation of high-strength bolts shall be provided where required by the authority having jurisdiction.

3.6.4.2.1 Anchor rods

Anchor rods shall be set accurately to the pattern and dimensions called for on the plans. The protrusion of the threaded ends through the connected material shall be sufficient to fully engage the threads of the nuts, but shall not be greater than the length of the threads on the bolts.

3.6.5 Structural Steel–Design

3.6.5.1 General

The design of structural steel for buildings and structures shall be in accordance with AISC 360-05. Where required, the seismic design of steel structures shall be in accordance with the additional provisions of Section 3.6.5.2.

3.6.5.2 Seismic requirements for steel structures

The design of structural steel structures to resist seismic forces shall be in accordance with the provisions of Section 3.6.5.2.1 or 3.6.5.2.2 for the appropriate Seismic Design Category.

3.6.5.2.1 Seismic Design Category A, B or C

Structural steel structures assigned to Seismic Design Category A, B or C shall be of any construction permitted in Section 3.6.5. An R factor as set forth in Section 12.2.1 of ASCE 7-05 for the appropriate steel system is permitted where the structure is designed and detailed in accordance with the provisions of AISC 341, Part I. Systems not detailed in accordance with the above shall use the R factor in Section 12.2.1 of ASCE 7-05 designated for “structural steel systems not specifically detailed for seismic resistance.”

3.6.5.2.2 Seismic Design Category D, E or F

Structural steel structures assigned to Seismic Design Category D, E or F shall be designed and detailed in accordance with AISC 341, Part I.

3.6.5.3 Seismic requirements for composite construction

The design, construction and quality of composite steel and concrete components that resist seismic forces shall conform to the requirements of the AISC 360-05 and ACI 318-05. An R factor as set forth in Section 12.2.1 of ASCE 7-05 for the appropriate composite steel and concrete system is permitted where the structure is designed and detailed in accordance with the provisions of AISC 341, Part II. In Seismic Design Category B or above, the design of such systems shall conform to the requirements of AISC 341, Part II.

3.6.5.3.1 Seismic Design Categories D, E and F

Composite structures are permitted in Seismic Design Categories D, E and F, subject to the limitations in Section 12.2.1 of ASCE7-05, where substantiating evidence is provided to demonstrate that the proposed system will perform as intended by AISC341, Part II. The substantiating evidence shall be subject to building official approval. Where composite elements or connections are required to sustain inelastic deformations, the substantiating evidence shall be based on cyclic testing.

3.6.6 Structural Steel—Fabrication and Erection

3.6.6.1 General

3.6.6.1.1 Scope

In the absence of specific instructions to the contrary in the Contract Documents, the trade practices that are defined in this SECTION shall govern the fabrication and erection of Structural Steel.

3.6.6.1.2 Referenced specifications, codes and standards

The following documents are referenced in this SECTION:

AASHTO Specification—The 2004 AASHTO LRFD Bridge Design Specifications, 3rd Edition, with interims, or the 2002 AASHTO Standard Specifications for Highway Bridges, 17th Edition, with interims.

AISC Manual of Steel Construction—
The AISC Manual of Steel Construction, 13th Edition.

AISC Seismic Provisions—The AISC Seismic Provisions for Structural Steel Buildings, March 9, 2005.

AISC Specification—The AISC Specification for Structural Steel Buildings, March 9, 2005.

ANSI/ASME B46.1—ANSI/ASME B46.1-95, Surface Texture (Surface Roughness, Waviness and Lay).

AREMA Specification—The 1999 AREMA Manual for Railway Engineering, Volume II—Structures, Chapter 15.

ASTMA6/A6M—
04a, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.

ASTMA53/A53M—02, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

ASTMA325—04, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105ksi Minimum Tensile Strength.

ASTMA325M—04, Standard Specification for High-Strength Bolts for Structural Steel Joints (Metric).

ASTMA490—04, *Standard Specification for Heat-Treated Steel Structural Bolts, 150ksi Minimum Tensile Strength.*

ASTMA490M—04, *Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric).*

ASTMA500—03a, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel*

Structural Tubing in Rounds and Shapes. No metric equivalent exists.

ASTM A501—01, *Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.* No metric equivalent exists.

ASTM A618—04, *Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing.* No metric equivalent exists.

ASTMA847—99a(2003), *Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low-Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance.* No metric equivalent exists.

ASTM F1852/F1852M—04, *Standard Specification for "Twist-Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105ksi Minimum Tensile Strength.*

AWSD1.1—The AWS D1.1 *Structural Welding Code—Steel*, 2004.

CASE Document 11—*An Agreement Between Structural Engineer of Record and Contractor for Transfer of Computer Aided Drafting (CAD) files on Electronic Media*, 2000

CASE Document 962—
The National Practice Guidelines for the Structural Engineer of Record, Fourth Edition, 2000.

RCSC Specification—
The Specification for Structural Joints Using ASTM A325 or A490 Bolts, 2004.

SSPC SP2—SSPC Surface Preparation Specification No. 2, Hand Tool Cleaning, 2004.

SSPC SP6—SSPC Surface Preparation Specification No. 6, Commercial Blast Cleaning, 2004.

3.6.6.1.3 Units

In this SECTION, dimensions, weights and other measures are given in U.S. customary units with rounded or rationalized metric-unit equivalents in brackets. Because the values stated in each system are not exact equivalents, the selective combination of values from each of the two systems is not permitted.

3.6.6.1.4 Responsibility for design

3.6.6.1.4.1 When the owner's designated representative for design provides the design, design drawings and specifications, the fabricator and the erector are not responsible for the suitability, adequacy or building-code conformance of the design.

3.6.6.1.4.2 When the owner enters into a direct contract with the fabricator to both design and fabricate an entire, completed steel structure, the fabricator shall be

responsible for the suitability, adequacy, conformance with owner-established performance criteria, and building-code conformance of the structural steel design. The owner shall be responsible for the suitability, adequacy and building-code conformance of the non-structural steel elements and shall establish the performance criteria for the structural steel frame.

3.6.6.1.5 Existing structures

3.6.6.1.5.1 Demolition and shoring of any part of an existing structure are not within the scope of work that is provided by either the fabricator or the erector. Such demolition and shoring shall be performed in a timely manner so as not to interfere with or delay the work of the fabricator and the erector.

3.6.6.1.5.2

Protection of an existing structure and its contents and equipment, so as to prevent damage from normal erection processes, is not within the scope of work that is provided by either the fabricator or the erector. Such protection shall be performed in a timely manner so as not to interfere with or delay the work of the fabricator or the erector.

3.6.6.1.5.3 Surveying or field dimensioning of an existing structure is not within the scope

of work that is provided by either the fabricator or the erector. Such surveying or field dimensioning, which is necessary for the completion of shop and erection drawings and fabrication, shall be performed and furnished to the fabricator in a timely manner so as not to interfere with or delay the work of the fabricator or the erector.

3.6.6.1.5.4

Abatement or removal of hazardous materials is not within the scope of work that is provided by either the fabricator or the erector. Such

abatement or removal shall be performed in a timely manner so as not to interfere with or delay the work of the fabricator and the erector.

3.6.6.1.6 Means, methods and safety of erection

3.6.6.1.6.1 The erector shall be responsible for the means, methods and safety of erection of the structural steel frame.

3.6.6.1.6.2 The structural engineer of record shall be responsible for the structural adequacy of the design of the structure in the completed project. The structural engineer of record shall not be responsible for the means, methods and safety of erection of the structural steel frame. See also Sections 3.6.6.3.1.4 and 3.6.6.7.10.

3.6.6.2 Classification of Materials

3.6.6.2.1 Definition of structural steel

Structural steel shall consist of the elements of the structural frame that are shown and sized in the structural design drawings, essential to support the design loads and described as:

Anchor rod that will receive structural steel.

Base plates.

Beams, including built-up beams, if made from standard structural shapes and/or plates.

Bearing plates.

Bearing of steel for girders, trusses or bridges. Bracing, if permanent.

Canopy framing, if made from standard structural shapes and/or plates.

Columns, including built-up columns, if made from standard structural shapes and/or plates.

Connection materials for framing structural steel to structural steel.

Cranestops, if made from standard structural shapes and/or plates.

Door frames, if made from standard structural shapes and/or plates and if part of the structural steel frame.

Edge angles and plates, if attached to the structural steel frame or steel (open-web) joists.

Embedded structural steel parts, other than bearing plates, that will receive structural steel.

Expansion joints, if attached to the structural steel frame.

Fasteners for connecting structural steel items: permanent shop bolts, nuts and washers; shop bolts, nuts and washers for shipment; field bolts, nuts and washers for permanent connections; and, permanent pins.

Floor-opening frames, if made from standard structural shapes and/or plates and attached to the structural steel frame or steel (open-web) joists.

Floor plates (checkered or plain), if attached to the structural steel frame.

Girders, including built-up girders, if made from standard structural shapes and/or plates.

Girts, if made from standard structural shapes.

Grillage beams and girders.

Hangers, if made from standard structural shapes, plates and/or rods and framing structural steel to structural steel.

Leveling nuts and washers.

Leveling plates.

Leveling screws.

Lintels, if attached to the structural steel frame.

Marquee framing, if made from standard structural shapes and/or plates.

Machinery supports, if made from standard structural shapes and/or plates and attached to the structural steel frame.

Monorail elements, if made from standard structural shapes and/or plates and attached to the structural steel frame.

Posts, if part of the structural steel frame.

Purlins, if made from standard structural shapes.

Relieving angles, if attached to the structural steel frame.

Roof-opening frames, if made from standard structural shapes and/or plates and attached to the structural steel frame or steel (open-web) joists.

Roof-screen support frames, if made from standard structural shapes.

Sag rods, if part of the structural steel frame and connecting structural steel to structural steel.

Shear stud connectors, if specified to be shop attached. Shims, if permanent.

Struts, if permanent and part of the structural steel frame. Tierods, if part of the structural steel frame.

Trusses, if made from standard structural shapes and/or built-up members. Wall-opening frames, if made from standard structural shapes and/or plates and attached to the structural steel frame. Wedges, if permanent.

Note: The fabricator shall fabricate the items in Section 3.6.6.2.1. Such items must be shown, sized and described in the structural design drawings. bracing includes vertical bracing for resistance to wind and seismic load and structural stability, horizontal bracing for floor and roof systems and permanent stability bracing for components of the structural steel frame.

3.6.6.2.2 Other steel, iron or metal items

Structural steel shall not include other steel, iron or metal items that are not generally described in Section 3.6.6.2.1, even where such items are shown in the structural design drawings or are attached to the structural steel frame. Other steel, iron or metal items include but are not limited to:

Bearings, if non-steel.

Cables for permanent bracing or suspension systems.

Castings.

Catwalks.

Chutes.

Cold-formed steel products.

Cold-rolled steel products, except those that are specifically covered in the AISC Specification.

Corner guards.

Crane rails, splices, bolts and clamps.

Crane stops, if not made from standard structural shapes or plates.

Door guards.

Embedded steel parts, other than bearing plates, that do not receive structural steel or that are embedded in precast concrete.

Expansion joints, if not attached to the structural steel frame.

Flag poles support steel.

Floor plates (checkered or plain), if not attached to the structural steel frame.

Forgings.

Gage-metal products. Grating.

Handrail.

Hangers, if not made from standard structural shapes, plates and/or rods or not framing structural steel to structural steel.

Hoppers.

Items that are required for the assembly or erection of materials that are furnished by trades other than the fabricator or erector.

Ladders.

Lintels, if not attached to the structural steel frame.

Masonry anchors.

Miscellaneous metal.

Ornamental metal framing.

Pressure vessels.

Reinforcing steel for concrete or masonry.

Relieving angles, if not attached to the structural steel frame.

Roof screen support frames, if not made from standard structural shapes.

Safety cages.

Shear stud connectors, if specified to be field installed.

Stacks.

Stairs.

Steel deck.

Steel (open-web) joists.

Steel joist girders.

Tanks.

Toe plates.

Trench or pit covers.

Note: Section 3.6.6.2.2 includes many items that may be furnished by the fabricator if contracted to do so by specific notation and detail in the contract documents.

3.6.6.3 Design Drawings and Specifications

3.6.6.3.1. Structural design drawings and specifications

Unless otherwise indicated in the contract documents, the structural design drawings shall be based upon consideration of the design loads and forces to be resisted by the structural steel frame in the completed project.

The structural design drawings shall clearly show the work that is to be performed and shall give the following information with sufficient dimensions to accurately convey the quantity and nature of the structural steel to be fabricated:

- (a) The size, section, material grade and location of all members;
- (b) All geometry and working points necessary for layout;
- (c) Floor elevations;
- (d) Column centers and offsets;
- (e) The camber requirements for members; and,
- (f) The information that is required in Sections 3.6.6.3.1.1 through 3.6.6.3.1.6.

The structural steel specifications shall include any special requirements for the fabrication and erection of the structural steel.

The structural design drawings, specifications and addenda shall be numbered and dated for the purposes of identification.

3.6.6.3.1.1 Permanent bracing, column stiffeners, column web doubler plates, bearing stiffeners in beams and girders, web reinforcement, openings for other trades and other special details, where required, shall be shown in sufficient detail in the structural design drawings so that the quantity, detailing and fabrication requirements for these items can be readily understood.

3.6.6.3.1.2 The owner's designated representative for design shall either show the completed design of the connections in the structural design drawings or allow the fabricator to select or complete the connection details while preparing the shop and erection drawings.

When the fabricator is allowed to select or complete the connection details, the following information shall be provided in the structural design drawings:

- (a) Any restrictions on the types of connections that are permitted;
- (b) Data concerning the loads, including shears, moments, axial forces and transfer forces, that are to be resisted by the individual members and their connections, sufficient to allow the fabricator to select or complete the connection details while preparing the shop and erection drawings;
- (c) Whether the data required in (b) is given at the service-load level or the factored-load level; and,
- (d) Whether LRFD or ASD is to be used in the selection or completion of connection details.

When the fabricator selects or completes the connection details, the fabricator shall utilize the requirements in the AISC Specification and the contract

documents and submit the connection details to the owner's designated representative for design for approval.

Note: When the owner's designated representative for design shows the completed design of the connections in the structural design drawings, the following information is included:

- (a) All weld sizes and lengths;
- (b) All bolt sizes, locations, quantities and grades;
- (c) All plate and angle sizes, thicknesses and dimensions; and,
- (d) All work point locations and related information.

3.6.6.3.1.3 When leveling plates are to be furnished as part of the contract requirements, their locations and required thickness and sizes shall be specified in the contract documents.

3.6.6.3.1.4 When the structural steel frame, in the completely erected and fully connected state, requires interaction with non-structural steel elements (see Section 3.6.6.2) for strength and/or stability, those non-structural steel elements shall be identified in the contract documents as required in Section 3.6.6.7.10.

Note: Examples of non-structural steel elements include diaphragms made of steel deck, diaphragms made of concrete on steel deck and masonry and/or concrete shear walls.

3.6.6.3.1.5 When camber is required, the magnitude, direction and location of cambers shall be specified in the structural design drawings.

3.6.6.3.1.6 Specific members or portions thereof that are to be left unpainted shall be identified in the contract documents. When shop painting is required, the painting requirements shall be specified in the Contract Documents, including the following information:

- (a) The identification of specific members or portions thereof to be painted;
- (b) The surface preparation that is required for these members;
- (c) The paint specifications and manufacturer's product identification that are required for these members; and,
- (d) The minimum dry-film shop-coat thickness that is required for these members.

3.6.6.3.2 Architectural, electrical and mechanical design drawings and specifications

All requirements for the quantities, sizes and locations of structural steel shall be shown or noted in the structural design drawings. The use of architectural, electrical and/or mechanical design drawings as a supplement to the structural design drawings is permitted for the purposes of defining detail configurations and construction information.

3.6.6.3.3 Discrepancies

When discrepancies exist between the design drawings and Specifications, the design drawings shall govern. When discrepancies exist between scale dimensions in the design drawings and the figures written in them, the figures shall govern. When discrepancies exist between the structural design drawings and the architectural, electrical or mechanical design drawings or design drawings for other trades, the structural design drawings shall govern.

When a discrepancy is discovered in the contract documents in the course of the fabricator's work, the fabricator shall promptly notify the owner's designated representative for construction so that the discrepancy can be resolved by the owner's designated representative for design. Such resolutions shall be timely so as not to delay the fabricator's work. See Section 3.6.6.3.5.

3.6.6.3.4 Legibility of design drawings

Design Drawings shall be clearly legible and drawn to an identified scale that is appropriate to clearly convey the information.

Note:

Historically, the most commonly accepted scale for structural steel plans has been 1/8 in. per ft [10 mm per 1000 mm]. There are, however, situations where a smaller or larger scale is appropriate. Ultimately, consideration must be given to the clarity of the drawing.

3.6.6.3.5 Revisions to the design drawings and specifications

Revisions to the design drawings and specifications shall be made either by issuing new design drawings and specifications or by reissuing the existing design drawings and specifications. In either case, all revisions, including revisions that are communicated through responses to RFIs or the annotation of shop and/or erection drawings (see Section 3.6.6.4), shall be clearly and individually indicated in the contract documents. The contract documents shall be dated and identified by revision number. Each design drawing shall be identified by the same drawing number throughout the duration of the project, regardless of the revision.

3.6.6.3.6 Fast-track project delivery

When the fast-track project delivery system is selected, release of the structural design drawings and specifications shall constitute a Release for construction, regardless of the status of the architectural, electrical, mechanical and other interfacing designs and

contract documents. Subsequent revisions, if any, shall be the responsibility of the owner and shall be made in accordance with Sections 3.6.6.3.5.

Note: The fast-

track project delivery system generally provides for a condensed schedule for the design and construction of a project. Under this delivery system, the owner elects to release for construction the structural design drawings and specifications, which may be partially complete, at a time that may precede the completion of and coordination with architectural, mechanical, electrical and other design work and contract documents. The release of these structural

al design drawings and specifications may also precede the release of the general conditions and division 1 specifications.

3.6.6.4 Shop and Erection Drawings

3.6.6.4.1 Owner responsibility

The owner shall furnish, in a timely manner and in accordance with the contract documents, complete structural design drawings and specifications that have been Released for construction. Unless otherwise noted, design drawings that are provided as part of a contract bid package shall constitute authorization by the owner that the design drawings are released for construction.

Note: When the owner issues released-for-construction design drawings and specifications, the fabricator and the erector rely on the fact that these are the owner's requirements for the project. This release is required by the fabricator prior to the ordering of material and the preparation and completion of shop and erection drawings.

3.6.6.4.2 Fabricator responsibility

Except as provided in Section 3.6.6.4.5, the fabricator shall produce shop and erection drawings for the fabrication and erection of the structural steel and is responsible for the following:

- (a) The transfer of information from the contract documents into accurate and complete shop and erection drawings; and,
- (b) The development of accurate, detailed dimensional information to provide for the fit-up of parts in the field.

Each shop and erection drawing shall be identified by the same drawing number throughout the duration of the project and shall be identified by revision number and date, with each specific revision clearly identified.

When the fabricator submits a request to change connection details that are described in the contract documents, the Fabricator shall notify the owner's designated representatives for design and construction in writing in advance of the submission of the shop and erection drawings. The owner's designated representative for design shall review and approve or reject the request in a timely manner.

When requested to do so by the owner's designated representative for design, the fabricator shall provide to the owner's designated representatives for design and construction its schedule for the submittal of shop and erection drawings so as to facilitate the timely flow of information between all parties.

3.6.6.4.3 Use of CAD files and/or copies of design drawings

The fabricator shall neither use nor reproduce any part of the design drawings as part of the shop or erection drawings without the written permission of the owner's designated representative for design. When CAD files or copies of the design drawings are made available for the fabricator's use, the fabricator shall accept this information under the following conditions:

- (a) All information contained in the CAD files or copies of the design drawings shall be considered instruments of service of the owner's designated representative for design and shall not be used for other projects, addition to the project or the completion of the project by others. CAD files and copies of the design drawings shall remain the property of the owner's designated representative for design and in no case shall the transfer of these CAD files or copies of the design drawings be considered a sale.
- (b) The CAD files or copies of the design drawings shall not be considered to be contract documents. In the event of a conflict between the design drawings and the CAD files or copies thereof, the design drawings shall govern;
- (c) The use of CAD files or copies of the design drawings shall not in any way obviate the Fabricator's responsibility for proper checking and coordination of dimensions, details, member sizes and fit-up and quantities of materials as required to facilitate the preparation of shop and erection drawings that are complete and accurate as required in Section 3.6.6.4.2; and,
- (d) The fabricator shall remove information that is not required for the fabrication or erection of the structural steel from the CAD files or copies of the design drawings.

3.6.6.4.4 Approval

Except as provided in Section 3.6.6.4.5, the shop and erection drawings shall be submitted to the owner's designated representatives for design and construction for review and approval. These drawings shall be returned to the fabricator within 14 calendar days. Approved shop and erection drawings shall be individually annotated by the owner's designated representatives for design and construction as either approved or approved subject to corrections noted. When so required, the fabricator shall subsequently make the corrections noted and furnish corrected shop and erection drawings to the owner's designated representatives for design and construction.

3.6.6.4.4.1 Approval of the shop and erection drawings, approval subject to corrections noted and similar approvals shall constitute the following:

- (a) Confirmation that the fabricator has correctly interpreted the contract documents in the preparation of those submittals;
- (b) Confirmation that the owner's designated representative for design has reviewed and approved the connection details shown on the shop and erection drawings and submitted in accordance with Section 3.6.6.3.1.2, if applicable; and,
- (c) Release by the owner's designated representatives for design and construction for the fabricator to begin fabrication using the approved submittals.

Such approval shall not relieve the fabricator of the responsibility for either the accuracy of the detailed dimensions in the shop and erection drawings or the general fit-up of parts that are to be assembled in the field.

The fabricator shall determine the fabrication schedule that is necessary to meet the requirements of the contract.

3.6.6.4.4.2 Unless otherwise noted, any additions, deletions or revisions that are indicated in response to RFI or on the approved shop and erection drawings shall constitute authorization by the owner that the additions, deletions or revisions are released for construction. The fabricator and the erector shall promptly notify the owner's designated representative for construction when any direction or notation in response to RFI or on the shop or erection drawing or other information will result in an additional cost and/or a delay. See Sections 3.6.6.3.5.

3.6.6.4.5 Shop and/or erection drawings not furnished by the fabricator

When the shop and erection drawings are not prepared by the fabricator, but are furnished by others, they shall be delivered to the fabricator in a timely manner. These shop and erection drawings shall be prepared, insofar as is practical, in accordance with the shop fabrication and detailing standards of the fabricator. The fabricator shall neither be responsible for the completeness or accuracy of shop and erection drawings so furnished, nor for the general fit-up of the members that are fabricated from them.

3.6.6.4.6. The RFI process

When Requests for Information (RFIs) are issued, the process shall include the maintenance of a written record of inquiries and responses related to interpretation and implementation of the contract documents, including the clarifications and/or revisions to the contract documents that result, if any. RFI shall not be used for the incremental release for construction of design drawings. When RFI is involved in discrepancies or revisions, see Sections 3.6.6.3.3, 3.6.6.3.5, and 3.6.6.4.4.2.

3.6.6.5 Materials

3.6.6.5.1 Mill materials

Unless otherwise noted in the contract documents, the fabricator is permitted to order the material that are necessary for fabrication when the fabricator receives contract documents that have been released for construction.

3.6.6.5.1.1 Unless otherwise specified by means of special testing requirements in the contract documents, mill testings shall be limited to those tests that are required for the material in the ASTM specifications indicated in the contract documents. Materials ordered to special material requirements shall be marked by the supplier as specified in ASTM A6/A6M Section 12 prior to delivery to the fabricator's shop or other point of use. Such material not so marked by the supplier, shall not be used until:

(a) Its identification is established by means of testing in accordance with the applicable ASTM specifications; and,

(b) A fabricator's identification mark, as described in Section 3.6.1.2 and 3.6.1.3, has been applied.

3.6.6.5.1.2 When mill material does not satisfy ASTM A6/A6M tolerances for camber, profile, flatness or sweep, the fabricator shall be permitted to perform corrective procedures, including the use of controlled heating and/or mechanical straightening, subject to the limitations in the AISC Specification.

3.6.6.5.1.3 When variations that exceed ASTM A6/A6M tolerances are discovered or occur after the receipt of mill material, the fabricator shall, at the fabricator's option, be permitted to perform the ASTM A6/A6M corrective procedures for mill reconditioning of the surface of structural steel shapes and plates.

3.6.6.5.1.4 When special tolerances that are more restrictive than those in ASTM A6/A6M are required for mill materials, such special tolerances shall be specified in the contract documents. The fabricator shall, at the fabricator's option, be permitted to order material to ASTM A6/A6M tolerances and subsequently perform the corrective procedures described in Sections 3.6.6.5.1.2 and 3.6.6.5.1.3.

3.6.6.5.2 Stock materials

3.6.6.5.2.1 If used for structural purposes, materials that are taken from stock by the fabricator shall be of a quality that is at least equal to that required in the ASTM Specifications indicated in the contract documents.

3.6.6.5.2.2 Certified mill test reports shall be accepted as sufficient record of the quality of materials taken from stock by the fabricator. The fabricator shall review and retain the certified mill test reports that cover such stock materials. However, the fabricator need not maintain records that identify individual pieces of stock material against individual certified mill test reports, provided the fabricator purchases stock materials that meet the requirements for material grade and quality in the applicable ASTM Specifications.

3.6.6.5.2.3 Stock materials that are purchased under no particular specification, under a specification that is less rigorous than the applicable ASTM Specifications or without certified mill test reports or other recognized test reports shall not be used without the approval of the owner's designated representative for design.

3.6.6.6 Shop Fabrication and Delivery

3.6.6.6.1 Identification of material

3.6.6.6.1.1 The fabricator shall be able to demonstrate by written procedure and actual practice a method of material

identification, visible up to the point of assembling members as follows:

(a) For shop-standard material, identification capability shall include shaped designation. Representative mill test reports shall be furnished by the fabricator if requested to do so by the owner's designated representative for design, either in the contract documents or in separate written instructions given to the fabricator prior to ordering mill materials.

(b) For material of grade other than shop-standard material, identification capability shall include shaped designation and material grade. Representative mill test reports shall be furnished by the fabricator if requested to do so by the owner's designated representative for design, either in the contract documents or in separate written instructions given to the fabricator prior to ordering mill materials.

(c) For material ordered in accordance with an ASTM supplement to another special material requirements in the contract documents, identification capability shall include shaped designation, material grade, and heat number.

The corresponding mill test reports shall be furnished by the fabricator if requested to do so by the owner's designated representative for design, either in the contract documents or in separate written instructions given to the fabricator prior to ordering mill materials.

Unless an alternative system is established in the fabricator's written procedures, shop-standard material shall be as follows:

Material	Shop-standard material grade
W and WT	ASTM A992
M, S, MT and ST	ASTM A36
HP	ASTM A36
L	ASTM A36
C and MC	ASTM A36
HSS	ASTM A500 grade B
Steel Pipe	ASTM A53 grade B
Plates and Bars	ASTM A36

3.6.6.6.1.2 During fabrication, up to the point of assembling members, each piece of material that is ordered to special material requirements shall carry a

fabricator's identification mark or an original supplier's identification mark.

The fabricator's identification mark shall be in accordance with the fabricator's established material identification system, which shall be on record and available prior to the start of fabrication for the information of the owner's designated representative for construction, the building-code authority and the inspector.

3.6.6.6.1.3 Members that are made of material that is ordered to special material requirements shall not be given the same assembling or erection marks as members made of other material, even if they are of identical dimensions and detail.

3.6.6.6.2 Preparation of material

3.6.6.6.2.1 The thermal cutting of structural steel by hand-guided or mechanically guided means is permitted.

3.6.6.6.2.2 Surfaces that are specified as "finished" in the contract documents shall have a roughness height value measured in accordance with ANSI/ASME B46.1 that is equal to or less than 500. The use of any fabricating technique that produces such a finish is permitted.

3.6.6.6.3 Fitting and fastening

3.6.6.6.3.1 Projecting elements of connection materials need not be straightened in the connecting plane, subject to the limitations in the AISC Specification.

3.6.6.6.3.2 Backing bars and run-off tabs shall be used in accordance with AWS D1.1 as required to produce sound welds. The fabricator or erector need not remove backing bars or run-off tabs unless such removal is specified in the contract documents. When the removal of backing bars is specified in the contract documents, such removal shall meet the requirements in AWS D1.1. When the removal of run-off tabs is specified in the contract documents, hand flame-cutting close to the edge of the finished member with no further finishing is permitted, unless other finishing is specified in the contract documents.

3.6.6.6.3.3 Unless otherwise noted in the shop drawings, high-strength bolts for shop-attached connection materials shall be installed in the shop in accordance with the requirements in the AISC Specification.

3.6.6.6.4 Fabrication tolerances

The tolerances on structural steel fabrications shall be in accordance with the requirements in Sections 3.6.6.6.4.1 through 3.6.6.6.4.6.

3.6.6.6.4.1

For members that have both ends finished (see Section 3.6.6.6.2.2) for contact

bearing, the variation in the overall length shall be equal to or less than $1/32$ in. [1mm]. For other members that frame to other structural steel elements, the variation in the detailed length shall be as follows:

(a) For members that are equal to or less than 30 ft [9000 mm] in length, the variations shall be equal to or less than $1/16$ in. [2mm].

(b) For members that are greater than 30 ft [9000 mm] in length, the variation shall be equal to or less than $1/8$ in. [3mm].

3.6.6.6.4.2 For straight structural members other than compression members, whether of a single standard structural shape or built-up, the variation in straightness shall be equal to or less than that specified for wide-flange shapes in ASTM A6/A6M, except when a smaller variation in straightness is specified in the contract documents. For straight compression members, whether of a standard structural shape or built-up, the variation in straightness shall be equal to or less than $1/1000$ of the axial length between points that are to be laterally supported. For curved structural members, the variation from the theoretical curvature shall be equal to or less than the variation in sweep that is specified for an equivalent straight member of the same straight length in ASTM A6/A6M.

In all cases, completed members shall be free of twists, bends and open joints. Sharp kinks or bends shall be cause for rejection.

3.6.6.6.4.3 For beams and trusses that are detailed without specified camber, the member shall be fabricated so that, after erection, any incidental camber due to rolling or shop fabrication is upward.

3.6.6.6.4.4 For beams that are specified in the contract documents with camber, beams received by the fabricator with 75% of the specified camber shall require no further cambering. Otherwise, the variation in camber shall be as follows:

(a) For beams that are equal to or less than 50 ft [15000 mm] in length, the variations shall be equal to or less than minus zero/plus $1/2$ in. [13mm].

(b) For beams that are greater than 50 ft [15000 mm] in length, the variation shall be equal to or less than minus zero/plus $1/2$ in. plus $1/8$ in. for each 10 ft or fraction thereof [13 mm plus 3 mm for each 3000 mm or fraction thereof] in excess of 50 ft [15000 mm] in length.

For the purpose of inspection, cambers shall be measured in the fabricator's shop in the unstressed condition.

3.6.6.6.4.5 For fabricated trusses that are specified in the contract documents with camber, the variation in camber at each specified camber point shall be equal to or less than plus or minus $1/800$ of the distance to that point from the nearest point of support. For the purpose of inspection, cambers shall be measured in the fabricator's shop in the unstressed condition. For fabricated trusses that

are specified in the contract documents without indication of camber, the foregoing requirements shall be applied at each panel point of the truss with a zero camber ordinate.

3.6.6.6.4.6

When permissible variations in the depths of beams and girders result in abrupt changes in depth at splices, such deviations shall be accounted for as follows:

(a)

For splices with bolted joints, the variations in depth shall be taken up with filler plates; and,

(b) For splices with welded joints, the weld profiles shall

be adjusted to conform to the variations in depth, the required cross-section of weld shall be provided and the slope of the weld surfaces shall meet the requirements in AWS D1.1.

3.6.6.6.5 Shop cleaning and painting (see also Section 3.6.6.3.1.6)

Structural steel that does not require shop paint shall be cleaned of oil and grease with solvent cleaners, and of dirt and other foreign material by sweeping with a fiber brush or other suitable means. For structural steel that is required to be shop painted, the requirements in Sections 3.6.6.6.5.1 through 3.6.6.6.5.4 shall apply.

3.6.6.6.5.1 The fabricator is not responsible for deterioration of the shop coat that may result from exposure to ordinary atmospheric conditions or corrosive conditions that are more severe than ordinary atmospheric conditions.

3.6.6.6.5.2 Unless otherwise specified in the contract documents, the fabricator shall, as a minimum, hand clean the structural steel of loose rust, loose mill scale, dirt and other foreign matter, prior to painting, by means of wire brushing or by other method selected by the fabricator, to meet the requirements of SSPC-SP2. If the fabricator's workmanship on surface preparation is to be inspected by the Inspector, such inspections shall be performed in a timely manner prior to the application of the shop coat.

3.6.6.6.5.3 Unless otherwise specified in the contract documents, paint shall be applied by brushing, spraying, rolling, flow coating, dipping or other suitable means, at the election of the fabricator. When the term "shop coat", "shop paint" or other equivalent term is used with no paint system specified, the fabricator's standard shop paint shall be applied to a minimum dry-film thickness of one mil [25µm].

3.6.6.6.5.4 Touch-up of abrasions caused by handling after painting shall be the responsibility of the contractor that performs touch-up in the field or field painting.

3.6.6.6. Marking and shipping of materials

3.6.6.6.1 Unless otherwise specified in the contract documents, erection marks shall be applied to the structural steel members by painting or other suitable means.

3.6.6.6.2 Bolt assemblies and loose bolts, nuts and washers shall be shipped in separate closed containers according to length and diameter, as applicable. Pins and other small parts and packages of bolts, nuts and washers shall be shipped in boxes, crates, kegs or barrels. A list and description of the material shall appear on the outside of each closed container.

3.6.6.7 Delivery of materials

3.6.6.7.1 Fabricated structural steel shall be delivered in a sequence that will permit efficient and economical fabrication and erection, and that is consistent with the requirements in the contract documents. If the owner or owner's designated representative for construction wishes to prescribe or control the sequence of delivery of materials, that entity shall specify the required sequence in the contract documents. If the owner's designated representative for construction contracts separately for delivery and for erection, the owner's designated representative for construction shall coordinate planning between contractors.

3.6.6.7.2 Anchor Rods, washers, nuts and other anchorage or grillage material that are to be built into concrete or masonry shall be shipped so that they will be available when needed. The owner's designated representative for construction shall allow the fabricator sufficient time to fabricate and ship such materials before they are needed.

3.6.6.7.3 If any shortage is claimed relative to the quantities of materials that are shown in the shipping statements, the owner's designated representative for construction or the erector shall promptly notify the fabricator so that the claim can be investigated.

3.6.6.7.4 Unless otherwise specified in the contract documents, and subject to the approved shop and erection drawings, the fabricator shall limit the number of field splices to that consistent with minimum project cost.

3.6.6.7.5 If material arrives at its destination in damaged condition, the receiving entity shall promptly notify the fabricator and carrier prior to unloading the material, or promptly upon discovery prior to erection.

3.6.6.7 Erection

3.6.6.7.1 Method of erection

Fabricated structural Steel shall be erected using methods and a sequence that will permit efficient and economical performance of erection, and that is

consistent with the requirements in the contract documents. If the owner or owner's designated representative for construction wishes to prescribe or control the method and/or sequence of erection, or specifies that certain members cannot be erected in their normal sequence, that entity shall specify the required method and sequence in the contract documents. If the owner's designated representative for construction contracts separately for fabrication services and for erection services, the owner's designated representative for construction shall coordinate planning between contractors.

3.6.6.7.2 Job-site conditions

The owner's designated representative for construction shall provide and maintain the following for the fabricator and the erector:

- (a) Adequate access roads into and through the job site for the safe delivery and movement of the material to be erected and of derricks, cranes, trucks and other necessary equipment under their own power;
- (b) A firm, properly graded, drained, convenient and adequate space at the job site for the operation of the erector's equipment, free from overhead obstructions, such as power lines, telephone lines or similar conditions; and,
- (c) Adequate storage space, when the structure does not occupy the full available job site, to enable the fabricator and the erector to operate at maximum practical speed.

Otherwise, the owner's designated representative for construction shall inform the fabricator and the erector of the actual job-site conditions and/or special delivery requirements prior to bidding.

3.6.6.7.3 Foundation, piers and abutments

The accurate location, strength and suitability of, and access to, all foundations, piers and abutments shall be the responsibility of the owner's designated representative for construction.

3.6.6.7.4 Lines and bench marks

The owner's designated representative for construction shall be responsible for the accurate location of lines and bench marks at the job site and shall furnish the erector with a plan that contains all such information. The owner's designated representative for construction shall establish offset lines and reference elevations at each level for the erector's use in the positioning of adjustable items (see section 3.6.7.13.1.3), if any.

3.6.6.7.5 Installation of anchor rods, foundation bolts and other embedded items

- 3.6.6.7.5.1** Anchor rods, foundation bolts and other embedded items shall be set by the owner's designated representative for construction in accordance with embedment drawings that have been approved by the owner's designated representatives for design and construction. The variation in location of these items from the dimensions shown in the embedment drawings shall be as follows:

- (a) The variation in dimension between the centres of any two anchor rods within an anchor-rod group shall be equal to or less than 1/8 in. [3 mm].
- (b) The variation in dimension between the centres of adjacent anchor-rod groups shall be equal to or less than 1/4 in. [6 mm].
- (c) The variation in elevation of the tops of anchor rods shall be equal to or less than plus or minus 1/2 in. [13 mm].
- (d) The accumulated variation in dimension between centres of anchor-rod groups along the column line through multiple anchor-rod groups shall be equal to or less than 1/4 in. per 100 ft [2 mm per 10 000 mm], but not to exceed a total of 1 in. [25 mm].
- (e) The variation in dimension from the centre of any anchor-rod group to the column line through that group shall be equal to or less than 1/4 in. [6 mm].

The tolerances that are specified in (b), (c) and (d) shall apply to offset dimensions shown in the structural design drawings, measured parallel and perpendicular to the nearest column line, for individual columns that are shown in the structural design drawings as offset from column lines.

3.6.6.7.5.2

Unless otherwise specified in the contract documents, anchor rods shall be set with their longitudinal axis perpendicular to the theoretical bearing surface.

3.6.6.7.5.3 Embedded items and connection materials that are part of the work of other trades, but that will receive structural steel, shall be located and set by the owner's designated representative for construction in accordance with an approved embedment drawing. The variation in location of these items shall be limited to a magnitude that is consistent with the tolerances that are specified in Section 3.6.7.13 for the erection of the structural steel.

3.6.6.7.5.4 All work that is performed by the owner's designated representative for construction shall be completed so as not to delay or interfere with the work of the fabricator and the erector. The owner's designated representative for construction shall conduct a survey of the as-built locations of anchor rods, foundation bolts and other embedded items, and shall verify that all items covered in Section 3.6.6.7.5 meet the corresponding tolerances. When corrective action is necessary, the owner's designated representative for construction shall obtain the guidance and approval of the owner's designated representative for design.

3.6.6.7.6 Installation of bearing devices

All leveling plates, leveling nuts and washers and loose base and bearing plates that can be handled without a derrick or crane are set to line and grade by the owner's designated representative for construction. Loose base and bearing

plates that require handling with a derrick or cranes shall be set by the erector to lines and grades established by the owner's designated representative for construction. The fabricator shall clearly scribe loose base and bearing plates with lines or other suitable marks to facilitate proper alignment.

Promptly after the setting of bearing devices, the owner's designated representative for construction shall check them for line and grade. The variation in elevation relative to the established grade for all bearing devices shall be equal to or less than plus or minus 1/8 in. [3mm]. The final location of bearing devices shall be the responsibility of the owner's designated representative for construction.

3.6.6.7.7 Grouting

Grouting shall be the responsibility of the owner's designated representative for construction. Leveling plates and loose base and bearing plates shall be promptly grouted after they are set and checked for line and grade. Columns with attached base plates, beams with attached bearing plates and others similar members with attached bearing devices that are temporarily supported on leveling nuts and washers, shims or others similar leveling devices, shall be promptly grouted after the structural steel frame or portion thereof has been plumbed.

Note:

In the majority of structures the vertical load from the column bases is transmitted to the foundation through structural grout. In general, there are three methods by which support is provided for column bases during erection:

- (a) Pre-grouted leveling plates or loose base plates;
- (b) Shims; and,
- (c) Leveling nuts and washers on the Anchor Rods beneath the column base.

3.6.6.7.8 Field connection material

3.6.6.7.8.1 The fabricator shall provide field connection details that are consistent with the requirements in the contract documents and that will, in the fabricator's opinion, result in economical fabrication and erection.

3.6.6.7.8.2 When the fabricator is responsible for erecting the structural steel, the fabricator shall furnish all material that are required for both temporary and permanent connection of the component parts of the structural steel frame.

3.6.6.7.8.3 When the erection of the structural steel is not performed by the fabricator, the fabricator shall furnish the following field connection material:

- (a) Bolts, nuts and washers of the required grade, type and size and in sufficient quantity for all structural steel-to-structural steel field connections that are to be permanently bolted, including an extra 2 percent of each bolt size (diameter and length);
- (b) Shims that are shown as necessary for make-up of permanent structural steel-to-structural steel connections; and,
- (c) Backing bars and run-off tabs that are required for field welding.

3.6.6.7.8.4 The erector shall furnish all welding electrodes, fit-up bolts and drift pins used for the erection of the Structural Steel.

3.6.6.7.9 Loose material

Unless otherwise specified in the contract documents, loose structural steel items that are not connected to the structural steel frames shall be set by the owner's designated representative for construction without assistance from the erector.

3.6.6.7.10 Temporary support of structural steel frames

3.6.6.7.10.1 The owner's designated representative for design shall identify the following in the contract documents:

- (a) The lateral-load-resisting system and connecting diaphragm elements that provide for lateral strength and stability in the completed structure; and,
- (b) Any special erection conditions or other considerations that are required by the design concept, such as the use of shores, jacks or loads that must be adjusted as erection progresses to set or maintain camber, position within specified tolerances or prestress.

3.6.6.7.10.2 The owner's designated representative for construction shall indicate to the erector prior to bidding, the installation schedule for non-structural steel elements of the lateral-load-resisting system and connecting diaphragm elements identified by the owner's designated representative for design in the contract documents.

3.6.6.7.10.3

Based upon the information provided in accordance with Sections 3.6.7.10.1 and 3.6.7.10.2, the erector shall determine, furnish and install all temporary supports, such as temporary guys, beams, falsework, cribbing or other elements required for the erection operation. These temporary supports shall be sufficient to secure the bare structural steel framing or any portion thereof against loads that are likely to be encountered during erection, including those due to wind and those that result from erection operations.

The erector need not consider loads during erection that result from the performance of work by, or the acts of, others, except as specifically identified by the owner's designated representatives for design and construction, nor those that are unpredictable, such as loads due to hurricane, tornado, earthquake, explosion or collision.

Temporary supports that are required during or after the erection of the structural steel frame for the support of loads caused by non-structural steel elements, including cladding, interior partitions and others such as elements that

t will induce or transmit loads to the structural steel frame during or after erection, shall be the responsibility of others.

3.6.6.7.10.4

All temporary supports that are required for the erection operation and furnished and installed by the erector shall remain the property of the erector and shall not be modified, moved or removed without the consent of the erector. Temporary supports provided by the erector shall remain in place until the portion of the structural steel frame that they brace is complete and the lateral-load-resisting system and connecting diaphragm elements identified by the owner's designated representative for design in accordance with Section 3.6.7.10.1 are installed. Temporary supports that are required to be left in place after the completion of Structural Steel erection shall be removed when no longer needed by the owner's designated representative for construction and returned to the erector in good condition.

3.6.6.7.11 Safety protection

3.6.6.7.11.1 The erector shall provide floor coverings, handrails, walkways and other safety protection for the erector's personnel as required by law and the applicable safety regulations. Unless otherwise specified in the contract documents, the erector is permitted to remove such safety protection from areas where the erection operations are completed.

3.6.6.7.11.2 When safety protection provided by the erector is left in an area for the use of other trades after the structural steel erection activity is completed, the owner's designated representative for construction shall:

- (a) Accept responsibility for and maintain this protection;
- (b) Indemnify the fabricator and the erector from damages that may be incurred from the use of this protection by other trades;
- (c) Ensure that this protection is adequate for use by other affected trades;
- (d) Ensure that this protection complies with applicable safety regulations when being used by other trades; and,
- (e) Remove this protection when it is no longer required and return it to the erector in the same condition as it was received.

3.6.6.7.11.3 Safety protection for other trades that are not under the direct employment of the erector shall be the responsibility of the owner's designated representative for construction.

3.6.6.7.11.4 When permanent steel decking is used for protective flooring and is installed by the owner's designated representative for construction, all such work shall be

scheduled and performed in a timely manner so as not to interfere with or delay the work of the fabricator or the erector. This sequence of installation that is used shall meet all safety regulations.

3.6.6.7.11.5 Unless the interaction and safety of activities of others, such as construction by others or the storage of materials that belong to others, are coordinated with the work of the erector by the owner's designated representative for construction, such activities shall not be permitted until the erection of the structural steel frame or portion thereof is completed by the erector and accepted by the owner's designated representative for construction.

3.6.6.7.12 Structural steel frame tolerances

The accumulation of the mill tolerances and fabrication tolerances shall not cause the erection tolerances to be exceeded.

3.6.6.7.13 Erection tolerances

Erection tolerances shall be defined relative to member working points and working lines, which shall be defined as follows:

- (a) For members other than horizontal members, the member working point shall be the actual centre of the member at each end of the shipping piece.
- (b) For horizontal members, the working point shall be the actual center line of the top flange or top surface at each end.
- (c) The member working lines shall be the straight line that connects the member working points.

The substitution of other working points is permitted for ease of reference, provided they are based upon the above definitions.

The tolerances on structural steel erections shall be in accordance with the requirements in Sections 3.6.7.13.1 through 3.6.7.13.3.

3.6.6.7.13.1

The tolerances on position and alignment of member working points and working lines shall be as described in Sections 3.6.7.13.1.1 through 3.6.7.13.1.3.

3.6.6.7.13.1.1

For an individual column shipping piece, the angular variation of the working line from a plumb line shall be equal to or less than $1/500$ of the distance between working points, subject to the following additional limitations:

- (a) For an individual column shipping piece that is adjacent to an elevator shaft, the displacement of member working points shall be equal to or less than 1 in. [25 mm] from the established column line in the first 20 stories. Above this level, an increase in the displacement of $1/32$ in. [1 mm] is permitted for each additional story up to a maximum displacement of 2 in. [50 mm] from the established column line.

(b) For an exterior individual column shipping piece, the displacement of member working points from the established column

line in the first 20

stories shall be equal to or less than 1 in. [25 mm] toward and 2 in. [50 mm] away from the building line. Above this level, an increase in the displacement of 1/16 in. [2 mm] is permitted for each additional story up to a maximum displacement of 2 in. [50 mm] toward and 3 in. [75 mm] away from the building line.

(c)

For an exterior individual column shipping piece, the member working points at any splice level for multi-tier buildings and at the top of columns for single-tier buildings shall fall within a horizontal envelope, parallel to the building line, that is equal to or less than 1 1/2 in. [38 mm] wide for buildings up to 300 ft [90 000 mm] in length. An increase in the width of this horizontal envelope of 1/2 in. [13 mm] is permitted for each additional 100 ft [30 000 mm] in length up to a maximum width of 3 in. [75 mm].

(d) For an exterior column shipping piece, the displacement of member working points from the established column line, parallel to the building line, shall be equal to or less than 2 in. [50 mm] in the first 20 stories. Above this level, an increase in the displacement of 1/16 in. [2 mm] is permitted for each additional story up to a maximum displacement of 3 in. [75 mm] parallel to the building line.

3.6.6.7.13.1.2

For members other than column shipping pieces, the following limitations shall apply:

(a)

For a member that consists of an individual, straight shipping piece without field splices, other than a cantilevered member, the variation in alignment shall be acceptable if it is caused solely by variations in column alignment and/or primary supporting member alignment that are within the permissible variations for the fabrication and erection of such members.

(b)

For a member that consists of an individual, straight shipping piece that connects to a column, the variation in the distance from the member

working point to the upper finished splice line of the column shall be equal to or less than plus 3/16 in. [5mm] and minus 5/16 in. [8mm].

(c) For a member that consists of an individual shipping piece that does not connect to a column, the variation in elevations shall be acceptable if it is caused solely by the variations in the elevations of the supporting members within the permissible variations for the fabrication and erection of these members.

(d) For a member that consists of an individual, straight shipping piece and that is a segment of a field as assembled unit

containing field splices between points of support, the plumbness, elevation and alignment shall be acceptable if the angular variation of the working line from the plan alignment is equal to or less than 1/500 of the distance between working points.

(e) For a cantilevered member that consists of an individual, straight shipping piece, the plumbness, elevation and alignment shall be acceptable if the angular variation of the working line from a straight line that is extended in the plan direction from the working point at its supported end is equal to or less than 1/500 of the distance from the working point at the free end.

(f) For a member of irregular shape, the plumbness, elevation and alignment shall be acceptable if the fabricated member is within its tolerances and the members that support it are within the tolerances specified in this SECTION.

(g) For a member that is fully assembled in the field in an unstressed condition, the same tolerances shall apply as if fully assembled in the shop.

(h) For a member that is field-assembled, element-by-element in place, temporary support shall be used or an alternative erection plan shall be submitted to the owner's designated representatives for design and construction. The tolerance in Section 7.13.1.2(d) shall be met in the supported condition with working points taken at the point(s) of temporary support.

3.6.6.7.13.1.3 For members that are identified as Adjustable Items by the owner's designated representative for design in the contract documents, the fabricator shall provide adjustable connections for these members to the supporting structural steel frame. Otherwise, the fabricator is permitted to provide non-adjustable connections. When adjustable items are specified, the owner's designated representative for design shall

indicate the total adjustability that is required for the proper alignment of these supports for other trades. The variation in the position and alignment of adjustable items shall be as follows:

(a) The variation in the vertical distance from the upper finished splice line of the nearest column to the support location specified in the structural design drawings shall be equal to or less than plus or minus 3/8 in. [10 mm].

(b) The variation in the horizontal distance from the established finish line at the particular floor shall be equal to or less than plus or minus 3/8 in. [10 mm].

(c) The variation in vertical and horizontal alignment at the abutting ends of adjustable items shall be equal to or less than plus or minus 3/16 in. [5 mm].

3.6.6.7.13.2 In the design of steel structures, the owner's designated representative for design shall provide for the necessary clearances and adjustments for material furnished by other trades to accommodate the mill tolerances, fabrication tolerances and erection tolerances in this section for the structural steel frame.

3.6.6.7.13.3 Prior to placing or applying any other materials, the owner's designated representative for construction shall determine that the location of the structural steel is acceptable for plumbness, elevation and alignment. The erector shall be given either timely notice of acceptance by the owner's designated representative for construction, or a listing of specific items that are to be corrected in order to obtain acceptance. Such notice shall be rendered promptly upon completion of any part of the work and prior to the start of work by other trades that may be supported, attached or applied to the structural steel frame.

3.6.6.7.14 Correction of errors

The correction of minor misfits by moderate amounts of reaming, grinding, welding or cutting, and the drawing of elements into line with drift pins, shall be considered to be normal erection operations. Errors that cannot be corrected using the foregoing means, or that require major changes in member or connection configuration, shall be promptly reported to the owner's designated representatives for design and construction and the fabricator by the erector, to enable the responsible entity to either correct the error or approve the most efficient and economical method of correction to be used by others.

3.6.6.7.15 Cuts, alterations and holes for other trades

Neither the fabricator nor the erector shall cut, drill or otherwise alter their work, nor the work of other trades, to accommodate other trades, unless such work is clearly specified in the contract documents. When such work is so specified, the owner's designated representatives for design and construction shall furnish complete information as to materials, size, location and number of alterations in a timely manner so as not to delay the preparation of shop and erection drawings.

3.6.6.7.16 Handling and storage

The erector shall take reasonable care in the proper handling and storage of the structural steel during erection operations to avoid the accumulation of excess dirt and foreign matter. The erector shall not be responsible for the removal from the structural steel of dust, dirt or other foreign matter that may accumulate during erection as the result of job-site conditions or exposure to the elements. The erector shall handle and store all bolts, nuts, washers and related fastening products in accordance with the requirements of the RCSC Specification.

3.6.6.7.17 Field painting

Neither the fabricator nor the erector is responsible to paint field bolt heads and nuts or field welds, nor to touch up abrasions of the shop coat, nor to perform any other field painting.

3.6.6.7.18 Final cleaning up

Upon the completion of erection and before final acceptance, the erector shall remove all of the erector's falsework, rubbish and temporary buildings.

3.6.6.8 Quality Assurance

3.6.6.8.1 General

3.6.6.8.1.1 The fabricator shall maintain a quality assurance program to ensure that the work is performed in accordance with the requirements in this SECTION, the AISC Specification and the contract documents. The fabricator shall have the option to use the AISC Quality Certification Program to establish and administer the quality assurance program.

Note: The AISC Quality Certification Program confirms to the construction industry that a certified structural steel fabrication shop has the capability by reason of commitment, personnel, organization, experience, procedures, knowledge and equipment to produce fabricated structural steel of the required quality for a given category of work. The AISC Quality Certification Program is not intended to involve inspection and/or judgment of product quality on individual projects. Neither is it intended to guarantee the quality of specific fabricated structural steel products.

3.6.6.8.1.2 The erector shall maintain a quality assurance program to ensure that the work is performed in accordance with the requirements in this SECTION, the AISC Specification and the contract documents. The Erector shall be capable of performing the erection of the structural steel, and shall provide the equipment, personnel and management for the scope, magnitude and required quality of each project. The Erector shall have the option to use the AISC Erector Certification Program to establish and administer the quality assurance program.

Note: The AISC Erector Certification Program confirms to the construction industry that a certified structural steel erector has the capability by reason of

commitment, personnel, organization, experience, procedures, knowledge and equipment to erect fabricated structural steel to the required quality for a given category of work. The AISC Erector Certification Program is not intended to involve inspection and/or judgment of product quality on individual projects. Neither is it intended to guarantee the quality of specific erected structural steel products.

3.6.6.8.1.3 When the owner requires more extensive quality assurance or independent inspection by qualified personnel, or requires that the fabricator be certified under the AISC Quality Certification Program and/or requires that the erector be certified under the AISC Erector Certification Program, this shall be clearly stated in the contract documents, including a definition of the scope of such inspection.

3.6.6.8.2 Inspection of mill material

Certified mill test reports shall constitute sufficient evidence that the mill product satisfies material order requirements. The fabricator shall make a visual inspection of material that is received from the mill, but need not perform any material tests unless the owner's designated representative for design specifies in the contract documents that additional testing is to be performed at the owner's expense.

3.6.6.8.3 Non-destructive testing

When non-destructive testing is required, the process, extent, technique and standards of acceptance shall be clearly specified in the contract documents.

3.6.6.8.4 Surface preparation and shop painting inspection

Inspection of surface preparation and shop paintings shall be planned for the acceptance of each operation as the fabricator completes it. Inspection of the paint system, including material and thickness, shall be made promptly upon completion of the paint application. When wet-film thickness is to be inspected, it shall be measured during the application.

3.6.6.8.5 Independent inspection

When inspection by personnel other than those of the fabricator and/or erector is specified in the contract documents, the requirements in Sections 3.6.6.8.5.1 through 3.6.6.8.5.6 shall be met.

3.6.6.8.5.1 The fabricator and the erector shall provide the inspector with access to all places where the work is being performed. A minimum of 24 hours notification shall be given prior to the commencement of work.

3.6.6.8.5.2 Inspection of shop work by the inspector shall be performed in the fabricator's shop to the fullest extent possible. Such inspections shall be timely, in-sequence and performed in such a manner as will not disrupt fabrication operations and will permit the repair of non-conforming work prior to any required painting while the material is still in-process in the fabrication shop.

3.6.6.8.5.3 Inspection of field work shall be promptly completed without delaying the progress or correction of the work.

3.6.6.8.5.4 Rejection of material or workmanship that is not in conformance with the contract documents shall be permitted at any time during the progress of the work. However, this provision shall not relieve the owner or the inspector of the obligation for timely, in-sequence inspections.

3.6.6.8.5.5 The fabricator, erector, and owner's designated representatives for design and construction shall be informed of deficiencies that are noted by the inspector promptly after the inspection. Copies of all reports prepared by the inspector shall be promptly given to the fabricator, erector and owner's designated representatives for design and construction. The necessary corrective work shall be performed in a timely manner.

3.6.6.8.5.6 The inspector shall not suggest, direct, or approve the fabricator or erector to deviate from the contract documents or the approved shop and erection drawings, or approve such deviation, without the written approval of the owner's designated representatives for design and construction.

3.6.6.9 Architecturally Exposed Structural Steel

3.6.6.9.1 General Requirements

When members are specifically designated as "Architecturally Exposed Structural Steel" or "AESS" in the contract documents, the requirements in Sections 3.6.6.1 through 3.6.6.8 shall apply as modified in Section 3.6.6.9. AESS members or components shall be fabricated and erected with the care and dimensional tolerances that are stipulated in Sections 3.6.6.9.2 through 3.6.6.9.4. The following additional information shall be provided in the contract documents when AESS is specified:

- (a) Specific identification of members or components that are AESS;
- (b) Fabrication and/or erection tolerances that are to be more restrictive than provided for in this SECTION, if any; and,
- (c) Requirements, if any, of a mock-up panel or components for inspection and acceptance standards prior to the start of fabrication.

3.6.6.9.2 Fabrication

3.6.6.9.2.1 The permissible tolerances for out-of-square or out-of-parallel, depth, width and symmetry of rolled shapes shall be as specified in ASTM A6/A6M. Unless otherwise specified in the contract documents, the exact matching of a butt joint cross-sectional configuration shall not be necessary. The as-fabricated straightness tolerances of members shall be one-half of the standard camber and sweep tolerances in ASTM A6/A6M.

3.6.6.9.2.2 The tolerances on overall profiled dimensions of member that are built-up from a series of standard structural shapes, plates and/or bars by welding shall be taken as the accumulation of the variations that are permitted for the component parts in ASTM A6/A6M. The as-fabricated straightness tolerances for the member as a whole shall be one-half the standard camber and sweep tolerances for rolled shapes in ASTM A6/A6M.

3.6.6.9.2.3 Unless specific visual acceptance criteria for welds show-through are specified in the contract documents, the members or components shall be acceptable as produced.

3.6.6.9.2.4 All copes, mitres and cuts in surfaces that are exposed to view shall be made with uniform gaps of 1/8 in. [3mm] if shown as open joints, or in reasonable contact if shown without gap.

3.6.6.9.2.5 All welds that are exposed to view shall be visually acceptable if they meet the requirements in AWS D1.1, except all groove and plug welds that are exposed to view shall not project more than 1/16 in. [2mm] above the exposed surface. Finishing or grinding of welds shall not be necessary, unless such treatment is required to provide for clearances or fit of other components.

3.6.6.9.2.6 Erection marks or other painted marks shall not be made on those surfaces of weathering steel AESS members that are to be exposed in the completed structure. Unless otherwise specified in the contract documents, the fabricator or shall clean weathering steel AESS members to meet the requirements of SSP C- SP6.

3.6.6.9.2.7 Stamped or raised manufacturer's identification marks shall not be filled, ground or otherwise removed.

3.6.6.9.2.8 Seams of hollow structural sections shall be acceptable as produced. Seams shall be oriented away from view or as directed in the contract documents.

3.6.6.9.3 Delivery of materials

The fabricator shall use special care to avoid bending, twisting or otherwise distorting the structural steel.

3.6.6.9.4 Erection

3.6.6.9.4.1 The erector shall use special care in unloading, handling and erecting the structural steel to avoid marking or distorting the structural steel. Care shall also be taken to minimize damage to any shop paint. If temporary braces or erection clips are used, care shall be taken to avoid the creation of unsightly surfaces upon removal. Tack welds shall be ground smooth and holes shall be filled with weld metal or body solder and smoothed by grinding or filing. The erector shall plan and execute all operations in such a manner that the close fit and neat appearance of the structure will not be impaired.

3.6.6.9.4.2 Unless otherwise specified in the contract documents, AESS members and component shall be plumbed, leveled and aligned to a tolerance that is one-half that permitted for non-AESS members. To accommodate these erection tolerances for AESS, the owner's designated representative for design shall specify connections between AESS members and non-AESS members,

masonry, concrete and other supports as adjustable items, in order to provide the erector with means for adjustment.

3.6.6.9.4.3 When AESS is backed with concrete, the owner's designated representative for construction shall provide sufficient shores, ties and strong backs to prevent sagging, bulging or similar deformation of the AESS members due to the weight and pressure of the wet concrete.

3.6.7 Steel Joists

3.6.7.1 General

The design, manufacture and use of open web steel joists and joist girders shall be in accordance with one of the following Steel Joist Institute (SJI) specifications:

1. SJI K-1.1
2. SJI LH/DLH-1.1
3. SJI JG-1.1

Where required, the seismic design of buildings shall be in accordance with the additional provisions of Section 6.5.2 or 6.10.5.

3.6.7.2 Design

The registered design professional shall indicate on the construction documents the steel joist and/or steel joist girder designations from the specifications listed in Section 3.6.6.1 and shall indicate the requirements for joist and joist girder design, layout, end supports, anchorage, non-SJI standard bridging, bridging termination connections and bearing connection design to resist uplift and lateral loads. These documents shall indicate special requirements as follows:

1. Special loads including:

- 1.1. Concentrated loads;
- 1.2. Nonuniform loads;
- 1.3. Net uplift loads;
- 1.4. Axial loads;
- 1.5. End moments; and
- 1.6. Connection forces.

2. Special considerations including:

- 2.1. Profiles for nonstandard joist and joist girder configurations (standard joist and joist girder configurations are as indicated in the SJI catalog);
 - 2.2. Oversized or other nonstandard web openings; and
 - 2.3. Extended ends.
3. Deflection criteria for live and total loads for non-SJI standard joists.

3.6.7.3 Calculations

The steel joist and joist girder manufacturer shall design the steel joists and/or steel joist girders in accordance with the current SJI specifications and load tables to support the load requirements of Section 3.6.6.2. The registered design professional may require submission of the steel joist and joist girder calculations as prepared by a registered design professional responsible for the product design. If requested by the registered design professional, the steel joist manufacturer shall submit design calculations with a cover letter bearing the seal and signature of the joist manufacturer's registered design professional. In addition to standard calculations under this seal and signature, submittal of the following shall be included:

1. Non-SJI standard bridging details (e.g. for cantilevered conditions, net uplift, etc.).
2. Connection details for:
 - 2.1. Non-SJI standard connections (e.g. flush-framed or framed connections);
 - 2.2. Field splices; and
 - 2.3. Joist headers.

3.6.7.4 Steel joist drawings

Steel joist placement plans shall be provided to show the steel joist products as specified on the construction documents and are to be utilized for field installation in accordance with specific project requirements as stated in Section 3.6.6.2. Steel placement plans shall include, at a minimum, the following:

1. Listing of all applicable loads as stated in Section 3.6.6.2 and used in the design of the steel joists and joist girders as specified in the construction documents.
2. Profiles for nonstandard joist and joist girder configurations (standard joist and joist girder configurations are as indicated in the SJI catalog).
3. Connection requirements for:
 - 3.1. Joist supports;
 - 3.2. Joist girder supports;
 - 3.3. Field splices; and
 - 3.4. Bridging attachments.
4. Deflection criteria for live and total loads for non-SJI standard joists.
5. Size, location and connections for all bridging.
6. Joist headers.

Steel joist placement plans do not require the seal and signature of the joist manufacturer's registered design professional.

3.6.7.5 Certification

At completion of fabrication, the steel joist manufacturer shall submit a certificate of compliance stating that work was performed in accordance with approved construction documents and with SJI standard specifications.

3.6.8 Steel Cable Structures

3.6.8.1 General

The design, fabrication and erection including related connections, and protective coatings of steel cables for buildings shall be in accordance with ASCE 19.

3.6.8.2 Seismic requirements for steel cable

The design strength of steel cables shall be determined by the provisions of ASCE 19 except as modified by these provisions.

1. A load factor of 1.1 shall be applied to the prestress force included in T3 and T4 as defined in Section 3.12.
2. In Section 3.2.1, Item (c) shall be replaced with “1.5 T3” and Item (d) shall be replaced with “1.5 T4.”

3.6.9 Steel Storage Racks

3.6.9.1 Storage racks

The design, testing and utilization of industrial steel storage racks shall be in accordance with the RMI Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks. Racks in the scope of this specification include industrial pallet racks, movable shelf racks and stacker racks and does not apply to other types of racks, such as drive-in and drive-through racks, cantilever racks, portable racks or rack buildings. Where required, the seismic design of storage racks shall be in accordance with the provisions of Section 15.5.3 of ASCE 7.

3.6.10 Cold-Formed Steel

3.6.10.1 General

The design of cold-formed carbon and low-alloy steel structural members shall be in accordance with AISI-NAS. The design of cold-formed stainless-steel structural members shall be in accordance with ASCE 8. Cold-formed steel light-framed construction shall comply with Section 3.6.10.

3.6.10.2 Composite Slabs on Steel Decks

Composite slabs of concrete and steel deck shall be designed and constructed in accordance with ASCE 3.

3.6.11 Cold-Formed Steel, Light-Framed Construction

3.6.11.1 General

The design, installation and construction of cold-formed carbon or low-alloy steel, structural and nonstructural steel framing shall be in accordance with AISI-General and AISI-NAS.

3.6.11.2 Headers

The design and installation of cold-formed steel box headers, back-to-back headers and single and double L-headers used in single-span conditions for load-carrying purposes shall be in accordance with AISI-Header, subject to the limitations therein.

3.6.11.3 Trusses

The design, quality assurance, installation and testing of cold-formed steel trusses shall be in accordance with AISI-Truss, subject to the limitations therein.

3.6.11.4 Wall Stud Design

The design and installation of cold-formed steel studs for structural and nonstructural walls shall be in accordance with AISI-WSD.

3.6.11.5 Lateral Design

The design of light-framed cold-formed steel walls and diaphragms to resist wind and seismic loads shall be in accordance with AISI-Lateral.

3.6.11.6 Prescriptive Framing

Detached one- and two-family dwellings and townhouses, up to two stories in height, shall be permitted to be constructed in accordance with AISI-PM, subject to the limitations therein.

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PART 3 STRUCTURAL DESIGN

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SECTION 3.7: MASONRY

3.7.1 General

3.7.1.1 Scope

This chapter shall govern the materials, design, construction and quality of masonry.

3.7.1.2 Design Methods

Masonry shall comply with the provisions of one of the following design methods in this Section as well as the requirements of Sections 3.7.1 through 3.7.4. Masonry designed by the allowable stress design provisions of Section 3.7.1.2.1, the strength design provisions of Section 3.7.1.2.2 or the prestressed masonry provisions of Section 3.7.1.2.3 shall comply with Section 3.7.5.

3.7.1.2.1 Allowable stress design

Masonry designed by the allowable stress design method shall comply with the provisions of Sections 3.7.6 and 3.7.7.

3.7.1.2.2 Strength design

Masonry designed by the strength design method shall comply with the provisions of Sections 3.7.6 and 3.7.8, except that autoclaved aerated concrete (AAC) masonry shall comply with the provisions of Section 3.7.6 and Chapter 1 and Appendix A of ACI 530/ASCE 5/TMS 402. AAC masonry shall not be used in the seismic-force-resisting system of structures classified as Seismic Design Category B, C, D, E or F.

3.7.1.2.3 Prestressed masonry

Prestressed masonry shall be designed in accordance with Chapters 1 and 4 of ACI 530/ASCE 5/TMS 402 and Section 3.7.6.

3.7.1.2.4 Empirical design

Masonry designed by the empirical design method shall comply with the provisions of Sections 3.7.6 and 3.7.9 or Chapter 5 of ACI 530/ASCE 5/TMS 402.

3.7.1.2.5 Glass unit masonry

Glass unit masonry shall comply with the provisions of Section 3.7.10 or Chapter 7 of ACI 530/ASCE 5/TMS 402.

3.7.1.2.6 Masonry veneer

Masonry veneer shall comply with the provisions of Chapter 14 or Chapter 6 of ACI 530/ASCE 5/TMS 402.

3.7.1.3 Design and Construction Documents

The construction documents shall show all of the items required by this PART including the following:

1. Design calculations (in design documents only)
2. Specified size, grade, type and location of reinforcement, anchors and wall ties.
3. Reinforcing bars to be welded and welding procedure.

4. Size and location of structural elements.

5. Provisions for dimensional changes resulting from elastic deformation, shrinkage, temperature and moisture.

3.7.1.3.1 Fireplace drawings

The construction documents shall describe in sufficient detail the location, size and construction of masonry fireplaces. The thickness and characteristics of materials and the clearances from walls, partitions and ceilings shall be clearly indicated.

3.7.2 Definition and Notation

3.7.2.1 Definitions

Following words and terms shall, for the purposes of this SECTION and as used elsewhere in this PART, have the meanings shown herein.

AAC MASONRY: Masonry made of autoclaved aerated concrete (AAC) units, manufactured without internal reinforcement and bonded together using thin- or thick-bed mortar.

ADOBE CONSTRUCTION: Construction in which the exterior load-bearing and non-loadbearing walls and partitions are of unfired clay masonry units, and floors, roofs and interior framing are wholly or partly of wood or other approved materials.

Adobe, stabilized: Unfired clay masonry units to which admixtures, such as emulsified asphalt, are added during the manufacturing process to limit the units' water absorption so as to increase their durability.

Adobe, unstabilized: Unfired clay masonry units that do not meet the definition of "Adobe, stabilized."

ANCHOR: Metal rod, wire or strap that secures masonry to its structural support.

ARCHITECTURAL TERRA COTTA: Plain or ornamental hard-burned modified clay units, larger in size than brick, with glazed or unglazed ceramic finish.

AREA:

Bedded: The area of the surface of a masonry unit that is in contact with mortar in the plane of the joint.

Gross cross-sectional: The area delineated by the out-to-out specified dimensions of masonry in the plane under consideration.

Net cross-sectional: The area of masonry units, grout and mortar crossed by the plane under consideration based on out-to-out specified dimensions.

AUTOCLAVED AERATED CONCRETE (AAC): Low-density cementitious product of calcium silicate hydrates, whose material specifications are defined in ASTM C 1386.

BED JOINT: The horizontal layer of mortar on which a masonry unit is laid.

BOND BEAM: A horizontal grouted element within masonry in which reinforcement is embedded.

BOND REINFORCING: The adhesion between steel reinforcement and mortar or grout.

BRICK

Calcium silicate (sand lime brick): A masonry unit made of sand and lime.

Clay or shale: A masonry unit made of clay or shale, usually formed into a rectangular prism while in the plastic state and burned or fired in a kiln.

Concrete: A masonry unit having the approximate shape of a rectangular prism and composed of inert aggregate particles embedded in a hardened cementitious matrix.

BUTTRESS: A projecting part of a masonry wall built integrally therewith to provide lateral stability.

CAST STONE: A building stone manufactured from Portland cement concrete precast and used as a trim, veneer or facing on or in buildings or structures.

CELL: A void space having a gross cross-sectional area greater than $1\frac{1}{2}$ square inches (967 mm²).

CHIMNEY: A primarily vertical enclosure containing one or more passageways for conveying flue gases to the outside atmosphere.

CHIMNEY TYPES

High-heat appliance type: An approved chimney for removing the products of combustion from fuel-burning, high-heat appliances producing combustion gases in excess of 2,000°F (1093°C) measured at the appliance flue outlet (see Section 3.21.13.11.3).

Low-heat appliance type: An approved chimney for removing the products of combustion from fuel-burning, low-heat appliances producing combustion gases not in excess of 1,000°F (538°C) under normal operating conditions, but capable of producing combustion gases of 1,400°F (760°C) during intermittent forced firing for periods up to 1 hour. Temperatures shall be measured at the appliance flue outlet.

Masonry type: A field-constructed chimney of solid masonry units or stones.

Medium-heat appliance type: An approved chimney for removing the products of combustion from fuel-burning, medium-heat appliances producing combustion gases not exceeding 2,000°F (1093°C) measured at the appliance flue outlet (see Section 3.7.13.11.2).

CLEANOUT: An opening to the bottom of a grout space of sufficient size and spacing to allow the removal of debris.

COLLAR JOINT: Vertical longitudinal joint between wythes of masonry or between masonry and backup construction that is permitted to be filled with mortar or grout.

COLUMN, MASONRY:An isolated vertical member whose horizontal dimension measured at right angles to its thickness does not exceed three times its thickness and whose height is at least four times its thickness.

COMPOSITE ACTION:Transfer of stress between components of a member designed so that in resisting loads, the combined components act together as a single member.

COMPOSITE MASONRY:Multiwythe masonry members acting with composite action.

COMPRESSIVE STRENGTH OF MASONRY:Maximum compressive force resisted per unit of net cross-sectional area of masonry, determined by the testing of masonry prisms or a function of individual masonry units, mortar and grout.

CONNECTOR:A mechanical device for securing two or more pieces, parts or member together, including anchors, wall ties and fasteners.

COVER:Distance between surface of reinforcing bar and edge of member.

DIAPHRAGM:A roof or floor system designed to transmit lateral forces to shear walls or other lateral-load-resisting elements.

DIMENSIONS

Actual: The measured dimension of a masonry unit or element.

Nominal: The specified dimension plus an allowance for the joints with which the units are to be laid. Thickness is given first, followed by height and then length.

Specified: The dimensions specified for the manufacture or construction of masonry, masonry units, joints or any other component of a structure.

EFFECTIVE HEIGHT: For braced members, the effective height is the clear height between lateral supports and is used for calculating the slenderness ratio. The effective height for unbraced members is calculated in accordance with engineering mechanics.

FIREPLACE: A hearth and fire chamber or similar prepared place in which a fire may be made and which is built in conjunction with a chimney.

FIREPLACE THROAT:The opening between the top of the firebox and the smoke chamber.

FOUNDATION PIER:An isolated vertical foundation member whose horizontal dimension measured at right angles to its thickness does not exceed three times its thickness and whose height is equal to or less than four times its thickness.

GLASS UNIT MASONRY:Masonry composed of glass units bonded by mortar.

GROUTED MASONRY

Grouted hollow-unit masonry:That form of grouted masonry construction in which certain designated cells of hollow units are continuously filled with grout.

Grouted multiwythe masonry: That form of grouted masonry construction in which the space between the wythes is solidly or periodically filled with grout.

HEAD JOINT: Vertical mortar joint placed between masonry units within the wythe at the time the masonry units are laid.

HEADER(Bonder): A masonry unit that connects two or more adjacent wythes of masonry.

HEIGHT, WALLS: The vertical distance from the foundation wall or other immediate support of such wall to the top of the wall.

MASONRY: A built-up construction or combination of building units or materials of clay, shale, concrete, glass, gypsum, stone or other approved units bonded together with or without mortar or grout or other accepted methods of joining.

Ashlar masonry: Masonry composed of various-sized rectangular units having sawed, dressed or squared bed surfaces, properly bonded and laid in mortar.

Coursed ashlar: Ashlar masonry laid in courses of stone of equal height for each course, although different courses shall be permitted to be of varying height.

Glass unit masonry: Masonry composed of glass units bonded by mortar.

Plain masonry: Masonry in which the tensile resistance of the masonry is taken into consideration and the effects of stresses in reinforcement are neglected.

Random ashlar: Ashlar masonry laid in courses of stone set without continuous joints and laid up without drawn patterns. When composed of material cut into modular heights, discontinuous but aligned horizontal joints are discernible.

Reinforced masonry: Masonry construction in which reinforcement acting in conjunction with the masonry is used to resist forces.

Solid masonry: Masonry consisting of solid masonry units laid contiguously with the joints between the units filled with mortar.

Unreinforced (plain) masonry: Masonry in which the tensile resistance of masonry is taken into consideration and the resistance of the reinforcing steel, if present, is neglected.

MASONRY UNIT: Brick, tile, stone, glass block or concrete block conforming to the requirements specified in Section 3.7.3.

Clay: A building unit larger in size than a brick, composed of burned clay, shale, fired clay or mixtures thereof.

Concrete: A building unit or block larger in size than 12 inches by 4 inches by 4 inches (305 mm by 102 mm by 102 mm) made of cement and suitable aggregates.

Hollow: A masonry unit whose net cross-sectional area in any plane parallel to the load-bearing surface is less than 75 percent of its gross cross-sectional area measured in the same plane.

Solid: A masonry unit whose net cross-sectional area in every plane parallel to the load-bearing surface is 75 percent or more of its gross cross-sectional area measured in the same plane.

MEAN DAILY TEMPERATURE:The average daily temperature of temperature extremes predicted by a local weather bureau for the next 24 hours.

MORTAR:A plastic mixture of approved cementitious materials, fine aggregates and water used to bond masonry or other structural units.

MORTAR, SURFACE-BONDING:A mixture to bond concrete masonry units that contains hydraulic cement, glass fiber reinforcement with or without inorganic fillers or organic modifiers and water.

PLASTIC HINGE:The zone in a structural member in which the yield moment is anticipated to be exceeded under loading combinations that include earthquakes.

PRESTRESSED MASONRY:Masonry in which internal stresses have been introduced to counteract potential tensile stresses in masonry resulting from applied loads.

PRISM:An assemblage of masonry units and mortar with or without grout used as a test specimen for determining properties of the masonry.

RUBBLE MASONRY:Masonry composed of roughly shaped stones.

Coursed rubble:Masonry composed of roughly shaped stones fitting approximately on level beds and well bonded.

Random rubble: Masonry composed of roughly shaped stones laid without regularity of coursing but well bonded and fitted together to form well-divided joints.

Rough or ordinary rubble:Masonry composed of unsquared field stones laid without regularity of coursing but well bonded.

RUNNING BOND:The placement of masonry units such that head joints in successive courses are horizontally offset at least one-quarter the unit length.

SHEAR WALL:

Detailed plain masonry shear wall: A masonry shear wall designed to resist lateral forces neglecting stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.

Intermediate prestressed masonry shear wall: A prestressed masonry shear wall designed to resist lateral forces considering stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.2.

Intermediate reinforced masonry shear wall: A masonry shear wall designed to resist lateral forces considering stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.

Ordinary plain masonry shear wall: A masonry shear wall designed to resist lateral forces neglecting stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.

Ordinary plain prestressed masonry shear wall: A prestressed masonry shear wall designed to resist lateral forces considering stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.1.

Ordinary reinforced masonry shear wall: A masonry shear wall designed to resist lateral forces considering stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.

Special prestressed masonry shear wall: A prestressed masonry shear wall designed to resist lateral forces considering stresses in reinforcement and designed in accordance with Section 3.7.6.1.1.3 except that only grouted, laterally restrained tendons are used.

Special reinforced masonry shear wall: A masonry shear wall designed to resist lateral forces considering stresses in reinforcement, and designed in accordance with Section 3.7.6.1.1.

SHELL: The outer portion of a hollow masonry unit as placed in masonry.

SPECIFIED: Required by design and construction documents.

SPECIFIED COMPRESSIVE STRENGTH OF MASONRY: f'_m . Minimum compressive strength, expressed as force per unit of net cross-sectional area, required of the masonry used in construction by the design and construction documents, and upon which the project design is based. Whenever the quantity f'_m is under the radical sign, the square root of numerical value only is intended and the result has units of pounds per square inch (psi) (MPa).

STACK BOND: The placement of masonry units in a bond pattern is such that head joints in successive courses are vertically aligned. For the purpose of this PART, requirements for stack bond shall apply to masonry laid in other than running bond.

STONE MASONRY: Masonry composed of field, quarried or cast stone units bonded by mortar.

Ashlar stone masonry: Stone masonry composed of rectangular units having sawed, dressed or squared bed surfaces and bonded by mortar.

Rubble stone masonry: Stone masonry composed of irregular-shaped units bonded by mortar.

STRENGTH:

Design strength: Nominal strength multiplied by a strength reduction factor.

Nominal strength: Strength of a member or cross section calculated in accordance with these provisions before application of any strength-reduction factors.

Required strength: Strength of a member or cross section required to resist factored loads.

THIN-BED MORTAR: Mortar for use in construction of AAC unit masonry with joints 0.06 inch (1.5 mm) or less.

TIE, LATERAL: Loop of reinforcing bar or wire enclosing longitudinal reinforcement.

TIE, WALL: A connector that connects wythes of masonry walls together.

TILE:A ceramic surface unit, usually relatively thin in relation to facial area, made from clay or a mixture of clay or other ceramic materials, called the body of the tile, having either a “glazed” or “unglazed” face and fired above red heat in the course of manufacture to a temperature sufficiently high enough to produce specific physical properties and characteristics.

TILE, STRUCTURAL CLAY:A hollow masonry unit composed of burned clay, shale, fire clay or mixture thereof, and having parallel cells.

WALL:A vertical element with a horizontal length-to-thickness ratio greater than three, used to enclose space.

Cavity wall: A wall built of masonry units or of concrete, or a combination of these materials, arranged to provide an air- space within the wall, and in which the inner and outer parts of the wall are tied together with metal ties.

Composite wall: A wall built of a combination of two or more masonry unitsbondedtogether,one forming the backup and the other forming the facing elements.

Dry-stacked, surface-bonded walls: A wall built of concrete masonry units where the units are stacked dry, without mortar on the bed or head joints, and where both sides of the wall are coated with a surface-bonding mortar.

Masonry-bonded hollow wall: A wall built of masonry units so arranged as to provide an airspace within the wall, and in which the facing and backing of the wall are bonded together with masonry units.

Parapet wall: The part of any wall entirely above the roof line.

WEB:Aninterior solid portion of a hollow masonry unit as placed in masonry.

WYTHE: Each continuous, verticalsectionof a wall,one masonry unit in thickness.

3.7.2.2 NOTATION

A_n = Netcross-sectional areaofmasonry, square inches(mm^2).

b = Effective width of rectangular member or width of flange for T and I sections, inches (mm).

d_b = Diameter of reinforcement, inches (mm).

F_s = Allowable tensile or compressive stress in reinforcement, psi (MPa).

f_r = Modulusof rupture, psi (MPa).

f_y = Specified yield stressofthereinforcement ortheanchor bolt, psi (MPa).

f'_{AAC} = Specified compressive strength of AAC masonry, the minimum compressive strength for a class of AAC masonry as specified in ASTM C 1386, psi (MPa).

f'_m = Specified compressive strength of masonry at age of 28 days, psi (MPa).

f'_{mi} = Specified compressive strength of masonry at the time of prestress transfer, psi (MPa).

K = The lesser of the masonry cover, clear spacing between adjacent reinforcement, or five times d_b , inches (mm).

L_s = Distance between supports, inches (mm).

L_w = Length of wall, inches (mm).

l_d = Required development length or lap length of reinforcement, inches (mm).

l_{de} = Embedment length of reinforcement, inches (mm).

P_w = Weight of wall tributary to section under consideration, pounds (N).

t = Specified wall thickness dimension or the least lateral dimension of a column, inches (mm).

V_n = Nominal shear strength, pounds (N).

V_u = Required shear strength due to factored loads, pounds (N).

W = Wind load, or related internal moments in forces.

= Reinforcement size factor.

ρ_n = Ratio of distributed shear reinforcement on plane perpendicular to plane of A_{mv} .

ρ_{max} = Maximum reinforcement ratio.

ϕ = Strength reduction factor.

3.7.3 Masonry Construction Materials

3.7.3.1 Concrete Masonry Units

Concrete masonry units shall conform to the following standards: ASTM C 55 for concrete brick; ASTM C 73 for calcium silicate face brick; ASTM C 90 for load-bearing concrete masonry units or ASTM C 744 for prefaced concrete and calcium silicate masonry units.

3.7.3.2 Clay or Shale Masonry Units

Clay or shale masonry units shall conform to the following standards: ASTM C 34 for structural clay load-bearing wall tile; ASTM C 56 for structural clay nonload-bearing wall tile; ASTM C 62 for building brick (solid masonry units made from clay or shale); ASTM C 1088 for solid units of thin veneer brick; ASTM C 126 for ceramic-glazed structural clay facing tile, facing brick and solid masonry units; ASTM C 212 for structural clay facing tile; ASTM C 216 for facing brick (solid masonry units made from clay or shale); ASTM C 652 for hollow brick (hollow masonry units made from clay or shale); and ASTM C 1405 for glazed brick (single-fired solid brick units).

EXCEPTION: Structural clay tile for nonstructural use in fire-proofing of structural members and in wall furring shall not be required to meet the compressive strength specifications. The fire-resistance rating shall be determined in accordance with ASTM E 119 and shall comply with the requirements of this Code.

3.7.3.3 AAC Masonry

AAC masonry units shall conform to ASTM C 1386 for the strength class specified.

3.7.3.4 Stone Masonry Units

Stone masonry units shall conform to the following standards: ASTM C 503 for **marble** building stone (exterior); ASTM C 568 for limestone building stone; ASTM C 615 for **granite** building stone; ASTM C 616 for sandstone building stone; or ASTM C 629 for **slate building** stone.

3.7.3.5 Ceramic Tile

Ceramic tile shall be as defined in, and shall conform to the requirements of, ANSI A137.1.

3.7.3.6 Glass Unit Masonry

Hollow glass units shall be partially evacuated and have a minimum average glass face thickness of 3/16 inch (4.8 mm). Solid glass-block units shall be provided when required. The surfaces of units intended to be in contact with mortar shall be treated with a polyvinyl butyral coating or latex-based paint. Reclaimed units shall not be used.

3.7.3.7 Second-Hand Units

Second-hand masonry units shall not be reused unless they conform to the requirements of new units. The units shall be of whole, sound materials and free from cracks and other defects that will interfere with proper laying or use. Old mortar shall be cleaned from the unit before reuse.

3.7.3.8 Mortar

Mortar for use in masonry construction shall conform to ASTM C 270 and shall conform to the proportion specifications of Table 3.7.1 or the property specifications of Table 3.7.2. Type S or N mortar shall be used for glass unit masonry. The amount of water used in mortar for glass unit masonry shall be adjusted to account for the lack of absorption. Retempering of mortar for glass unit masonry shall not be permitted after initial set. Unused mortar shall be discarded within 2½ hours after initial mixing, except that unused mortar for glass unit masonry shall be discarded within 1½ hours after initial mixing.

3.7.3.9 Surface-Bonding Mortar

Surface-bonding mortar shall comply with ASTM C 887. Surface bonding of concrete masonry units shall comply with ASTM C 946.

3.7.3.10 Mortars for Ceramic Wall and Floor Tile

Portland cement mortars for installing ceramic wall and floor tile shall comply with ANSI A108.1A and ANSI A108.1B and be of the compositions indicated in Table 3.7.3.

TABLE 3.7.3 CERAMIC TILE MORTAR COMPOSITIONS

LOCATION	MORTAR	COMPOSITION
Walls	Scratch-coat	1 cement; 1/5 hydrated lime; 4 dry or 5 damp sand
	Setting bed and leveling coat	1 cement; 1/2 hydrated lime; 5 damp sand to 1 cement, 1 hydrated lime, 7 damp sand

Floors	Setting bed	1 cement; 1/10 hydrated lime; 5 dry or 6 damp sand; or 1 cement; 5 dry or 6 damp sand
Ceilings	Scratch-coat and sand bed	1 cement; 1/2 hydrated lime; 2 1/2 dry sand or 3 damp sand

3.7.3.10.1 Dry-set Portland cement mortars

Premixed prepared Portland cement mortars, which require only the addition of water and are used in the installation of ceramic tile, shall comply with ANSI A118.1. The shear bond strength for tile set in such mortar shall be as required in accordance with ANSI A118.1. Tile set in dry-set Portland cement mortar shall be installed in accordance with ANSI A108.5.

3.7.3.10.2 Latex-modified Portland cement mortar

Latex-modified Portland cement thin-set mortars in which latex is added to dry-set mortar as a replacement for all or part of the gauging water that are used for the installation of ceramic tile shall comply with ANSI A118.4. Tile set in latex-modified Portland cement shall be installed in accordance with ANSI A108.5.

3.7.3.10.3 Epoxy mortar

Ceramic tile set and grouted with chemical-resistant epoxy shall comply with ANSI A118.3. Tile set and grouted with epoxy shall be installed in accordance with ANSI A108.6.

3.7.3.10.4 Furan mortar and grout

Chemical-resistant furan mortar and grout that are used to install ceramic tile shall comply with ANSI A118.5. Tile set and grouted with furan shall be installed in accordance with ANSI A108.8.

TABLE 3.7.1 MORTAR PROPORTIONS

MORTAR	TYPE	PROPORTIONS BY VOLUME (cementitious materials)								AGGREGATE MEASURED IN A DAMP, LOOSE CONDITION
		Portland cement ^a or blended cement ^b	Masonry cement ^c			Mortar cement ^d			HYDRATED LIME ^e OR LIME PUTTY	
			M	S	N	M	S	N		
Cement-lime	M	1	—	—	—	—	—	—	¹ / ₄	Not less than 2 ¹ / ₄ and not more than 3 times the sum of the separate volumes of cementitious materials
	S	1	—	—	—	—	—	—	over ¹ / ₄ to ¹ / ₂	
	O	1	—	—	—	—	—	—	over ¹ / ₂ to 1 ¹ / ₄	
Mortar cement	M	1	—	—	—	—	—	1	—	
	M		—	—	—	1	—	—	—	
	S	¹ / ₂	—	—	—	—	—	1	—	
	N	—	—	—	—	—	1	—	—	
Masonry cement	O	—	—	—	—	—	—	—	—	
	M	1	—	—	1	—	—	—	—	
	M	—	1	—	—	—	—	—	—	
	S	¹ / ₂	—	—	1	—	—	—	—	
	N	—	—	—	—	—	—	—	—	
	O	—	—	1	—	—	—	—	—	

a. Portland cement conforming to the requirements of ASTM C 150.

b. Blended cement conforming to the requirements of ASTM C 595.

c. Masonry cement conforming to the requirements of ASTM C 91.

d. Mortar cement conforming to the requirements of ASTM C 1329.

e. Hydrated lime conforming to the requirements of ASTM C 207.

TABEL 3.7.2 MORTAR PROPERTIES

MORTAR	TYPE	AVERAGE COMPRESSIVE ^b STRENGTH AT 28 DAYS minimum (psi)	WATER RETENTION ^c minimum (%)	AIR CONTENT maximum (%)
Cement-lime	M	2,500	7	12
	S	1,800	5	12
	N	750	7	14 ^c
	O	750	5	14 ^c
Mortar cement	M	2,500	7	12
	S	1,800	5	12
	N	750	7	14 ^c
	O	750	5	14 ^c
Masonry cement	M	2,500	7	18
	S	1,800	5	18
	N	750	7	20 ^d
	O	750	5	20 ^d

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa.

a. This aggregate ratio (measured in damp, loose condition) shall not be less than $2\frac{1}{4}$ and not more than 3 times the sum of the separate volumes of cementitious materials.

b. Average of three 2-inch cubes of laboratory-prepared mortar, in accordance with ASTM C 270.

c. When structural reinforcement is incorporated in cement-lime or mortar cement mortars, the maximum air content shall not exceed 12 percent.

d. When structural reinforcement is incorporated in masonry cement mortar, the maximum air content shall not exceed 18 percent.

3.7.3.10.5 Modified epoxy-emulsion mortar and grout

Modified epoxy-emulsion mortar and grout that are used to install ceramic tile shall comply with ANSI A118.8. Tile set and grouted with modified epoxy-emulsion mortar and grout shall be installed in accordance with ANSI A108.9.

3.7.3.10.6 Organic adhesives

Water-resistant organic adhesives used for the installation of ceramic tile shall comply with ANSI A136.1. The shear bond strength after water immersion shall not be less than 40 psi (275 kPa) for Type I adhesive and not less than 20 psi (138 kPa) for Type II adhesive when tested in accordance with ANSI A136.1. Tile set in organic adhesives shall be installed in accordance with ANSI A108.4.

3.7.3.10.7 Portland cement grouts

Portland cement grouts used for the installation of ceramic tile shall comply with ANSI A118.6. Portland cement grouts for tile work shall be installed in accordance with ANSI A108.10.

3.7.3.11 Mortar for AAC Masonry

Thin-bed mortar for AAC masonry shall comply with Section 3.7.3.11.1. Mortar for leveling courses of AAC masonry shall comply with Section 3.7.3.11.2.

3.7.3.11.1 Thin-bed mortar for AAC masonry

Thin-bed mortar for AAC masonry shall be specifically manufactured for use with AAC masonry. Testing to verify mortar properties shall be conducted by the thin-bed mortar manufacturer and confirmed by an independent testing agency:

1. The compressive strength of thin-bed mortar, as determined by ASTM C 109, shall meet or exceed the strength of the AAC masonry units.
2. The shear strength of thin-bed mortar shall meet or exceed the shear strength of the AAC masonry units for wall assemblages tested in accordance with ASTM E519.
3. The flexural tensile strength of thin-bed mortar shall not be less than the modulus of rupture of the masonry units. Flexural strength shall be determined by testing in accordance with ASTM E 72 (transverse load test), ASTM E 518 Method A (flexural bond strength test) or ASTM C 1072 (flexural bond strength test).
 - 3.1. For conducting flexural strength tests in accordance with ASTM E 518, at least five test specimens shall be constructed as stack-bonded prisms at least 32 inches (810 mm) high. The type of mortar specified by the AAC unit manufacturer shall be used.
 - 3.2. For flexural strength tests in accordance with ASTM C 1072, test specimens shall be constructed as stack-bonded prisms comprised with at least three bed joints. A total of at least five joints shall be tested using the type of mortar specified by the AAC unit manufacturer.
4. The splitting tensile strength of AAC masonry assemblages composed of two AAC masonry units bonded with one thin-bed mortar joint shall be determined in accordance with ASTM C 1006 and shall equal or exceed $2.4\sqrt{f'_{AAC}}$.

3.7.3.11.2 Mortar for leveling courses of AAC masonry

Mortar used for the leveling courses of AAC masonry shall conform to Section 3.7.3.8 and shall be Type M or S.

3.7.3.12 Grout

Grout shall conform to Table 3.7.4 or to ASTM C 476. When grout conforms to ASTM C 476, the grout shall be specified by proportion requirements or property requirements.

TABLE 3.7.4 GROUT PROPORTIONS BY VOLUME FOR MASONRY CONSTRUCTION

TYPE	PARTS BY VOLUME OF PORTLAND CEMENT OR BLENDED CEMENT	PARTS BY VOLUME OF HYDRATED LIME OR LIME PUTTY	AGGREGATE, MEASURED IN A DAMP, LOOSE CONDITION	
			Fine	Coarse
Fine grout	1	1	$2\frac{1}{4}$ -3 times the sum of the volumes of the cementitious	—

Coarse grout	1	1	$2^{1/4}$ -3 times the sum of the volumes of the cementitious materials	1-2 times the sum of the volumes of the cementitious materials

3.7.3.13 Metal Reinforcement and Accessories

Metal reinforcement and accessories shall conform to Sections 3.7.3.13.1 through 3.7.3.13.8.

3.7.3.13.1 Deformed reinforcing bars

Deformed reinforcing bars shall conform to one of the following standards: ASTM A 615 for deformed and plain billet-steel bars for concrete reinforcement; ASTM A 706 for low-alloy steel deformed bars for concrete reinforcement; ASTM A 767 for zinc-coated reinforcing steel bars; ASTM A 775 for epoxy-coated reinforcing steel bars; and ASTM A 996 for rail and axle steel-deformed bars for concrete reinforcement.

3.7.3.13.2 Joint reinforcement

Joint reinforcement shall comply with ASTM A 951. The maximum spacing of crosswires in

ladder-type joint reinforcement and point of connection of cross wires to longitudinal wires of truss-type reinforcement shall be 16 inches (400 mm).

3.7.3.13.3 Deformed reinforcing wire

Deformed reinforcing wire shall conform to ASTM A 496.

3.7.3.13.4 Wire fabric

Wire fabric shall conform to ASTM A 185 for plain steel-welded wire fabric for concrete reinforcement or ASTM A 497 for welded deformed steel wire fabric for concrete reinforcement.

3.7.3.13.5 Anchors, ties and accessories

Anchors, ties and accessories shall conform to the following standards: ASTM A 36 for structural steel; ASTM A 82 for plain steel wire for concrete reinforcement; ASTM A 185 for plain steel-welded wire fabric for concrete reinforcement; ASTM A 240 for chromium and chromium-nickel stainless steel plate, sheet and strip; ASTM A 307 Grade A for anchor bolts; ASTM A 480 for flat rolled stainless and heat-resisting steel plate, sheet and strip; and ASTM A 1008 for cold-rolled carbon steel sheet.

3.7.3.13.6 Prestressing tendons

Prestressing tendons shall conform to one of the following standards:

1. Wire ASTM A 421
2. Low-relaxation wire ASTM A 421
3. Strand ASTM A 416
4. Low-relaxation strand ASTM A 416

5. Bar. ASTM A 722

EXCEPTIONS:

1. Wire, strands and bars not specifically listed in ASTM A 421, ASTM A 416 or ASTM A 722 are permitted, provided they conform to the minimum requirements in ASTM A 421, ASTM A 416 or ASTM A 722 and are approved by the architect/engineer.
2. Bars and wires of less than 150 kips per square inch (ksi) (1034 MPa) tensile strength and conforming to ASTM A 82, ASTM A 510, ASTM A 615, ASTM A 996 or ASTM A 706 are permitted to be used as prestressed tendons, provided that:
 - 2.1. The stress relaxation properties have been assessed by tests according to ASTM E 328 for the maximum permissible stress in the tendon.
 - 2.2. Other non-stress-related requirements of ACI 530/ASCE 5/TMS 402,

Chapter 4, addressing prestressing tendons are met.

3.7.3.13.7 Corrosion protection

Corrosion protection for prestressing tendons shall comply with the requirements of ACI 530.1/ASCE 6/TMS 602, Article 2.4G. Corrosion protection for prestressing anchorages, couplers and end blocks shall comply with the requirements of ACI 530.1/ASCE 6/TMS 602, Article 2.4H. Corrosion protection for carbon steel accessories used in exterior wall construction or interior walls exposed to a mean relative humidity exceeding 75 percent shall comply with either Section 3.7.3.13.7.2 or 3.7.3.13.7.3. Corrosion protection for carbon steel accessories used in interior walls exposed to a mean relative humidity equal to or less than 75 percent shall comply with either Section 3.7.3.13.7.1, 3.7.3.13.7.2 or 3.7.3.13.7.3.

3.7.3.13.7.1 Mill galvanized

Mill galvanized coatings shall be applied as follows:

1. For joint reinforcement, wall ties, anchors and inserts, a minimum coating of 0.1 ounce per square foot (31g/m^2) complying with the requirements of ASTM A 641 shall be applied.
2. For sheet metal ties and sheet metal anchors, a minimum coating complying with Coating Designation G-60 according to the requirements of ASTM A 653 shall be applied.
3. For anchor bolts, steel plates or bars not exposed to the earth, weather or a mean relative humidity exceeding 75 percent, a coating is not required.

3.7.3.13.7.2 Hot-dipped galvanized

Hot-dipped galvanized coatings shall be applied after fabrication as follows:

1. For joint reinforcement, wall ties, anchors and inserts,

a minimum coating of 1.5 ounces per square foot (458 g/m²) complying with the requirements of ASTM A 153, Class B shall be applied.

2. For sheet metal ties and anchors, the requirements of ASTM A 153, Class B shall be met.
3. For steel plates and bars, the requirements of either ASTM A 123 or ASTM A 153, Class B shall be met.

3.7.3.13.7.3 Epoxy coatings

Carbon steel accessories shall be epoxy coated as follows:

1. For joint reinforcement, the requirements of ASTM A 884, Class A, Type 1 having a minimum thickness of 7 mils (175 μm) shall be met.
2. For wire ties and anchors, the requirements of ASTM A 899, Class C

having a minimum thickness of 20 mils (508 μm) shall be met.

3. For sheet metal ties and anchors, a minimum thickness of 20 mils (508 μm) per surface shall be provided or a minimum thickness in accordance with the manufacturer's specifications shall be provided.

3.7.3.13.8 Tests

Where unidentified reinforcement is approved for use, not less than three tension and three bending tests shall be made on representative specimens of the reinforcement from each shipment and grade of reinforcing steel proposed for use in the work.

3.7.4 Construction

3.7.4.1 Masonry Construction

Masonry construction shall comply with the requirements of Sections 3.7.4.1.1 through 3.7.4.5 and with ACI 530.1/ASCE 6/TMS 602.

3.7.4.1.1 Tolerances

Masonry, except masonry veneer, shall be constructed within the tolerances specified in ACI 530.1/ASCE 6/TMS 602.

3.7.4.1.2 Placing mortar and units

Placement of mortar and clay and concrete units shall comply with Sections 3.7.4.1.2.1, 3.7.4.1.2.2, 3.7.4.1.2.3 and 3.7.4.1.2.5. Placement of mortar and glass unit masonry shall comply with Sections 3.7.4.1.2.4 and 3.7.4.1.2.5. Placement of thin-bed mortar and AAC masonry shall comply with Section 3.7.4.1.2.6.

3.7.4.1.2.1 Bed and head joints

Unless otherwise required or indicated on the construction documents,

headbed joints shall be $\frac{3}{8}$ inch (9.5 mm) thick, except that the thickness of the bed joint of the starting course placed over foundations shall not be less than $\frac{1}{4}$ inch (6.4 mm) and not more than $\frac{3}{4}$ inch (19.1 mm).

3.7.4.1.2.1.1 Open-end units

Open-end units with beveled ends shall be fully grouted. Head joints of open-end units with beveled ends need not be mortared. The beveled ends shall form a grout key that permits grouts within $\frac{5}{8}$ inch (15.9 mm) of the face of the unit. The units shall be tightly butted to prevent leakage of the grout.

3.7.4.1.2.2 Hollow units

Hollow units shall be placed such that face shells of bed joints are fully mortared. Webs shall be fully mortared in all courses of piers, columns, pilasters, in the starting course on foundations where adjacent cells or cavities

are to be grouted, and where otherwise required. Head joints shall be mortared a minimum distance from each face equal to the face shell thickness of the unit.

3.7.4.1.2.3 Solid units

Unless otherwise required or indicated on the construction documents, solid units shall be placed in fully mortared bed and head joints. The ends of the units shall be completely buttered. Head joints shall not be filled by slushing with mortar. Head joints shall be constructed by shoving mortar tight against the adjoining unit. Bed joints shall not be furrowed deep enough to produce voids.

3.7.4.1.2.4 Glass unit masonry

Glass units shall be placed so head and bed joints are filled solidly. Mortar shall not be furrowed.

Unless otherwise required, head and bed joints of glass unit masonry shall be $\frac{1}{4}$ inch (6.4 mm) thick, except that vertical joint thickness of radial panels shall not be less than $\frac{1}{8}$ inch (3.2 mm). The bed joint thickness tolerance shall be minus $\frac{1}{16}$ inch (1.6 mm) and plus $\frac{1}{8}$ inch (3.2 mm). The head joint thickness tolerance shall be plus or minus $\frac{1}{8}$ inch (3.2 mm).

3.7.4.1.2.5 Placement in mortar

Units shall be placed while the mortar is soft and plastic. Any unit disturbed to the extent that the initial bond is broken after initial positioning shall be removed and relaid in fresh mortar.

3.7.4.1.2.6 Thin-bed mortar and AAC masonry units

AAC masonry construction shall begin with a leveling course of masonry meeting the requirements of Section 3.7.4.1.2. Subsequent courses of AAC masonry units shall be laid with thin-bed mortar using a special notched trowel manufactured for use with thin-bed mortar to spread the mortar so that it completely fills the bed joints.

Unless otherwise specified, the head joints shall be similarly filled. Joints in AAC

masonry shall be approximately 1/16 inch (1.5 mm) and shall be formed by striking on the ends and tops of AAC masonry units with a rubber mallet. Minor adjustments in unit position shall be made while the mortar is still soft and plastic by tapping it into the proper position. Minor sanding of the exposed faces of AAC masonry shall be permitted to provide a smooth and plumb surface.

3.7.4.1.2.7 Grouted masonry

Between grout pours, a horizontal construction joint shall be formed by stopping all wythes at the same elevation and with the grout stopping a minimum of 1½ inches (38 mm) below a mortar joint, except at the top of the wall. Where bond beams occur, the grout pour shall be stopped a minimum of ½ inch (12.7 mm) below the top of the masonry.

3.7.4.1.3 Installation of wall ties

The ends of wall ties shall be embedded in mortar joints. Walltie ends shall engage outer face shells of hollow units by at least ½inch (12.7 mm). Wire wall ties shall be embedded at least 1½ inches (38 mm) into the mortar bed of solid masonry units or solid-grouted hollow units. Wall ties shall not be bent after being embedded in grout or mortar.

3.7.4.1.4 Chases and recesses

Chases and recesses shall be constructed as masonry units are laid. Masonry directly above chases or recesses wider than 12inches(305 mm) shall be supported on lintels.

3.7.4.1.5 Lintels

The design for lintels shall be in accordance with the masonry design provisions of either Section3.7.7 or 3.7.8. Minimum length of end support shall be 4 inches (102 mm).

3.7.4.1.6 Support on wood

Masonry shall not be supported on wood girders or other forms of wood construction.

3.7.4.1.7 Masonry protection

The top of unfinished masonry work shall be covered to protect the masonry from the weather.

3.7.4.1.8 Weep holes

Weep holes provided in the outside wythe of masonry walls shall be at a maximum spacing of33 inches (838 mm) on center (o.c.). Weep holes shall not beless than 3/16inch (4.8 mm) in diameter.

3.7.4.2 Corbeledmasonry

Except for corbels designed perSection 3.7.4 or 3.7.8, the following shall apply:

1. Corbels shall be constructed of solid masonry units.
2. The maximum corbeledprojection beyond the face of the wall shall not exceed:
 - 2.1. One-half of the wall thicknessfor multiwythe walls bonded by mortar or grout and wall ties or masonry headers or
 - 2.2. One-halfthe wythe thicknessforsingle wythewalls , masonrybondedhollowwalls, multiwythe walls with open collarjoints and

veneer walls.

3. The maximum projection of one unit shall not exceed:

3.1. One-half the nominal unit height of the unit or

3.2. One-third the nominal thickness of the unit or wythe.

4. The back surface of the corbelled section shall remain within 1 inch (25mm) of plane.

3.7.4.2.1 Molded cornices

Unless structural support and anchorage are provided to resist the overturning moment, the center of gravity of projecting masonry or molded cornices shall lie within the middle one-third of the supporting wall. Terra cotta and metal cornices shall be provided with a structural frame of approved noncombustible material anchored in an approved manner.

3.7.4.3 Cold Weather Construction

The cold weather construction provisions of ACI 530.1/ASCE 6/TMS 602, Article 1.8 C, or the following procedures shall be implemented when either the ambient temperature falls below 40°F (4°C) or the temperature of masonry units is below 40°F (4°C).

3.7.4.3.1 Preparation

1. Temperatures of masonry units shall not be less than 20°F (-7°C) when laid in the masonry. Masonry units containing frozen moisture, visible ice or snow on their surface shall not be laid.
2. Visible ice and snow shall be removed from the top surface of existing foundations and masonry to receive new construction. These surfaces shall be heated to above freezing, using methods that do not result in damage.

3.7.4.3.2 Construction

The following requirements shall apply to work in progress and shall be based on ambient temperature.

3.7.4.3.2.1 Construction requirements for temperatures between 40°F (4°C) and 32°F (0°C). The following construction requirements shall be met when the ambient temperature is between 40°F (4°C) and 32°F (0°C):

1. Glass unit masonry shall not be laid.
2. Water and aggregates used in mortar and grout shall not be heated above 140°F (60°C).
3. Mortar sand or mixing water shall be heated to produce mortar temperatures between 40°F (4°C) and 120°F (49°C) at the time of mixing. When water and aggregates for grout are below 32°F (0°C), they shall be heated.

3.7.4.3.2.2 Construction requirements for temperatures between 32°F (0°C) and 25°F (-4°C). The requirements of Section 2104.3.2.1 and the following construction requirements shall be met when the ambient temperature is between 32°F (0°C) and 25°F (-4°C):

1. The mortar temperature shall be maintained above freezing until

used in masonry.

2. Aggregates and mixing water for grout shall be heated to produce grout temperature between 70°F (21°C) and 120°F (49°C) at the time of

mixing. Grout temperature shall be maintained above 70°F (21°C) at the time of grout placement.

3. Heat AAC masonry units to a minimum temperature of 40°F (4°C) before installing thin-bed mortar.

3.7.4.3.2.3 Construction requirements for temperatures between 25°F (-4°C) and 20°F (-7°C). The requirements of Sections 3.7.4.3.2.1 and 3.7.4.3.2.2 and the following construction requirements shall be met when the ambient temperature is between 25°F (-4°C) and 20°F (-7°C):

1. Masonry surfaces under construction shall be heated to 40°F (4°C).

2. Wind breaks or enclosures shall be provided when the wind velocity exceeds 15 miles per hour (mph) (24 km/h).

3. Prior to grouting, masonry shall be heated to a minimum of 40°F (4°C).

3.7.4.3.2.4 Construction requirements for temperatures below 20°F (-7°C). The requirements of Sections 3.7.4.3.2.1, 3.7.4.3.2.2 and 3.7.4.3.2.3 and the following construction requirement shall be met when the ambient temperature is below 20°F (-7°C): Enclosures and auxiliary heat shall be provided to maintain air temperature within the enclosure to above 32°F (0°C).

3.7.4.3.3 Protection

The requirements of this Section and Sections 3.7.4.3.3.1 through 3.7.4.3.3.5 apply after the masonry is placed and shall be based on anticipated minimum daily temperature for grouted masonry and anticipated mean daily temperature for ungrouted masonry.

3.7.4.3.3.1 Glass unit masonry

The temperature of glass unit masonry shall be maintained above 40°F (4°C) for 48 hours after construction.

3.7.4.3.3.2 AAC masonry

The temperature of AAC masonry shall be maintained above 32°F (0°C) for the first 4 hours after thin-bed mortar application.

3.7.4.3.3.3 Protection requirements for temperatures between 40°F (4°C) and

25°F (-4°C). When the temperature is between 40°F (4°C) and 25°F (-4°C), newly constructed masonry shall be covered with a weather-resistive membrane for 24 hours after being completed.

3.7.4.3.3.4 Protection requirements for temperatures between 25°F (-4°C) and 20°F (-7°C). When the temperature is between 25°F (-4°C) and 20°F

(-7°C), newly constructed masonry shall be completely covered with weather-

resistiveinsulating blankets, or equal protection, for 24 hours after being completed. The time period shall be extended to 48 hours for grouted masonry, unless the only cement in the grout is Type III Portland cement.

3.7.4.3.3.5Protection requirements for temperatures below 20°F (-7°C). When the temperature is below 20°F (-7°C), newly constructed masonry shall be maintained at a temperature above 32°F (0°C) for at least 24 hours after being completed by using heated enclosures, electric heating blankets, infrared lamps or other acceptable methods. The time period shall be extended to 48 hoursfor grouted masonry, unless the only cement in the grout is Type III Portland cement.

3.7.4.4 Hot Weather Construction

The hot weather construction provisions of ACI 530.1/ASCE 6/TMS 602, Article 1.8 D, or the following procedures shall be implemented when the temperature or the temperatureand wind-velocity limits of this Section are exceeded.

3.7.4.4.1 Preparation

The following requirements shall be met prior to conducting masonry work.

3.7.4.4.1.1 Temperature

When the ambient temperature exceeds 100°F (38°C), or exceeds 90°F (32°C) with a wind velocity greater than 8 mph (3.5 m/s):

1. Necessary conditions and equipment shall be provided to produce mortar having a temperature below 120°F (49°C).
- 2.Sand piles shall bemaintained in a damp, loose condition.

3.7.4.4.1.2 Special conditions

When the ambient temperature exceeds 115°F (46°C), or 105°F (40°C) with a wind velocity greater than 8 mph (3.5 m/s), the requirements of Section 7.4.4.1.1 shall be implemented, and materials and mixing equipment shall beshaded from direct sunlight.

3.7.4.4.2 Construction

The following requirements shall be met while masonry work is in progress.

3.7.4.4.2 Temperature

When the ambient temperature exceeds 100°F (38°C), or exceeds 90°F (32°C) with a wind velocity greater than 8 mph (3.5 m/s):

1. The temperature of mortar and grout shall be maintained below 120°F (49°C).
2. Mixers, mortar transport containers and mortar boards shall be flushed with cool water before they come into contact with mortar ingredients or mortar.
3. Mortar consistency shall be maintained by retempering with cool water.
- 4.Mortar shall be used within 2 hours of initial mixing.
5. Thin-bed mortar shall be spread no more than 4 feet (1219 mm) ahead of AAC masonry units.

6. AAC masonry units shall be placed within one minute after spreading thin-bed mortar.

3.7.4.4.2.2 Special conditions

When the ambient temperature exceeds 115°F (46°C), or exceeds 105°F (40°C) with a wind velocity greater than 8 mph (3.5 m/s), the requirements of Section 3.7.4.4.2.1 shall be implemented and cool mixing water shall be used for mortar and grout. The use of ice shall be permitted in the mixing water prior to use. Ice shall not be permitted in the mixing water when added to the other mortar or grout materials.

3.7.4.4.3 Protection

When the mean daily temperature exceeds 100°F (38°C) or exceeds 90°F (32°C) with a wind velocity greater than 8 mph (3.5 m/s), newly constructed masonry shall be fog sprayed until damp at least three times a day until the masonry is three days old.

3.7.4.5 Wetting of Brick

Brick (clay or shale) at the time of laying shall require wetting if the unit's initial rate of water absorption exceeds 30 grams per 30 square inches (19355 mm²) per minute or 0.035 ounce per square inch (1 g/645 mm²) per minute, as determined by ASTM C 67.

3.7.5 Quality Assurance

3.7.5.1 General

A quality assurance program shall be used to ensure that the constructed masonry is in compliance with the construction documents. The quality assurance program shall comply with the inspection and testing requirements specified.

3.7.5.2 Acceptance Relative to Strength Requirements

3.7.5.2.1 Compliance with f'_m and f'_{AAC} . Compressive strength of masonry shall be considered satisfactory if the compressive strength of each masonry wythe and grouted collar joint equals or exceeds the value of f'_m for clay and concrete masonry and f'_{AAC} for AAC masonry. For partially grouted clay and concrete masonry, the compressive strength of both the grouted and ungrouted masonry shall equal or exceed the applicable f'_m . At the time of prestress, the compressive strength of the masonry shall equal or exceed f'_{mi} , which shall be less than or equal to f'_m .

3.7.5.2.2 Determination of compressive strength

The compressive strength for each wythe shall be determined by the unit strength method or by the prism test method as specified herein.

3.7.5.2.2.1 Unit strength method

3.7.5.2.2.1.1 Clay masonry

The compressive strength of masonry shall be determined based on the strength of the units and the type of mortar specified using Table 7.5, provided:

1. Units conform to ASTM C 62, ASTM C 216 or ASTM C 652 and

are sampled and tested in accordance with ASTM C 67.

2. Thickness of bed joints does not exceed 5/8 inch (15.9 mm).
3. For grouted masonry, the grout meets one of the following requirements:
 - 3.1. Grout conforms to ASTM C 476.
 - 3.2. Minimum grout compressive strength equals or exceeds f'_m but not less than 2,000 psi (13.79 MPa). The compressive strength of grout shall be determined in accordance with ASTM C 1019.

TABEL 3.7.5 COMPRESSIVE STRENGTH OF CLAY MASONRY

NET AREA COMPRESSIVE STRENGTH OF CLAY MASONRY UNITS (psi)		NET AREA COMPRESSIVE STRENGTH OF MASONRY (psi)
Type M or S mortar	Type N mortar	
1,700	2,100	1,000
3,350	4,150	1,500
4,950	6,200	2,000
6,600	8,250	2,500
8,250	10,300	3,000
9,900	—	3,500
13,200	—	4,000

For SI: 1 pound per square inch = 0.00689 MPa.

3.7.5.2.1.2 Concrete masonry

The compressive strength of masonry shall be determined based on the strength of the unit and type of mortar specified using Table 7.6, provided:

1. Units conform to ASTM C 55 or ASTM C 90 and are sampled and tested in accordance with ASTM C 140.
2. Thickness of bed joints does not exceed 5/8 inch (15.9 mm).
3. For grouted masonry, the grout meets one of the following requirements:
 - 3.1. Grout conforms to ASTM C 476.
 - 3.2. Minimum grout compressive strength equals or exceeds f'_m but not less than 2,000 psi (13.79 MPa). The compressive strength of grout shall be determined in accordance with ASTM C 1019.

TABEL 3.7.6 COMPRESSIVE STRENGTH OF CONCRETE MASONRY

NET AREA COMPRESSIVE STRENGTH OF CONCRETE MASONRY UNITS (psi)		NET AREA COMPRESSIVE STRENGTH OF MASONRY (psi) ^a
Type M or S mortar	Type N mortar	
1,250	1,300	1,000

1,900	2,150	1,500
2,800	3,050	2,000
3,750	4,050	2,500
4,800	5,250	3,000

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 0.00689 MPa.

a. For units less than 4 inches in height, 85 percent of the values listed.

3.7.5.2.2.1.3 AAC masonry

The compressive strength of AAC masonry shall be based on the strength of the AAC masonry unit only and the following shall be met:

1. Units conform to ASTM C 1386.
2. Thickness of bed joints does not exceed 1/8 inch (3.2 mm).
3. For grouted masonry, the grout meets one of the following requirements:
 - 3.1. Grout conforms to ASTM C 476.
 - 3.2. Minimum grout compressive strength equals or exceeds f'_{AAC} but not less than 2,000 psi (13.79 MPa). The compressive strength of grout shall be determined in accordance with ASTM C 1019.

3.7.5.2.2.2 Prism test method

3.7.5.2.2.2.1 General

The compressive strength of clay and concrete masonry shall be determined by the prism test method:

1. Where specified in the construction documents.
2. Where masonry does not meet the requirements for application of the unit strength method in Section 3.7.5.2.2.1.

3.7.5.2.2.2.2 Number of prisms per test

A prism test shall consist of three prisms constructed and tested in accordance with ASTM C 1314.

3.7.5.3 Testing Prisms from Constructed Masonry

When approved by the building official, acceptance of masonry that does not meet the requirements of Section 3.7.5.2.2.1 or 3.7.5.2.2.2 shall be permitted to be based on tests of prisms cut from the masonry construction in accordance with Sections 3.7.5.3.1, 3.7.5.3.2 and 3.7.5.3.3

3.7.5.3.1 Prism Sampling and Removal

A set of three masonry prisms that are at least 28 days old shall be saw cut from the masonry for each 5,000 square feet (465 m²) of the wall area that is in question but not

less than one set of three masonry prisms for the project. The length, width and height dimensions of the prisms shall comply with the requirements of ASTM C 1314. Transporting, preparation and testing of prisms shall be in accordance with ASTM C1314.

3.7.5.3.2 Compressive strength calculations

The compressive strength of prisms shall be the value calculated in accordance ASTM C 1314, except that the net cross-sectional area of the prism shall be based on the net mortar bedded area.

3.7.5.3.3 Compliance

Compliance with the requirement for the specified compressive strength of masonry, f'_m , shall be considered satisfied provided the modified compressive strength equals or exceeds the specified f'_m . Additional testing of specimens cut from locations in question shall be permitted.

3.7.6 Seismic Design

3.7.6.1 Seismic Design Requirements for Masonry

Masonry structures and components shall comply with the requirements in Section 3.1.14.2.2 and Section 3.1.14.3, 3.1.14.4, 3.1.14.5, 3.1.14.6 or 3.1.14.7 of ACI 530/ASCE 5/TMS 402 depending on the structure's Seismic Design Category. All masonry walls, unless isolated on three edges from in-plane motion of the basic structural systems, shall be considered to be part of the seismic-force-resisting system. In addition, the following requirements shall be met.

3.7.6.1.1 Basic seismic-force-resisting system

Buildings relying on masonry shear walls as part of the basic seismic-force-resisting system shall comply with Section 3.1.14.2.2 of ACI 530/ASCE 5/TMS 402 or with Section 3.7.6.1.1.1, 3.7.6.1.1.2 or 3.7.6.1.1.3

3.7.6.1.1.1 Ordinary plain prestressed masonry shear walls

Ordinary plain prestressed masonry shear walls shall comply with the requirements of Chapter 4 of ACI 530/ASCE 5/TMS 402.

3.7.6.1.1.2 Intermediate prestressed masonry shear walls

Intermediate prestressed masonry shear walls shall comply with the requirements of Section 3.1.14.2.2.4 of ACI 530/ASCE 5/TMS 402 and shall be designed by Chapter 4, Section 3.4.4.3, of ACI 530/ASCE 5/TMS 402 for flexural strength and by Section 3.3.3.4.1.2 of ACI 530/ASCE 5/TMS 402 for shear strength. Sections 3.1.14.2.2.5, 3.3.3.3.5 and 3.3.3.4.3.2(c) of ACI 530/ASCE 5/TMS 402 shall be applicable for reinforcement. Flexural elements subjected to load reversals shall be symmetrically reinforced. The nominal moment strength at any section along a member shall not be less than one-fourth the maximum moment strength. The cross-sectional area of bonded tendons shall be considered to contribute to the minimum reinforcement in Section 3.1.14.2.2.4 of ACI 530/ASCE 5/TMS 402. Tendons shall be located in cells that are grouted the full height of the wall.

3.7.6.1.1.3 Special prestressed masonry shear walls

Special prestressed masonry shear walls shall comply with the requirements of Section 3.1.14.2.2.5 of ACI 530/ASCE 5/TMS 402 and shall be designed by Chapter 4, Section 3.4.4.3, of ACI 530/ASCE 5/TMS 402 for flexural strength and by Section 3.3.3.4.1.2 of ACI 530/ASCE 5/TMS 402 for shear strength. Sections 3.1.14.2.2.5(a), 3.3.3.3.5 and 3.3.3.4.3.2(c) of ACI 530/ASCE 5/TMS 402 shall be applicable for reinforcement. Flexural elements subjected to load reversals shall be symmetrically reinforced. The nominal moment strength at any section along a member shall not be less than one-fourth the maximum moment strength. The cross-sectional area of bonded tendons shall be considered to contribute to the minimum reinforcement in Section 3.1.14.2.2.5 of ACI 530/ASCE 5/TMS 402.

3.7.6.1.1.3.1 Prestressing tendons

Prestressing tendons shall consist of bars conforming to ASTM A722.

3.7.6.1.1.3.2 Grouting

All cells of the masonry wall shall be grouted.

3.7.6.2 Anchorage of Masonry Walls

Masonry walls shall be anchored to the roof and floors that provide lateral support for the wall in accordance with Section 1604.8.2.

3.7.6.3 Seismic Design Category B

Structures assigned to Seismic Design Category B shall conform to the requirements of Section 3.1.14.4 of ACI 530/ASCE 5/TMS 402 and to the additional requirements of this Section.

3.7.6.3.1 Masonry walls not part of the lateral-force-resisting system

Masonry partition walls, masonry screen walls and other masonry elements that are not designed to resist vertical or lateral loads, other than those induced by their own mass, shall be isolated from the structure so that the vertical and lateral forces are not imparted to these elements. Isolation joints and connectors between these elements and the structure shall be designed to accommodate the design story drift.

3.7.6.4 Additional Requirements for Structures in Seismic Design Category C

Structures assigned to Seismic Design Category C shall conform to the requirements of Section 3.7.6.3, Section 3.1.14.5 of ACI 530/ASCE 5/TMS 402 and the additional requirements of this Section.

3.7.6.4.1 Design of discontinuous members that are part of the lateral-force-resisting system

Columns and pilasters that are part of the lateral-force-resisting system and that support reactions from discontinuous stiff members such as walls shall be provided with transverse reinforcement spaced at no more than one-fourth of the least nominal dimension of the column or pilaster. The minimum transverse reinforcement ratio shall be 0.0015. Beams supporting reactions from discontinuous walls or frames shall be provided

with transverse reinforcement spaced at no more than one-half of the nominal depth of the beam. The minimum transverse reinforcement ratio shall be 0.0015.

3.7.6.5 Additional requirements for structures in Seismic Design Category D

Structures assigned to Seismic Design Category D shall conform to the requirements of Section 3.7.6.4, Section 3.1.14.6 of ACI 530/ASCE 5/TMS 402 and the additional requirements of this Section.

3.7.6.5.1 Loads for shear walls designed by the working stress design method

When calculating in-plane shear or diagonal tension stresses by the working stress design method, shear walls that resist seismic forces shall be designed to resist 1.5 times the seismic forces. The 1.5 multiplier need not be applied to the overturning moment.

3.7.6.5.2 Shear wall shear strength

For a shear wall whose nominal shear strength exceeds the shear corresponding to development of its nominal flexural strength, two shear regions exist.

For all cross sections within a region defined by the base of the shear wall and a plane at a distance L_w above the base of the shear wall, the nominal shear strength shall be determined by Equation (7.1).

$$V_n = A_n \rho_n f_y \quad \text{Eq. (7.1)}$$

The required shear strength for this region shall be calculated at a distance $L_w/2$ above the base of the shear wall, but not to exceed one-half story height.

For the other region, the nominal shear strength of the shear wall shall be determined from Section 3.7.8.

3.7.6.6 Additional Requirements for Structures in Seismic Design Category E or F

Structures assigned to Seismic Design Category E or F shall conform to the requirements of Section 3.7.6.5 and Section 3.1.14.7 of ACI 530/ASCE 5/TMS 402.

3.7.7 Allowable Stress Design

3.7.7.1 General

The design of masonry structures using allowable stress design shall comply with Section 2106 and the requirements of Chapters 1 and 2 of ACI 530/ASCE 5/TMS 402 except as modified by Sections 3.7.7.2 through 3.7.7.8.

3.7.7.2 ACI 530/ASCE 5/TMS 402, Section 3.2.1.2, load combinations

Delete Section 3.2.1.2.1.

3.7.7.3 ACI 530/ASCE 5/TMS 402, Section 2.1.3, design strength

Delete Sections 3.2.1.3.4 through 3.2.1.3.4.3.

3.7.7.4 ACI 530/ASCE 5/TMS 402, Section 3.2.1.6, columns

Add the following text to Section 3.2.1.6:

3.2.1.6.6 Light-frame construction. Masonry columns used only to support light-frame roofs of carports, porches, sheds or similar structures with a maximum area of 450 square feet (41.8 m²) assigned to Seismic Design Category A, B or C are permitted to be designed and constructed as follows:

1. Concrete masonry materials shall be in accordance with Section 3.7.3.1 of this PART of the Code. Clay or shale masonry units shall be in accordance with Section 3.7.3.2 of this PART of the Code.
2. The nominal cross-sectional dimension of columns shall not be less than 8 inches (203 mm).
3. Columns shall be reinforced with not less than one No. 4 bar centered in each cell of the column.
4. Columns shall be grouted solid.
5. Columns shall not exceed 12 feet (3658 mm) in height.
6. Roofs shall be anchored to the columns. Such anchorage shall be capable of resisting the design loads specified in this PART of this Code.
7. Where such columns are required to resist uplift loads, the columns shall be anchored to their footings with two No. 4 bars extending a minimum of 24 inches (610 mm) into the columns and bent horizontally a minimum of 15 inches (381 mm) in opposite directions into the footings. One of these bars is permitted to be the reinforcing bar specified in Item 3 above. The total weight of a column and its footing shall not be less than 1.5 times the design uplift load.

3.7.7.5 ACI 530/ASCE 5/TMS 402, Section 3.2.1.10.7.1.1, lap splices

Modify Section 3.2.1.10.7.1.1 as follows:

3.2.1.10.7.1.1 The minimum length of lap splices for reinforcing bars in tension or compression, l_d , shall be

$$l_d = 0.002d_b f_s \quad \text{Eq. (7.2)}$$

For SI: $l_d = 0.29d_b f_s$

but not less than 12 inches (305 mm). In no case shall the length of the lapped splice be less than 40 bar diameters.

where:

d_b = Diameter of reinforcement, inches (mm).

f_s = Computed stress in reinforcement due to design loads, psi (MPa).

In regions of moment where the design tensile stresses in the reinforcement are greater than 80 percent of the allowable steel tension stress, F_s , the lap length of splices shall be increased not less than 50 percent of the minimum required length. Other equivalent means of stress transfer to accomplish the same 50 percent increase shall be permitted.

Where epoxy coated bars are used, lap length shall be increased by 50 percent.

3.7.7.6 ACI 530/ASCE 5/TMS 402, Section 3.2.1.10.7, splices of reinforcement

Modify Section 3.2.1.10.7 as follows:

3.2.1.10.7 Splices of reinforcement. Lap splices, welded splices or mechanical splices are permitted in accordance with the provisions of this section. All welding shall conform to AWS D1.4. Reinforcement larger than No. 9 (M#29) shall be spliced using mechanical connections in accordance with Section 2.1.10.7.3.

3.7.7.7 ACI 530/ASCE 5/TMS 402, Section 3.2.3.6, maximum bar size

Add the following to Chapter 3.2:

3.2.3.6 Maximum bar size. The bar diameter shall not exceed one-eighth of the nominal wall thickness and shall not exceed one-quarter of the least dimension of the cell, course or collar joint in which it is placed.

3.7.7.8 ACI 530/ASCE 5/TMS 402, Section 3.2.3.7, maximum reinforcement percentage

Add the following text to Chapter 3.2:

3.2.3.7 Maximum reinforcement percentage. Special reinforced masonry shear walls having a shear span ratio, M/Vd , equal to or greater than 1.0 and having an axial load, P , greater than $0.05 f'_m A_n$ that are subjected to in-plane forces shall have a maximum reinforcement ratio, ρ_{max} , not greater than that computed as follows:

$$\rho_{max} = \frac{nf'_m}{2f_y \left(n + \frac{f_y}{f'_m} \right)} \quad \text{Eq. (7.3)}$$

The maximum reinforcement ratio does not apply in the out-of-plane direction.

3.7.8 Strength Design of Masonry

3.7.8.1 General

The design of masonry structures using strength design shall comply with Section 3.7.6 and the requirements of Chapters 1 and 3 of ACI 530/ASCE 5/TMS 402, except as modified by Sections 3.7.8.2 through 3.7.8.4.

EXCEPTION: AAC masonry shall comply with the requirements of Chapter 1 and Appendix A of ACI 530/ASCE 5/TMS 402.

3.7.8.2 ACI 530/ASCE 5/TMS 402, Section 3.3.3.3.3 development

Add the following text to Section 3.3.3.3.3:

The required development length of reinforcement shall be determined by Equation (3-15), but shall not be less than 12 inches (305 mm) and need not be greater than $72 d_b$.

3.7.8.3 ACI 530/ASCE 5/TMS 402, Section 3.3.3.3.4, splices

Modify items (b) and (c) of Section 3.3.3.4 as follows:

3.3.3.4 (b). A welded splice shall have the bars butted and welded to develop at least 125 percent of the yield strength, f_y , of the bar in tension or compression, as required. Welded splices shall be of ASTM A706 steel reinforcement. Welded splices shall not be permitted in plastic hinge zones of

intermediate or special reinforced walls or special moment frames of masonry.

3.3.3.4 (c). Mechanical splices shall be classified as Type 1 or 2 according to Section 21.2.6.1 of ACI 318. Type 1 mechanical splices shall not be used within a plastic hinge zone or within a beam-column joint of intermediate or special reinforced masonry shear walls or special moment frames. Type 2 mechanical splices are permitted in any location within a member.

3.7.8.4 ACI 530/ASCE 5/TMS 402, Section 3.3.3.3.5, maximum areas of flexural tensile reinforcement

Add the following text to Section 3.3.3.3.5:

3.3.3.3.5.5 For special prestressed masonry shear walls, strain in all prestressing steel shall be computed to be compatible with a strain in the extreme tension reinforcement equal to five times the strain associated with the reinforcement yield stress, f_y . The calculation of the maximum reinforcement shall consider forces in the prestressing steel that correspond to these calculated strains.

3.7.9 Empirical Design of Masonry

3.7.9.1 General

Empirically designed masonry shall conform to this SECTION or Chapter 5 of ACI 530/ASCE 5/TMS 402.

3.7.9.1.1 Limitations

The use of empirical design of masonry shall be limited as follows:

1. Empirical design shall not be used for buildings assigned to Seismic Design Category D, E or F, nor for the design of the seismic-force-resisting system for buildings assigned to Seismic Design Category B or C.
2. Empirical design shall not be used for masonry elements that are part of the lateral force-resisting system where the basic wind speed exceeds 110 mph (79 m/s).
3. Empirical design shall not be used for interior masonry elements that are not part of the lateral-force-resisting system in buildings other than enclosed buildings as defined in Chapter 6 of ASCE 7 in:
 - 3.1. Buildings over 180 feet (55 100 mm) in height.
 - 3.2. Buildings over 60 feet (18 400 mm) in height where the basic wind speed exceeds 90 mph (40 m/s).
 - 3.3. Buildings over 35 feet (10 700 mm) in height where the basic wind speed exceeds 100 mph (45 m/s).
 - 3.4. Where the basic wind speed exceeds 110 mph (79 m/s).
4. Empirical design shall not be used for exterior masonry elements that are not part of the lateral-force-resisting system and that are more than 35 feet (10 700 mm) above ground:
 - 4.1. Buildings over 180 feet (55 100 mm) in height.
 - 4.2. Buildings over 60 feet (18 400 mm) in height where the basic wind

speed exceeds 90 mph (40 m/s).

4.3. Buildings over 35 feet (10 700 mm) in height where the basic wind speed exceeds 100 mph (45 m/s).

5. Empirical design shall not be used for exterior masonry elements that are less than or equal to 35 feet (10700 mm) above ground where the basic wind speed exceeds 110 mph (79 m/s).

6. Empirical design shall only be used when the resultant of gravity loads is within the centre third of the wall thickness and within the central area bounded by lines at one-third of each cross-sectional dimension of foundation piers.

7. Empirical design shall not be used for AAC masonry.

In buildings that exceed one or more of the above limitations, masonry shall be designed in accordance with the engineered design provisions of Section 3.7.7 or 3.7.8 or the foundation wall provisions of Section 1805.5.

3.7.9.2 Lateral Stability

3.7.9.2.1 Shear walls

Where the structure depends upon masonry walls for lateral stability, shear walls shall be provided parallel to the direction of the lateral forces resisted.

3.7.9.2.1.1 Cumulative length of shear walls

In each direction in which shear walls are required for lateral stability, shear walls shall be positioned in two separate planes. The minimum cumulative length of shear walls provided shall be 0.4 times the long dimension of the building. Cumulative length of shear walls shall not include openings or any element with a length that is less than one-half its height.

3.7.9.2.1.2 Maximum diaphragm ratio

Masonry shear walls shall be spaced so that the length-to-width ratio of each diaphragm transferring lateral forces to the shear walls does not exceed the values given in Table 3.7.7.

TABLE 3.7.7 DIAPHRAGM LENGTH-TO-WIDTH RATIOS

FLOOR OR ROOF DIAPHRAGM CONSTRUCTION	MAXIMUM LENGTH-TO-WIDTH RATIO OF DIAPHRAGM PANEL
Cast-in-place concrete	5:1
Precast concrete	4:1
Metal deck with concrete fill	3:1
Metal deck with no fill	2:1
Wood	2:1

3.7.9.2.2 Roofs

The roof construction shall be designed so as not to impart out-of-plane lateral thrust to the walls under roof gravity load.

3.7.9.2.3 Surface-bonded walls

Dry-stacked, surface-bonded concrete masonry walls shall comply with the requirements of this SECTION for masonry wall construction, except where otherwise noted in this Section.

3.7.9.2.3.1 Strength

Dry-stacked, surface-bonded concrete masonry walls shall be of adequate strength and proportions to support all superimposed loads without exceeding the allowable stresses listed in Table 3.7.8. Allowable stresses not specified in Table 3.7.8 shall comply with the requirements of ACI 530/ASCE 5/TMS 402.

**TABEL 3.7.8 ALLOWABLE STRESS GROSS CROSS-SECTIONAL AREA
FOR DRY-STACKED, SURFACE-BONDED CONCRETE MASONRY WALLS**

DESCRIPTION	MAXIMUM ALLOWABLE STRESS (psi)
Compression standard block	45
Flexural tension	
Horizontal span	30
Vertical span	18
Shear	10

For SI: 1 pound per square inch = 0.006895 MPa.

3.7.9.2.3.2 Construction

Construction of dry- stacked, surface-bonded masonry walls, including stacking and leveling of units, mixing and application of mortar and curing and protection shall comply with ASTM C 946.

3.7.9.3 Compressive Stress Requirements

3.7.9.3.1 Calculations

Compressive stresses in masonry due to vertical dead plus live loads, excluding wind or seismic loads, shall be determined in accordance with Section 3.7.9.3.2.1. Dead and live loads shall be as specified in this PART of the Code, with live load reductions as permitted in this Code.

3.7.9.3.2 Allowable compressive stresses

The compressive stresses in masonry shall not exceed the values given in Table 3.7.9. Stress shall be calculated based on specified rather than nominal dimensions.

3.7.9.3.2.1 Calculated compressive stresses

Calculated compressive stresses for single wythe walls and for multiwythe composite masonry walls shall be determined by dividing the design load by the gross cross-sectional area of the member. The area of openings, chases or recesses in walls shall not be included in the gross

cross-sectional area of the wall.

3.7.9.3.2.2 Multiwythe walls

The allowable stress shall be as given in Table 7.9 for the weakest combination of the units used in each wythe.

3.7.9.4 Lateral support

3.7.9.4.1 Intervals

Masonry walls shall be laterally supported in either the horizontal or vertical direction at intervals not exceeding those given in Table 3.7.10.

TABLE 3.7.10 WALL LATERAL SUPPORT REQUIREMENTS

CONSTRUCTION	MAXIMUM WALL LENGTH TO THICKNESS OR WALL HEIGHT TO THICKNESS
Bearing walls	
Solid units or fully grouted	20
All others	18
Nonbearing walls Exterior	18
Interior	36

3.7.9.4.2 Thickness

Except for cavity walls and cantilever walls, the thickness of a wall shall be its nominal thickness measured perpendicular to the face of the wall. For cavity walls, the thickness shall be determined as the sum of the nominal thicknesses of the individual wythes. For cantilever walls, except for parapets, the ratio of height-to-nominal thickness shall not exceed 6 for solid masonry or 4 for hollow masonry. For parapets, see Section 3.7.9.5.4.

3.7.9.4.3 Support elements

Lateral support shall be provided by cross walls, pilasters, buttresses or structural frame members when the limiting distance is taken horizontally, or by floors, roofs acting as diaphragms or structural frame members when the limiting distance is taken vertically.

3.7.9.5 Thickness of Masonry

Minimum thickness requirements shall be based on nominal dimensions of masonry.

3.7.9.5.1 Thickness of walls

The thickness of masonry walls shall conform to the requirements of Section 3.7.9.5.

3.7.9.5.2 Minimum thickness

3.7.9.5.2.1 Bearing walls

The minimum thickness of masonry bearing walls more than one storey high shall be 8 inches (203 mm). Bearing walls of one-storey buildings shall not be less

than 6 inches (152 mm) thick.

3.7.9.5.2.2 Rubble stone walls

The minimum thickness of rough, random or coursed rubble stone walls shall be 16 inches (406 mm).

3.7.9.5.2.3 Shear walls

The minimum thickness of masonry shear walls shall be 8 inches (203 mm).

3.7.9.5.2.4 Foundation walls

The minimum thickness of foundation walls shall be 8 inches (203 mm) and as required by Section 3.7.9.5.3.1.

TABEL 3.7.9 ALLOWABLE COMPRESSIVE STRESSES FOR EMPIRICAL DESIGN OF MASONRY

CONSTRUCTION; COMPRESSIVE STRENGTH OF UNIT GROSS AREA (psi)	ALLOWABLE COMPRESSIVE STRESSES ^a GROSS CROSS-SECTIONAL AREA (psi)	
	Type M or S mortar	Type N mortar
Solid masonry of brick and other solid units of clay or shale; sand-lime or concrete brick: 8,000 or greater 4,500 2,500 1,500	350 225 160 115	300 200 140 100
Grouted masonry, of clay or shale; sand- lime or concrete: 4,500 or greater 2,500 1,500	225 160 115	200 140 100
Solid masonry of solid concrete masonry units: 3,000 or greater 2,000 1,200	225 160 115	200 140 100
Masonry of hollow load-bearing units: 2,000 or greater 1,500 1,000 700	140 115 75 60	120 100 70 55
Hollow walls (non-composite masonry bonded) ^b Solid units: 2,500 or greater 1,500 Hollow units	160 115 75	140 100 70
Stone ashlar masonry: Granite Limestone or marble Sandstone or cast stone	720 450 360	640 400 320
Rubble stone masonry Coursed, rough or random	120	100

For SI: 1 pound per square inch = 0.006895 MPa.

a. Linear interpolation for determining allowable stresses for masonry units having compressive strengths which are in

mediate between those given in the table is permitted.

- b. Where floor and roof loads are carried upon new wythe, the gross cross-sectional area is that of the wythe under load; if both wythes are loaded, the gross cross-sectional area is that of the wall minus the area of the cavity between the wythes. Walls bonded with metal ties shall be considered as non-composite walls unless collar joints are filled with mortar or grout.

3.7.9.5.2.5 Foundation piers

The minimum thickness of foundation piers shall be 8 inches (203 mm).

3.7.9.5.2.6 Parapet walls

The minimum thickness of parapet walls shall be 8 inches (203 mm) and as required by Section 3.7.9.5.4.1.

3.7.9.5.2.7 Change in thickness

Where walls of masonry of hollow units or masonry bonded hollow walls are decreased in thickness, a course or courses of solid masonry shall be interposed between the wall below and the thinner wall above, or special units or construction shall be used to transmit the loads from face shells or wythes above to those below.

3.7.9.5.3 Foundation walls

Foundation walls shall comply with the requirements of Section 3.7.9.5.3.1 or 3.7.9.5.3.2.

3.7.9.5.3.1 Minimum thickness

Minimum thickness for foundation walls shall comply with the requirements of Table 3.7.11. The provisions of Table 3.7.11 are only applicable where the following conditions are met

1. The foundation wall does not exceed 8 feet (2438 mm) in height between lateral supports;
2. The terrain surrounding foundation walls is graded to drain surface water away from foundation walls;
3. Backfill is drained to remove ground water away from foundation walls;
4. Lateral support is provided at the top of foundation walls prior to backfilling;
5. The length of foundation walls between perpendicular masonry walls or pilasters is a maximum of three times the basement wall height;
6. The backfill is granular and soil conditions in the area are non-expansive; and
7. Masonry is laid in running bond using Type M or S mortar.

TABLE 3.7.11 FOUNDATION WALL CONSTRUCTION

WALL CONSTRUCTION	NOMINAL WALL THICKNESS (inches)	MAXIMUM DEPTH OF UNBALANCED BACKFILL (feet)
Fully grouted masonry	8	7
	10	8
	12	8
Hollow unit masonry	8	5
	10	6
	12	7
Solid unit masonry	8	5
	10	7
	12	7

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm

3.7.9.5.3.2 Design requirements

Where the requirements of Section 3.7.9.5.3.1 are not met, foundation walls shall be designed in accordance with PART 4 of this Code.

3.7.9.5.4 Parapet walls

3.7.9.5.4.1 Minimum thickness

The minimum thickness of unreinforced masonry parapets shall meet Section 3.7.9.5.2.6 and their height shall not exceed three times their thickness.

3.7.9.6 Bond

3.7.9.6.1 General

The facing and backing of multiwythe masonry walls shall be bonded in accordance with Section 3.7.9.6.2, 3.7.9.6.3, 3.7.9.6.4.

3.7.9.6.2 Bonding with masonry headers

3.7.9.6.2.1 Solid units

Where the facing and backing (adjacent wythes) of solid masonry construction are bonded by means of masonry headers, no less than 4 percent of the wall surface of each face shall be composed of headers extending not less than 3 inches (76 mm) into the backing. The distance between adjacent full-length headers shall not exceed 24 inches (610 mm) either vertically or horizontally. In walls in which a single header does not extend through the wall, headers from the opposite sides shall overlap at least 3 inches (76 mm), or headers from opposite sides shall be covered with another header course overlapping the header below at least 3 inches (76 mm).

3.7.9.6.2.2 Hollow units

Where two or more hollow units are used to make up the thickness of a wall, the stretcher courses shall be bonded at vertical intervals not exceeding 34 inches (864 mm) by lapping at least 3 inches (76 mm) over the unit below, or by lapping at vertical intervals not exceeding 17 inches (432 mm) with units that are at least 50 percent greater in thickness than the units below.

3.7.9.6.2.3 Masonry bonded hollow walls

In masonry bonded hollow walls, the facing and backing shall be bonded so that not less than 4 percent of the wall surface of each face is composed of masonry bonded units extending not less than 3 inches (76 mm) into the backing. The distance between adjacent bonders shall not exceed 24 inches (610 mm) either vertically or horizontally.

3.7.9.6.3 Bonding with wall ties or joint reinforcement

3.7.9.6.3.1 Bonding with wall ties

Except as required by Section 7.9.6.3.1.1, where the facing and backing (adjacent wythes) of masonry walls are bonded with wire size W2.8 (MW18) wall ties or metal wire of equivalent stiffness embedded in the horizontal mortar joints, there shall be at least one metal tie for each $4\frac{1}{2}$ square feet (0.42 m²) of wall area. The maximum vertical distance between ties shall not exceed 24 inches (610 mm), and the maximum horizontal distance shall not exceed 36 inches (914 mm). Rods or ties bent to rectangular shape shall be used with hollow masonry units laid with the cells vertical. In other walls, the ends of ties shall be bent to 90-degree (1.57 rad) angles to provide hooks no less than 2 inches (51 mm) long. Wall ties shall be without drips. Additional bonding ties shall be provided at all openings, spaced not more than 36 inches (914 mm) apart around the perimeter and within 12 inches (305 mm) of the opening.

3.7.9.6.3.1.1 Bonding with adjustable wall ties

Where the facing and backing (adjacent wythes) of masonry are bonded with adjustable wall ties, there shall be at least one tie for each 1.77 square feet (0.164 m²) of wall area. Neither the vertical nor horizontal spacing of the adjustable wall ties shall exceed 16 inches (406 mm). The maximum vertical offset of bed joints from one wythe to the other shall be $1\frac{1}{4}$ inches (32 mm). The maximum clearance between connecting parts of the ties shall be $1/16$ inch (1.6 mm). When pintle legs are used, ties shall have at least two wire size W2.8 (MW 18) legs.

3.7.9.6.3.2 Bonding with prefabricated joint reinforcement

Where the facing and backing (adjacent wythes) of masonry are bonded with prefabricated joint reinforcement, there shall be at least one cross wire serving as a tie for each $2\frac{2}{3}$ square feet (0.25 m²) of wall area. The vertical spacing of the joint reinforcing shall not exceed 24 inches (610 mm). Cross wires on prefabricated joint reinforcement shall not be less than W1.7 (MW11) and shall be without drips. The longitudinal wires shall be embedded in the mortar.

3.7.9.6.4 Bonding with natural or cast stone

3.7.9.6.4.1 Ashlar masonry

In ashlar masonry, bonder units, uniformly distributed, shall be provided to the extent of not less than 10 percent of the wall area. Such bonder units shall extend not less than 4 inches (102 mm) into the backing wall.

3.7.9.6.4.2 Rubble stone masonry

Rubble stone masonry 24 inches (610 mm) or less in thickness shall have bonders units with a maximum spacing of 36 inches (914 mm) vertically and 36 inches (914 mm) horizontally, and if the masonry is of greater thickness than 24 inches (610 mm), shall have one bonders unit for each 6 square feet (0.56 m²) of wall surface on both sides.

3.7.9.6.5 Masonry bonding pattern

3.7.9.6.5.1 Masonry laid in running bond

Each wythe of masonry shall be laid in running bond, head joints in successive courses shall be offset by not less than one-fourth the unit length or the masonry walls shall be reinforced longitudinally as required in Section 3.7.9.6.5.2.

3.7.9.6.5.2 Masonry laid in stack bond

Where unit masonry is laid with less head joint offset than in Section 3.7.9.6.5.1, the minimum area of horizontal reinforcement placed in mortar bed joints or in bond beams spaced not more than 48 inches (1219 mm) apart, shall be 0.0003 times the vertical cross-sectional area of the wall.

3.7.9.7 Anchorage

3.7.9.7.1 General

Masonry elements shall be anchored in accordance with Sections 3.7.9.7.2 through 3.7.9.7.4.

3.7.9.7.2 Intersecting walls

Masonry walls depending upon one another for lateral support shall be anchored or bonded at locations where they meet or intersect by one of the methods indicated in Sections 3.7.9.7.2.1 through 3.7.9.7.2.5.

3.7.9.7.2.1 Bonding pattern

Fifty percent of the units at the intersection shall be laid in an overlapping masonry bonding pattern, with alternate units having a bearing of not less than 3 inches (76 mm) on the unit below.

3.7.9.7.2.2 Steel connectors

Walls shall be anchored by steel connectors having a minimum section of ¼ inch (6.4 mm) by 1½ inches (38 mm), with ends bent up at least 2 inches (51 mm) or with cross pins to form anchorage. Such anchors shall be at least 24 inches (610 mm) long and the maximum spacing shall be 48 inches (1219 mm).

3.7.9.7.2.3 Joint reinforcement

Walls shall be anchored by joint reinforcement spaced at a maximum distance of 8 inches (203 mm). Longitudinal wires of such reinforcement shall be at least wire size W1.7 (MW11) and shall extend at least 30 inches (762 mm) in each direction at the intersection.

3.7.9.7.2.4 Interior non-load-bearing walls

Interior non-load-bearing walls shall be anchored at their intersection, at vertical intervals of not more than 16 inches (406 mm) with joint reinforcement or ¼-inch (6.4 mm) mesh galvanized hardware cloth.

3.7.9.7.2.5 Ties, joint reinforcement or anchors

Other metal ties, joint reinforcement or anchors, if used, shall be spaced to provide equivalent area of anchorage to that required by this Section.

3.7.9.7.3 Floor and roof anchorage

Floor and roof diaphragms providing lateral support to masonry shall comply with the live loads specified in this PART of the Code and shall be connected to the masonry in accordance with Sections 3.7.9.7.3.1 through 3.7.9.7.3.3. Roof loading shall be determined in accordance with PART 3 of this Code and, when net uplift occurs, uplift shall be resisted entirely by an anchorage system designed in accordance with

the provisions of Sections 3.2.1 and 3.2.3, Sections 3.3.1 and 3.3.3 or Chapter 4 of ACI 530/ASCE5/TMS 402.

3.7.9.7.3.1 Wood floor joists

Wood floor joists bearing on masonry walls shall be anchored to the wall at intervals not to exceed 72 inches (1829 mm) by metal strap anchors. Joists parallel to the wall shall be anchored with metal straps spaced not more than 72 inches (1829 mm) o.c. extending over or under and secured to at least three joists. Blocking shall be provided between joists at each strap anchor.

3.7.9.7.3.2 Steel floor joists

Steel floor joists bearing on masonry walls shall be anchored to the wall with 3/8-inch (9.5 mm) round bars, or their equivalent, spaced not more than 72 inches (1829 mm) o.c. Where joists are parallel to the wall, anchors shall be located at joist bridging.

3.7.9.7.3.3 Roof diaphragms

Roof diaphragms shall be anchored to masonry walls with ½-inch-diameter (12.7 mm) bolts, 72 inches (1829 mm) o.c. or their equivalent. Bolts shall extend and be embedded at least 15 inches (381 mm) into the masonry, or be hooked or welded to not less than 0.20 square inch (129 mm²) of bond beam reinforcement placed not less than 6 inches (152 mm) from the top of the wall.

3.7.9.7.4 Walls adjoining structural framing

Where walls are dependent upon the structural frame for lateral support, they shall be anchored to the structural members with metal anchors or otherwise keyed to the structural members. Metal anchors shall consist of ½-inch (12.7 mm) bolts spaced at 48 inches (1219 mm) o.c. embedded 4 inches (102 mm) into the masonry, or their equivalent area.

3.7.9.8 Adobe Construction

Adobe construction shall comply with this section and shall be subject to the requirements of this Section for Type V construction.

3.7.9.8.1 Unstabilized adobe

3.7.9.8.1.1 Compressive strength

Adobe units shall have an average compressive strength of 300 psi (2068 kPa) when tested in accordance with ASTM C 67. Five samples shall be tested and no individual unit is permitted to have a compressive strength of less than 250 psi (1724 kPa).

3.7.9.8.1.2 Modulus of rupture

Adobe units shall have an average modulus of rupture of 50 psi (345 kPa) when tested in accordance with the following procedure. Five samples shall be tested and no individual unit shall have a modulus of rupture of less than 35 psi (241 kPa).

3.7.9.8.1.2.1 Support conditions

A cured unit shall be simply supported by 2-inch-diameter (51 mm) cylindrical supports located 2 inches (51 mm) in from each end and extending the full width of the unit.

3.7.9.8.1.2.2 Loading conditions

A 2-inch-diameter (51 mm) cylinder shall be placed at midspan parallel to the supports.

3.7.9.8.1.2.3 Testing procedure

A vertical load shall be applied to the cylinder at the rate of 500 pounds per minute (37 N/s) until failure occurs.

3.7.9.8.1.2.4 Modulus of rupture determination

The modulus of rupture shall be determined by the equation:

$$f_r = 3WL_s / 2bt^2 \quad \text{Eq. (7.4)}$$

where, for the purposes of this section only:

b = Width of the test specimen measured parallel to the loading cylinder, inches (mm).

f_r = Modulus of rupture, psi (MPa).

L_s = Distance between supports, inches (mm).

t = Thickness of the test specimen measured parallel to the direction of load, inches (mm).

W = The applied load at failure, pounds (N).

3.7.9.8.1.3 Moisture content requirements

Adobe units shall have a moisture content not exceeding 4 percent by weight.

3.7.9.8.1.4 Shrinkage cracks

Adobe units shall not contain more than three shrinkage cracks and any single shrinkage crack shall not exceed 3 inches (76 mm) in length or 1/8

inch (3.2 mm) in width.

3.7.9.8.2 Stabilized adobe

3.7.9.8.2.1 Material requirements

Stabilized adobe shall comply with the material requirements of unstabilized adobe in addition to Sections 3.7.9.8.2.1.1 and 3.7.9.8.2.1.2.

3.7.9.8.2.1.1 Soil requirements

Soil used for stabilized adobe units shall be chemically compatible with the stabilizing material.

3.7.9.8.2.1.2 Absorption requirements

A 4-inch (102 mm) cube, cut from a stabilized adobe unit dried to a constant weight in a ventilated oven at 212°F to 239°F (100°C to 115°C), shall not absorb more than 2½ percent moisture by weight when placed upon a constantly water-saturated, porous surface for seven days. A minimum of five specimens shall be tested and each specimen shall be cut from a separate unit.

3.7.9.8.3 Allowable stress

The allowable compressive stress based on gross cross-sectional area of adobe shall not exceed 30 psi (207 kPa).

3.7.9.8.3.1 Bolts

Bolt values shall not exceed those set forth in Table 3.7.12.

3.7.9.8.4 Construction

3.7.9.8.4.1 General

3.7.9.8.4.1.1 Height restrictions

Adobe construction shall be limited to buildings not exceeding one story, except that two-story construction is allowed when designed by a registered design professional.

3.7.9.8.4.1.2 Mortar restrictions

Mortar for stabilized adobe units shall comply with this Section or adobe soil. Adobe soil used as mortar shall comply with material requirements for stabilized adobe. Mortar for unstabilized adobe shall be Portland cement mortar.

TABLE 3.7.12 ALLOWABLE SHEAR ON BOLTS IN ADOBE MASONRY

DIAMETER OF BOLTS (inches)	MINIMUM EMBEDMENT (inches)	SHEAR (pounds)
1/2	—	—
5/8	12	200
3/4	15	300
7/8	18	400
1	21	500
1 1/8	24	600

For SI: 1 inch = 25.4 mm, 1 pound = 4.448 N.

3.7.9.8.4.1.3 Mortar joints

Adobe units shall be laid with full head and bed joints and in full running bond.

3.7.9.8.4.1.4 Parapetwalls

Parapet walls constructed of adobe units shall be waterproofed.

3.7.9.8.4.2 Wall thickness

The minimum thickness of exterior walls in one-story buildings shall be 10 inches (254 mm). The walls shall be laterally supported at intervals not exceeding 24 feet (7315 mm). The minimum thickness of interior load-bearing walls shall be 8 inches (203 mm). In no case shall the unsupported height of any wall constructed of adobe units exceed 10 times the thickness of such wall.

3.7.9.8.4.3 Foundations

3.7.9.8.4.3.1 Foundation support

Walls and partitions constructed of adobe units shall be supported by foundations or footings that extend not less than 6 inches (152 mm) above adjacent ground surfaces and are constructed of solid masonry (excluding adobe) or concrete. Footings and foundations shall comply with PART 4 of this Code.

3.7.9.8.4.3.2 Lower course requirements

Stabilized adobe units shall be used in adobe walls for the first 4 inches (102 mm) above the finished first-floor elevation.

3.7.9.8.4.4 Isolated piers or columns

Adobe units shall not be used for isolated piers or columns in a load-bearing capacity. Walls less than 24 inches (610 mm) in length shall be considered isolated piers or columns.

3.7.9.8.4.5 Tie beams

Exterior walls and interior load-bearing walls constructed of adobe units shall have a continuous tie beam at the level of the floor or roof bearing and meeting the following requirements.

3.7.9.8.4.5.1 Concrete tie beams

Concrete tie beams shall be a minimum depth of 6 inches (152 mm) and a minimum width of 10 inches (254 mm). Concrete tie beams shall be continuously reinforced with a minimum of two No. 4 reinforcing bars. The ultimate compressive strength of concrete shall be at least 2,500 psi (17.2 MPa) at 28 days.

3.7.9.8.4.5.2 Wood tie beams

Wood tie beams shall be solid or built up of lumber having a minimum nominal thickness of 1 inch (25 mm), and shall have a minimum depth of 6 inches (152 mm) and a minimum width of 10 inches (254 mm). Joints in

wood tie beams shall be spliced a minimum of 6 inches (152 mm). Nosplices shall be allowed within 12 inches (305 mm) of an opening. Wood used in tie beams shall be approved naturally decay-resistant or pressure-treated wood.

3.7.9.8.4.6 Exterior finish

Exterior walls constructed of unstabilized adobe units shall have their exterior surface covered with a minimum of two coats of Portland cement plaster having a minimum thickness of 3/4 inch (19.1 mm) and conforming to ASTM C 926. Lathing shall comply with ASTM C 1063. Fasteners shall be spaced at 16 inches (406 mm) o.c. maximum. Exposed wood surfaces shall be treated with an approved wood preservative or other protective coating prior to lath application.

3.7.9.8.4.7 Lintels

Lintels shall be considered structural members and shall be designed in accordance with the applicable provisions of this PART of this Code.

3.7.10 Glass Unit Masonry

3.7.10.1 Scope

This section covers the empirical requirements for non-load-bearing glass unit masonry elements in exterior or interior walls.

3.7.10.1.1 Limitations

Solid or hollow approved glass block shall not be used in fire walls, party walls, fire barriers or fire partitions, or for load-bearing construction. Such blocks shall be erected with mortar and reinforcement in metal channel-type frames, structural frames, masonry- or concrete recesses, embedded panel anchors as provided for both exterior and interior walls or other approved joint materials. Wood strip framing shall not be used in walls required to have a fire-resistance rating by other provisions of this Code.

EXCEPTIONS:

1. Glass-block assemblies having a fire protection rating of not less than 3/4 hour shall be permitted as opening protectives in fire barriers and fire partitions that have a required fire-resistance rating of 1 hour or less and do not enclose exit stairways or exit passageways.
2. Glass-block assemblies.

3.7.10.2 Units

Hollow or solid glass-block units shall be standard or thin units.

3.7.10.2.1 Standard units

The specified thickness of standard units shall be at least $3\frac{7}{8}$ inches (98 mm).

3.7.10.2.2 Thin units

The specified thickness of thin units shall be $3\frac{1}{8}$ inches (79 mm) for hollow units or 3 inches (76 mm) for solid units.

3.7.10.3 Panel size

3.7.10.3.1 Exterior standard-unit panels

The maximum area of each individual exterior standard-unit panel shall be 144 square feet (13.4 m^2) when the design wind pressure is 20 psf (958 N/m^2). The maximum panel dimension between structural supports shall be 25 feet (7620 mm) in width or 20 feet (6096 mm) in height. The panel areas are permitted to be adjusted in accordance with Figure 3.7.1 for other wind pressures.

3.7.10.3.2 Exterior thin-unit panels

The maximum area of each individual exterior thin-unit panel shall be 85 square feet (7.9 m^2). The maximum dimension between structural supports shall be 15 feet (4572 mm) in width or 10 feet (3048 mm) in height. Thin units shall not be used in applications where the design wind pressure exceeds 20 psf (958 N/m^2).

3.7.10.3.3 Interior panels

The maximum area of each individual standard-unit panel shall be 250 square feet (23.2 m^2). The maximum area of each thin-unit panel shall be 150 square feet (13.9 m^2). The maximum dimension between structural supports shall be 25 feet (7620 mm) in width or 20 feet (6096 mm) in height.

3.7.10.3.4 Solid units

The maximum area of solid glass-block wall panels in both exterior and interior walls shall not be more than 100 square feet (9.3 m^2).

3.7.10.3.5 Curved panels

The width of curved panels shall conform to the requirements of Sections 7.10.3.1, 7.10.3.2 and 7.10.3.3, except additional structural supports shall be provided at locations where a curved section joins a straight section, and at inflection points in multi-curved walls.

3.7.10.4 Support

3.7.10.4.1 General requirements

Glass unit masonry panels shall be isolated so that in-plane loads are not imparted to the panel.

3.7.10.4.2 Vertical

Maximum total deflection of structural members supporting glass unit masonry shall not exceed $l/600$.

3.7.10.4.2.1 Support on wood construction

Glass unit masonry having an installed weight of 40 psf (195 kg/m^2) or less and a maximum height of 12 feet (3658 mm) shall be permitted to be supported on wood construction.

3.7.10.4.2.2 Expansion Joint

A vertical expansion joint in glass unit masonry shall be provided to isolate the glass unit masonry supported by wood construction from that supported by other types of construction.

3.7.10.4.3 Lateral

Glass unit masonry panels more than one unit wide or one unit high shall be laterally supported along their tops and sides. Lateral support shall be provided by panel anchors along the top and sides spaced not more than 16 inches (406 mm) o.c. or by channel-type restraints. Glass unit masonry panels shall be recessed at least 1 inch (25 mm) within channels and chases. Channel-type restraints shall be oversized to accommodate expansion material in the opening and packing and sealant between the framing restraints and the glass unit masonry perimeter units. Lateral supports for glass unit masonry panels shall be designed to resist applied loads, or a minimum of 200 pounds per lineal foot (plf) (2919 N/m) of panel, whichever is greater.

EXCEPTIONS:

1. Lateral support at the top of glass unit masonry panels that are no more than one unit wide shall not be required.
2. Lateral support at the sides of glass unit masonry panels that are no more than one unit high shall not be required.

3.7.10.4.3.1 Single unit panels

Single unit glass unit masonry panels shall conform to the requirements of Section 3.7.10.4.3, except lateral support shall not be provided by panel anchors.

3.7.10.5 Expansion Joints

Glass unit masonry panels shall be provided with expansion joints along the top and sides at structural supports. Expansion joints shall have sufficient thickness to accommodate displacements of the supporting structure, but shall not be less than 3/8 inch (9.5 mm) in thickness. Expansion joints shall be entirely free of mortar or other debris and shall be filled with resilient material. The sills of glass-block panels shall be coated with approved water-based asphaltic emulsion, or other elastic waterproofing material, prior to laying the first mortar course.

3.7.10.6 Mortar

Mortar for glass unit masonry shall comply with Section 3.7.3.8.

3.7.10.7 Reinforcement

Glass unit masonry panels shall have horizontal joint reinforcement spaced not more than 16 inches (406 mm) on centre, located in the mortar bed joint, and extending the entire length of the panel but not across expansion joints. Longitudinal wires shall be lapped a minimum of 6 inches (152 mm) at splices. Joint reinforcement shall be placed in the bed joint immediately below and above openings in the panel. The reinforcement shall have not less than two parallel longitudinal wires of size W1.7 (MW11), and have welded cross wires of size W1.7 (MW11).

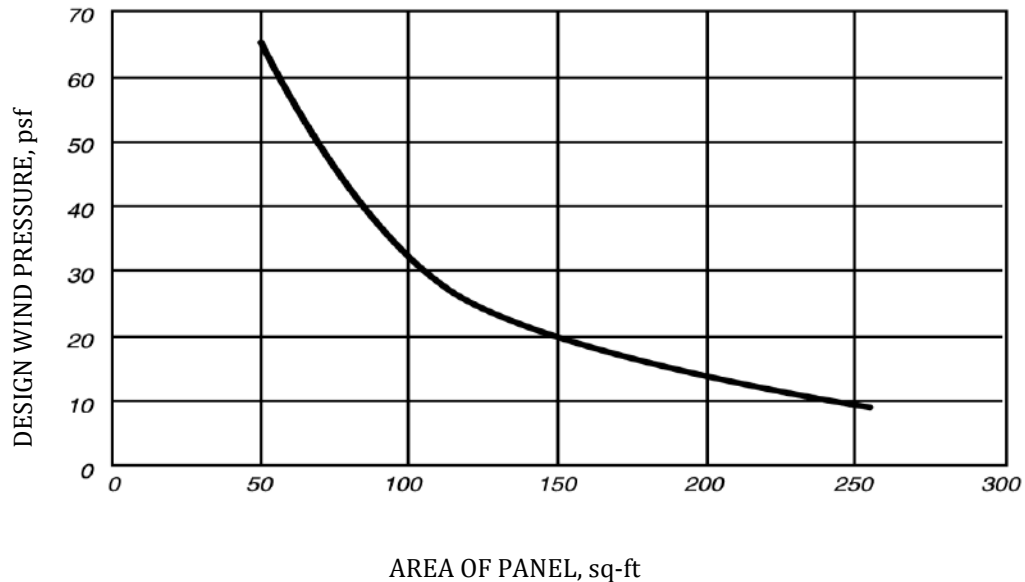
3.7.11 Masonry Fireplaces

3.7.11.1 Definition

A masonry fireplace is a fireplace constructed of concrete or masonry. Masonry fireplaces shall be constructed in accordance with this Section.

3.7.11.2 Footings and Foundations

Footings for masonry fire-places and their chimneys shall be constructed of concrete or solid masonry at least 12 inches (305 mm) thick and shall extend at least 6 inches (153 mm) beyond the face of the fire- place or foundation wall on all sides. Footings shall be founded on natural undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be at least 12 inches (305 mm) below finished grade.



For SI: 1 square foot = 0.0929 m², 1 pound per square foot = 47.9 N/m².

FIGURE 3.7.1

GLASS MASONRY DESIGN WIND LOAD RESISTANCE

3.7.11.2.1 Ash dump cleanout

Cleanout openings, located within foundation walls below fireboxes, when provided, shall be equipped with ferrous metal or masonry doors and frames constructed to remain tightly closed, except when in use. Cleanouts shall be accessible and located so that ash removal will not create a hazard to combustible materials.

3.7.11.3 Seismic Reinforcing

Masonry or concrete fireplaces shall be constructed, anchored, supported and reinforced as required in this Section. In Seismic Design Category D, masonry and concrete fireplaces shall be reinforced and anchored as detailed in Sections 3.7.11.3.1, 3.7.11.3.2, 3.7.11.4 and 3.7.11.4.1 for chimneys serving fireplaces. In Seismic Design Category A, B or C, reinforcement and seismic anchorage is not required. In Seismic Design Category E or F, masonry and concrete chimneys shall be reinforced in accordance with the requirements of Sections 3.7.1 through 3.7.8.

3.7.11.3.1 Vertical reinforcing

For fireplaces with chimneys up to 40 inches (1016 mm) wide, four No. 4 continuous vertical bars, anchored in the foundation, shall be placed in the concrete between wythes of solid masonry or within the cells of hollow unit masonry and grouted in accordance

with Section 3.11.3.12. For fireplaces with chimneys greater than 40 inches (1016 mm) wide, two additional No. 4 vertical bars shall be provided for each additional 40 inches (1016 mm) in width or fraction thereof.

3.7.11.3.2 Horizontal reinforcing

Vertical reinforcement shall be placed enclosed within 1/4-inch (6.4 mm) ties or other reinforcing of equivalent net cross-sectional area, spaced not to exceed 18 inches (457 mm) on centre in concrete; or placed in the bed joints of unit masonry at a minimum of every 18 inches (457 mm) of vertical height. Two such ties shall be provided at each bend in the vertical bars.

3.7.11.4 Seismic Anchorage

Masonry and concrete chimneys in Seismic Design Category D shall be anchored at each floor, ceiling or roof line more than 6 feet (1829 mm) above grade, except where constructed completely within the exterior walls. Anchorage shall conform to the following requirements.

3.7.11.4.1 Anchorage

Two 3/16-inch by 1-inch (4.8 mm by 25.4 mm) straps shall be embedded a minimum of 12 inches (305 mm) into the chimney. Straps shall be hooked around the outer bars and extend 6 inches (152 mm) beyond the bend. Each strap shall be fastened to a minimum of four floor joists with two 1/2-inch (12.7 mm) bolts.

3.7.11.5 Firebox Walls

Masonry fireboxes shall be constructed of solid masonry units, hollow masonry units grouted solid, stone or concrete. When a lining of firebrick at least 2 inches (51 mm) in thickness or other approved lining is provided, the minimum thickness of back and sidewalls shall each be 8 inches (203 mm) of solid masonry, including the lining. The width of joints between firebricks shall not be greater than 1/4 inch (6.4 mm). When no lining is provided, the total minimum thickness of back and sidewalls shall be 10 inches (254 mm) of solid masonry. Firebrick shall conform to ASTM C 27 or ASTM C 1261 and shall be laid with medium-duty refractory mortar conforming to ASTM C 199.

3.7.11.5.1 Steel fireplace units

Steel fireplace units are permitted to be installed with solid masonry to form a masonry fireplace provided they are installed according to either the requirements of their listing or the requirements of this section. Steel fireplace units incorporating a steel firebox lining shall be constructed with steel not less than 1/4 inch (6.4 mm) in thickness, and an air-circulating chamber which is ducted to the interior of the building. The firebox lining shall be encased with solid masonry to provide a total thickness at the back and sides of not less than 8 inches (203 mm), of which not less than 4 inches (102 mm) shall be of solid masonry or concrete. Circulating air ducts employed with steel fireplace units shall be constructed of metal or masonry.

3.7.11.6 Firebox Dimensions

The firebox of a concrete or masonry fireplace shall have a minimum depth of 20 inches (508 mm). The throat shall not be less than 8 inches (203 mm) above the fireplace opening. The throat opening shall not be less than 4 inches (102 mm) in

depth. The cross-sectional area of the passageway above the firebox, including the throat, damper and smoke chamber, shall not be less than the cross-sectional area of the flue.

EXCEPTION:

Rumford fireplaces shall be permitted provided that the depth of the fireplace is at least 12 inches (305 mm) and at least one-third of the width of the fireplace opening, and the throat is at least 12 inches (305 mm) above the lintel, and at least 1/20 the cross-sectional area of the fireplace opening.

3.7.11.7 Lintel and Throat

Masonry over a fireplace opening shall be supported by a lintel of noncombustible material. The minimum required bearing length on each end of the fireplace opening shall be 4 inches (102 mm). The fireplace throat or damper shall be located a minimum of 8 inches (203 mm) above the top of the fireplace opening.

3.7.11.7.1 Damper

Masonry fireplaces shall be equipped with a ferrous metal damper located at least 8 inches (203 mm) above the top of the fireplace opening. Dampers shall be installed in the fireplace or at the top of the flue venting the fireplace, and shall be operable from the room containing the fireplace. Damper controls shall be permitted to be located in the fireplace.

3.7.11.8 Smoke Chamber Walls

Smoke chamber walls shall be constructed of solid masonry units, hollow masonry units grouted solid, stone or concrete. Corbeling of masonry units shall not leave unit

cores exposed to the inside of the smoke chamber. The inside surface of corbeled masonry shall be parged smooth. Where no lining is provided, the total minimum thickness of front, back and sidewalls shall be 8 inches (203 mm) of solid masonry. When a lining of firebrick at least 2 inches (51 mm) thick, or a lining of vitrified clay at least 5/8 inch (15.9 mm) thick, is provided, the total minimum thickness of front, back and sidewalls shall be 6 inches (152 mm) of solid masonry, including the lining. Firebrick shall conform to ASTM C 27 or ASTM C 1261 and shall be laid with refractory mortar conforming to ASTM C 199.

3.7.11.8.1 Smoke chamber dimensions

The inside height of the smoke chamber from the fireplace throat to the beginning of the flue shall not be greater than the inside width of the fireplace opening. The inside surface of the smoke chamber shall not be inclined more than 45 degrees (0.76 rad) from vertical when prefabricated smoke chamber linings are used or when the smoke chamber walls are rolled or sloped rather than corbeled. When the inside surface of the smoke chamber is formed by corbeled masonry, the walls shall not be corbeled more than 30 degrees (0.52 rad) from vertical.

3.7.11.9 Hearth and Hearth Extension

Masonry fireplace hearths and hearth extensions shall be constructed of concrete or masonry, supported by noncombustible materials, and reinforced to carry their own weight and all imposed loads. No combustible material shall remain against the underside of hearths or hearth extensions after construction.

3.7.11.9.1 Hearth thickness

The minimum thickness of fireplace hearths shall be 4 inches (102 mm).

3.7.11.9.2 Hearth extension thickness

The minimum thickness of hearth extensions shall be 2 inches (51 mm).

EXCEPTION:

When the bottom of the firebox opening is raised at least 8 inches (203 mm) above the top of the hearth extension, a hearth extension of not less than 3/8-inch-thick (9.5 mm) brick, concrete, stone, tile or other approved noncombustible material is permitted.

3.7.11.10 Hearth Extension Dimensions

Hearth extensions shall extend at least 16 inches (406 mm) in front of, and at least 8 inches (203 mm) beyond, each side of the fireplace opening. Where the fireplace opening is 6 square feet (0.557 m²) or larger, the hearth extension shall extend at least 20 inches (508 mm) in front of, and at least 12 inches (305 mm) beyond, each side of the fireplace opening.

3.7.11.11 Fireplace clearance

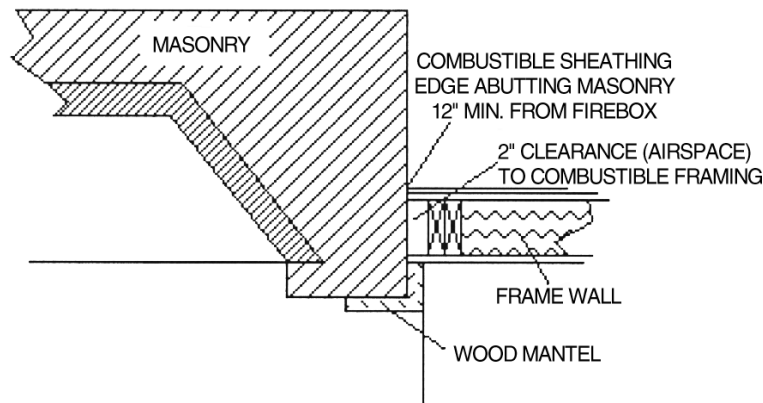
Any portion of a masonry fireplace located in the interior of a building or within the exterior wall of a building shall have a clearance to combustibles of not less than 2 inches (51 mm) from the front faces and sides of masonry fireplaces and not less than 4 inches (102 mm) from

the back faces of masonry fireplaces. The airspace shall not be filled, except to provide fireblocking in accordance with Section 3.7.11.12.

EXCEPTIONS:

1. Masonry fireplaces listed and labeled for use in contact with combustibles in accordance with UL 127 and installed in accordance with the manufacturer's installation instructions are permitted to have combustible material in contact with their exterior surfaces.
2. When masonry fireplaces are constructed as part of masonry or concrete walls, combustible materials shall not be in contact with the masonry or concrete walls less than 12 inches (306 mm) from the inside surface of the nearest firebox lining.
3. Exposed combustible trim and the edges of sheathing materials, such as wood siding, flooring and drywall, are permitted to abut the masonry fireplace sidewalls and hearth extension, in accordance with Figure 3.7.2, provided such combustible trim or sheathing is a minimum of 12 inches (306 mm) from the inside surface of the nearest firebox lining.
4. Exposed combustible mantels or trim is permitted to be placed directly on

the masonry fireplace front surrounding the fireplace opening, provided such combustible materials shall not be placed within 6 inches (153 mm) of a fireplace opening. Combustible material directly above and within 12 inches (305 mm) of the fireplace opening shall not project more than 1/8 inch (3.2 mm) for each 1-inch (25 mm) distance from such opening. Combustible materials located along the sides of the fireplace opening that project more than 1½ inches (38 mm) from the face of the fireplace shall have an additional clearance equal to the projection.



For SI: 1 inch = 25.4 mm

FIGURE 3.7.2

ILLUSTRATION OF EXCEPTION TO FIREPLACE CLEARANCE PROVISION

3.7.11.12 Fireplace Fireblocking

All spaces between fireplaces and floors and ceilings through which fireplaces pass shall be fireblocked with noncombustible material securely fastened in place. The fireblocking of spaces between wood joists, beams or headers shall be to a depth of 1 inch (25 mm) and shall only be placed on strips of metal or metal lath laid across the spaces between combustible material and the chimney.

3.7.11.13 Exterior Air

Factory-built or masonry fireplaces covered in this section shall be equipped with an exterior air supply to ensure proper fuel combustion unless the room is mechanically ventilated and controlled so that the indoor pressure is neutral or positive.

3.7.11.13.1 Factory-built fireplaces

Exterior combustion air ducts for factory-built fireplaces shall be listed components of the fireplace, and installed according to the fireplace manufacturer's instructions.

3.7.11.13.2 Masonry fireplaces

Listed combustion air ducts for masonry fireplaces shall be installed according to the terms of their listing and manufacturer's instructions.

3.7.11.13.3 Exterior air intake

The exterior air intake shall be capable of providing all combustion air from the exterior

of the dwelling. The exterior air intake shall not be located within the garage, attic, basement or crawl space of the dwelling nor shall the air intake be located at an elevation higher than the firebox. The exterior air intake shall be covered with a corrosion-resistant screen of ¼-inch (6.4 mm) mesh.

3.7.11.13.4 Clearance

Unlisted combustion air ducts shall be installed with a minimum 1-inch (25 mm) clearance to combustibles for all parts of the duct within 5 feet (1524 mm) of the duct outlet.

3.7.11.13.5 Passageway

The combustion airpassageway shall be a minimum of 6 square inches (3870 mm²) and not more than 55 square inches (0.035 m²), except that combustion air systems for listed fireplaces or for fireplaces tested for emissions shall be constructed according to the fireplace manufacturer's instructions.

3.7.11.13.6 Outlet

The exterior air outlet is permitted to be located in the back or sides of the firebox chamber or within 24 inches (610 mm) of the firebox opening on or near the floor. The outlet shall be closable and designed to prevent burning material from dropping into concealed combustible spaces.

3.7.12 Masonry Heaters

3.7.12.1 Definition

A masonry heater is a heating appliance constructed of concrete or solid masonry, hereinafter referred to as "masonry," which is designed to absorb and store heat from a solid fuel fire built in the firebox by routing the exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox may include flow in a horizontal or downward direction before entering the chimney and which delivers heat by radiation from the masonry surface of the heater.

3.7.12.2 Installation

Masonry heaters shall be installed in accordance with this Section and comply with one of the following:

1. Masonry heaters shall comply with the requirements of ASTM E1602; or
2. Masonry heaters shall be listed and labeled in accordance with UL 1482 and installed in accordance with the manufacturer's installation instructions.

3.7.12.3 Footings and Foundation

The firebox floor of a masonry heater shall be a minimum thickness of 4 inches (102 mm) of noncombustible material and be supported on a noncombustible footing and foundation in accordance with Section 3.7.13.2.

3.7.12.4 Seismic Reinforcing

In Seismic Design Category D, E and F, masonry heaters shall be anchored to the masonry foundation in accordance with Section 3.7.13.3. Seismic reinforcing

shall not be required within the body of a masonry heater with a height that is equal to or less than 3.5 times its body width and where the masonry chimney serving the heater is not supported by the body of the heater. Where the masonry chimney shares a common wall with the facing of the masonry heater, the chimney portion of the structure shall be reinforced in accordance with Section 3.7.13.

3.7.12.5 Masonry Heater Clearance

Combustible materials shall not be placed within 36 inches (765 mm) of the outside surface of a masonry heater in accordance with NFPA 211, Section 8-7 (clearances for solid fuel-burning appliances), and the required space between the heater and combustible material shall be fully vented to permit the free flow of air around all heater surfaces.

EXCEPTIONS:

1. When the masonry heater wall thickness is at least 8 inches (203 mm) thick of solid masonry and the wall thickness of the heat exchange channels is at least 5 inches (127 mm) thick of solid masonry, combustible materials shall not be placed within 4 inches (102 mm) of the outside surface of a masonry heater. A

clearance of at least 8 inches (203 mm) shall be provided between the gas-tight capping slab of the heater and a combustible ceiling.

2. Masonry heaters listed and labeled in accordance with UL 1482 and installed in accordance with the manufacturer's instructions.

3.7.13 Masonry Chimneys

3.7.13.1 Definition

A masonry chimney is a chimney constructed of concrete or masonry, hereinafter referred to as "masonry." Masonry chimneys shall be constructed, anchored, supported and reinforced as required in this Section.

3.7.13.2 Footings and Foundations

Footings for masonry chimneys shall be constructed of concrete or solid masonry at least 12 inches (305 mm) thick and shall extend at least 6 inches (152 mm) beyond the face of the foundation or support wall on all sides. Footings shall be founded on natural undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be at least 12 inches (305 mm) below finished grade.

3.7.13.3 Seismic reinforcing

Masonry or concrete chimneys shall be constructed, anchored, supported and reinforced as required in this Section. In Seismic Design Category D, masonry and concrete chimneys shall be reinforced and anchored as detailed in Sections 3.7.13.3.1, 3.7.13.3.2 and 3.7.13.4. In Seismic Design Category A, B or C, reinforcement and seismic anchorage is not required. In Seismic Design Category E or F, masonry and concrete chimneys shall be reinforced in accordance with the requirements of Sections 3.7.1 through 3.7.8.

3.7.13.3.1 Vertical reinforcing

For chimneys up to 40 inches (1016 mm) wide, four No. 4 continuous vertical bars anchored in the foundation shall be placed in the concrete between wythes of solid masonry or within the cells of hollow unit masonry and grouted in accordance with Section 3.7.3.12. Grout shall be prevented from bonding with the flue liner so that the flue liner is free to move with thermal expansion. For chimneys greater than 40 inches (1016 mm) wide, two additional No. 4 vertical bars shall be provided for each additional 40 inches (1016 mm) in width or fraction thereof.

3.7.13.3.2 Horizontal reinforcing.

Vertical reinforcement shall be placed enclosed within 1/4-inch (6.4 mm) ties, or other reinforcing of equivalent net cross-sectional area, spaced not to exceed 18 inches (457 mm) o.c. in concrete, or placed in the bed joints of unit masonry, at a minimum of every 18 inches (457 mm) of vertical height. Two such ties shall be provided at each bend in the vertical bars.

3.7.13.4 Seismic Anchorage

Masonry and concrete chimneys and foundations in Seismic Design Category D shall be anchored at each floor, ceiling or roof line more than 6 feet (1829 mm) above grade, except where constructed completely within the exterior walls. Anchorage shall conform to the following requirements.

3.7.13.4.1 Anchorage

Two 3/16-inch by 1-inch (4.8 mm by 25 mm) straps shall be embedded a minimum of 12 inches (305 mm) into the chimney. Straps shall be hooked around the outer bars and extend 6 inches (152 mm) beyond the bend. Each strap shall be fastened to a minimum of four floor joists with two 1/2-inch (12.7 mm) bolts.

3.7.13.5 Corbeling

Masonry chimneys shall not be corbeled more than half of the chimney's wall thickness from a wall or foundation, nor shall a chimney be corbeled from a wall or foundation that is less than 12 inches (305 mm) in thickness unless it projects equally on each side of the wall, except that on the second storey of a two-storey dwelling, corbeling of chimneys on the exterior of the enclosing walls is permitted to equal the wall thickness. The projection of a single course shall not exceed one-half the unit height or one-third of the unit bed depth, whichever is less.

3.7.13.6 Changes in Dimension

The chimney wall or chimney flue lining shall not change in size or shape within 6 inches (152 mm) above or below where the chimney passes through floor components, ceiling components or roof components.

3.7.13.7 Offsets

Where a masonry chimney is constructed with a fireclay flue liner surrounded by one wythe of masonry, the maximum offset shall be such that the centreline of the flue above the offset does not extend beyond the centre of the chimney wall below the offset. Where the chimney offset is supported by masonry below the offset in an approved manner, the maximum offset limitations shall not apply.

Each individual corbeled masonry course of the offset shall not exceed the projection limitations specified in Section 3.7.13.5.

3.7.13.8 Additional Load

Chimneys shall not support loads other than their own weight unless they are designed and constructed to support the additional load. Masonry chimneys are permitted to be constructed as part of the masonry walls or concrete walls of the building.

3.7.13.9 Termination

Chimneys shall extend at least 2 feet (610 mm) higher than any portion of the building within 10 feet (3048 mm), but shall not be less than 3 feet (914 mm) above the highest point where the chimney passes through the roof.

3.7.13.9.1 Spark arrestors

Where a spark arrestor is installed on a masonry chimney, the spark arrestor shall meet all of the following requirements:

1. The net free area of the arrestor shall not be less than four times the net free area of the outlet of the chimney flue it serves.
2. The arrestor screen shall have heat and corrosion resistance equivalent to 19-gage galvanized steel or 24-gage stainless steel.
3. Openings shall not permit the passage of spheres having a diameter greater than 1/2 inch (13 mm) nor block the passage of spheres having a diameter less than 3/8 inch (11 mm).
4. The spark arrestor shall be accessible for cleaning and the screen or chimney cap shall be removable to allow for cleaning of the chimney flue.

3.7.13.10 Wall Thickness

Masonry chimney walls shall be constructed of concrete, solid masonry units or hollow masonry units grouted solid with not less than 4 inches (102 mm) nominal thickness.

3.7.13.10.1 Masonry veneer chimneys

Where masonry is used as veneer for a framed chimney, through flashing and weep holes shall be provided.

3.7.13.11 Flue Lining (Material)

Masonry chimneys shall be lined. The lining material shall be appropriate for the type of appliance connected, according to the terms of the appliance listing and the manufacturer's instructions.

3.7.13.11.1 Residential-type appliances (general)

Flue lining systems shall comply with one of the following:

1. Clay flue lining complying with the requirements of ASTM C 315, or equivalent.
2. Listed chimney lining systems complying with UL 1777.
3. Factory-built chimneys or chimney units listed for installation within masonry chimneys.

4. Other approved materials that will resist corrosion, erosion, softening or cracking from flue gases and condensate at temperatures up to 1,800°F (982°C).

3.7.13.11.1.1 Flue linings for specific appliances

Flue linings other than those covered in Section 3.7.13.11.1 intended for use with specific appliances shall comply with Sections 3.7.13.11.1.2 through 3.7.13.11.1.4 and Sections 3.7.13.11.2 and 3.7.13.11.3.

3.7.13.11.1.2 Gas appliances

Flue lining systems for gas appliances shall be in accordance with the International Fuel Gas Code.

3.7.13.11.1.3 Pellet fuel-burning appliances

Flue lining and vent systems for use in masonry chimneys with pellet fuel-burning appliances shall be limited to flue lining systems complying with Section 3.7.13.11.1 and pellet vents listed for installation within masonry chimneys (see Section 3.7.13.11.1.5 for marking).

3.7.13.11.1.4 Oil-fired appliances approved for use with L-vent

Flue lining and vent systems for use in masonry chimneys with oil-fired appliances approved for use with Type L vent shall be limited to flue lining systems complying with Section 3.7.13.11.1 and listed chimney liners complying with UL641 (see Section 3.7.13.11.1.5 for marking).

3.7.13.11.1.5 Notice of usage

When a flue is relined with a material not complying with Section 3.7.13.11.1, the chimney shall be plainly and permanently identified by a label attached to a wall, ceiling or other conspicuous location adjacent to where the connector enters the chimney. The label shall include the following message or equivalent language: "This chimney is for use only with (type or category of appliance) that burns (type of fuel). Do not connect other types of appliances."

3.7.13.11.2 Concrete and masonry chimneys for medium-heat appliances

3.7.13.11.2.1 General

Concrete and masonry chimneys for medium-heat appliances shall comply with Sections 3.7.13.1 through 3.7.13.5.

3.7.13.11.2.2 Construction

Chimneys for medium-heat appliances shall be constructed of solid masonry units or of concrete with walls a minimum of 8 inches (203 mm) thick, or with stone masonry a minimum of 12 inches (305 mm) thick.

3.7.13.11.2.3 Lining

Concrete and masonry chimneys shall be lined with an approved medium-duty refractory brick a minimum of 4½ inches (114 mm) thick laid on the 4½-inch bed (114 mm) in an approved medium-duty refractory mortar. The lining

shall start 2 feet (610 mm) or more below the lowest chimney connector entrance. Chimneys terminating 25 feet (7620 mm) or less above a chimney connector entrance shall be lined to the top.

3.7.13.11.2.4 Multiple passageway

Concrete and masonry chimneys containing more than one passageway shall have the liners separated by a minimum 4-inch-thick (102 mm) concrete or solid masonry wall.

3.7.13.11.2.5 Termination height

Concrete and masonry chimneys for medium-heat appliances shall extend a minimum of 10 feet (3048 mm) higher than any portion of any building within 25 feet (7620 mm).

3.7.13.11.2.6 Clearance

A minimum clearance of 4 inches (102 mm) shall be provided between the exterior surfaces of a concrete or masonry chimney for medium-heat appliances and combustible material.

3.7.13.11.3 Concrete and masonry chimneys for high-heat appliances

3.7.13.11.3.1 General

Concrete and masonry chimneys for high-heat appliances shall comply with Sections 3.7.13.1 through 3.7.13.5.

3.7.13.11.3.2 Construction

Chimneys for high-heat appliances shall be constructed with double walls of solid masonry units or of concrete, each wall to be a minimum of 8 inches (203 mm) thick with a minimum airspace of 2 inches (51 mm) between the walls.

3.7.13.11.3.3 Lining

The inside of the interior wall shall be lined with an approved high-duty refractory brick, a minimum of 4½ inches (114 mm) thick laid on the 4½-inch bed (114 mm) in an approved high-duty refractory mortar. The lining shall start at the base of the chimney and extend continuously to the top.

3.7.13.11.3.4 Termination height

Concrete and masonry chimneys for high-heat appliances shall extend a minimum of 20 feet (6096 mm) higher than any portion of any building within 50 feet (15 240 mm).

3.7.13.11.3.5 Clearance

Concrete and masonry chimneys for high-heat appliances shall have approved clearance from buildings and structures to prevent overheating combustible materials, permit inspection and maintenance operations on the chimney and prevent danger of burns to persons.

3.7.13.12 Clay flue lining (installation)

Clay flue liners shall be installed in accordance with ASTM C 1283 and extend from a point not less than 8 inches (203 mm) below the lowest inlet or, in the case

of fireplaces, from the top of the smoke chamber to a point above the enclosing walls. The lining shall be carried up vertically, with a maximum slope no greater than 30 degrees (0.52 rad) from the vertical.

Clay flue liners shall be laid in medium-duty refractory mortar conforming to ASTM C 199 with tight mortar joints left smooth on the inside and installed to maintain an air space or insulation not to exceed the thickness of the flue liner separating the flue liners from the interior face of the chimney masonry walls. Flue lining shall be supported on all sides. Only enough mortar shall be placed to make the joint and hold the liners in position.

3.7.13.13 Additional Requirements

3.7.13.13.1 Listed materials

Listed materials used as flue linings shall be installed in accordance with the terms of their listings and the manufacturer's instructions.

3.7.13.13.2 Space around lining

The space surrounding a chimney lining system or vent installed within a masonry chimney shall not be used to vent any other appliance.

EXCEPTION:

This shall not prevent the installation of a separate flue lining in accordance with the manufacturer's instructions.

3.7.13.14 Multiple Flues

When two or more flues are located in the same chimney, masonry wythes shall be built between adjacent flue linings. The masonry wythes shall be at least 4 inches (102 mm) thick and bonded into the walls of the chimney.

EXCEPTION:

When venting only one appliance, two flues are permitted to adjoin each other in the same chimney with only the flue lining separation between them. The joints of the adjacent flue linings shall be staggered at least 4 inches (102 mm).

3.7.13.5 Flue Area (Appliance)

Chimney flues shall not be smaller in area than the area of the connector from the appliance. Chimney flues connected to more than one appliance shall not be less than the area of the largest connector plus 50 percent of the areas of additional chimney connectors.

EXCEPTIONS:

1. Chimney flues serving oil-fired appliances sized in accordance with NFPA 31.
2. Chimney flues serving gas-fired appliances sized in accordance with the International Fuel Gas Code.

3.7.13.16 Flue Area (Masonry Fireplace)

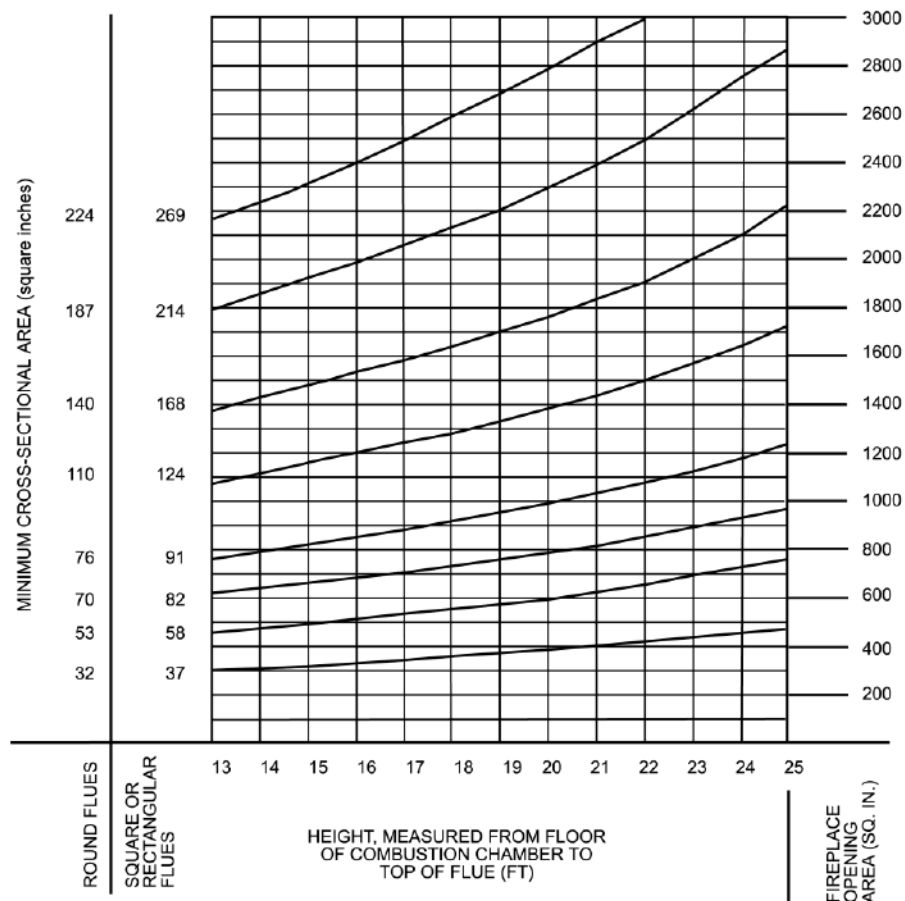
Flue sizing for chimneys serving fireplaces shall be in accordance with Section 3.7.13.16.1 or 3.7.13.16.2.

3.7.13.16.1 Minimum area

Round chimney flues shall have a minimum net cross-sectional area of at least 1/12 of the fire- place opening. Square chimney flues shall have a minimum net cross-sectional area of at least 1/10 of the fireplace opening. Rectangular chimney flues with an aspect ratio less than 2 to 1 shall have a minimum net cross-sectional area of at least 1/10 of the fireplace opening. Rectangular chimney flues with an aspect ratio of 2 to 1 or more shall have a minimum net cross-sectional area of at least 1/8 of the fireplace opening.

3.7.13.16.2 Determination of minimum area

The minimum net cross-sectional area of the flue shall be determined in accordance with Figure 3.7.3. A flue size providing at least the equivalent net cross-sectional area shall be used. Cross-sectional areas of clay flue linings are as provided in Tables 3.7.13 and 3.7.14 or as provided by the manufacturer or as measured in the field. The height of the chimney shall be measured from the firebox floor to the top of the chimney flue.



For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm². a. Flue sizes are based on ASTM C 315.

FIGURE 3.7.3 FLUE SIZES FOR MASONRY CHIMNEYS

TABLE 3.7.13 NET CROSS-SECTIONAL AREA OF ROUND FLUES SIZESa

FLUE SIZE, INSIDE DIAMETER (inches)	CROSS-SECTIONAL AREA (square inches)

6	28
7	38
8	50
10	78
10 ³ / ₄	90
12	113
15	176
18	254

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm².

a. Flue sizes are based on ASTM C 315.

TABLE 3.7.14 NET CROSS-SECTIONAL AREA OF SQUARE AND RECTANGULAR FLUE SIZES

FLUE SIZE, OUTSIDE NOMINAL DIMENSIONS (inches)	CROSS-SECTIONAL AREA (square inches)
4.5×8.5	23
4.5×13	34
8×8	42
8.5×8.5	49
8×12	67
8.5×13	76
12×12	102
8.5×18	101
13×13	127
12×16	131
13×18	173
16×16	181
16×20	222
18×18	233
20×20	298
20×24	335
24×24	431

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm².

3.7.13.17 Inlet

Inlets to masonry chimneys shall enter from the side. Inlets shall have a thimble of fireclay, rigid refractory material or metal that will prevent the connector from pulling out of the inlet or from extending beyond the wall of the liner.

3.7.13.18 Masonry Chimney Cleanout Openings

Cleanout openings shall be provided within 6 inches (152 mm) of the base of each flue within every masonry chimney. The upper edge of the cleanout shall be located at least 6 inches (152 mm) below the lowest chimney inlet opening. The height of the opening shall be at least 6 inches (152 mm). The cleanout shall be provided with a noncombustible cover.

EXCEPTION:

Chimney flues serving masonry fireplaces, where cleaning is possible through the fireplace opening.

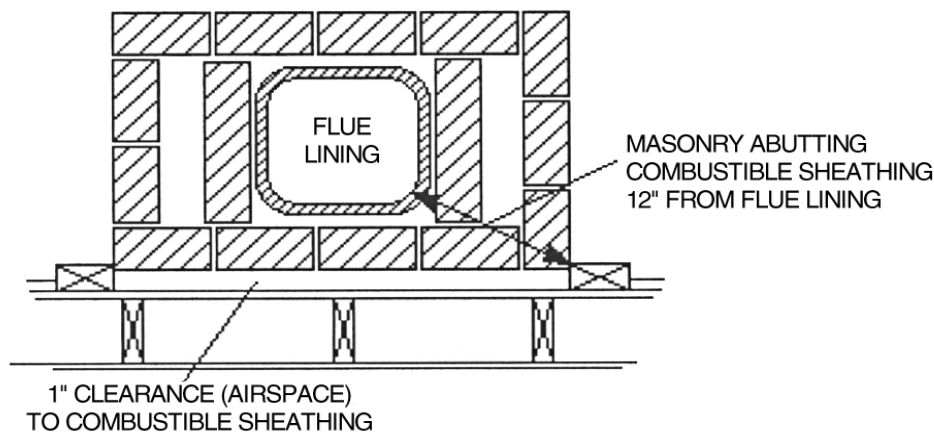
3.7.13.19 Chimney Clearances

Any portion of a masonry chimney located in the interior of the building or within the exterior wall of the building shall have a minimum airspace clearance to combustibles of 2 inches (51

mm). Chimneys located entirely outside the exterior walls of the building, including chimneys that pass through the soffit or cornice, shall have a minimum airspace clearance of 1 inch (25 mm). The airspace shall not be filled, except to provide fireblocking in accordance with Section 3.7.13.20.

EXCEPTIONS:

1. Masonry chimneys equipped with a chimney lining system listed and labeled for use in chimneys in contact with combustibles in accordance with UL 1777, and installed in accordance with the manufacturer's instruction, are permitted to have combustible material in contact with their exterior surfaces.
2. Where masonry chimneys are constructed as part of masonry or concrete walls, combustible materials shall not be in contact with the masonry or concrete wall less than 12 inches (305 mm) from the inside surface of the nearest flue lining.
3. Exposed combustible trim and the edges of sheathing materials, such as wood siding, are permitted to abut the masonry chimney sidewalls, in accordance with Figure 7.4, provided such combustible trim or sheathing is a minimum of 12 inches (305 mm) from the inside surface of the nearest flue lining. Combustible material and trim shall not overlap the corners of the chimney by more than 1 inch (25mm).



For SI: 1 inch = 25.4 mm.

FIGURE 3.7.4 ILLUSTRATION OF EXCEPTION THREE CHIMNEY CLEARANCE PROVISION

3.7.13.20 Chimney Fireblocking

All spaces between chimneys and floors and ceilings through which chimneys pass shall be fireblocked with noncombustible material securely fastened in place. The fireblocking of spaces between wood joists, beams or headers shall be to a depth of 1 inch (25 mm) and shall only be placed on strips of metal or metal lath laid across the spaces between combustible material and the chimney.

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PART 4
SOILS AND FOUNDATIONS

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4.1 GENERAL

4.1.1 Scope

This section covers soil and foundation design for all buildings such as individual footings, combined footings, strip footings, rafts, piles and other foundation systems to ensure safety and serviceability without exceeding the permissible stresses of foundation material and the bearing capacity of the supporting soil. Some parameters related to seismic – resistant designs are also included.

This section is formulated with a view to implement in national and economical policies in soils and foundations, such that the design of buildings can be accomplished with safety and usability, using advanced technology, with economy and rationality, assuring the quality and protection of the environment.

Design of soil and foundation must be carried out based on the principles of suiting measures to local conditions, using local materials, protecting the environment and economizing on resources. The design shall be painstakingly performed with comprehensive consideration given to the type of structures, availability of materials and geotechnical survey data of soil and rock.

4.1.2 Design

Allowable bearing pressures, allowable stresses and design formulae provided in this section shall be used with the allowable stress design load combinations specified in Structural Design Section 3.2.1. The quality and design of materials used structurally in excavations, footings and foundations shall conform to the requirements specified in this code (see Section on Structural Design, Concrete, Masonry and Steel). Safety during construction and the protection of adjacent public and private properties shall govern the design and construction of excavations and fills.

4.1.2.1 Foundation design for seismic overturning

Where the foundation is proportioned using the load combinations specified in Structural Design Section 3.4.2, and the computation of the seismic overturning moment is by the equivalent lateral-force method or the modal analysis, the proportioning shall be in accordance with Section 3.4.2.

4.1.2.1.1 Reduction of Foundation Overturning

Overturning effects at the soil foundation interface are permitted to be reduced by 25 percent for foundations of structures that satisfy both of the following conditions:

- a) The structure is designed in accordance with the Equivalent Lateral Force Analysis as set forth in Structural Design Section 3.4.2.
- b) The structure is not an inverted pendulum or cantilevered column type structure.

Overturning effects at the soil-foundation interface are permitted to be reduced by 10 percent for foundations of structures designed in accordance with the modal analysis requirements of Structural Design Section 3.4.2.

4.1.3 Definitions

For the purpose of this Section, the following definitions shall apply.

4.1.3.1 Soil

Clay. Very fine – grained soil (the particles are less than 0.002 mm in size), consisting mainly of hydrate silicate of aluminum. Clay is a plastic cohesive soils which shrinks on drying, expands on wetting and when compressed it gives up water. It comes from the chemical decomposition and disintegration of rock constituents.

Clay (Firm) or (Medium Stiff). A clay which at its natural water content can be moulded by substantial pressure with the fingers and can be excavated with a spade.

Clay (Very soft). (Soft), A clay which at its natural water content can be easily moulded with the fingers and readily excavated.

Clay (Stiff), (Very Stiff), (Hard). A clay which at its natural water content cannot be moulded with fingers and require a pick or pneumatic spade for its removal.

Gravel. Cohesionless aggregates of angular or rounded or semi – rounded fragments of more or less unaltered rocks or minerals. The size is larger than 2.0 mm and less than 60 mm.

Hard Rock. A fresh rock which is normally required blasting or chiseling for excavation.

Laterite and Lateritic soils. Laterite which possess reddish colour should be regarded as a highly weathered material resulted from the concentration of hydrate oxides of iron and aluminum. In the laterite, the ratio of silica oxide (SiO_2) to sesquioxides (Fe_2O_3 , Al_2O_3) is usually less than 1.33. Laterite are good foundation soils and it can be used as subbase material for road and small airfield construction. Lateritic soil has the reddish colour and the ratio of silica oxide (SiO_2) to sesquioxides (Fe_2O_3 , Al_2O_3) is generally from 1.33 to 2. They are fair to good foundation materials for buildings. Lateritic soils can be divided into three groups; ferruginous soil, ferrallitic soils and ferrisols soils. Ferruginous soil can have better strength than others. The clay minerals of lateritic soils are mostly kaolinite in nature.

Liquefaction. The phenomenon of liquefaction is generally associated with cohesion-less soils. It results from seismic shaking that is of a sufficient intensity and duration. It occurs most commonly in loose, saturated, granular soils that are uniformly graded and that contain few fines. Although sands are especially susceptible, liquefaction is also known to develop in some silts and gravels. The generation of excess pore pressure due to rapid loading under un-drained condition is hallmark of all liquefaction phenomena.

Predominant Period of Soil. It is a parameter that provides a useful tool, although somewhat crude representation of the frequency content of a ground motion. The predominant period is defined as the period of vibration corresponding to the maximum value of the Fourier amplitude spectrum (FAS). During an earthquake, the buildings which have the natural periods of as same as the predominant period of underlying soil deposits will be felt strong shaking and are liable to severe damage.

Problematic Soil

(a) Expansive Soil. Foundation materials that exhibit volume change when there are changes in their moisture content are referred to as expansive or swelling clay soils. More detailed is shown in Appendix A.

(b) Dispersive Soil. The soil which disperse in the presence of water and can therefore be easily scoured. The most major soil type is CLAY and SILT combination with some amount of sand. The index properties give no indication about this treacherous soil. Detail criteria and suggested tests are shown in Appendix A.

(c) Peat. Peat is a fibrous mass of organic matter in various stages of decomposition and dark brown and black in color and of spongy consistency.

(d) Black Cotton Soil. It is the inorganic clay of medium to high compressibility. They form a major soil group in middle parts of Myanmar. They are predominantly montmorillonitic in structure and Black or Blackish Grey or Greenish brown in color. They are characterized by high shrinkage and swelling properties.

Sand. Sand is cohesionless soils, the soil particles do not tend to stick together. The particle size ranges from 0.06 mm to 2 mm.

Sand (Fine). Sand which contains particles of size greater than 0.06 mm and less than 0.02 mm

Sand (Medium). Sand which contains particles of size greater than 0.02 mm and less than 0.6 mm

Sand (Coarse). Sand which contains particles of size greater than 0.6 mm and less than 2 mm

Silt. A fine grained soil with little or no plasticity, the size of particles ranges from 0.002 mm to 0.06 mm.

Soft Rock. A rocky cemented material which offers a high resistance to picking up with pick axes and sharp tools but which does not normally require blasting or chiseling for excavation.

Soil. Sediments or other unconsolidated accumulations of soil particles produced by the physical and chemical decomposition of rock and which may or may not contain organic matter, soil is not solid matter but contains air and water between the soil particles.

Soil (Coarse Grained). Soil which includes the coarse and large siliceous and unaltered products of weathered rock is regarded as coarse grained soil. They possess no plasticity and tend to lack cohesion when in dry state.

Soil (Fine Grained). Soil where more than 50% of the material less than 60mm is smaller than 0.06mm. Soil consisting of fine and altered products of weathered rocks, possessing cohesion and plasticity in their natural state is regarded as fine grained soil.

Soil Amplification. Soil amplification is the ratio of amplitude of displacement of the objective layer (surface) to that of the reference layer (engineering bedrock). It is a function with respect to frequency and is equivalent with the ratio of acceleration. The areas covered with thick, soft soil generally show higher amplification. Basin effects also have a great control on amplification characteristics of soil deposits. Some severe damages during an earthquake are mainly related to soil amplification.

4.1.3.2 Shallow Foundation

Back Fill. Material used to raise the ground level to fill a depression, or for construction of an embankment.

Bearing Capacity Safe (q_s). [$\approx$ gross allowable bearing capacity ($q'_{all} = q_u/FS$)

The maximum pressure which the soil can carry safely without risk of shear failure. It is equal to the net safe bearing capacity plus original overburden pressure. It is also referred to as the ultimate bearing capacity divided by the factor of safety.

$$q_s = q_{ns} + \gamma D = q_{nu}/F + \gamma D = q_u/FS$$

Bearing Capacity. The supporting power of a soil or rock is referred to as its bearing capacity.

Bearing Capacity, Ultimate (q_u). It is defined as the minimum gross pressure intensity at the base of the foundation at which the soil fails in shear. (or) The intensity of loading on the foundation which would cause shear failure of the soil

Bearing Pressure, Allowable (q_o). It is the net loading intensity at which neither the soil fails in shear nor there excessive settlement detrimental to the structure.

Continuous Spread Footing. These are also known as wall footings or strip footings and are used to support bearing walls.

Combined Footing. It supports more than one column. It is useful when columns are located too close together for each to have its own footing.

Factor of Safety. It is applied to the ultimate bearing capacity (net) to arrive at the value of the safe bearing capacity (net).

Footing. It is a portion of the foundation of a structure that transmits loads directly to the soil.

Foundation. It is the part of the structure which is in direct contact with and transmitting loads to the ground.

Ring Spread Footing. These are continuous footings that have been wrapped into a circle. It is commonly used to support the walls of above ground circular storage tanks.

Shallow Foundation. Foundations that have a depth of embedment to width ration of approximately less than four.

Spread Footing. It is an enlargement at the bottom of a column or bearing wall that spreads the applied structural loads over a sufficiently large soil area.

Strip Footing. A footing providing a continuous longitudinal ground bearing.

Mat Foundation (Raft Foundation). A mat is essentially a very large spread footing that usually encompasses the entire footprint of the structure. They are also known as raft foundation.

4.1.3.3 Deep Foundation

Augered uncased piles. Augered uncased piles are constructed by depositing concrete into an uncased auger hole, either during or after the withdrawal of the auger.

Bearing Pile. The pile which transfers the load to a stronger stratum underlying the weak zone.

Batter Pile (Raker Pile). The pile which is installed at an angle to the vertical.

Bored Pile. A pile formed with or without a casing by drilling a hole and subsequently filling it with plain or reinforced concrete.

Belled piers. Belled piers are cast-in-place concrete piers constructed with a base that is larger than the diameter of the remainder of the pier. The belled base is designed to increase the load-bearing area of the pier in end bearing.

Caisson piles. Caisson piles are cast-in-place concrete piles extending into bedrock. The upper portion of a caisson pile consists of a cased pile that extends to the bedrock. The lower portion of the caisson pile consists of an uncased socket drilled into the bedrock.

Concrete-filled steel pipe and tube piles. Concrete-filled steel pipe and tube piles are constructed by driving a steel pipe or tube section into the soil and filling the pipe or tube section with concrete. The steel pipe or tube section is left in place during and after the deposition of the concrete.

Cut -off Level. It is the level where the installed pile is cut-off to connect the pile cap or beams or any other structural components at that level. (or)The prescribed elevation at which the top of a pile is cut. This may be above or below ground level.

Driven uncased piles. Driven uncased piles are constructed by driving a steel shell into the soil to shore an unexcavated hole that is later filled with concrete. The steel casing is lifted out of the hole during the deposition of the concrete.

Driven Precast Pile. The precast piles are constructed in concrete (reinforced or pre-stressed) which is cast and cured in a casting yard and subsequently driven into the ground until it has attained sufficient strength.

Driven Cast-in Situ Pile. A pile installed by driving a permanent or temporary casing, and filling the hole so formed with plain or reinforced concrete.

Enlarged base piles. Enlarged base piles are cast-in-place concrete piles constructed with a base that is larger than the diameter of the remainder of the pile. The enlarged base is designed to increase the load-bearing area of the pile in end bearing.

Flexural Length. Flexural length is the length of the pile from the first point of zero lateral deflection to the underside of the pile cap or grade beam.

Friction Pile. The pile which carries the load by mobilizing the friction along its sides.

Factor of Safety. It is the ratio of the ultimate load capacity of a pile to the safe load (working load) of a pile.

Jacked Pile. A pile, usually in short section, which is forced into ground by jacking it against a reaction from the kentledge.

Kentledge. Material used to add temporary loading to a structure or as a dead weight in a loading test.

Micropiles. Micropiles are 16-inch-diameter (406 mm) or less bored, grouted-in-place piles incorporating steel pipe (casing) and/or steel reinforcement.

Negative Skin Friction. A downward frictional force acting to the shaft of a pile caused by the consolidation of compressible strata. It has the effect to increase the loading on the pile and reducing the factor of safety.

Pile Foundations. Pile foundations consist of concrete, wood or steel structural elements either driven into the ground or cast in place. Piles are relatively slender in comparison to their length, with lengths exceeding 12 times the least horizontal dimension. Piles derive their load-carrying capacity through skin friction, end bearing or a combination of both.

Pier Foundations. Pier foundations consist of isolated masonry or cast-in-place concrete structural elements extending into firm materials. Piers are relatively short in comparison to their width, with lengths less than or equal to 12 times the least horizontal dimension of the pier. Piers derive their load-carrying capacity through skin friction, through end bearing, or a combination of both.

Pile Raft. A foundation formed of piles and a raft acting together.

Pile Cap. A concrete block cast on the head of a pile or a group of piles to transmit the load from the structure to the pile or group of piles.

Steel-cased piles. Steel-cased piles are constructed by driving a steel shell into the soil to shore an unexcavated hole. The steel casing is left permanently in place and filled with concrete.

Test Pile. A pile installed before the commencement of the main piling works, to which a load is applied to determine the load/settlement characteristics of the pile and the surrounding soil.

Tension Pile. A pile that is designed to resist a tensile force.

Timber piles. Timber piles are round, tapered timbers with the small (tip) end embedded into the soil.

Ultimate Load. The maximum load which a pile can carry before failure of ground or failure of pile materials.

Working Load (allowable load). The load which the pile is designed to carry.

4.1.4 ABBREVIATION AND SYMBOLS

A_g	Pile cross-sectional area, square inches
A_{ch}	Core area defined by spiral outside diameter
a_{max}	Peak ground acceleration of the site
A_{sh}	Cross-sectional area of transverse reinforcement
CLSM	Controlled low- strength material
CPT	Cone Penetration Test
CQHP	Committee for Quality control of High-rise building construction Project
CRR	Cyclic Resistance Ratio of the in situ soil
CSR	Cyclic Stress Ratio of the in situ soil
D	Depth of Soil
E	Modulus of Elasticity
FAS	Fourier amplitude spectrum
FI	No. of fracture
FS	Factor of Safety
f'_c	Specified compressive strength of concrete
f_{yh}	Yield strength of spiral reinforcement
f_{pc}	The effective stress on the gross section
F_y	Minimum specified yield strength
F_b	Bending at fiber stress
F_v	Longitudinal shear
F_c	Axial compression
F_{cb}	Axial compression when combined with bending
$F_{c(per)}$	Compression perpendicular to grain
$F_{t(par)}$	Tension parallel to grain
$F_{t(per)}$	Tension perpendicular to grain
f_y	Yield strength of the steel

g	Acceleration due to gravity (32.2 ft/s ² or 9.81 m/s ²)
GPR	Ground-Probing Rader
h_c	Cross-sectional dimension of pile core measured center to center of hoop reinforcement
IP	Induce polarization survey
k_s	Modulus of Sub-grade Reaction
LL	Liquid Limit
P	Axial load on pile, pounds
PGA	Peak Ground Acceleration
PGV	Peak Ground Velocity
PGD	Peak Ground Displacement
RQD	Rock Quality Designation
SASW	Spectral Analysis of Surface Wave
S.C.R	Solid Core Recovery
SP	Self – potential survey
SPT	Standard Penetration Test
T.C.R	Total Core Recovery
TDEM	Electromagnetic Survey
TEM	Transient Electromagnetic
v_s^{30}	Average shear wave velocity of upper 30 m depth
VLF	Very low frequency
q	Bearing Pressure
q_a	Bearing Pressure, Allowable
q_s	Bearing Capacity, Safe
q_{ns}	Bearing Capacity, Net Safe
q_{nu}	Bearing Capacity, Net Ultimate
q_u	Bearing Capacity, Ultimate
w	Water content
σ_{vo}	Total vertical stress at a particular depth
σ'_{vo}	Vertical effective stress at a particular depth
r_d	Depth reduction factor or stress reduction coefficient
s	Spacing of transverse reinforcement measured along length of pile
c	Cohesion
w	Water Content
γ	Unit Weight of Soil

δ	Settlement
σ_{vo}	Total vertical stress at a particular depth where the liquefaction analysis is being performed.
σ'_{vo}	Vertical effective stress at a particular depth where the liquefaction analysis is being
r_d	Depth reduction factor or stress reduction coefficient
ρ_s	Spiral reinforcement index (vol. spiral/vol. core).

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4.2.4.2 Spectral Response Acceleration Parameters

4.2.4.3 Soil Amplification

4.2.4.4 Fundamental Frequency and Predominant Period

4.2.4.5 Seismic Response Analysis

4.2.5 Report Preparation and Geotechnical Criteria

4.2 SITE INVESTIGATION

4.2.1 Geotechnical Site Investigation

Geotechnical site investigation is the process of evaluating the geotechnical character of a site. It may include one or more of the followings:

- Evaluation of the geology and hydrogeology of the site.
- Examination of existing geotechnical information pertaining to the site.
- Excavating or boring in soil or rock.
- In-situ assessment of geotechnical properties of materials.
- Recovery of samples of soil or rock for examination, identification, recording, testing or display.
- Testing of soil or rock samples to quantify properties relevant to the purpose of the investigation.
- Reporting of results.

The specific procedure for geotechnical investigation of a particular site will depend on the geographical and geological conditions and nature of the proposed construction. A timely and intelligently planned site exploration should be considered a pre – requisite for efficient, safe, economical design and construction.

The following general procedure should conduct for site investigation.

- a) Desk study
- b) Site reconnaissance
- c) Subsurface investigation

4.2.1.1 Desk study

In general, any investigation should start with the collection and examination of the existing data on soil and rock and any available geological information relating to the site. Terrain conditions on the proposed site must also be studied. A desk study should typically include collection of geological and engineering geological data through geologic maps, structural geology maps as shown in Appendix B, previous reports, study of aerial photographs, satellite images, and topographic maps.

4.2.1.2 Site reconnaissance

This should involve a walk-over or drive-over of the site area in order to study the character and variability of the ground, select appropriate site investigation methods and visually classify any existing soil or rock exposures.

On going over the site, the study of the following features may be useful: local topography, excavations, cuttings, quarries, evidences of erosion, landslides, fills, water levels in wells and streams, flood marks, and drainage patterns, etc. If there has been an earlier use of the site, information should be gathered in particular about the location of fills and excavations. The present land use should be noted along with any constraints on access for exploration equipment.

4.2.1.3 Subsurface Investigation

The methods of site investigation are largely dependent upon the nature of the ground to be investigated and engineering practices. Adequate subsurface investigation should be carried out prior to the design and construction of the proposed development. In some instances it may be appropriate

that this is done before acquiring a building site or making other investments dependent upon a particular site. The procedures for investigation, sampling, and testing shall be in accordance with the appropriate ASTM or AASHTO standards.

4.2.1.3.1 Purpose of Subsurface Investigation

The purpose of subsurface investigation is to assess the nature and sequence of the subsurface soils and rocks; groundwater conditions and the physical and mechanical properties of the subsurface materials.

Some typical examples of the purpose of subsurface investigations are as follows:-

- a) To establish suitable horizontal and vertical location of a proposed structure on the site.
- b) To locate and evaluate borrow materials for construction of earth embankments for highways or an earth dam.
- c) To locate and evaluate sands and gravels suitable for highway aggregate, concrete aggregate, filter material or slope.
- d) To determine the need for subgrade or foundation treatment to support loads or to control water movement.
- e) To estimate foundation settlement or evaluate the stability of slopes or foundation.

4.2.1.3.2 Methods of Subsurface Investigation.

Some of the following methods may be selected and applied during the site investigation depending on the requirements of the proposed structures. Detailed procedures and the applicability of each method are described in Appendix C.

A summary of their applications is shown in Table 4.2.1.3.2.1.

- a) Open Trial Pits (Test Pits) Method
- b) Auger Boring (Hand Auger Method)
- c) Shell and Auger Boring
- d) Wash Boring
- e) Standard Penetration Test
- f) Cone Penetration Test
- g) Rotary Boring
- h) Percussion Boring

Table 4.2.1.3.2.1 Exploration objectives and suggested applicable methods

Sr. No.	Purpose of Exploration	Open Trial Pit/ Test pit	Hand Auger Boring	Shell & Auger boring	Wash Boring	SPT	CPT	Rotary Boring	Percussion Boring
1.	Faults	√						√	
2.	Deep – land							√	√
3.	Shallow – land	√	√	√	√	√	√		√
4.	Subaqueous							√	
5.	Soft-soil depth		√	√	√	√	√	√	√
6.	Sliding masses	√	√	√	√		√		
7.	Rock depth							√	√
8.	Rock-mass conditions							√	
9.	Disturbed Soil samples	√	√	√	√	√		√	
10.	Representative Soil samples	√	√	√	√	√		√	
11.	Undisturbed Soil samples	√	√	√	√			√	
12.	Rock cores							√	
13.	1 to 2 - Storeyed Buildings (3 - 9 m Depth)	√	√	√	√	√	√	√	√
14.	2 to 6 - Storeyed Buildings (9 - 20 m Depth)	√	√	√	√	√	√	√	√
15.	(7 to 8 - Storeyed Buildings (20 - 30 m Depth)				√	√	√	√	√
16.	High – rise Buildings (9 – Storeyed and above) (30 - 80 m Depth)				√	√	√	√	√

Note: The depths mentioned in Table 4.2.1.3.2.1 are only the minimum requirements. Site investigation should be carried out to sufficient extent and depth to establish the significant soil strata and ground variation. Boreholes should go more than 5 meters into hard stratum with SPT blow counts of 100 or more than 3 times pile diameters beyond the intended founding level.)

4.2.1.3.2.2 Hydrogeological Investigation

Groundwater is generally collected and moves in interconnected voids, pore spaces, cracks, fissures, joints, bedding planes and other openings in soil and rock formations beneath the ground surface. The level of the water table is not stationary. It fluctuates according to the rainfall or seasons. The hydrogeological condition of a proposed site potentially has a great effect on foundation design consideration.

For investigation of the groundwater table, the following methods are suggested to be applied and types of water table should be described according to Appendix D.

4.2.1.3.2.2.1 Method of Groundwater Table Investigation

4.2.1.3.2.2.1.1 Logging at Test Borehole

One day after drilling, the standing groundwater level is usually measured by a level indicator or measuring tape. If drilling of the test borehole is continued on another day, the water table must be measured before and after drilling.

4.2.1.3.2.2.1.2 Installation of Piezometer and Logging

After the completion of drilling the test borehole to the required depth, a piezometer can be installed inside a PVC slotted screen and can be used to measure the water table for an extended period.

4.2.1.3.2.2.1.3 Permeability Tests and Filtration of Groundwater

Some of the following tests may be applied according to the client's requirements.

1) Permeability

These are primarily seepage tests:

- a) Variable head test
- b) Constant head test

The variable head test is typically carried out in cased boreholes below the ground water table or in slow draining soils. The borehole is filled with water and rate of fall is measured against time. An alternative approach is to bail water from the hole and record the rate of rise in the water level until the rise becomes negligible.

The constant head test is typically carried out in unsaturated granular soils. The ground around the hole is saturated by adding metered quantities of water to the hole until the quantity decreases to a steady value. Water continues to be added to maintain a constant level recording the quantity of water added at regular intervals.

(2) Packer Test

The general test involves installing packers in boreholes and expanding them with air pressure to seal off sections of the borehole. Water under pressure is introduced between the packers and the elapsed time and volume of water pumped into the rock mass is noted. Curves of flow versus pressure are plotted and approximate values for the rock mass permeability can be estimated.

One of two procedures is used depending on rock quality. The common procedure, used in poor to moderately poor rock with hole collapse problems, involves drilling the hole to some depth and performing the test with a single packer. Casing is installed if necessary and the hole is advanced to the next test depth. In good quality rock where the hole remains open, the hole is drilled to the final depth and testing proceeds in sections from the bottom up with two packers. Packer spacing depends on rock quality.

(3) Pumping Test

Pumping tests are usually carried out in gravity wells or artesian wells in soil and rock. The well is pumped at a constant rate until a cone of drawdown measured in observation wells has stabilized (recharge equals the pumping rate). Values of the soil or rock mass permeability can be obtained from the test results.

4.2.1.3.2.3 Geotechnical Instrumentation

The primary requirement of any instrument is that it should be capable of determining a required parameter, such as water pressure, or displacement, without leading to a change in that parameter as a result of the presence of the instrument in the soil. Instrumentation for displacement measurement and pore water pressure and groundwater level measurements are presented in Appendix E.

4.2.1.4 Number and Position of Borehole locations.

The number of boreholes and their locations depend on the following:

- 1. type and size of the project
- 2. soil variability

Factors to be considered in test site selection include the proposed development layout, the site geology and access constraints. The extent to which these factors influence, test site selection will depend on the specific details of each project. A number of examples are described as follows:

- 1. For large buildings, boreholes should be located close to the proposed foundations;
- 2. For an industrial plant with a few items of heavy plant and numerous items of light plant, a grid pattern for most of the site would be appropriate with additional holes located at the proposed heavy plant sites;
- 3. Test pits should not be located in the intended footing positions for houses because of the weakening of the ground by the excavation. Where the layout of a proposed housing estate is known, future road alignments, property boundaries or service line easements (prior to installation of services) are preferred locations to building envelopes for test pits.
- 4. For bridges, boreholes should be located at the proposed abutment and pier locations.
- 5. For railways and highways in steep terrain, target boreholes locations should include proposed cuts;

Access is a factor which can influence test site location. Access onto peat swamps, tidal flats and mangrove areas can be very difficult. These are also areas which have a high probability of containing soft unstable soils, which will create problems for future development. Consideration as to how to gain access to such areas should be given at the proposal stage of a project. Existing buildings spoil piles or drainage channels may also prevent drill rig or excavator access.

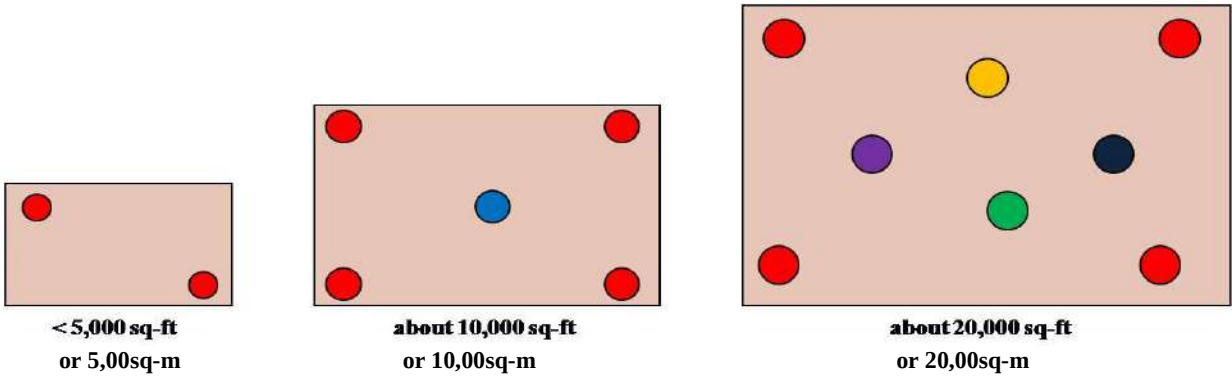


Figure 4.2.1.4 Suggested numbers, position and locations of Minimum Number of Boreholes

Suggested number and locations of boreholes are shown in Table 4.2.1.4 (1) and 4.2.1.4 (2).

Table 4.2.1.4 (1) Suggested number and locations of boreholes

Project	Distance between borings (meter) Horizontal Stratification of Soil and Rock			Minimum number of Boreholes for each structures
	Uniform	Average	Erratic	
3- 8 story buildings	50	30	15	4
1 -2-storey buildings	60	30	15	3

The borehole spacing suggested by the Committee for Quality control of High-rise building construction Projects (C.Q.H.P) (minimum number of borings = 2 boreholes) is as follows:

1. One boring for every 2500 sq-ft (or) 250 sq-m of built-over area < 10,000 sq-ft (or) 1,000 sq-m.
2. One boring for every extra 5,000 sq-ft (or) 500 sq-m for large area projects > 10,000 sq-ft (or) 1,000 sq-m.
3. Additional borings for irregular soil conditions.

Table 4.2.1.4 (2) Suggested number and locations of boreholes

Area for Investigation	Boring Spacing (meter) / Boring number
New site of wide extent	borings 60 to 150 m apart
site on soft compressible strata	30 to 60 m at building locations.
Large structure (closely spaced footings)	Space borings 15 m in both directions , foundation walls at machinery or elevator
Low-load warehouse (large area)	Minimum of 4 borings at the corners
Isolated foundations 250 to 10,00sq-m	Minimum of 3 borings around perimeter
Isolated rigid foundation, < 250 sq-m	Min: of 2 borings at opposite corners
Major waterfront structures (drydocks)	space borings generally < 15 m. Add critical locations, deep pumped well, gate seat, tunnel, or culverts.
Long bulkhead or wharf wall.	borings on line of wall at 60 m spacing.
Slope stability, deep cuts, embankments	3 to 5 borings on line in critical direction
Water retaining structures	Space preliminary borings 60 m, cutoff, critical abutment

4.2.1.4.1 Depth of Boring.

Sowers (1979) suggested specified depth criteria as follows:

Minimum depth of borings = $10 S^{0.7}$ (ft) or $3 S^{0.7}$ (m) (for narrow and light buildings)

Minimum depth of borings = $20 S^{0.7}$ (ft) or $6 S^{0.7}$ (m) (for wide and heavy buildings)

Where, S = the number of stories in the building

The Committee for Quality control of High-rise building construction Project (CQHP) suggested the following depth specifications.

1. Shallow foundations specified depth as 1.5 times lesser dimension ($B < L$) (Limit to 30ft (or) 10 m minimum)
2. Deep foundations: Minimum depth of borings = $15 S^{0.7}$ (ft) or $5 S^{0.7}$ (m) (Limit to 3 consecutive SPT values ≥ 50)

(Note: As stated in Clause 3.4.2 of ACI 336.3R-93 (reapproved in 1998) for Design and construction of Drilled Piers, Boring depth should be adequate to investigate settlement of the bearing stratum below the pier. Where practical, at least one boring should go into bedrock.)

(Site investigation should be carried out to sufficient extent and depth to establish the significant soil strata and ground variation. (a) The number of boreholes should be the greater of (i) one borehole per 300sq m or (ii) one borehole at every interval between 10m to 30m, but not less than 3 boreholes in a project site. (b) Boreholes should go more than 5 meters into hard stratum with SPT blow counts of 100 or more than 3 times pile diameters beyond the intended founding level.)

4.2.1.5 Geophysical Methods

The existing methods and techniques of geophysical exploration can be adapted with some modifications to most targets of environmental and engineering interest (shallow depth). In principle, all the geophysical techniques that have been advised for subsurface investigations essentially detect a discontinuity; that is, one underground region differs sufficiently from another in some physical properties such as density, magnetic susceptibility, elasticity, spontaneous polarization, electric resistivity and conductivity, dielectric permittivity, radioactivity and thermal conductivity and so on. The common geophysical methods using in engineering practice are as follows and their summary of application is shown in Table 4.2.1.5.

1. Seismic Survey (Hammering, Blasting)
2. Electrical Methods (Resistivity, IP, SP, VES)
3. Magnetic Survey
4. Time Domain Electromagnetic Survey (TDEM)
5. Gravity Survey
6. Radioactivity Survey

A detailed explanation of each method is presented in Appendix F.

Table 4.2.1.5 Common geophysical methods and its application

Sr. No.	Purpose of Investigation	Magnetic	Gravity	Electrical				Electromagnetic			Seismic	
		Normal	Normal	SP	VES	ER	IP	VLF	GPR	TEM	Reft	Refr
1.	Subsurface Cavities					√						
2.	Clays, Peat and Soil			√		√			√			
3.	Construction Sites								√			√
4.	Fissures zones in rock					√		√	√			
5.	Fracture zones in rock	√	√			√			√			√
6.	Geological Mapping	√	√									
7.	Groundwater in crystalline rock					√		√				
8.	Groundwater in sedimentary areas				√							
9.	Groundwater flow			√								
10.	Overburden thickness				√							√
11.	Pollution of soil and groundwater					√						
12.	Saltwater invasion					√	√					
13.	Sand deposits								√			√

4.2.1.6 Sampling and Testing

The frequency of sampling and testing in an investigation depends on the information that is already available about the ground conditions and the technical objectives of the investigation.

4.2.1.6.1 Methods of Sampling.

1. In Standard Penetration Test (SPT) (ASTM D1586-99), use the split-spoon sampler for disturbed samples and use the piston tube steel sampler for undisturbed samples.
2. Hand augering method for undisturbed samples.
3. Test pitting for disturbed and undisturbed samples
4. Rotary drilling (manual) for s for disturbed and undisturbed samples and disturbed samples.

Some special techniques of sampling and testing are shown in the following Table 2.3.12 (1).

Table 4.2.1.6.1 (1) Some special techniques of sampling and insitu testing

Type of Ground	Special Techniques
Sand	SPT, CPT, sand samplers
Soft Sensitive Clay	CPT, Flat Plate Dilatometer, borehole or penetration shear vane, thin wall open tube or piston sampler, continuous soil sampler, large diameter samplers
Hard Stony Clay	Plate bearing test, pressure meter, rotary core sampling
Rock	Pressure meter, rotary core drilling using larger core sizes than 70 mm diameter

4.2.1.6.1.1 Soil samples

The selection of a sampling technique depends on the quality of the sample that is required and the character the ground, particularly the extent of disturbance by the sampling process. In choosing a sampling method, it should be made clear whether the mass properties or the intact materials properties of the ground are to be determined.

Sampling methods will differ according to the types of building for which the investigation is being carried out. The following procedure should be followed during sampling.

1. For low rise buildings, houses and sites where the soil profile is expansive, the upper about 1 – 3 m of the profile is critical and sufficient samples should be recovered from this depth interval to characterize the founding conditions.
2. Samples, both disturbed and undisturbed, should be taken in every 1m (more samples will be required if there is a lithologic change within 1m).
3. The collected samples must be sent urgently to the laboratory within two days, or the samples must be stored well enough to maintain their natural conditions.

The weight of sample must be as shown in Table 4.2.1.6.1 (2)

Table 4.2.1.6.1 (2) The recommended weight of soil samples for different tests (BS 5930-99)

Purpose of Sample	Soil	Mass of Sample Required (kg)
Soil identification, including Atterberg's Limits, Sieve analysis, Moisture content test	Clay, Silt, Sand	1
	Fine and Medium Gravel	5
	Coarse Gravel	30
Compaction Tests	All	25 – 60
Comprehensive examination of construction materials, including soil stabilization	Clay, Silt, Sand	100
	Fine and Medium Gravel	130
	Coarse Gravel	160

Complete detailed descriptions must be included on each sample bag as follows:

1. Location (GPS), Project name
2. Sample No.
3. Depth from where to where
4. Collector's name
5. Date of sampling
6. Investigation and Sampling Method

4.2.1.6.1.1.1 Disturbed and Undisturbed Samples.

1. The Standard Penetration Test (SPT) splitspoon sampler may be used for disturbed samples but the piston tube steel sampler or thin wall tube sampler must be used for undisturbed samples.
2. The hand augering method is suitable for obtaining disturbed samples. Undisturbed samples require the use of a thin wall tube sampler.
3. Test pitting is suitable for disturbed samples and for obtaining undisturbed samples either by cutting blocks of soil or using a thin wall tube sampler.

4. Rotary drilling (manual) is suitable for obtaining both disturbed and undisturbed core samples

4.2.1.6.1.1.2 Representative samples

The samples collected at a proposed site should be representative of the natural conditions of the soil such as natural moisture content and density and should be free from remolding effects.

4.2.1.6.1.2 Rock Samples

It is well known that rocks masses are non-homogeneous and the properties of samples taken from one portion of the rock may be different from those taken from another location. Therefore sampling should be properly done to represent the rock mass.

Samples can usually be collected from the field in the form of large blocks in the case of surface and near surface deposits by breaking from the parent body manually using steel hammers. When the deposit is deep under the ground, the samples can be obtained in the form of cores obtained from diamond drilling and large blocks may be available from blasting.

The following procedure should be followed during sampling.

1. Store the samples in the Core-box.
2. On the core-box, a detailed description must be included as follows:
 - (i) Borehole No., Location (GPS), Project Name.
 - (ii) Depth from where to where
 - (iii) Logger's name
 - (iv) Rock Quality Designation (RQD)
 - (v) Total Core Recovery (T.C.R)
 - (vi) Solid Core Recovery (S.C.R)
 - (vii) Core recovery (%)
 - (viii) No. of fractures (FI)
3. One core-box must have at least 3m of core run.
4. Cores must be placed in the core-box as soon as the drilling is finished and core losses must be shown systematically as well.
5. Photographs of core samples must be taken after placing the core in the core-box.
6. The core samples in the box must be covered with plastic sheets.
7. Core-boxes with core samples must be locked and stored in cool place.
8. The core samples for laboratory tests must be handled well, placed carefully onto PVC tubing, sealed with wax and covered with plastic sheets.

4.2.1.6.2 Protection, Handling, Labeling of Samples

4.2.1.6.2.1 Protection and Handling.

Samples may cost a considerable sum of money to obtain and should be treated with great care. Ideally, samples should be moisture-proofed immediately after collection either by waxing, spraying, or packing in polythene bags or sheets. They should be transported and stored under cover, and generally protected from excessive changes in humidity and temperature. Temperature must be

between 20° C and 45° C. The usefulness of laboratory test results depends on the quality of samples at the time they are tested.

4.2.1.6.2.2 Labeling

All samples should be labeled with a unique reference number immediately after being collected. The label should show all necessary information about the sample (site name, borehole number, depth, top and bottom of a core, etc) and should also be recorded on the daily field report. The label should be marked with indelible ink and be sufficiently robust to withstand the effects of the environment and transportation.

4.2.1.6.3 Visual Examination and Description of Laboratory Samples

Information about the grading and plasticity of soils can be estimated from visual inspection of bulk samples obtained during drilling and from tube samples. Information about the structures and fabric of soils cracks in rocks can be visually examined from high quality samples.

The description of samples of soil and rock tested in the laboratory forms an important part of the record of the test results. Such descriptions should be included on the laboratory work sheet. Descriptions of samples noted in the laboratory should be compared with the equivalent field descriptions and any anomalies should be resolved.

4.2.2 Laboratory Tests

1. Grain Size analysis
 - (i) Dry – sieve analysis to 75 microns (No. 200 Sieve)
 - (ii) Wet – sieve analysis for soil less than 75 microns (No. 200 Sieve)
 - Pipette method
 - Hydrometer analysis
2. Test for determination of water content and dry unit weight of soil
3. Test for determination of specific gravity
4. Test for determination of consistency of soil
5. Shear strength tests
6. Compaction test
7. California Bearing Ratio (CBR) Test
8. Permeability tests
9. Consolidation tests
10. Dispersibility tests
11. Other tests
 - (i) Vane shear test
 - (ii) Swelling pressure test
 - (iii) Free swell test
 - (iv) Linear shrinkage test

4.2.2.2 Result Presentation.

A common sample form for presentation of test results is shown in Appendix G.

4.2.3 Soil and Rock Classification

4.2.3.1 Classification of Soil According to ASTM D-2487-00.

A soil classification system divides soil into groups and sub-groups based on common engineering properties such as the grain-size distribution, liquid limit and plastic limit. The major classification system presently in use is the American Society for Testing Materials (ASTM). The ASTM system was originally proposed by A. Casagrande in 1942 and was later revised and adopted by the United States Bureau of Reclamation and U.S Army Corps of Engineers in 1969. The system is used extensively in geotechnical works. The symbols and terminology shown in Table 4.2.3.1 (1) and Table 4.2.3.1 (2) are used for identification. Classification of non – plastic and plastic soils and sample forms of classification are shown in Tables 4.2.3.1 (3), 4.2.3.1 (4) and 4.2.3.1 (5).

Table 4.2.3.1 (1) Terminology used to denote percentage by weight of each component

Descriptive Term	Range of Proportion
Trace (eg. trace sand, trace clay)	1 – 9 %
Some (eg. Some sand, some clay)	10 – 19 %
Adjective (eg. Sandy, silty)	20 – 34 %
Major soil (eg. SAND, CLAY, SILT)	≥ 35 %

Table 4.2.3.1 (2) Symbols for Soil Identification in ASTM System

Symbol	Description
G	Gravel
S	Sand
M	Silt
C	Clay
O	Organic Silts and Clay
Pt	Peat and highly organic soils
H	High plasticity
L	Low Plasticity
W	Well graded
P	Poorly graded

Terminologies used to indicate the compactness and consistency of disturbed materials are described in the following tables.

Table 4.2.3.1 (3) Compactness of non – plastic soil based on SPT values

Compactness of non – plastic soil	SPT values Blows / foot (or) Blows / 0.305 m	Relative Density (%)
Very Loose	0 – 4	0 – 20
Loose	4 – 10	20 – 40
Medium Dense	10 – 30	40 – 70
Dense	30 – 50	70 – 90
Very Dense	> 50	> 90

Table 4.2.3.1 (4) Consistency of plastic soil based on UCS values and SPT values

Consistency of plastic soil	Range of Unconfined Compressive Strength			SPT values Blows /foot (or) Blows / 0.305 m
	(psf)	(KN/Sq.meter)	(Ton/Sq.ft)	
Very soft	0 – 500	< 25	< 0.25	0 – 2
Soft	500 – 1000	25 – 50	0.25 – 0.5	2 – 4
Medium Stiff (firm)	1000 – 2000	50 – 100	0.5 – 1.0	5 – 12
Stiff	2000 – 4000	100 – 200	1.0 – 2.0	12 – 25
Very Stiff	4000 – 6000	200 – 300	2.0 – 3.0	25 – 40
Hard	6000 – 8000	300 – 400	3.0 – 4.0	40 – 50
Very Hard	> 8000	> 400	> 4.0	> 50

The classification of soil at the proposed site should be described as shown in the following sample form.

Table 4.2.3.1 (5) Sample form of soil classification

Compactness or Consistency of soil	Colour	Soil Type	Others (If have)
eg. Very Dense	Reddish Brown	SAND and SILT	With lime powder
eg. Stiff	Yellowish Grey	Silty CLAY	With broken bricks

Unified Soil Classification System (USCS) which is adopted as ASTM D-2487-00 is also application for classification of soil. The plasticity chart and characteristics of soil groups with the group symbols for various types of soil in USCS are shown in Appendix H.

4.2.3.2 Classification of Soil According to $\bar{v}_s^{30}$ (Seismic Site Classification)

For seismic design consideration, the soil is generally classified based on their average shear wave velocity of upper 30 m depth, $\bar{v}_s^{30}$, of soil layers as shown in Table 4.2.3.2.

$$\bar{v}_s^{30} = \frac{\sum_{i=1}^n t_i}{\sum_{i=1}^n t_i / v_{si}}$$

Where,

$\bar{v}_s^{30}$ = Average S-wave velocity in upper 30 m depth

n = Number of soil layers

t_i = Thickness of i^{th} soil layer

v_{si} = S-wave velocity of i^{th} soil layer

Table 4.2.3.2 Seismic Site Classification

Site Class	$\bar{v}_s^{30}$	$\bar{N}$
E (Soft Soil)	< 600 ft/s (< 175 m/s)	< 15
D (Medium Dense Soil)	600 – 1,200 ft/s (175 – 350 m/s)	15 – 50
C (Dense Soil)	1,200 – 2,500 ft/s (120- 250 m/s)	> 50

4.2.3.3 Classification of Construction Materials

4.2.3.3.1 Materials for Concrete Aggregate

Material suitable for use as concrete aggregate, shall comply with the requirements of ASTM C-33-03.

4.2.3.3.2 Materials for backfills.

Materials which are classified within Group (a) in Table 4.2.3.3.2 are suitable for use as backfill materials. Materials which are classified as Group (b) in Table 4.2.3.3.2 are unsuitable for use as backfill but may be designated for other uses.

Various types of backfills are shown in Table 4.2.3.3.2.

Table 4.2.3.3.2 Various Types of Backfills

DESCRIPTION OF BACKFILL MATERIAL	UNIFIED SOIL CLASSIFICATION
Group (a)	
Well-graded, clean gravels; gravel-sand mixes	GW
Poorly graded clean gravels; gravel-sand mixes	GP
Silty gravels, poorly graded gravel-sand mixes	GM
Clayey gravel, poorly graded gravel-and-clay mixes	GC
Well-graded, clean sands; gravelly sand mixes	SW
Poorly graded clean sands; sand-gravel mixes	SP
Silty sands, poorly graded sand-silt mixes	SM
Sand-silt clay mix with plastic fines	SM-SC
Clayey sands, poorly graded sand-clay mixes	SC
Inorganic silts and clayey silts	ML
Mixture of inorganic silt and clay	ML-CL
Inorganic clays of low to medium plasticity	CL
Group (b)	
Organic silts and silt clays, low plasticity	OL
Inorganic clayey silts, elastic silts	MH
Inorganic clays of high plasticity	CH
Organic clays and silty clays	OH

4.2.4 Seismic Design Category

4.2.4.1 Site class definitions.

The design categories A, B, C, D, E, F shall be classified based on the average shear wave velocity at upper 30 m (100 ft) depth, standard penetration resistance, and un-drained shear strength of soil in accordance with Section 3.4.1 of Structural Design.

When the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the building official or geotechnical data determines that Site Class E or F soil is likely to be present at the site.

4.2.4.2 Spectral Response Acceleration Parameters

4.2.4.2.1 Preparation of Maps of Response Acceleration of 0.2s and 1s

The parameters S_s and S_1 shall be determined from the prepared 0.2 and 1-second spectral response acceleration maps or shall be determined based on seismic source to site distance, magnitude of designed earthquake, focal depth and v_s^{30} for a particular site of interest. Where S_1 is less than or equal to 0.04 and S_s is less than or equal to 0.15, the structure is permitted to be assigned to Seismic Design Category A.

4.2.4.2.2 Values of Site Coefficient F_a

According to Section 3.4.1 of Structural Design.

4.2.4.2.3 Values of Site Coefficient F_v

According to Section 3.4.1 of Structural Design.

4.2.4.3 Soil Amplification

1D seismic response analysis by using equivalent linear method should be used to obtain the amplification factor of underlying soil of a proposed site. Amplification is the ratio of amplitude of the objective layer to those of the reference layer, and is a function with respect to frequency.

For high – rise buildings (generally starting from 9 – storeys), the calculated amplification based on soil data from the proposed site should be used for design consideration.

4.2.4.4 Fundamental Frequency and Predominant Period

Fundamental Frequency or Predominant Period of underlying soil is one of the important parameters in seismic resistant design consideration. Buildings with similar natural period of resonance and resonance frequency to those of the supporting soil can be expected to suffer severe damage during an earthquake.

The frequency or period that is corresponding to peak soil amplification is usually regarded as the Fundamental Frequency or Predominant Period of that soil for that site. These parameters can be obtained through seismic response analysis.

4.2.4.5 Seismic Response Analysis

This is the most important and most reliable approach that can be conducted for seismic resistant design of a structure. It is a simulation based on the specific soil parameters of the site, the shear wave velocity structure and generated or recorded bedrock motion.

Seismic Response Analysis will give all the required parameters for the design of various structures, including high – rise buildings, such as peak ground acceleration, peak ground velocity, peak ground displacement, amplification factor, fundamental frequency and predominant period. The general procedure for 1D seismic response analysis is shown in Appendix I.

4.2.5 Report Preparation and Geotechnical Criteria.

The buildings of 9 storeys and above are generally regarded as high – rise buildings. For such buildings, the geotechnical investigation report should be prepared according to the instructions of the Committee for Quality Control of High – Rise Buildings. These instructions are summarized as follows.

The site investigation, laboratory testing and report shall include the following components:

- (a) Environmental study of the site and surrounding area.
- (b) A site location plan and a site area plan with the number of boreholes, depths, elevation and their locations marked on the plan.
- (c) A subsurface investigation and sampling of the foundation soils shall be carried out in accordance with the standard methods adopted in Myanmar for high-rise buildings.
- (d) The following tests shall be carried out as appropriate for the site conditions.
 1. Visual soil classification
 2. Tests for Moisture content and density of all soil samples
 3. Grain size analysis for selected samples
 4. Atterberg's Limits Tests (liquid limit, plastic limit, and plasticity index) for semi-plastic and plastic soil.

5. Unconfined compressive strength test for semi-plastic soils and plastic soils.
 6. Direct shear test for selected soil samples or triaxial compression test for selected soil samples.
 7. Specific gravity test for selected soil samples.
 8. Consolidation test for semi-plastic soils or plastic soil samples for shallow foundation.
- (e) Seismicity of the area, liquefaction, predominant period, fundamental frequency, and amplification (site effects) of soils at a proposed site should be included.
 - (f) For high – rise buildings, seismic response analysis has to be included for seismic-resistant design practices.
 - (g) Soil profiles with standard soil descriptions, depths, elevation, groundwater levels and the results of in-situ testing such as the standard penetration tests (SPT) and/or vane shear tests shall be provided for each borehole. If rock was encountered, the report should include a description of the rock including the degree of weathering and fracturing, compressive strength and rock quality designation (RQD) if core was recovered.
 - (h) A geological description of the site shall be provided.
 - (i) Recommendations shall be presented for alternative types of foundations along with founding depths and any precautions that are relevant.
 - (j) For shallow foundations, recommended allowable bearing capacity values at various depths should be provided for each borehole profile..
 - (k) The results of any other appropriate tests and other general recommendations for foundation design and construction should also be presented in the report.
 - (l) Photographs of the site, and site investigation should also be included.
 - (m) The report should include a discussion of the advantages and disadvantages of the proposed site with respect to the proposed high-rise development.

For other geotechnical investigation reports (9 – storeyed and above), the sampling method mentioned in above will keep on applying. For lower buildings (less than 9 – storeyed), proper types of sampling methods (e.g, standard drilling method) may apply and soil sampling methods must be included in report. In soil reports, standards of sampling and standard for tests must be clearly described.

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PART 4 SOILS AND FOUNDATIONS

SECTION 4.3: EXCAVATION, GRADING AND FILL

4.3.1 Excavations near footing or foundations

4.3.2 Placement of backfill

4.3.3 Site grading

4.3.4 Grading and fill in flood hazard areas

4.3.5 Compacted fill material

4.3.6 Controlled low-strength material

4.3 EXCAVATION, GRADING AND FILL

4.3.1 Excavations near footing or foundations

Excavations for any purpose shall not remove lateral support from any footing or foundation without first underpinning or protecting the footing or foundation against settlement or lateral translation.

4.3.2 Placement of backfill

Excavations outside the foundation shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or shall be backfilled with a controlled low-strength material (CLSM). The backfill shall be placed in lifts and compacted in a manner that does not damage the foundation, the waterproofing or the damp-proofing material.

4.3.3 Site grading

The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5 percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall. If physical obstruction or allotment boundaries prohibit 10 feet (3048mm) of horizontal distance, a 5 percent slope shall be provided to an approved alternative method of diverting water away from the foundation. Swales used for this purpose shall be sloped a minimum of 2 percent where located within 10 feet (3048 mm) of the building foundation. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped a minimum of 2 percent away from the building.

4.3.4 Grading and Filling in Flood Hazard Areas

1. Unless such fill is placed, compacted and sloped to minimize shifting, slumping and erosion during the rise and fall of flood water and, as applicable, wave action.
2. In floodways, unless it has been demonstrated through hydrologic and hydraulic analyses, performed by a registered design professional in accordance with standard engineering practice, that the proposed grading or fill, or both, will not result in increased flood levels during the occurrence of the design flood.
3. In flood hazard areas subject to high velocity wave action, unless such fill is conducted and/or placed to avoid diversion of water and waves toward any building or structure.
4. Where design flood elevations are specified but floodways have not been designated, unless it has been demonstrated that the cumulative effect of the proposed flood hazard area encroachment, when combined with all other existing and anticipated flood hazard area encroachments, will not increase the design flood elevation more than 1 foot (305 mm) at any point.

4.3.5 Compacted Fill Material

Where footings bear onto compacted fill material, the compacted fill shall comply with the provisions of an approved report, which shall contain the following.

1. Specifications for the preparation of the site prior to placement of compacted fill material.
2. Specifications for material to be used as compacted fill.
3. Test methods to be used to determine the maximum dry density and optimum moisture content of the material to be used as compacted fill.
4. Maximum allowable thickness of each lift of compacted fill material.

5. Field test methods for determining the in – place dry density of the compacted fill.
6. The minimum acceptable in-place dry density expressed as a percentage of the maximum dry density determined in accordance with Item 3.
7. The number and frequency of field tests required to determine compliance with Item 6.

4.3.6 Controlled Low-Strength Material

Where footings will bear on controlled low- strength material (**CLSM**), the **CLSM** shall comply with the provisions of an approved report, which shall contain the following:

1. Specifications for the preparation of the site prior to placement of the CLSM.
2. Specifications for the CLSM.
3. Laboratory or field test method (s) to be used to determine the compressive strength or bearing capacity of the CLSM.
4. Test methods for determining the acceptance of the CLSM in the field.
5. Number and frequency of field tests required to determine compliance with Item 4.

4.3.7 Soil improvement

Suitable improvement methods should be applied according to the requirements of proposed sites.

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PART 4 SOILS AND FOUNDATIONS

SECTION 4.4: DESIGN RECOMMENDATIONS FOR SOILS AND ROCKS

- 4.4.1 Basic Design Concepts for Expensive and Black Cotton Soil
- 4.4.2 Basic Design Concepts for potential landslide area
- 4.4.3 Strength Parameters of Soils and Rocks
- 4.4.4 Lateral Earth Pressure (*Both Static and Dynamic*)
- 4.4.5 Design Parameters (Static Load)
- 4.4.6 Seismic Design Parameters (Seismic Load)
 - 4.4.6.1 Average shear wave velocity of upper 30 m depth, v_s^{30}
 - 4.4.6.2 Spectral Response acceleration
 - 4.4.6.3 PGA, PGV, PGD
 - 4.4.6.4 Amplification of Soil
 - 4.4.6.5 Fundamental Frequency and Predominant Period of Soil

4.4 DESIGN RECOMMENDATIONS FOR SOILS AND ROCKS

4.4.1 Basic Design Concepts for Expansive Soil and Black Cotton Soil

Most of the expansive soils likely to be encountered in Myanmar have formed residually over rocks, particularly basalts. These soils generally contain a large percentage of active clay content. Montmorillonite is the predominant clay mineral in expansive soils. Tropical expansive soils, often called Black Cotton Soil (in Myanmar), are major foundation problems in America, Africa, and Asia. The term “Black Cotton Soil” is believed to have originated in India where the locations of these soils are favorable for growing cotton. All expansive soils have a high water holding capacity and it is not possible to completely dry the soil in oven at a temperature of 110° C. The high percentage of clay is responsible for high volumetric changes during wetting and drying. The soil in the dry state can often have high strength, but the soils become soft when in the wet state. During summer and dry seasons, the soil shrinks volumetrically (in three dimensions).

The thickness of black cotton soils are typically in the range of about 4meter depth from ground surface.

The depth at which structures are founded in black cotton soils depends on such factors as the structural design, amount of permissible movement, soil characteristics and profile, and expected moisture variations over the life of the structure.

The use of mats, stiffened rafts, strip footings or individual pad footings will require special evaluation of site specific soil-structure interaction, design of structural elements accordingly and/or special soil treatment or replacement methods.

Where the thickness of expansive soil is less than 2 meter, the observed expansive soil layer could be removed and replaced with suitable non-reactive material. . However, if the thickness of the expansive soil layer is more than 2meter., it may be appropriate to treat the layer by stabilization using cement or lime or some other special treatment.

Moisture variation in expansive soils should be minimized by implementing the following essential points:

- a) Providing a good drainage system around the outside of buildings.
- b) Avoiding sewage pipes passing near the buildings either surface or subsurface and leading such pipes directly away from the structure at right angles to exterior walls. Such pipes and connections should be well designed to avoid danger of leakage.
- c) Keeping taps and other water connections in gardens and walls away from the structure.
- d) Planting trees at a distance equal to the mature height of the trees. They should not be planted closer to the structures. Many shrubs also absorb large quantities of moisture from a soil and can cause volume changes of expansive soils.
- e) Providing good ventilation and drainage below a suspended floor - this can be helpful in maintaining moisture equilibrium.
- f) Paving areas around the structures – this is often advantageous in maintaining a uniform moisture content beneath the structure. Adequate insulation by membranes, such as asphalt or asphalted fiber glass, is helpful in protecting the moisture losses of soil and penetration of surface water.
- g) Protecting and backfilling of all foundation excavations in expansive soil areas without delay in order to minimize changes in the natural moisture regime.
- h) Providing an appropriate layout and type of ground beams for such soil.

- i) Some engineers suggested that safe soil bearing capacity of expansive soils should be taken just over swelling pressure of that soil.

4.4.2 Basic Design Concepts for Potential Landslide Areas

Slope stability analysis should first be performed in such areas to establish whether various stability measures have to be performed to ensure the stability of buildings.

The main causes that influence landslide potential in Myanmar are: (i) gravity and the gradient of the slope, (ii) hydrogeological characteristics of the slope, (iii) presence of troublesome earth material, (iv). processes of erosion, (v) man-made causes, (vi) geological conditions, and (vii) occurrence of a triggering event.

The general procedure for slope stability analysis is presented in Appendix J.

4.4.3 Strength Parameters of Soils and Rocks

To assist with footing design, the strength parameters for soils and rocks which are encountered at the proposed sites have to be determined. The angle of internal friction, ' ϕ ' and cohesion, ' c ' are two main shear strength parameters of soils and rocks and are dependent on many factors such as; the types of soil and rock, moisture content, the presence of micro fractures, rate of loading, permeability, stress history and so on. The shear strength, compressive strength and tensile strength of soil and rock have to be calculated by using any available methods and approaches. Both results from in-situ tests in the field and results from laboratory tests have to be considered.

4.4.4 Lateral Earth Pressure (*Both Static and Dynamic*)

The seismic behavior of earth retaining structures depends on the total lateral earth pressure that develops during an earthquake. These total pressures include both static gravitational pressure that exists before an earthquake occurs and the dynamic pressure induced by the earthquake. The lateral earth pressure for retaining structures needs to be calculated for both static and dynamic loading conditions.

For static earth pressure (both active and passive pressures), Rankine Theory (1857) or Coulomb Theory (1776) or Logarithmic spiral method or Stress – Deformation Analysis such as finite element analysis should be conducted.

Calculation of seismic lateral earth pressure on a retaining structure is one of the important applications of the pseudo-static (quasi-static) seismic inertial force. For calculation of dynamic earth pressure (both active and passive pressures), Mononobe – Okabe method (1929) or Steedman – Zeng method (1990) or finite element analysis should be performed.

4.4.5 Design Parameters (Static Load)

The following parameters have to be determined and submitted to the design engineers for consideration in the design for static loading conditions.

- a) Natural water content in soil
- b) Specific Gravity and Density
- c) Dry Unit Weight
- d) Specific Gravity of soil particles
- e) Natural Void Ratio
- f) Saturation
- g) Water Ratio

- h) Liquid limit
 - i) Plastic Limit
 - j) Plastic Ratio
 - k) Liquid Ratio
 - l) Coefficient of Compression
 - m) Compression Modulus
 - n) Angle of Internal Friction
 - o) Cohesion
 - p) Coefficient of Collapsible (Angle of repose)
 - q) Initial Pressure of Collapsible
- (To evaluate stability, informality, bearing capacity of foundation)

4.4.6 Seismic Design Parameters (Seismic Load)

For seismic – resistant design, considerations of high – rise buildings and infrastructures, the following parameters are recommended.

4.4.6.1 Average shear wave velocity of upper 30 m depth, $\bar{v}_s^{30}$

The evaluation of strong motions and site effects of local soil conditions requires information on shear wave velocity especially for areas where thick sediment layers are overlying bedrock.

- a) The average shear wave velocity at upper 30 m depth, ($\bar{v}_s^{30}$) will be used for classification of seismic design categories as in Structural Design Section 4.2.3.2.
- b) $\bar{v}_s^{30}$ will be used for determination of soil amplification factor during an earthquake.
- c) $\bar{v}_s^{30}$ will also be used seismic response analysis for determination of soil amplification factor during an earthquake.

The average shear wave velocity of the top 30 m, v_s^{30} can be evaluated by some geophysical methods or by SPT results.

4.4.6.2 Spectral Response acceleration

The response acceleration will be determined from maps or from empirical calculation by using some attenuation relationships or from response analysis for high – rise buildings and important public buildings.

4.4.6.3 PGA, PGV, PGD

The peak ground acceleration (PGA), peak ground velocity (PGV) and peak ground displacement (PGD) of soil will be calculated by response analysis and should be used in seismic resistant design considerations.

4.4.6.4 Amplification of Soil

The amplification of soil should be calculated by response analysis for high – rise buildings and where thick sediment layers are observed.

4.4.6.5 Fundamental Frequency and Predominant Period of Soil.

The fundamental frequency and predominant period of soil will be calculated by response analysis and should be used for seismic resistant designs.

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PART 4 SOILS AND FOUNDATIONS

SECTION	4.5:	FOOTINGS AND FOUNDATIONS
	4.5.1	General
	4.5.1.1	Allowable Load Bearing Values of Soils
	4.5.1.2	Settlement
	4.5.1.3	Modulus of Subgrade Reaction
	4.5.1.4	Liquefaction
	4.5.1.5	General Construction Requirements
	4.5.1.6	Damp proofing and Waterproofing
	4.5.2	Shallow Foundation
	4.5.2.1	Design Information and Consideration
	4.5.2.2	Depth of Foundations
	4.5.2.3	Foundation on or adjacent to slopes
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	4.5.2.6	Short Piling
	4.5.3	Deep Foundation
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	4.5.3.2	Driven Pile Foundations
	4.5.3.3	Cast-In-Place Concrete Pile Foundations
	4.5.3.4	Composite Piles
	4.5.3.5	Pier Foundations

4.5 FOOTINGS AND FOUNDATIONS

4.5.1 General

4.5.1.1 Allowable Load Bearing Values of Soils

4.5.1.1.1 Presumptive load-bearing values.

The presumptive load-bearing values provided in Table 4.5.1.1.1 shall be used with the allowable stress design load combinations specified in Structural Design Section **2.1.3**. The maximum allowable foundation pressure, lateral pressure or lateral sliding-resistance values for supporting soils near the surface shall not exceed the values specified in Table 4.5.1.1.1 unless data to substantiate the use of a higher value are submitted and approved. Presumptive load-bearing values shall apply to materials with similar physical characteristics and dispositions. Mud, organic silt, organic clays, peat or unprepared fill shall not be assumed to have a presumptive load-bearing capacity unless data to substantiate the use of such a value are submitted.

Exception: A presumptive load-bearing capacity is permitted to be used where the building official deems the load-bearing capacity of mud, organic silt or unprepared fill is adequate for the support of lightweight and temporary structures.

4.5.1.1.2 Allowable load-bearing pressure by calculation

An assessment of the allowable load-bearing pressure shall be based on the engineering properties of the soil, that is, cohesion, angle of internal friction, density, etc. The bearing capacity shall be calculated from stability considerations of shear and a factor of safety of 2.5 shall be adopted for safe bearing capacity. The potential effects of interference of adjacent foundations should be taken into account.

The procedure for determining the ultimate bearing capacity and allowable bearing pressure of shallow foundations based on shear and allowable settlement criteria shall be calculated by approved analytical, numerical or empirical methods. The bearing pressure beneath a stiff foundation may be assumed to be distributed linearly. The distribution of bearing pressure beneath a flexible foundation may be derived by modeling the foundation as a beam or slab resting on a deforming continuum or series of springs, with appropriate stiffness and strength.

Table 4.5.1.1.1 Allowable Foundation and lateral pressure

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf) ^d	LATERAL BEARING (psf/below natural grade) ^d	LATERAL SLIDING	
			Coefficient of friction ^a	Resistance (psf) ^b
1. Crystalline bedrock	12,000	1,200	0.7	-
2. Sedimentary and foliated rock	4,000	400	0.35	-
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	-
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel	2,000	150	0.25	-
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	500 ^c	30	-	40

For SI: 1 pound per square foot = 0.0479 kPa.

1 pound per square foot per foot = 0.157 kPa/m.

- a. Coefficient to be multiplied by the dead load.
- b. Lateral sliding resistance value to be multiplied by the contact area.
- c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 500 psf, the allowable bearing capacity shall be determined by a soils investigation.
- d. An increase of 1/3 is permitted when using the alternate load combinations in structural design section that include wind or earthquake loads.

4.5.1.1.3 Lateral sliding resistance

Where the loading is not normal to the foundation base, foundations shall be checked against failure by sliding on the base. The resistance of structural walls to lateral sliding shall be calculated by combining the values derived from the lateral bearing and the lateral sliding resistance shown in Table 4.5.1.1.1 unless data to substantiate the use of higher values are submitted for approval. For clay, sandy clay, silty clay and clayey silt, in no case shall the lateral sliding resistance exceed one-half the dead load.

4.5.1.1.3.1 Increases in allowable lateral sliding resistance

The resistance values derived from the table are permitted to be increased by the tabular value for each additional foot (305 mm) of depth to a maximum of 15 times the tabular value.

4.5.1.2 Settlement

4.5.1.2.1 Design consideration for settlement calculation

Calculations of settlements shall include both immediate and long-term settlement. The following three components of settlement should be considered for partially or fully saturated soils:

- 1) immediate settlement; for fully-saturated soil due to shear deformation at constant volume, and for partially-saturated soil due to both shear deformation and volume reduction;
- 2) settlement caused by consolidation;
- 3) settlement caused by creep.

Special consideration should be given to soils such as organic soils and sensitive clays, in which settlement may be prolonged almost indefinitely due to creep. For estimating settlement in soils, the depth to be considered will depend on the size and shape of the foundation, the variation in soil stiffness with depth and the spacing of foundation elements. For individual pad footings this depth may be roughly estimated as 2 times the foundation width and may be up to 4 times the foundation width for strip footings. The depth may be reduced for lightly-loaded, wider foundation such as rafts. This approach is not valid for very soft soils. Any possible settlement caused by self-weight compaction of the soil, flooding and vibration in fill and collapsible soils shall be assessed.

The permissible values of total and differential settlement for a given type of structure may be taken as given in Table 4.5.1.2.1.

4.5.1.3 Modulus of Sub-grade Reaction, k_s .

It is defined as the pressure applied by the footing divided by the resulting settlement.

$$k_s = \frac{q}{\delta}$$

Where test data are not available, the modulus of subgrade reaction k_s shall be reasonably estimated by following formula.

$$k_s = 12 \text{ (FS)} q_a \text{ (SI)}$$

Values of k_s may also be estimated using Table 4.5.1.3.

Table 4.5.1.3 Range of Values of Modulus of Subgrade Reaction, k_s

Soil	K_s , pcf	K_s , KN/m ³
Loose sand	30-100	4800-16000
Medium dense sand	60-500	9600-80000
Dense sand	400-800	64000-128000
Clayey medium dense sand	200-500	12000-80000
Silty medium dense sand	150-100	24000-48000
Clayey soil:		
$q_a \leq 200$ kPa (4 ksf)	75-150	12000-24000
$200 \leq q_a \leq 400$ kPa	150-300	24000-48000
$q_a \geq 800$ kPa	>300	>48000

Note: Use values as guide and for comparison when using appropriate equation

4.5.1.4 Liquefaction

Liquefaction is the sudden and large decrease of shear strength of a submerged cohesionless soil caused by contraction of the soil structure, produced by shock or earthquake-induced shear strains, associated with a sudden but temporary increase of pore water pressures. Liquefaction occurs when the increase in pore water pressures causes the effective stress to become equal to zero and the soil behaves as liquid. Liquefaction potential should be evaluated if site parameters meet the following criteria.

1. Soil having less than 15% of the particles, based on dry weight, that are finer than 0.005 mm (% finer than 0.005 mm < 15%)
2. Soil having a liquid limit (LL) less than 35. (LL < 35)
3. Soil having water content w greater than 0.9 of the liquid limit. ($w > 0.9$ LL)
4. Soil below the groundwater table
5. Site having potential of a peak ground acceleration a_{max} greater than 0.10g or local magnitude 5 or larger

The Factor of Safety (FS) against liquefaction shall be defined as

$$FS = CRR / CSR$$

where

CRR = Cyclic Resistance Ratio of the in situ soil

CSR = Cyclic Stress Ratio of the in situ soil

$$CSR = 0.65 r_d \left(\frac{\sigma_{vo}}{\sigma'_{vo}} \right) \left(\frac{a_{max}}{g} \right)$$

where

a_{max} = peak ground acceleration of the site

g = acceleration of gravity (32.2 ft/s² or 9.81 m/s²)

σ_{vo} = total vertical stress at a particular depth where the liquefaction analysis is being performed.

σ'_{vo} = vertical effective stress at a particular depth where the liquefaction analysis is being performed.

r_d = depth reduction factor or stress reduction coefficient

$$r_d = 1 - 0.00366 z \text{ (z in feet)}$$

$$r_d = 1 - 0.012 z \text{ (z in meter)}$$

CRR shall be determined by Figure 4.5.1.4 which has been developed for an earthquake magnitude of 7.5 and for other different magnitudes, the CRR values shall be multiplied by the magnitude scaling factor indicated in Table 4.5.1.4.

Table 4.5.1.2.1 Permissible Differential Settlement and Tilt

Sl No.	Type of Structure	Isolated Foundations						Raft Foundations					
		Sand and Hard Clay			Plastic Clay			Sand and Hard Clay			Plastic Clay		
		Maximum settlement mm	Differential settlement mm	Angular distortion mm	Maximum settlement mm	Differential settlement mm	Angular distortion mm	Maximum settlement mm	Differential settlement mm	Angular distortion mm	Maximum settlement mm	Differential settlement mm	Angular distortion mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	For steel structure	50	.003 3L	1/300	50	.003 3L	1/300	75	.003 3L	1/300	100	.003 3L	1/300
ii)	For reinforced concrete structures	50	.001 5L	1/666	75	.001 5L	1/666	75	.002 1L	1/500	100	.002 0L	1/500
iii)	For multistoreyed buildings												
	a) RC or steel framed buildings with panel walls	60	.002L	1/500	75	.002L	1/500	75	.002 5L	1/400	125	.003 3L	1/300
	b) For load bearing walls												
	1) $L/H = 2^*$	60	.000 2L	1/5 000	60	.000 2L	1/5000	← Not likely to be encountered →					
	2) $L/H = 7^*$	60	.000 4L	1/2 500	60	.000 4L	1/2500						
iv)	For water towers and silos	50	.001 5L	1/666	75	.001 5L	1/666	100	.002 5L	1/400	125	.002 5L	1/400

NOTE — The values given in the table may be taken only as a guide and the permissible total settlement/differential settlement and tilt (angular distortion) in each case should be decided as per requirements of the designer.

L denotes the length of deflected part of wall/raft or centre-to-centre distance between columns.

H denotes the height of wall from foundation footing.

* For intermediate ratios of L/H , the values can be interpolated.

Table 4.5.1.4 Magnitude Scaling Factor

Anticipated earthquake magnitude	Magnitude Scaling Factor (MSF)
8 ½	0.89
7 ½	1.00
6 ¾	1.13
6	1.32
5 ¼	1.50

Note: To determine the Cyclic Resistance Ratio of the in situ soil, multiply the magnitude scaling factor indicated above by the Cyclic Resistance Ratio determined from Fig. 4.5.1.4.

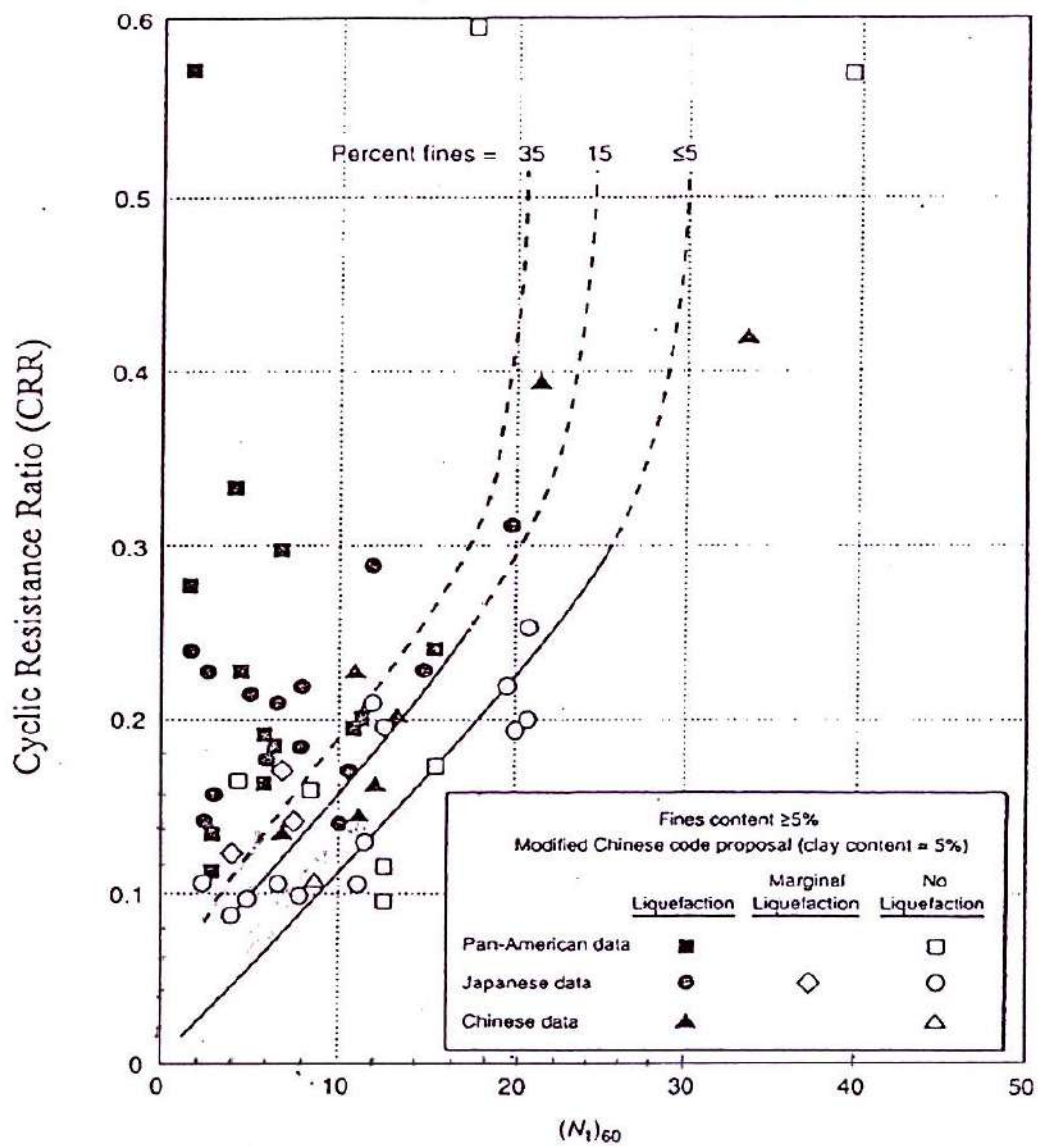


Figure 4.5.1.4 Cyclic Resistance Ratio of the in Situ Soil

4.5.1.5 General Construction Requirements

4.5.1.5.1 Concrete strength

Concrete in footings shall have a specified compressive strength (f'_c) of not less than 2,500 pounds per square inch (psi) (17241.38 Kpa) at 28 days.

4.5.1.5.2 Footing seismic ties

Where a structure is assigned to Seismic Design Category D, E or F in accordance with Section 1613, individual spread footings founded on soil defined in Section 1613.5.2 as Site Class E or F shall be interconnected by ties. Ties shall be capable of carrying, in tension or compression, a force equal to the product of the larger footing load times the seismic coefficient, SDS, divided by 10 unless it is demonstrated that equivalent restraint is provided by reinforced concrete beams within slabs on grade or reinforced concrete slabs on grade.

4.5.1.5.3 Plain concrete footings

The edge thickness of plain concrete footings supporting walls of other than light-frame construction shall not be less than 8 inches (203 mm) where placed on soil.

Exception: For plain concrete footings supporting Group R-3 occupancies, the edge thickness is permitted to be 6 inches (152 mm), provided that the footing does not extend beyond a distance greater than the thickness of the footing on either side of the supported wall.

4.5.1.5.4 Placement of concrete

Concrete footings shall not be placed through water unless a tremie or other method approved by the building official is used. Where placed under or in the presence of water, the concrete shall be deposited by approved means to ensure minimum segregation of the mix and negligible turbulence of the water.

4.5.1.5.5 Protection of concrete

Concrete footings shall be protected from freezing during depositing and for a period of not less than five days thereafter. Water shall not be allowed to flow through the deposited concrete.

4.5.1.5.6 Forming of concrete

Concrete footings are permitted to be cast against the earth where, in the opinion of the building official, soil conditions do not require forming. Where forming is required, it shall be in accordance with Chapter 6 of ACI 318.

4.5.1.6 Damp Proofing and Waterproofing

4.5.1.6.1 General

Walls or portions that retain earth and enclose interior spaces and floors below grade shall be damp proofed and water proofed in accordance with this section. Groups other than residential or institutional, omission of damp proofed and water proofed for those spaces are not detrimental effect to the building or occupancy.

4.5.1.6.1.1 Story above grade plane

Where a basement is considered a story above graded plane and the basement floor and wall is partially below the finished ground level for 25 percent or more of the perimeter, the floor and walls shall be damp proofed and a foundation drain shall be installed. The foundation drain shall be installed around the portion of the perimeter where the basement floor is below ground level.

4.5.1.6.1.2 Under floor space

Unless an approved drainage system is provided, the ground level of the under-floor space shall be as high as the outside finished ground level where the ground water table rises to within 6 inches (152 mm) of the ground level at the outside building perimeter, or that the surface water does not readily drain from the building site.

4.5.1.6.1.2.1 Flood hazard areas

For buildings and structures in flood hazard areas, the finished ground level of an under-floor space such as crawl space shall be equal to or higher than the outside finished ground level.

4.5.1.6.1.3 Ground-water control

The floor and walls shall be damp proofed, where the ground water table is lowered and maintained at an elevation not less than 6 inches (152 mm) below the bottom of the lowest floor. The design of the system to lower the ground-water table shall be based on accepted principles of engineering.

4.5.1.6.2 Damp proofing

Floors and walls shall be damp proofed where the ground-water investigation indicates that a hydrostatic pressure will not occur.

4.5.1.6.2.1 Floors

Damp proofing materials for floors shall be installed between the floor and the base course, except where a separate floor is provided above a concrete slab. Damp proofing materials shall be used locally available materials or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions.

4.5.1.6.2.2 Walls

Damp proofing materials for walls shall be installed on the exterior surface of the wall, and shall extend from the top of the footing to above ground level. Damp proofing materials for walls shall be used locally available materials or other approved materials.

4.5.1.6.2.2.1 Surface preparation of walls

All the holes and recesses on the concrete walls shall be sealed by bituminous material or other approved methods or materials prior to the application of damp proofing materials. Unit masonry walls shall be parged on the exterior surface below ground level with not less than 0.375 inches (10 mm) of Portland cement. The parging shall be coved at the footing.

Exception: Parging of unit masonry walls is not required where a material is approved for direct application to the masonry.

4.5.1.6.3 Water proofing

Floors and walls shall be water proofed where the ground-water investigation indicates that a hydrostatic pressure condition exists, and design does not include a ground-water control system.

4.5.1.6.3.1 Floors

Concrete floors are required to be water proofed and designed and constructed to resist the hydrostatic pressures to which the floors will be subjected. Waterproofing shall be accomplished by placing a membrane of locally available materials or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instruction.

4.5.1.6.3.2 Walls

Concrete walls and masonry walls are required to be water proofed and shall be designed and constructed to withstand hydrostatic pressures and other lateral loads to which the wall be subjected. Water proofing shall be applied from the bottom of the wall to not less than 12 inches (305 mm) above the maximum elevation of the ground-water table. The remainder of the wall shall be damp proofed. Water proofing materials for walls shall be used locally available materials or other approved materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instruction.

4.5.1.6.3.2.1 Surface preparation of walls

The walls shall be prepared prior to application of waterproofing materials on concrete or masonry walls.

4.5.1.6.3.3 Joints and penetrations

Joints in walls and floors, joints between the wall and floor and penetrations of the wall and floor shall be made water-tight utilizing approved methods and materials.

4.5.1.6.4 Subsoil drainage system

Where a hydrostatic pressure condition does not exist, damp proofing shall be provided and a base shall be installed under the floor and a drain installed around the foundation perimeter.

4.5.2 Shallow Foundation

4.5.2.1 Design Information and Consideration

4.5.2.1.1 Design Information

For the satisfactory design of foundations, the following information is necessary:

- a) The type and condition of the soil or rock to which the foundation transfers the loads;
- b) The general layout of the columns and load bearing walls showing the estimated loads, including moments and torques due to various loads (dead load, imposed load, wind load, seismic load) coming on the foundation units;
- c) The allowable bearing pressure of the soils;
- d) The changes in ground water level, drainage and flooding conditions and also the chemical conditions of the subsoil water, particularly with respect to its sulphate content;
- e) The behaviour of the buildings, topography and environment/ surroundings adjacent to the site, the type and depths of foundations and the bearing pressure assumed; and Seismic zone of the region.
- f) Seismic zone of the region.

4.5.2.1.2 Design Consideration

4.5.2.1.2.1 Design

Footings shall be designed that the allowable bearing capacity of the soil is not exceeded, and that differential settlement is minimized.

4.5.2.1.2.2 Design loads

Footings shall be designed for the most unfavorable effects due to the combinations of loads specified in Structural Design Section. The dead load is permitted to include the weight of foundations, footings and overlying fill. Reduced live loads, as specified in Structural Design Section, are permitted to be used in the design of footings. Where machinery operations or other vibrations are transmitted through the foundation, consideration shall be given in the footing design to prevent detrimental disturbances of the soil.

4.5.2.2 Depth of Foundations

The minimum depth of foundations below the undisturbed ground surface shall be 24 inches (609mm). On rock or such other weather resisting natural ground, removal of the top soil may be all that is required. In such cases, the surface shall be cleaned and, if necessary, stepped or otherwise prepared so as to provide a suitable bearing and thus prevent slipping or other unwanted movements. Where shallow sub-soils are of a shifting or moving character, foundation shall be carried to a sufficient depth to ensure stability.

4.5.2.2.1 Foundation at Different Levels.

Where footings are adjacent to sloping ground or where the bottoms of the footings of a structure are at different levels or at levels different from those of the footings of adjoining structures, the depth of the footings shall be such that the difference in footing elevations shall be subject to the following limitations:

- a) When the ground surface slopes downward adjacent to a footing, the sloping surface shall not intersect a frustum of bearing material under the footing having sides which make an angle of 30° with the horizontal for soil and horizontal distance from the lower edge of the footing to the sloping surface shall be at least 24 inches (609 mm) for rock and 36 inches (914 mm) for soil (see Figure 4.5.2.2.1 (1)).
- b) In the case of footings in granular soil, a line drawn between the lower adjacent edges of adjacent footings shall not have a steeper slope than 30° (see Figure 4.5.2.2.1 (2)).
- c) In case of footing of clayey soils a line drawn between the lower adjacent edge of the upper footing and the upper adjacent edge of lower footing shall not have a steeper slope than 30° (see Figure 4.5.2.2.1 (3)).

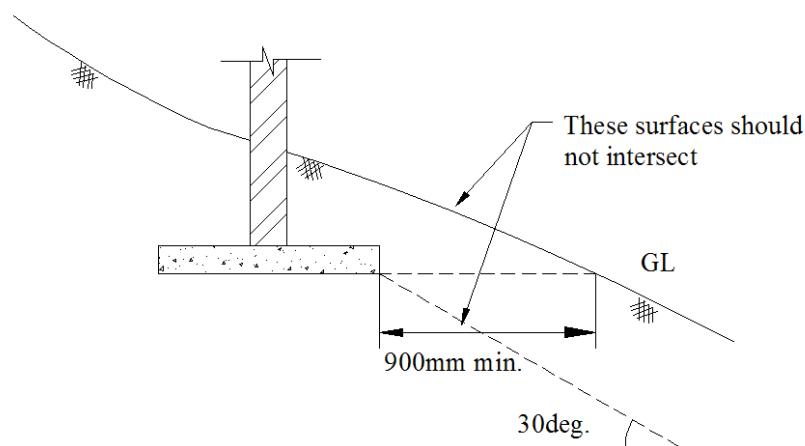


Figure 4.5.2.2.1 (1) Footing in Sloping Ground

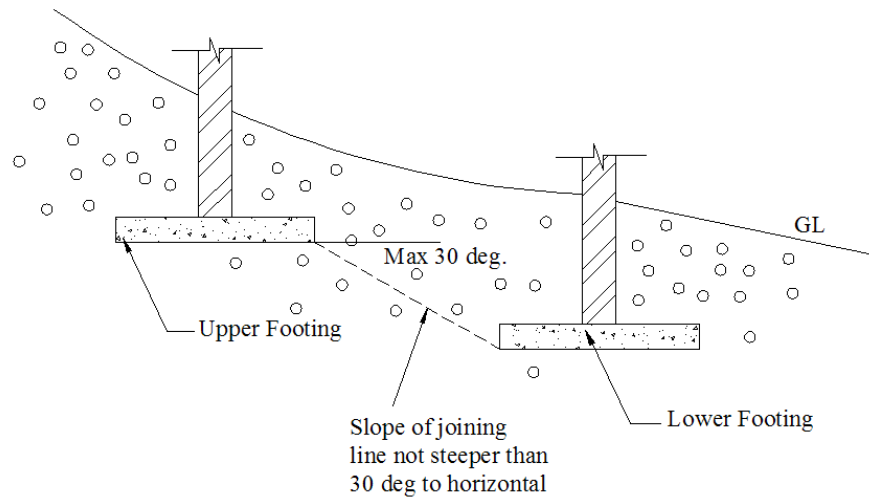


Figure 4.5.2.2.1 (2) Footing in Granular Soil

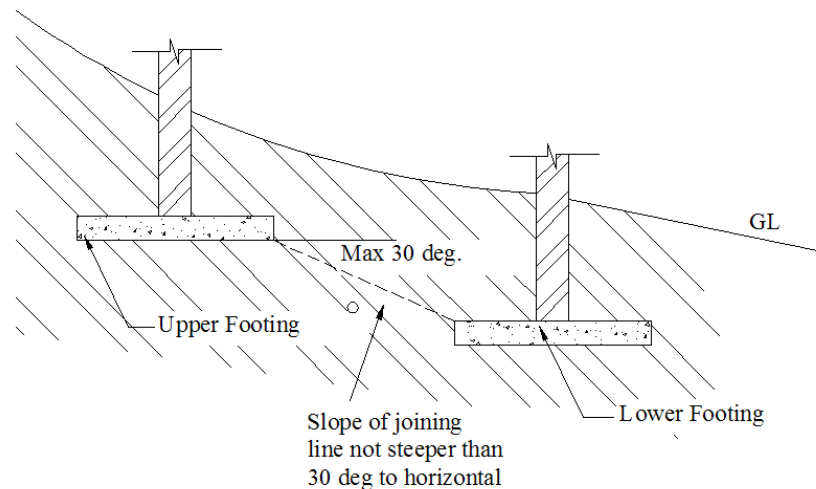


Figure 4.5.2.2.1 (3) Footing in Clayey Soil

4.5.2.3 Foundation on or adjacent to slopes

The placement of buildings and structures on or adjacent to slopes steeper than one unit vertical in three units horizontal (33.3-percent slope) shall conform to Sections 4.5.2.3.1 through 4.5.2.3.5.

4.5.2.3.1 Building clearance from ascending slopes

In general, buildings below slopes shall be set a sufficient distance from the slope to provide protection from slope drainage erosion and shallow failures. Except as provided for in Section 4.5.2.3.5 and Figure 4.5.2.3.1 and 4.5.2.3.2, the following criteria will be assumed to provide this protection. Where the existing slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the toe of the slope shall be assumed to be at the intersection of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees to the horizontal. Where a retaining wall is constructed at the toe of the slope, the height of the slope shall be measured from the top of the wall to the top of the slope.

4.5.2.3.2 Footing setback from descending slope surface

Footings on or adjacent to slope surfaces shall be founded in firm material with an embedment and set back from the slope surface sufficient to provide vertical and lateral support for the footing without detrimental settlement. Except as provided for in Section 4.5.2.3.5 and Figure 4.5.2.3.1 and 4.5.2.3.3, the following setback is deemed adequate to meet the criteria. Where the slope is steeper than 1 unit vertical in 1 unit horizontal (100-percent slope), the required setback shall be measured from an imaginary plane 45 degrees to the horizontal, projected upward from the toe of the slope.

4.5.2.3.3 Pools

The setback between pools regulated by this code and slopes shall be equal to one-half the building footing setback distance required by this section. That portion of the pool wall within a horizontal distance of 7 feet (2134 mm) from the top of the slope shall be capable of supporting the water in the pool without soil support.

4.5.2.3.4 Foundation elevation

On graded sites, the top of any exterior foundation shall extend above the elevation of the street gutter at point of discharge or the inlet of an approved drainage device a minimum of 12 inches (305 mm) plus 2 percent. Alternate elevations are permitted subject to the approval of the building official, provided it can be demonstrated that required drainage to the point of discharge and away from the structure is provided at all locations on the site.

4.5.2.3.5 Alternate setback and clearance

Alternate setbacks and clearances are permitted, subject to the approval of the building official. The building official is permitted to require an investigation and recommendation of a registered design professional to demonstrate that the intent of this section has been satisfied. Such an investigation shall include consideration of material, height of slope, slope gradient, load intensity and erosion characteristics of slope material.

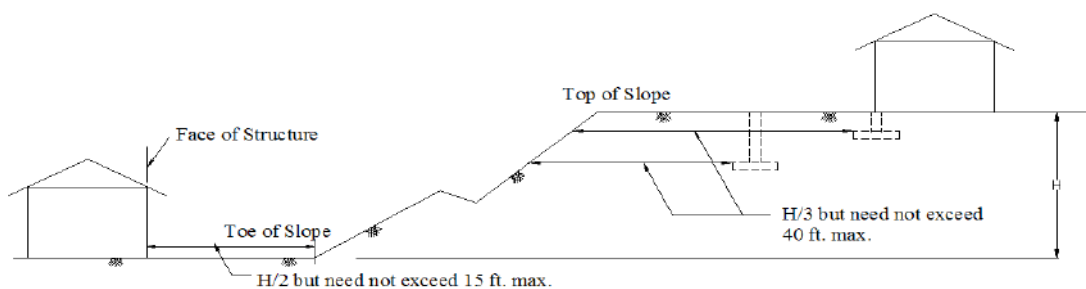


Figure 4.5.2.3.1 Foundation Clearances from Slopes

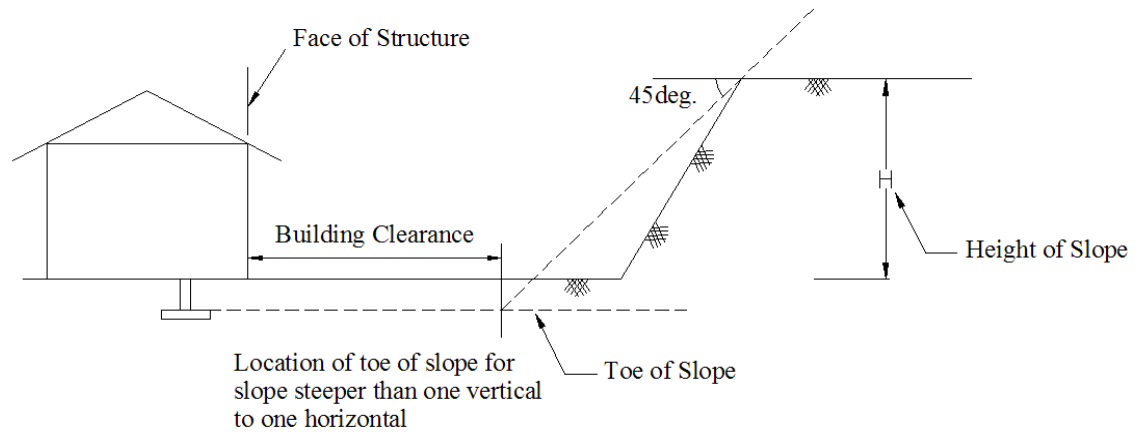


Figure 4.5.2.3.2 Foundation Clearances from Ascending Slopes

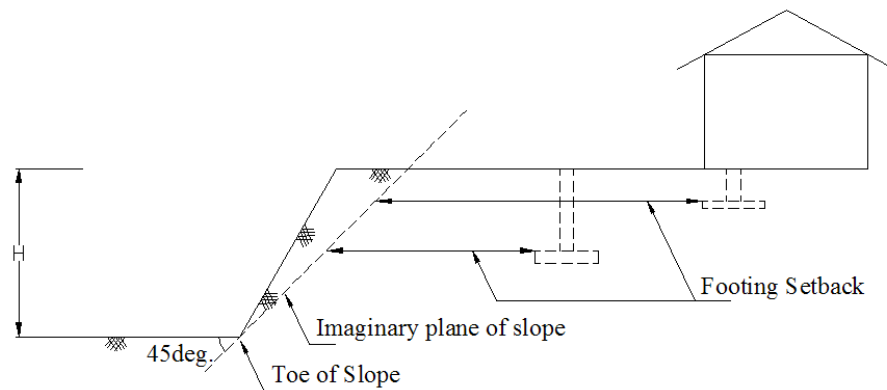


Figure 4.5.2.3.3 Foundation Setback from Descending Slopes

4.5.2.4 Spread Foundations

4.5.2.4.1 Pad Foundation (Isolated Footing)

For buildings such as low rise dwellings and lightly framed structures, pad foundations may be of unreinforced concrete provided that the angle of spread of load from the column or base plate to the outer edge of the ground bearing does not exceed one vertical to $\frac{1}{2}$ horizontal for masonry or one vertical to one horizontal for cement concrete and that the stresses in the concrete due to bending and shear do not exceed permissible stresses. Where brick or masonry foundations have been used, the same rules shall apply.

For buildings other than low rise and lightly framed structures, it is customary to use reinforced concrete foundations. The thickness of the foundation should under no circumstances be less than 6 inches (152 mm) and will generally be greater than this to maintain cover to reinforcement where provided. Where concrete foundations are used they should be designed in accordance with the code of practice appropriate to the loading assumptions.

4.5.2.4.2 Strip foundations

Similar considerations to those for pad foundations apply to strip foundations. On sloping sites strip foundations should be on a horizontal bearing, stepped where necessary to maintain adequate depth.

4.5.2.4.2.1 Continuous wall foundations

In continuous wall foundations it is recommended that reinforcement be provided wherever an abrupt change in magnitude of load or variation in ground support occurs. Continuous wall foundations will normally be constructed in mass concrete provided that the angle of spread of load from the edge of the wall base to the outer edge of the ground bearing does not exceed one (vertical) in one (horizontal). Foundations on sloping ground, and where re-grading is likely to take place, may require to be designed as retaining walls to accommodate steps between adjacent ground floor slabs or finished ground levels. At all changes of level unreinforced foundations should be lapped at the steps for a distance at least equal to the thickness of the foundation or a minimum of 12 inches (300 mm). Where the height of the step exceeds the thickness of the foundation, special precautions should be taken. The thickness of reinforced strip foundations should be not less than 6 inches (152 mm), and care should be taken with the excavation levels to ensure that this minimum thickness is maintained.

For the longitudinal spread of loads, sufficient reinforcement should be provided to withstand the tensions induced. It will sometimes be desirable to make strip foundations of inverted tee beam sections, in order to provide adequate stiffness in the longitudinal direction. At corners and junctions the longitudinal reinforcement of each wall foundation should be lapped.

4.5.2.5 Raft foundations

Suitably designed raft foundations may be used in the following circumstances.

- a) For lightly loaded structures on soft natural ground where it is necessary to spread the load, or where there is variable support due to natural variations, made ground or weaker zones. In this case the function of the raft is to act as a bridge across the weaker zones. Rafts may form part of compensated foundations.
- b) Where differential settlements are likely to be significant. The raft will require special design, involving an assessment of the disposition and distribution of loads, contact pressures and stiffness of the soil and raft.
- c) Design of the raft and structure to accommodate subsidence requires consideration by suitably qualified persons; the effects of mining may often involve provision of a flexible structure.
- d) When buildings such as low rise dwellings and lightly framed structures have to be erected on soils susceptible to excessive shrinking and swelling, consideration should then be given to raft foundations placed on fully compacted selected fill material used as replacement for the surface layers.
- e) For heavier structures where the ground conditions are such that there are unlikely to be significant differential settlements or heave, individual loads may be accommodated by isolated foundations. If these foundations occupy a large part of the available area they may, subject to design considerations, be joined to form a raft.

4.5.2.6 Short Piling

Where it is necessary to transmit foundation loads from buildings such as low rise dwellings or lightly framed structures through soft or made ground, or unstable formations or shrinking/swelling clays more than about 6.5 ft (2000 mm) deep, the use of short piles should be considered as an alternative to shallow foundations, particularly where a high groundwater table is encountered. The type, method of construction, size and load capacity should be carefully

considered in relation to the associated requirements of pile caps and ground beams necessary to transfer loads from the superstructure to the piles.

4.5.3 Deep Foundation

4.5.3.1 General requirements

4.5.3.1.1 General

Pier and pile foundations shall be designed and installed on the basis of a foundation investigation as defined in section 4.2, unless sufficient data upon which to base the design and installation is available.

The investigation and report provisions of Section 4.2 shall be expanded to include, but not be limited to, the following:

1. Recommended pier or pile types and installed capacities.
2. Recommended center-to-center spacing of piers or piles.
3. Driving criteria.
4. Installation procedures.
5. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity where required).
6. Pier or pile load test requirements.
7. Durability of pier or pile materials.
8. Designation of bearing stratum or strata.
9. Reductions for group action, where necessary.

4.5.3.1.2 Special types of piles

The use of types of piles not specifically mentioned herein is permitted, subject to the approval of the building official, upon the submission of acceptable test data, calculations and other information relating to the structural properties and load capacity of such piles. The allowable stresses shall not in any case exceed the limitations specified herein.

4.5.3.1.3 Pile caps

Pile caps shall be of reinforced concrete, and shall include all elements to which piles are connected, including grade beams and mats. The soil immediately below the pile cap shall not be considered as carrying any vertical load. The tops of piles shall be embedded not less than 3 inches (76 mm) into pile caps and the caps shall extend at least 4 inches (102 mm) beyond the edges of piles. The tops of piles shall be cut back to sound material before capping.

4.5.3.1.4 Stability

Piers or piles shall be braced to provide lateral stability in all directions. Three or more piles connected by a rigid cap shall be considered braced, provided that the piles are located in radial directions from the centroid of the group not less than 60 degrees apart. A two-pile group in a rigid cap shall be considered to be braced along the axis connecting the two piles. Methods used to brace piers or piles shall be subject to the approval of the building official. Piles supporting walls shall be driven alternately in lines spaced at least 1 foot (305 mm) apart and located symmetrically under the center of gravity of the wall load carried, unless effective measures are

taken to provide for eccentricity and lateral forces, or the wall piles are adequately braced to provide for lateral stability. A single row of piles without lateral bracing is permitted for one- and two-family dwellings and lightweight construction not exceeding two stories or 35 feet (10668 mm) in height, provided the centers of the piles are located within the width of the foundation wall.

4.5.3.1.5 Structural integrity

Piers or piles shall be installed in such a manner and sequence as to prevent distortion or damage that may adversely affect the structural integrity of piles being installed or already in place.

4.5.3.1.6 Splices

Splices shall be constructed so as to provide and maintain true alignment and position of the component parts of the pier or pile during installation and subsequent thereto and shall be of adequate strength to transmit the vertical and lateral loads and moments occurring at the location of the splice during driving and under service loading. Splices shall develop not less than 50 percent of the least capacity of the pier or pile in bending. In addition, splices occurring in the upper 10 feet (3048 mm) of the embedded portion of the pier or pile shall be capable of resisting at allowable working stresses the moment and shear that would result from an assumed eccentricity of the pier or pile load of 3 inches (76 mm), or the pier or pile shall be braced in accordance with Section 4.5.3.1.4 to other piers or piles that do not have splices in the upper 10 feet (3048 mm) of embedment.

4.5.3.1.7 Allowable pier or pile loads.

4.5.3.1.7.1 Determination of allowable loads

The allowable axial and lateral loads on piers or piles shall be determined by an approved formula, load tests or method of analysis.

4.5.3.1.7.2 Driving criteria

Allowable compressive load on any pile shall be determined by the application of an approved driving formula. Allowable loads shall be verified by load tests in accordance with Section 4.5.3.1.7.3. The formula or wave equation load shall be determined for gravity-drop or power-actuated hammers and the hammer energy used shall be the maximum consistent with the size, strength and weight of the driven piles. The introduction of fresh hammer cushion or pile cushion material just prior to final penetration is not permitted.

4.5.3.1.7.3 Load tests

Where design compressive loads per pier or pile are greater than those permitted or where the design load for any pier or pile foundation is in doubt, control test piers or piles shall be tested in accordance with ASTM D 1143 or ASTM D 4945. At least one pier or pile shall be test loaded in each area of uniform subsoil conditions. Where required by the building official, additional piers or piles shall be load tested where necessary to establish the safe design capacity. The resulting allowable loads shall not be more than one-half of the ultimate axial load capacity of the test pier or pile as assessed by one of the published methods with consideration for the test type, duration and subsoil. The ultimate axial load capacity shall be determined by a registered design professional with consideration given to tolerable total and differential settlements at design load in accordance with settlement analysis. In subsequent installation of the balance of foundation piles, all piles shall be deemed to have a supporting capacity equal to the control pile where such piles are of the same type, size and relative length as the test pile; are installed using the same or comparable methods and equipment as the test pile; are installed in similar subsoil conditions as the test pile; and, for driven piles, where the rate of penetration (e.g., net displacement per blow) of

such piles is equal to or less than that of the test pile driven with the same hammer through a comparable driving distance.

4.5.3.1.7.3.1 Load test evaluation

It shall be permitted to evaluate pile load tests with any of the following methods:

1. Davisson Offset Limit.
2. Brinch-Hansen 90% Criterion.
3. Butler-Hoy Criterion.
4. Other methods approved by the building official.

4.5.3.1.7.3.2 Non-destructive testing

For quality assurance of concrete piles, non-destructive integrity test may be carried out prior to construction of beam or caps.

4.5.3.1.7.4 Allowable frictional resistance

The assumed frictional resistance developed by any pier or uncased cast-in-place pile shall not exceed one-sixth of the bearing value of the soil material as set forth in Table 4.1, up to a maximum of 500 psf (24 kPa), unless a greater value is allowed by the building official after a soil investigation, is submitted or a greater value is substantiated by a load test.

4.5.3.1.7.5 Uplift capacity

Where required by the design, the uplift capacity of a single pier or pile shall be determined by an approved method of analysis based on a minimum factor of safety of three or by load tests conducted in accordance with ASTM D 3689. The maximum allowable uplift load shall not exceed the ultimate load capacity as determined in Section 4.5.3.1.7.3 divided by a factor of safety of two. For pile groups subjected to uplift, the allowable working uplift load for the group shall be the lesser of:

1. The proposed individual pile uplift working load times the number of piles in the group.
2. Two-thirds of the effective weight of the pile group and the soil contained within a block defined by the perimeter of the group and the length of the pile.

4.5.3.1.7.6 Load-bearing capacity

Piers, individual piles and groups of piles shall develop ultimate load capacities of at least twice the design working loads in the designated load-bearing layers. Analysis shall show that no soil layer underlying the designated load-bearing layers causes the load-bearing capacity safety factor to be less than two.

4.5.3.1.7.7 Bent piers or piles

The load-bearing capacity of piers or piles discovered to have a sharp or sweeping bend shall be determined by an approved method of analysis or by load testing a representative pier or pile.

4.5.3.1.7.8 Overloads on piers or piles

The maximum compressive load on any pier or pile due to mis-location shall not exceed 110 percent of the allowable design load.

4.5.3.1.8 Lateral support

4.5.3.1.8.1 General

Any soil other than fluid soil shall be deemed to afford sufficient lateral support to the pier or pile to prevent buckling and to permit the design of the pier or pile in accordance with accepted engineering practice and the applicable provisions of this code.

4.5.3.1.8.2 Unbraced piles

Piles standing unbraced in air, water or in fluid soils shall be designed as columns in accordance with the provisions of this code. Such piles driven into firm ground can be considered fixed and laterally supported at 5 feet (1524 mm) below the ground surface and in soft material at 10 feet (3048 mm) below the ground surface unless otherwise prescribed by the building official after a foundation investigation by an approved agency.

4.5.3.1.8.3 Allowable lateral load

Where required by the design, the lateral load capacity of a pier, a single pile or a pile group shall be determined by an approved method of analysis or by lateral load tests to at least twice the proposed design working load. The resulting allowable load shall not be more than one-half of that test load that produces a gross lateral movement of 1 inch (25.4 mm) at the ground surface.

4.5.3.1.9 Use of higher allowable pier or pile stresses

Allowable stresses greater than those specified for piers or for each pile type are permitted where supporting data justifying such higher stresses is filed with the building official. Such substantiating data shall include:

1. A soils investigation in accordance with Section 4.2.
2. Pier or pile load tests in accordance with Section 4.5.3.1.7.3, regardless of the load supported by the pier or pile.

The design and installation of the pier or pile foundation shall be under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pier or pile foundations who shall certify to the building official that the piers or piles as installed satisfy the design criteria.

4.5.3.1.10 Piles in subsiding areas

Where piles are installed through subsiding fills or other subsiding strata and derive support from underlying firmer materials, consideration shall be given to the downward frictional forces that may be imposed on the piles by the subsiding upper strata. Where the influence of subsiding fills is considered as imposing loads on the pile, the allowable stresses specified in this chapter are permitted to be increased where satisfactory substantiating data are submitted.

4.5.3.1.11 Negative Skin Friction or Down Drag Force

When a soil stratum, through which a pile shaft has penetrated into an underlying hard stratum, compresses as a result of either its being unconsolidated or its being under a newly placed fill or as a result of re-moulding during driving of the pile, a drag down force is generated along the pile shaft up to a point in depth where the surrounding soil does not move downwards relative to the pile shaft. Recognition of the existence of such a phenomenon shall be made and a suitable reduction shall be made to the allowable load, where appropriate.

4.5.3.1.12 Settlement analysis

The settlement of piers, individual piles or groups of piles shall be estimated based on approved methods of analysis. The predicted settlement shall cause neither harmful distortion of, nor instability in, the structure, nor cause any stresses to exceed allowable values.

4.5.3.1.13 Pre-excavation

The use of jetting, augering or other methods of pre-excavation shall be subject to the approval of the building official. Where permitted, pre-excavation shall be carried out in the same manner as used for piers or piles subject to load tests and in such a manner that will not impair the carrying capacity of the piers or piles already in place or damage adjacent structures. Pile tips shall be driven below the pre-excavated depth until the required resistance or penetration is obtained.

4.5.3.1.14 Installation sequence

Piles shall be installed in such sequence as to avoid compaction the surrounding soil to the extent that other piles cannot be installed properly, and to prevent ground movements that are capable of damaging adjacent structures.

4.5.3.1.15 Use of vibratory drivers

Vibratory drivers shall only be used to install piles where the pile load capacity is verified by load tests in accordance with Section 4.5.3.1.7.3. The installation of production piles shall be controlled according to power consumption, rate of penetration or other approved means that ensure pile capacities equal or exceed those of the test piles.

4.5.3.1.16 Pile drivability

Pile cross sections shall be of sufficient size and strength to withstand driving stresses without damage to the pile, and to provide sufficient stiffness to transmit the required driving forces.

4.5.3.1.17 Protection of pile materials

Where boring records or site conditions indicate possible deleterious action on pier or pile materials because of soil constituents, changing water levels or other factors, the pier or pile materials shall be adequately protected by materials, methods or processes approved by the building official. Protective materials shall be applied to the piles so as not to be rendered ineffective by driving. The effectiveness of such protective measures for the particular purpose shall have been thoroughly established by satisfactory service records or other evidence.

4.5.3.1.18 Use of existing piers or piles

Piers or piles left in place where a structure has been demolished shall not be used for the support of new construction unless satisfactory evidence is submitted to the building official, which indicates that the piers or piles are sound and meet the requirements of this code. Such piers or piles shall be load tested or redriven to verify their capacities. The design load applied to such piers or piles shall be the lowest allowable load as determined by tests or re-driving data.

4.5.3.1.19 Heaved piles

Piles that have heaved during the driving of adjacent piles shall be redriven as necessary to develop the required capacity and penetration, or the capacity of the pile shall be verified by load tests in accordance with Section 4.5.3.1.7.3.

4.5.3.1.20 Identification

Pier or pile materials shall be identified for conformity to the specified grade with this identity maintained continuously from the point of manufacture to the point of installation or shall be

tested by an approved agency to determine conformity to the specified grade. The approved agency shall furnish an affidavit of compliance to the building official.

4.5.3.1.21 Pier or pile location plan

A plan showing the location and designation of piers or piles by an identification system shall be filed with the building official prior to installation of such piers or piles. Detailed records for piers or individual piles shall bear an identification corresponding to that shown on the plan.

4.5.3.1.22 Spacing of Piles

The centre to centre spacing of a pile is considered from two aspects as follows:

- a) Practical aspects of installing the piles; and
- b) The nature of the load transfer to the soil and possible reduction in bearing capacity of a group of piles thereby.

In the case of piles founded on a very hard stratum and deriving their capacity mainly from end bearing, the spacing will be governed by the competency of the end bearing strata. The minimum spacing in such cases shall be 2.5 times the diameter of the shaft. In case of piles resting on rock, a spacing of two times the diameter may be adopted. Piles deriving their bearing capacity mainly from friction shall be sufficiently apart to ensure that the zones of soil from which the piles derive their support do not overlap to such an extent that their bearing values are reduced. Generally, the spacing in such cases shall not be less than three times the diameter of the shaft. In the case of loose sand or filling, closer spacing than in dense sand may be possible, in driven piles since displacement during the piling may be absorbed by vertical and horizontal compaction of the strata. The minimum spacing in such strata may be two times the diameter of the shaft.

4.5.3.1.23 Special inspection

4.5.3.1.23.1 Pier foundations

Special inspections shall be performed during installation and testing of pier foundations as required by Table 4.5. The approved soils report, required by Section 4.2, and the documents prepared by the registered design professional in responsible charge shall be used to determine compliance.

4.5.3.1.23.2 Pile foundations

Special inspections shall be performed during installation and testing of pile foundations as required by Table 4.6. The approved soils report, required by Section 4.2, and the documents prepared by the registered design professional in responsible charge shall be used to determine compliance.

Table 4.5.3.1.23.2 (1) Required Verification and Inspection of Pier Foundations

VERIFICATION AND INSPECTION TASK	CONTINUOUS DURING TASK LISTED	PERIODICALLY DURING TASK LISTED
1. Verify pier materials, sizes and lengths comply with the requirements.	X	✓
2. Verify placement locations and plumbness, confirm pier diameters, bell diameters (if applicable), lengths, embedment into bedrock (if applicable) and adequate end capacity.	X	✓

3. For concrete piers, perform additional inspections as specified in special inspection required for concrete construction	✓	✓
4. For masonry piers, perform additional inspections as specified in special inspection required for masonry construction	✓	✓

Table 4.5.3.1.23.2 (2) Required Verification and Inspection of Pile Foundations

VERIFICATION AND INSPECTION TASK	CONTINUOUS DURING TASK LISTED	PERIODICALLY DURING TASK LISTED
1. Verify pier materials, sizes and lengths comply with the requirements.	X	✓
2. Determine capacities of test piles and conduct additional load tests, as required.	X	✓
3. Observe driving operations and maintain complete and accurate records for each pile.	✓	✓
4. Verify placement locations and plumpness, confirm type and size of hammer, record number of blows per foot of penetration, determine required capacity, record tip and butt elevations and document any pile damage.	✓	✓
5. For steel piles, perform additional inspections as specified in special inspection required for steel construction	✓	✓
6. For concrete piles and concrete-filled piles, perform additional inspections as specified in special inspection required for concrete construction	✓	✓
7. For specialty piles, perform additional inspections as determined by the registered design professional in responsible charge.	✓	✓
8. For augured uncased piles and caisson piles, perform inspections in accordance with pier foundations.	✓	✓

4.5.3.1.24 Seismic design of piers or piles

4.5.3.1.24.1 Seismic Design Category C

Where a structure is assigned to Seismic Design Category C in accordance with Part 3 (Structural Design), the following shall apply. Individual pile caps, piers or piles shall be interconnected by ties. Ties shall be capable of carrying, in tension and compression, a force equal to the product of the larger pile cap or column load times the seismic coefficient, SDS, divided by 10 unless it can be demonstrated that equivalent restraint is provided by reinforced concrete beams within slabs on grade, reinforced concrete slabs on grade, confinement by competent rock, hard cohesive soils or very dense granular soils.

Exception: Piers supporting foundation walls, isolated interior posts detailed so the pier is not subject to lateral loads, lightly loaded exterior decks and patios of Group R-3 and U occupancies not exceeding two stories of light-frame construction, are not subject to

interconnection if it can be shown the soils are of adequate stiffness, subject to the approval of the building official.

4.5.3.1.24.1.1 Connection to pile cap

Concrete piles and concrete-filled steel pipe piles shall be connected to the pile cap by embedding the pile reinforcement or field-placed dowels anchored in the concrete pile in the pile cap for a distance equal to the development length. For deformed bars, the development length is the full development length for compression or tension, in the case of uplift, without reduction in length for excess area. Alternative measures for laterally confining concrete and maintaining toughness and ductile-like behavior at the top of the pile will be permitted provided the design is such that any hinging occurs in the confined region. Ends of hoops, spirals and ties shall be terminated with seismic hooks, turned into the confined concrete core. The minimum transverse steel ratio for confinement shall not be less than one-half of that required for columns. For resistance to uplift forces, anchorage of steel pipe (round HSS sections), concrete-filled steel pipe or H-piles to the pile cap shall be made by means other than concrete bond to the bare steel section.

Exception: Anchorage of concrete-filled steel pipe piles is permitted to be accomplished using deformed bars developed into the concrete portion of the pile. Splices of pile segments shall develop the full strength of the pile, but the splice need not develop the nominal strength of the pile in tension, shear and bending when it has been designed to resist axial and shear forces and moments from the load combinations of Structural Design Section.

4.5.3.1.24.1.2 Design details

Pier or pile moments, shears and lateral deflections used for design shall be established considering the nonlinear interaction of the shaft and soil, as recommended by a registered design professional. Where the ratio of the depth of embedment of the pile-to-pile diameter or width is less than or equal to six, the pile may be assumed to be rigid. Pile group effects from soil on lateral pile nominal strength shall be included where pile center-to-center spacing in the direction of lateral force is less than eight pile diameters. Pile group effects on vertical nominal strength shall be included where pile center- to-center spacing is less than three pile diameters. The pile uplift soil nominal strength shall be taken as the pile uplift strength as limited by the frictional force developed between the soil and the pile. Where a minimum length for reinforcement or the extent of closely spaced confinement reinforcement is specified at the top of the pier or pile, provisions shall be made so that those specified lengths or extents are maintained after pier or pile cutoff.

4.5.3.1.24.2 Seismic Design Category D, E or F

Where a structure is assigned to Seismic Design Category D, E or F in accordance with Structural Design (Section 1613), the requirements for Seismic Design Category C given in Section 4.5.3.1.24.1 shall be met, in addition to the following. Provisions of ACI 318, Section 21.10.4, shall apply when not in conflict with the provisions of Sections 4.5.3. Concrete shall have a specified compressive strength of not less than 3,000 psi (20.68 MPa) at 28 days.

Exceptions: 1. Group R or U occupancies of light-framed construction and two stories or less in height are permitted to use concrete with a specified compressive strength of not less than 2,500 psi (17.2MPa) at 28 days. 2. Detached one- and two-family dwellings of light-frame construction and two stories or less in height are not required to comply with the provisions of ACI 318, Section 21.10.4.3. Section 21.10.4.4(a) of ACI 318 need not apply to concrete piles.

4.5.3.1.24.2.1 Design details for piers, piles and grade beams

Piers or piles shall be designed and constructed to withstand maximum imposed curvatures from earthquake ground motions and structure response. Curvatures shall include free-field soil strains modified for soil-pile-structure interaction coupled with pier or pile deformations induced by lateral pier or pile resistance to structure seismic forces. Concrete piers or piles on Site Class E or F sites, as determined in Structural Design Section, shall be designed and detailed in accordance with Sections 21.4.5.1, 21.4.4.2 and 21.4.5.3 of ACI 318 within seven pile diameters of the pile cap and the interfaces of soft to medium stiff clay or liquefiable strata. For precast prestressed concrete piles, detailing provisions as given in Section 4.5.3.2.2.3.2.1 and 4.5.3.2.2.3.2.2 shall apply. Grade beams shall be designed as beams in accordance with ACI 318, Chapter 21. When grade beams have the capacity to resist the forces from the load combinations in Structural Design Section, they need not conform to ACI 318, Chapter 21.

4.5.3.1.24.2.2 Connection to pile cap

For piles required to resist uplift forces or provide rotational restraint, design of anchorage of piles into the pile cap shall be provided considering the combined effect of axial forces due to uplift and bending moments due to fixity to the pile cap. Anchorage shall develop a minimum of 25 percent of the strength of the pile in tension. Anchorage into the pile cap shall be capable of developing the following:

1. In the case of uplift, the lesser of the nominal tensile strength of the longitudinal reinforcement in a concrete pile, or the nominal tensile strength of a steel pile, or the pile uplift soil nominal strength factored by 1.3 or the axial tension force resulting from the load combinations of Structural Design Section 4.1.5.
2. In the case of rotational restraint, the lesser of the axial and shear forces, and moments resulting from the load combinations of Structural Design Section 4.1.5 or development of the full axial, bending and shear nominal strength of the pile.

4.5.3.1.24.2.3 Flexural strength

Where the vertical lateral-force-resisting elements are columns, the grade beam or pile cap flexural strengths shall exceed the column flexural strength. The connection between batter piles and grade beams or pile caps shall be designed to resist the nominal strength of the pile acting as a short column. Batter piles and their connection shall be capable of resisting forces and moments from the load combinations of Structural Design Section 4.1.5

4.5.3.2 Driven Pile Foundation

4.5.3.2.1 Timber piles

Timber piles shall be designed with the prevailing code. Only structural timber shall be used for piles.

4.5.3.2.1.1 Materials

Round timber piles shall conform to ASTM D 25.

4.5.3.2.1.2 Preservative treatment

Timber piles used to support permanent structures shall be treated unless it is established that the tops of the untreated timber piles will be below the lowest ground-water level assumed to exist during the life of the structure. Preservative-treated timber piles shall be subject to a quality control program administered by an approved agency. Pile cutoffs shall be treated.

4.5.3.2.1.3 Defective piles

Any substantial sudden increase in rate of penetration of a timber pile shall be investigated for possible damage. If the sudden increase in rate of penetration cannot be correlated to soil strata, the pile shall be removed for inspection or rejected.

4.5.3.2.1.4 Allowable stresses

The allowable stresses of timber pile shall not exceed values specified in Table 4.7.

Table 4.5.3.2.1.4 Allowable Working Stresses for Sawn Timbers (Psi)

Symbol	Description	Pyinkado	Teak	Padauk	In/Kanyin
F_b	Bending at fiber stress	2500	2000	2500	1500
F_v	Longitudinal shear	240	120	175	130
F_c	Axial compression	1900	1200	1700	760
F_{cb}	Axial compression when combine with bending	1900	1200	1700	760
$F_{c(per)}$	Compression perpendicular to grain	970	450	1050	400
$F_{t(par)}$	Tension parallel to grain where reduced by notches, daps, connectors or abrupt changes in section	1600	960	1350	610
$F_{t(par)}$	Tension parallel to grain where no stress concentration exists	1900	1200	1700	760
$F_{t(per)}$	Tension perpendicular to grain	60	40	60	60
E	Modulus of Elasticity	2.0+E6	1.44+E6	1.65+E6	1.3+E6
Note: 1psi = 6.8966Kpa					

4.5.3.2.2 Precast concrete piles

4.5.3.2.2.1 The materials, reinforcement and installation of precast concrete piles

It shall conform to Sections 4.5.3.2.2.1 through 4.5.3.2.2.4.

4.5.3.2.2.1.1 Design and manufacture

Piles shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by handling, driving and service loads.

4.5.3.2.2.1.2 Minimum dimension

The minimum lateral dimension shall be 6 inches (152 mm).

4.5.3.2.2.1.3 Reinforcement

Longitudinal steel shall be arranged in a symmetrical pattern and be laterally tied with steel ties or wire spiral spaced not more than 4 inches (102 mm) apart, center to center, for a distance of 2 feet (610 mm) from the ends of the pile; and not more than 6 inches (152 mm) elsewhere except that at the ends of each pile, the first five ties or spirals shall be spaced 1 inch (25.4 mm) center to center. The gage of ties and spirals shall be as follows:

For piles having a diameter of 16 inches (406 mm) or less, wire shall not be smaller 6 mm.

For piles having a diameter of more than 16 inches (406 mm) and less than 20 inches (508 mm), wire shall not be smaller than 8 mm.

For piles having a diameter of 20 inches (508 mm) and larger, wire shall not be smaller than 9 mm.

4.5.3.2.2.1.4 Installation

Piles shall be handled and driven so as not to cause injury or overstressing, which affects durability or strength.

4.5.3.2.2.2 Precast non prestressed piles

Precast non prestressed concrete piles shall conform to Sections 4.5.3.2.2.2.1 through 4.5.3.2.2.2.5.

4.5.3.2.2.2.1 Materials

Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 3,000 psi (20.68 MPa).

4.5.3.2.2.2.2 Minimum reinforcement

The minimum amount of longitudinal reinforcement shall be 0.8 percent of the concrete section and shall consist of at least four bars.

4.5.3.2.2.2.2.1 Seismic reinforcement in Seismic Design Category C

Where a structure is assigned to Seismic Design Category C in accordance with Section 1613, the following shall apply. Longitudinal reinforcement with a minimum steel ratio of 0.01 shall be provided throughout the length of precast concrete piles. Within three pile diameters of the bottom of the pile cap, the longitudinal reinforcement shall be confined with closed ties or spirals of a minimum 3/8 inch (10 mm) diameter. Ties or spirals shall be provided at a maximum spacing of eight times the diameter of the smallest longitudinal bar, not to exceed 6 inches (152 mm). Throughout the remainder of the pile, the closed ties or spirals shall have a maximum spacing of 16 times the smallest longitudinal bar diameter not to exceed 8 inches (203 mm).

4.5.3.2.2.2.2.2 Seismic reinforcement in Seismic Design Category D, E or F

Where a structure is assigned to Seismic Design Category D, E or F in accordance with Section 1613, the requirements for Seismic Design Category C in Section 4.5.3.2.3.2.1 shall apply except as modified by this section. Transverse confinement reinforcement consisting of closed ties or equivalent spirals shall be provided in accordance with Sections 21.4.4.1, 21.4.4.2 and liquefiable sites and where spirals are used as the 21.4.4.3 of ACI 318 within three pile diameters of the bottom of the pile cap. For other than Site Class E or F, or transverse reinforcement, a volumetric ratio of spiral reinforcement of not less than one-half that required by Section 21.4.4.1(a) of ACI 318 shall be permitted.

4.5.3.2.2.2.3 Allowable stresses

The allowable compressive stress in the concrete shall not exceed 33 percent of the 28-day specified compressive strength (f'_c) applied to the gross cross-sectional area of the pile. The allowable compressive stress in the reinforcing steel shall not exceed 40 percent of the yield strength of the steel (f_y) or a maximum of 30,000 psi (207 MPa). The allowable tensile stress in the reinforcing steel shall not exceed 50 percent of the yield strength of the steel (f_y) or a maximum of 24,000 psi (165 MPa).

4.5.3.2.2.2.4 Installation

A precast concrete pile shall not be driven before the concrete has attained a compressive strength of at least 75 percent of the 28-day specified compressive strength (f'_c), but not less than the strength sufficient to withstand handling and driving forces.

4.5.3.2.2.2.5 Concrete cover

Reinforcement for piles that are not manufactured under plant conditions shall have a concrete cover of not less than 2 inches (51 mm). Reinforcement for piles manufactured under plant control conditions shall have a concrete cover of not less than 1.25 inches (32 mm) for No. 5 bars and smaller, and not less than 1.5 inches (38 mm) for No. 6 through No. 11 bars except that longitudinal bars spaced less than 1.5 inches (38 mm) clear distance apart shall be considered bundled bars for which the minimum concrete cover shall be equal to that for the equivalent diameter of the bundled bars. Reinforcement for piles exposed to seawater shall have a concrete cover of not less than 3 inches (76 mm).

4.5.3.2.2.3 Precast prestressed piles

Precast prestressed concrete piles shall conform to the requirements of Sections 4.5.3.2.2.3.1 through 4.5.3.2.2.3.5.

4.5.3.2.2.3.1 Materials

Prestressing steel shall conform to ASTM A 416. Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 5,000 psi (34.48 MPa).

4.5.3.2.2.3.2 Design

Precast prestressed piles shall be designed to resist stresses induced by handling and driving as well as by loads. The effective prestress in the pile shall not be less than 400 psi (2.76 MPa) for piles up to 30 feet (9144 mm) in length, 550 psi (3.79 MPa) for piles up to 50 feet (15 240 mm) in length and 700 psi (4.83 MPa) for piles greater than 50 feet (15 240 mm) in length. Effective prestress shall be based on an assumed loss of 30,000 psi (207 MPa) in the prestressing steel. The tensile stress in the prestressing steel shall not exceed the values specified in ACI 318.

4.5.3.2.2.3.2.1 Design in Seismic Design Category C

Where a structure is assigned to Seismic Design Category C in accordance with Structural Design Section 1613, the following shall apply. The minimum volumetric ratio of spiral reinforcement shall not be less than 0.007 or the amount required by the following formula for the upper 20 feet (6096 mm) of the pile.

$$\rho_s = 0.12 f'_c / f_{yh} \quad (\text{Equation 4.5-1})$$

where:

f'_c = Specified compressive strength of concrete, psi (MPa).

f_{yh} = Yield strength of spiral reinforcement $\leq$ 85,000 psi (586 MPa).

ρ_s = Spiral reinforcement index (vol. spiral/vol. core).

At least one-half the volumetric ratio required by Equation 4-1 shall be provided below the upper 20 feet (6096 mm) of the pile.

The pile cap connection by means of dowels as indicated in Section 4.5.3.1.24 is permitted. Pile cap connection by means of developing pile reinforcing strand is permitted provided that the pile reinforcing strand results in a ductile connection.

4.5.3.2.2.3.2.2 Design in Seismic Design Category D, E or F

Where a structure is assigned to Seismic Design Category D, E or F in accordance with Section 1613, the requirements for Seismic Design Category C in Section 4.5.3.2.2.3.2.1 shall be met, in addition to the following:

1. Requirements in ACI 318, Chapter 21, need not apply, unless specifically referenced.
2. Where the total pile length in the soil is 35 feet (10668 mm) or less, the lateral transverse reinforcement in the ductile region shall occur through the length of the pile. Where the pile length exceeds 35 feet (10 668 mm), the ductile pile region shall be taken as the greater of 35 feet (10668 mm) or the distance from the underside of the pile cap to the point of zero curvature plus three times the least pile dimension.
3. In the ductile region, the center-to-center spacing of the spirals or hoop reinforcement shall not exceed one-fifth of the least pile dimension, six times the diameter of the longitudinal strand, or 8 inches (203 mm), whichever is smaller.
4. Circular spiral reinforcement shall be spliced by lapping one full turn and bending the end of the spiral to a 90-degree hook or by use of a mechanical or welded splice complying with Sec. 12.14.3 of ACI 318.
5. Where the transverse reinforcement consists of circular spirals, the volumetric ratio of spiral transverse reinforcement in the ductile region shall comply with the following:

$$\rho_s = 0.25(f'_c / f_{yh})(A_g / A_{ch} - 1.0)[0.5 + 1.4P/(f'_c A_g)] \quad (\text{Equation 4.5-2})$$

but not less than:

$$\rho_s = 0.12(f'_c / f_{yh})[0.5 + 1.4P/(f'_c A_g)] \quad (\text{Equation 4.5-3})$$

and need not exceed:

$$\rho_s = 0.021 \quad (\text{Equation 4.5-4})$$

where:

A_g = Pile cross-sectional area, square inches (mm^2).

A_{ch} = Core area defined by spiral outside diameter, square inches (mm^2).

f'_c = Specified compressive strength of concrete, psi (MPa).

f_{yh} = Yield strength of spiral reinforcement $\leq 85,000$ psi (586 MPa).

P = Axial load on pile, pounds (kN), as determined from Equations 16-5 and 16-6.

ρ_s = Volumetric ratio (vol. spiral/ vol. core).

This required amount of spiral reinforcement is permitted to be obtained by providing an inner and outer spiral.

6. When transverse reinforcement consists of rectangular hoops and cross ties, the total cross-sectional area of lateral transverse reinforcement in the ductile region with spacings, and perpendicular to dimension, h_c , shall conform to:

$$A_{sh} = 0.3sh_c (f'_c / f_{yh})(A_g / A_{ch} - 1.0)[0.5 + 1.4P/(f'_c A_g)] \quad (\text{Equation 4.5-5})$$

but not less than:

$$A_{sh} = 0.12sh_c (f'_c / f_{yh})[0.5 + 1.4P/(f'_c A_g)] \quad (\text{Equation 4.5-6})$$

where:

$f_{yh} = \leq 70,000$ psi (483 MPa).

h_c = Cross-sectional dimension of pile core measured center to center of hoop reinforcement, inch (mm).

s = Spacing of transverse reinforcement measured along length of pile, inch (mm).

A_{sh} = Cross-sectional area of transverse reinforcement, square inches (mm²).

f'_c = Specified compressive strength of concrete, psi (MPa).

The hoops and cross ties shall be equivalent to deformed bars not less than 10 mm in size. Rectangular hoop ends shall terminate at a corner with seismic hooks.

Outside of the length of the pile requiring transverse confinement reinforcing, the spiral or hoop reinforcing with a volumetric ratio not less than one-half of that required for transverse confinement reinforcing shall be provided.

4.5.3.2.3.3 Allowable stresses

The allowable design compressive stress, f_c , in concrete shall be determined as follows:

$$f_c = 0.33 f'_c - 0.27 f_{pc} \quad (\text{Equation 4.5-7})$$

where:

f'_c = The 28-day specified compressive strength of the concrete.

f_{pc} = The effective prestress stress on the gross section.

4.5.3.2.3.4 Installation

A prestressed pile shall not be driven before the concrete has attained a compressive strength of at least 75 percent of the 28-day specified compressive strength (f'_c), but not less than the strength sufficient to withstand handling and driving forces.

4.5.3.2.3.5 Concrete cover

Prestressing steel and pile reinforcement shall have a concrete cover of not less than 1 1/4 inches (32 mm) for square piles of 12 inches (305 mm) or smaller size and 1 1/2 inches (38 mm) for larger piles, except that for piles exposed to seawater, the minimum protective concrete cover shall not be less than 2 1/2 inches (64 mm).

4.5.3.2.3 Structural steel piles

Structural steel piles shall conform to the requirements of Sections 4.5.3.2.3.1 through 4.5.3.2.3.4.

4.5.3.2.3.1 Materials

Structural steel piles, steel pipe and fully welded steel piles fabricated from plates shall conform to ASTM A36, ASTM A252, ASTM A283, ASTM A572, ASTM A 588, ASTM A 690, ASTM A 913 or ASTM A992.

4.5.3.2.3.2 Allowable stresses

The allowable axial stresses shall not exceed 35 percent of the minimum specified yield strength (F_y).

Exception: Where justified in accordance with Section 4.5.3.1.9, the allowable axial stress is permitted to be increased above $0.35F_y$, but shall not exceed $0.5F_y$.

4.5.3.2.3.3 Dimensions of H-piles

Sections of H-piles shall comply with the following:

1. The flange projections shall not exceed 14 times the minimum thickness of metal in either the flange or the web and the flange widths shall not be less than 80 percent of the depth of the section.
2. The nominal depth in the direction of the web shall not be less than 8 inches (203 mm).
3. Flanges and web shall have a minimum nominal thickness of 3/8 inch (10 mm).

4.5.3.2.3.4 Dimensions of steel pipe piles

Steel pipe piles driven open ended shall have a nominal outside diameter of not less than 8 inches (203 mm). The pipe shall have a minimum cross section of 0.34 square inch (219 mm²) to resist each 1,000 foot-pounds (1356 N-m) of pile hammer energy, or shall have the equivalent strength for steels having a yield strength greater than 35,000 psi (241 Mpa) or the wave equation analysis shall be permitted to be used to assess compression stresses induced by driving to evaluate if the pile section is appropriate for the selected hammer. Where pipe wall thickness less than 0.179 inch (4.6 mm) is driven open ended, a suitable cutting shoe shall be provided.

4.5.3.3 Cast-In-Place Concrete Pile Foundations

4.5.3.3.1 General

The materials, reinforcement and installation of cast-in-place concrete piles shall conform to Sections 4.5.3.3.1.1 through 4.5.3.3.1.3.

4.5.3.3.1.1 Materials

Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 2,500 psi (17.24 MPa). Where concrete is placed through a funnel hopper at the top of the pile, the concrete mix shall be designed and proportioned so as to produce a cohesive workable mix having a slump of not less than 4 inches (102 mm) and not more than 8 inches (203 mm). Where concrete is to be pumped, the mix design including slump shall be adjusted to produce a pumpable concrete.

4.5.3.3.1.2 Reinforcement

Except for steel dowels embedded 5 feet (1524 mm) or less in the pile and as provided in Section 4.5.3.3.3.4, reinforcement where required shall be assembled and tied together and shall be placed in the pile as a unit before the reinforced portion of the pile is filled with concrete except in augered uncased cast-in-place piles. Tied reinforcement in augered uncased cast-in-place piles shall be placed after piles are concreted, while the concrete is still in a semi fluid state.

4.5.3.3.1.2.1 Reinforcement in Seismic Design Category C

Where a structure is assigned to Seismic Design Category C in accordance with Section 1613, the following shall apply. A minimum longitudinal reinforcement ratio of 0.0025 shall be provided for uncased cast-in-place concrete drilled or augered piles, piers or caissons in the top one-third of the pile length, a minimum length of 10 feet (3048 mm) below the ground or that required by analysis, whichever length is greatest. The minimum reinforcement ratio, but no less than that ratio required by rational analysis, shall be continued throughout the flexural length of the pile. There shall be a minimum of four longitudinal bars with closed ties (or equivalent spirals) of a minimum 3/8 inch (9 mm) diameter provided at 16-longitudinal-bar diameter maximum spacing. Transverse confinement reinforcement with a maximum spacing of 6 inches (152 mm) or 8-longitudinal-bar diameters, whichever is less, shall be provided within a distance equal to three times the least pile dimension of the bottom of the pile cap.

4.5.3.3.1.2.2 Reinforcement in Seismic Design Category D, E or F

Where a structure is assigned to Seismic Design Category D, E or F in accordance with Section 1613, the requirements for Seismic Design Category C given above shall be met, in addition to the following. A minimum longitudinal reinforcement ratio of 0.005 shall be provided for uncased cast-in-place drilled or augered concrete piles, piers or caissons in the top one-half of the pile length a minimum length of 10 feet (3048 mm) below ground or throughout the flexural length of the pile, whichever length is greatest. The flexural length shall be taken as the length of the pile to a point where the concrete section cracking moment strength multiplied by 0.4 exceeds the required moment strength at that point. There shall be a minimum of four longitudinal bars with transverse confinement reinforcement provided in the pile in accordance with Sections 21.4.4.1, 21.4.4.2 and 21.4.4.3 of ACI 318 within three times the least pile dimension of the bottom of the pile cap. A transverse spiral reinforcement ratio of not less than one-half of that required in Section 21.4.4.1(a) of ACI 318 for other than Class E, F or liquefiable sites is permitted. Tie spacing throughout the remainder of the concrete section shall neither exceed 12-longitudinal-bar diameters, one-half the least dimension of the section, nor 12 inches (305 mm). Ties shall be a minimum of 10 mm bars for piles with a least dimension up to 20 inches (508 mm), and 12 mm bars for larger piles.

4.5.3.3.1.3 Concrete placement

Concrete shall be placed in such a manner as to ensure the exclusion of any foreign matter and to secure a full-sized shaft. Concrete shall not be placed through water except where a tremie or other approved method is used. When depositing concrete from the top of the pile, the concrete shall not be chuted directly into the pile but shall be poured in a rapid and continuous operation through a funnel hopper centered at the top of the pile.

4.5.3.3.2 Enlarged base piles

Enlarged base piles shall conform to the requirements of Sections 4.5.3.3.2.1 through 4.5.3.3.2.5.

4.5.3.3.2.1 Materials

The maximum size for coarse aggregate for concrete shall be 3/4 inch (19.1 mm). Concrete to be compacted shall have a zero slump.

4.5.3.3.2.2 Allowable stresses

The maximum allowable design compressive stress for concrete not placed in a permanent steel casing shall be 25 percent of the 28-day specified compressive strength (f'_c). Where the concrete is placed in a permanent steel casing, the maximum allowable concrete stress shall be 33 percent of the 28-day specified compressive strength (f'_c).

4.5.3.3.2.3 Installation

Enlarged bases formed either by compacting concrete or driving a precast base shall be formed in or driven into granular soils. Piles shall be constructed in the same manner as successful prototype test piles driven for the project. Pile shafts extending through peat or other organic soil shall be encased in a permanent steel casing. Where a cased shaft is used, the shaft shall be adequately reinforced to resist column action or the annular space around the pile shaft shall be filled sufficiently to reestablish lateral support by the soil. Where pile heave occurs, the pile shall be replaced unless it is demonstrated that the pile is undamaged and capable of carrying twice its design load.

4.5.3.3.2.4 Load-bearing capacity

Pile load-bearing capacity shall be verified by load tests in accordance with Section 4.5.3.1.7.3

4.5.3.3.2.5 Concrete cover

The minimum concrete cover shall be 2 1/2 inches (64 mm) for uncased shafts and 1 inch (25 mm) for cased shafts.

4.5.3.3.3 Drilled or augered uncased piles

Drilled or augered uncased piles shall conform to Sections 4.5.3.3.3.1 through 4.5.3.3.3.5.

4.5.3.3.3.1 Allowable stresses

The allowable design stress in the concrete of drilled or augered uncased piles shall not exceed 33 percent of the 28-day specified compressive strength (f'_c). The allowable compressive stress of reinforcement shall not exceed 40 percent of the yield strength of the steel or 25,500 psi (175.8 MPa).

4.5.3.3.3.2 Dimensions

The pile length shall not exceed 30 times the average diameter. The minimum diameter shall be 12 inches (305 mm).

Exception: The length of the pile is permitted to exceed 30 times the diameter, provided that the design and installation of the pile foundation are under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pile foundations. The registered design professional shall certify to the building official that the piles were installed in compliance with the approved construction documents.

4.5.3.3.3.3 Installation

Where pile shafts are formed through unstable soils and concrete is placed in an open-drilled hole, a steel liner shall be inserted in the hole prior to placing the concrete. Where the steel liner is withdrawn during concreting, the level of concrete shall be maintained above the bottom of the liner at a sufficient height to offset any hydrostatic or lateral soil pressure. Where concrete is placed by pumping through a hollow-stem auger, the auger shall be permitted to rotate in a clockwise direction during withdrawal. The auger shall be withdrawn in continuous increments. Concreting pumping pressures shall be measured and maintained high enough at all times to offset hydrostatic and lateral earth pressures. Concrete volumes shall be measured to ensure that the volume of concrete placed in each pile is equal to or greater than the theoretical volume of the hole created by the auger. Where the installation process of any pile is interrupted or a loss of concreting pressure occurs, the pile shall be redrilled to 5 feet (1524 mm) below the elevation of the tip of the auger when the installation was interrupted or concrete pressure was lost and reformed. Augered cast-in-place piles shall not be installed within six pile diameters center to center of a pile filled with concrete less than 12 hours old, unless approved by the building official. If the concrete level in any completed pile drops due to installation of an adjacent pile, the pile shall be replaced.

4.5.3.3.3.4 Reinforcement

For piles installed with a hollow-stem auger where full-length longitudinal steel reinforcement is placed without lateral ties, the reinforcement shall be placed through the hollow stem of the auger prior to filling the pile with concrete. All pile reinforcement shall have a concrete cover of not less than 2.5 inches (64 mm).

Exception: Where physical constraints do not allow the placement of the longitudinal reinforcement prior to filling the pile with concrete or where partial-length longitudinal reinforcement is placed without lateral ties, the reinforcement is allowed to be placed after the piles are completely concreted but while concrete is still in a semifluid state.

4.5.3.3.3.5 Reinforcement in Seismic Design Category C, D, E or F

Where a structure is assigned to Seismic Design Category C, D, E or F in accordance with Section 1613, the corresponding requirements of Sections 4.5.3.3.1.2.1 and 4.5.3.3.1.2.2 shall be met.

4.5.3.3.4 Driven uncased piles

Driven uncased piles shall conform to Sections 4.5.3.3.4.1 through 4.5.3.3.4.4.

4.5.3.3.4.1 Allowable stresses

The allowable design stress in the concrete shall not exceed 25 percent of the 28-day specified compressive strength (f'_c) applied to a cross-sectional area not greater than the inside area of the drive casing or mandrel.

4.5.3.3.4.2 Dimensions

The pile length shall not exceed 30 times the average diameter. The minimum diameter shall be 12 inches (305 mm).

Exception: The length of the pile is permitted to exceed 30 times the diameter, provided that the design and installation of the pile foundation is under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and pile foundations. The registered design professional shall certify to the building official that the piles were installed in compliance with the approved design.

4.5.3.3.4.3 Installation

Piles shall not be driven within six pile diameters center to center in granular soils or within one-half the pile length in cohesive soils of a pile filled with concrete pile rises or drops, the pile shall be replaced. Piles shall not less than 48 hours old unless approved by the building official. If the concrete surface in any completed be installed in soils that could cause pile heave.

4.5.3.3.4.4 Concrete cover

Pile reinforcement shall have a concrete cover of not less than 2.5 inches (64 mm), measured from the inside face of the drive casing or mandrel.

4.5.3.3.5 Steel-cased piles

Steel-cased piles shall comply with the requirements of Sections 4.5.3.3.5.1 through 4.4.3.3.5.4.

4.5.3.3.5.1 Materials

Pile shells or casings shall be of steel and shall be sufficiently strong to resist collapse and sufficiently water tight to exclude any foreign materials during the placing of concrete. Steel shells shall have a sealed tip with a diameter of not less than 8 inches (203 mm).

4.5.3.3.5.2 Allowable stresses

The allowable design compressive stress in the concrete shall not exceed 33 percent of the 28-day specified compressive strength (f'_c). The allowable concrete compressive stress shall be $0.40 (f'_c)$ for that portion of the pile meeting the conditions specified in Sections 4.5.3.3.5.2.1 through 4.5.3.3.5.2.4.

4.5.3.3.5.2.1 Shell thickness

The thickness of the steel shell shall not be less than manufacturer's standard gage No. 14 gage (0.068 inch) (1.75 mm) minimum.

4.5.3.3.5.2.2 Shell type

The shell shall be seamless or provided with seams of strength equal to the basic material and be of a configuration that will provide confinement to the cast-in-place concrete.

4.5.3.3.5.2.3 Strength

The ratio of steel yield strength (f_y) to 28-day specified compressive strength (f'_c) shall not be less than six.

4.5.3.3.5.2.4 Diameter

The nominal pile diameter shall not be greater than 16 inches (406 mm).

4.5.3.3.5.3 Installation

Steel shells shall be mandrel driven their full length in contact with the surrounding soil. The steel shells shall be driven in such order and with such spacing as to ensure against distortion of or injury to piles already in place. A pile shall not be driven within four and one-half average pile diameters of a pile filled with concrete less than 24 hours old unless approved by the building official. Concrete shall not be placed in steel shells within heave range of driving.

4.5.3.3.5.4 Reinforcement

Reinforcement shall not be placed within 1 inch (25 mm) of the steel shell. Reinforcing shall be required for unsupported pile lengths or where the pile is designed to resist uplift or unbalanced lateral loads.

4.5.3.3.5.4.1 Seismic reinforcement

Where a structure is assigned to Seismic Design Category C, D, E or F in accordance with Section 1613, the reinforcement requirements for drilled or augered uncased piles in Section 4.5.3.3.5 shall be met.

Exception: A spiral-welded metal casing of a thickness no less than the manufacturer's standard gage No. 14 gage [0.068 inch (1.7 mm)] is permitted to provide concrete confinement in lieu of the closed ties or equivalent spirals required in an uncased concrete pile. Where used as such, the metal casing shall be protected against possible deleterious action due to soil constituents, changing water levels or other factors indicated by boring records of site conditions.

4.5.3.3.6 Concrete-filled steel pipe and tube piles

Concrete-filled steel pipe and tube piles shall conform to the requirements of Sections 4.5.3.3.6.1 through 4.5.3.3.6.5.

4.5.3.3.6.1 Materials

Steel pipe and tube sections used for piles shall conform to ASTM A 252 or ASTM A 283. Concrete shall conform to Section 4.5.3.3.1.1. The maximum coarse aggregate size shall be 3/4 inch (19.1 mm).

4.5.3.3.6.2 Allowable stresses

The allowable design compressive stress in the concrete shall not exceed 33 percent of the 28-day specified compressive strength (f'_c). The allowable design compressive stress in the steel shall not exceed 35 percent of the minimum specified yield strength of the steel (F_y), provided F_y shall not be assumed greater than 36,000 psi (248 MPa) for computational purposes.

Exception: Where justified in accordance with Section 4.5.3.1.9, the allowable stresses are permitted to be increased to 0.50 F_y .

4.5.3.3.6.3 Minimum dimensions

Piles shall have a nominal outside diameter of not less than 8 inches (203 mm) and a minimum wall thickness in accordance with Section 4.5.3.2.3.4. For mandrel-driven pipe piles, the minimum wall thickness shall be 1/10 inch (2.5 mm).

4.5.3.3.6.4 Reinforcement

Reinforcement steel shall conform to Section 4.5.3.1.9. Reinforcement shall not be placed within 1 inch (25 mm) of the steel casing.

4.5.3.3.6.4.1 Seismic reinforcement

Where a structure is assigned to Seismic Design Category C, D, E or F in accordance with Section 1613, the following shall apply. Minimum reinforcement no less than 0.01 times the cross-sectional area of the pile concrete shall be provided in the top of the pile with a length equal to two times the required cap embedment anchorage into the pile cap, but not less than the tension development length of the reinforcement. The wall thickness of the steel pipe shall not be less than 3/16 inch (5 mm).

4.5.3.3.6.5 Placing concrete

The placement of concrete shall conform to Section 4.5.3.3.1.3, but is permitted to be chuted directly into smooth-sided pipes and tubes without a centering funnel hopper.

4.5.3.3.7 Caisson piles

Caisson piles shall conform to the requirements of Sections 4.5.3.3.7.1 through 4.5.3.3.7.6.

4.5.3.3.7.1 Construction

Caisson piles shall consist of a shaft section of concrete-filled pipe extending to bedrock with an uncased socket drilled into the bedrock and filled with concrete. The caisson pile shall have a full-length structural steel core or a stub core installed in the rock socket and extending into the pipe portion a distance equal to the socket depth.

4.5.3.3.7.2 Materials

Pipe and steel cores shall conform to the material requirements in Section 1809.3. Pipes shall have a minimum wall thickness of 3/8 inch (9.5 mm) and shall be fitted with a suitable steel-driving shoe welded to the bottom of the pipe. Concrete shall have a 28-day specified compressive strength (f_c) of not less than 4,000 psi (27.58 MPa). The concrete mix shall be designed and proportioned so as to produce a cohesive workable mix with a slump of 4 inches to 6 inches (102 mm to 152 mm).

4.5.3.3.7.3 Design

The depth of the rock socket shall be sufficient to develop the full load-bearing capacity of the caisson pile with a minimum safety factor of two, but the depth shall not be less than the outside diameter of the pipe. The design of the rock socket is permitted to be predicated on the sum of the allowable load-bearing pressure on the bottom of the socket plus bond along the sides of the socket. The minimum outside diameter of the caisson pile shall be 18 inches (457 mm), and the diameter of the rock socket shall be approximately equal to the inside diameter of the pile.

4.5.3.3.7.4 Structural core

The gross cross-sectional area of the structural steel core shall not exceed 25 percent of the gross area of the caisson. The minimum clearance between the structural core and the pipe shall be 2

inches (51 mm). Where cores are to be spliced, the ends shall be milled or ground to provide full contact and shall be full-depth welded.

4.5.3.3.7.5 Allowable stresses

The allowable design compressive stresses shall not exceed the following: concrete, $0.33 f'_c$; steel pipe, $0.35 F_y$ and structural steel core, $0.50 F_y$.

4.5.3.3.7.6 Installation

The rock socket and pile shall be thoroughly cleaned of foreign materials before filling with concrete. Steel cores shall be bedded in cement grout at the base of the rock socket. Concrete shall not be placed through water except where a tremie or other approved method is used

4.5.3.3.8 Micropiles

Micropiles shall conform to the requirements of Sections 4.5.3.3.8.1 through 4.5.3.3.8.5.

4.5.3.3.8.1 Construction

Micropiles shall consist of a grouted section reinforced with steel pipe or steel reinforcing. Micropiles shall develop their load-carrying capacity through a bond zone in soil, bedrock or a combination of soil and bedrock. The full length of the micropile shall contain either a steel pipe or steel reinforcement.

4.5.3.3.8.2 Materials

Grout shall have a 28-day specified compressive strength (f'_c) of not less than 4,000 psi (27.58 MPa). The grout mix shall be designed and proportioned so as to produce a pumpable mixture. Reinforcement steel shall be deformed bars in accordance with ASTM A 615 Grade 60 or 75 or ASTM A 722 Grade 150. Pipe/casing shall have a minimum wall thickness of 3/16 inch (4.8 mm) and as required to meet Section 4.5.3.1.6. Pipe/casing shall meet the tensile requirements of ASTM A 252 Grade 3, except the minimum yield strength shall be as used in the design submittal [typically 50,000 psi to 80,000 psi (345 MPa to 552 MPa)] and minimum elongation shall be 15 percent.

4.5.3.3.8.3 Allowable stresses

The allowable design compressive stress on grout shall not exceed $0.33 f'_c$. The allowable design compressive stress on steel pipe and steel reinforcement shall not exceed the lesser of $0.4 F_y$, or 32,000 psi (220 MPa). The allowable design tensile stress for steel reinforcement shall not exceed $0.60 F_y$. The allowable design tensile stress for the cement grout shall be zero.

4.5.3.3.8.4 Reinforcement

For piles or portions of piles grouted inside a temporary or permanent casing or inside a hole drilled into bedrock or a hole drilled with grout, the steel pipe or steel reinforcement shall be designed to carry at least 40 percent of the design compression load. Piles or portions of piles grouted in an open hole in soil without temporary or permanent casing and without suitable means of verifying the hole diameter during grouting shall be designed to carry the entire compression load in the reinforcing steel. Where a steel pipe is used for reinforcement, the portion of the cement grout enclosed within the pipe is permitted to be included at the allowable stress of the grout.

4.5.3.3.8.4.1 Seismic reinforcement

Where a structure is assigned to Seismic Design Category C, a permanent steel casing shall be provided from the top of the pile down 120 percent times the flexural length. The flexural length

is the length of the pile from the first point of zero lateral deflection to the underside of the pile cap or grade beam. Where a structure is assigned to Seismic Design Category D, E or F, the pile shall be considered as an alternative system. The alternative pile system design, supporting documentation and test data shall be submitted to the building official for review and approval.

4.5.3.3.8.5 Installation

The pile shall be permitted to be formed in a hole advanced by rotary or percussive drilling methods, with or without casing. The pile shall be grouted with a fluid cement grout. The grout shall be pumped through a tremie pipe extending to the bottom of the pile until grout of suitable quality returns at the top of the pile.

The following requirements apply to specific installation methods:

1. For piles grouted inside a temporary casing, the reinforcing steel shall be inserted prior to withdrawal of the casing. The casing shall be withdrawn in a controlled manner with the grout level maintained at the top of the pile to ensure that the grout completely fills the drill hole.
2. During withdrawal of the casing, the grout level inside the casing shall be monitored to check that the flow of grout inside the casing is not obstructed. For a pile or portion of a pile grouted in an open drill hole in soil without temporary casing, the minimum design diameter of the drill hole shall be verified by a suitable device during grouting.
3. For piles designed for end bearing, a suitable means shall be employed to verify that the bearing surface is properly cleaned prior to grouting.
4. Subsequent piles shall not be drilled near piles that have been grouted until the grout has had sufficient time to harden.
5. Piles shall be grouted as soon as possible after drilling is completed.
6. For piles designed with casing full length, the casing must be pulled back to the top of the bond zone and reinserted or some other suitable means shall be employed to verify grout coverage outside the casing.

4.5.3.4 Composite Piles

4.5.3.4.1 General

Composite piles shall conform to the requirements of Sections 4.5.3.4.2 through 4.5.3.4.5.

4.5.3.4.2 Design

Composite piles consisting of two or more approved pile types shall be designed to meet the conditions of installation.

4.5.3.4.3 Limitation of load

The maximum allowable load shall be limited by the capacity of the weakest section incorporated in the pile.

4.5.3.4.4 Splices

Splices between concrete and steel or wood sections shall be designed to prevent separation both before and after the concrete portion has set, and to ensure the alignment and transmission of the total pile load. Splices shall be designed to resist uplift caused by upheaval during driving of adjacent piles, and shall develop the full compressive strength and not less than 50 percent of the tension and bending strength of the weaker section.

4.5.3.4.5 Seismic reinforcement

Where a structure is assigned to Seismic Design Category C, D, E or F in accordance with Section 1613, the following shall apply. Where concrete and steel are used as part of the pile assembly, the concrete reinforcement shall comply with that given in Sections 4.5.3.3.1.2.1 and 4.5.3.3.1.2.2 or the steel section shall comply with Section 4.5.3.3.6.4.1.

4.5.3.5 Pier Foundations

4.5.3.5.1 General

Isolated and multiple piers used as foundations shall conform to the requirements of Sections 4.5.3.5.2 through 4.5.3.5.10, as well as the applicable provisions of Section 4.4.3.1.

4.5.3.5.2 Lateral dimensions and height

The minimum dimension of isolated piers used as foundations shall be 2 feet (610 mm), and the height shall not exceed 12 times the least horizontal dimension.

4.5.3.5.3 Materials

Concrete shall have a 28-day specified compressive strength (f'_c) of not less than 2,500 psi (17.24 MPa). Where concrete is placed through a funnel hopper at the top of the pier, the concrete mix shall be designed and proportioned so as to produce a cohesive workable mix having a slump of not less than 4 inches (102 mm) and not more than 6 inches (152 mm). Where concrete is to be pumped, the mix design including slump shall be adjusted to produce a pump able concrete.

4.5.3.5.4 Reinforcement

Except for steel dowels embedded 5 feet (1524 mm) or less in the pier, reinforcement where required shall be assembled and tied together and shall be placed in the pier hole as a unit before the reinforced portion of the pier is filled with concrete.

Exception: Reinforcement is permitted to be wet set and the 2 1/2- inch (64 mm) concrete cover requirement be reduced to 2 inches (51 mm) for Group R-3 and U occupancies not exceeding two stories of light-frame construction, provided the construction method can be demonstrated to the satisfaction of the building official. Reinforcement shall conform to the requirements of Sections 4.5.3.3.1.2.1 and 4.5.3.3.1.2.2.

Exceptions:

1. Isolated piers supporting posts of Group R-3 and U occupancies not exceeding two stories of light-frame construction are permitted to be reinforced as required by rational analysis but not less than a minimum of one No. 4 bar, without ties or spirals, when detailed so the pier is not subject to lateral loads and the soil is determined to be of adequate stiffness.
2. Isolated piers supporting posts and bracing from decks and patios appurtenant to Group R-3 and U occupancies not exceeding two stories of light-frame construction are permitted to be reinforced as required by rational analysis but not less than one No. 4 bar, without ties or spirals, when the lateral load, E , to the top of the pier does not exceed 200 pounds (890 N) and the soil is determined to be of adequate stiffness.
3. Piers supporting the concrete foundation wall of Group R-3 and U occupancies not exceeding two stories of light-frame construction are permitted to be reinforced as required by rational analysis but not less than two No. 4 bars, without ties or spirals, when it can be shown the concrete pier will not rupture when designed for

the maximum seismic load, E_m , and the soil is determined to be of adequate stiffness.

4. Closed ties or spirals where required by Section 4.5.3.3.1.2.2 are permitted to be limited to the top 3 feet (914 mm) of the piers 10 feet (3048 mm) or less in depth supporting Group R-3 and U occupancies of Seismic Design Category D, not exceeding two stories of light-frame construction.

4.5.3.5.5 Concrete placement

Concrete shall be placed in such a manner as to ensure the exclusion of any foreign matter and to secure a full-sized shaft. Concrete shall not be placed through water except where a tremie or other approved method is used. When depositing concrete from the top of the pier, the concrete shall not be chute directly into the pier but shall be poured in a rapid and continuous operation through a funnel hopper centered at the top of the pier.

4.5.3.5.6 Belled bottoms

Where pier foundations are belled at the bottom, the edge thickness of the bell shall not be less than that required for the edge of footings. When the sides of the bell slope at an angle less than 60 degrees (1 rad) from the horizontal, the effects of vertical shear shall be considered.

4.5.3.5.7 Masonry

Where the unsupported height of foundation piers exceeds six times the least dimension, the allowable working stress on piers of unit masonry shall be reduced in accordance with ACI 530/ASCE 5/TMS 402.

4.5.3.5.8 Concrete

Where adequate lateral support is not provided, and the unsupported height to least lateral dimension does not exceed three, piers of plain concrete shall be designed and constructed as pilasters in accordance with ACI 318. Where the unsupported height to least lateral dimension exceeds three, piers shall be constructed of reinforced concrete, and shall conform to the requirements for columns in ACI 318.

Exception: Where adequate lateral support is furnished by the surrounding materials as defined in Section 4.5.3.1.8, piers are permitted to be constructed of plain or reinforced concrete. The requirements of ACI 318 for bearing on concrete shall apply.

4.5.3.5.9 Steel shell

Where concrete piers are entirely encased with a circular steel shell, and the area of the shell steel is considered reinforcing steel, the steel shall be protected under the conditions specified in Section 4.5.3.1.17. Horizontal joints in the shell shall be spliced to comply with Section 1808.2.7.

4.5.3.5.10 Dewatering

Where piers are carried to depths below water level, the piers shall be constructed by a method that will provide accurate preparation and inspection of the bottom, and the depositing or construction of sound concrete or other masonry in the dry.

APPENDIX A

Problematic Soils

a) Expansive Soil

Foundation materials that exhibit volume change when there are changes in their moisture content are referred to as expansive or swelling clay soils.

Typical expansive or swelling materials are highly plastic clays and clay shale that often contain colloidal clay minerals such as the montmorillonites.

Expansive soils include marls, clayey siltstones, sandstones and saprolites.

Problems that may occur in structures on expansive soils relate to the 'differential movement of the soils (i.e., heave or settlement caused by change in soil moisture).

b) Dispersive Soil

Soils which disperse in the presence of water and can therefore be easily scoured are described as dispersive. The most predominant soil type is CLAY and SILT combinations with some amount of sand. Index properties (Atterberg limits) give no indication about this treacherous soil.

1. Dispersive soils are structurally unstable and disperse in water, back into their basic particles: sand, silt and clay.
2. Dispersible soils are highly erodible and present problems for successfully managing erosion and sedimentation.
3. Dispersion is caused by the presence of sodium.
4. The ratio of salinity (EC) to sodicity (SAR) determines the effects of salts and sodium on soils.
5. The swelling factor predicts whether sodium-induced dispersion or salinity-induced flocculation will have the greatest affect on the soil physical properties.
6. Soils are divided in accordance with the Principle of Emerson Aggregate Test into seven classes on the basis of their coherence in water with one further class being distinguished by the presence of calcium-rich minerals.
7. Determining Emerson Class Number of Aggregate

When immerse air-dry aggregates in water:

Slaking occurred after 2 hours and 20 hours.

Class-1	:	Complete dispersion.
Class-2	:	Some dispersion
Class-3	:	Dispersion

Sub-classes for Type 2 and 3 Aggregates

(i) Slight milkiness		
(ii) Obvious milkiness, < 50 % of aggregate affected		
(iii) Obvious milkiness, > 50 % of aggregate affected		
(iv) Total dispersion leaving only sand grains		
Class-4	:	No dispersion (with the presence of carbonate or gypsum)

Class-7 : No dispersion but swelling, No slaking.

Class-8 : No dispersion, No slaking, No swelling.

(i) After the preparation of 1:5 Soil:Water suspension and shaking for 10 minutes and standing for 5 minutes

Class-5 : Dispersion $DP \geq 6$

Class-6 : Complete Flocculation $DP \leq 6$

(Other classifications such as the Pinhole Test, SCS dispersion test (Double Hydrometer test) and Soil Chemical test are also used to assess soil dispersivity.

Slaking

When water is applied to most soils, the aggregates within the soil tend to 'melt' or break down. This process of slaking is common in most soils and results in problems such as crusting and hard setting, particularly in soils with loamy surfaces, such as the red brown earths.

In situations where the degree of slaking is considered important, a slaking subclass is allowed;

0 No change

1 Aggregate breaks open but remains intact

2 Aggregate breaks down into smaller aggregate

3 Aggregate breaks down completely into sand grains

Thixotropic

A term applied to certain types of solid/liquid systems which are effectively solid when stationary but become mobile liquids when subjected to shearing stresses.

c) Peat

Peat is a fibrous mass of organic matter in various stages of decomposition and dark brown and black in color and of spongy consistency.

d) Black Cotton Soil

It is inorganic clay of medium to high compressibility. Black Cotton Soils form a major soil group in middle parts of Myanmar. They are predominantly montmorillonitic in structure and black or blackish grey or greenish brown in color. They are characterized by high shrinkage and swelling properties.

APPENDIX B

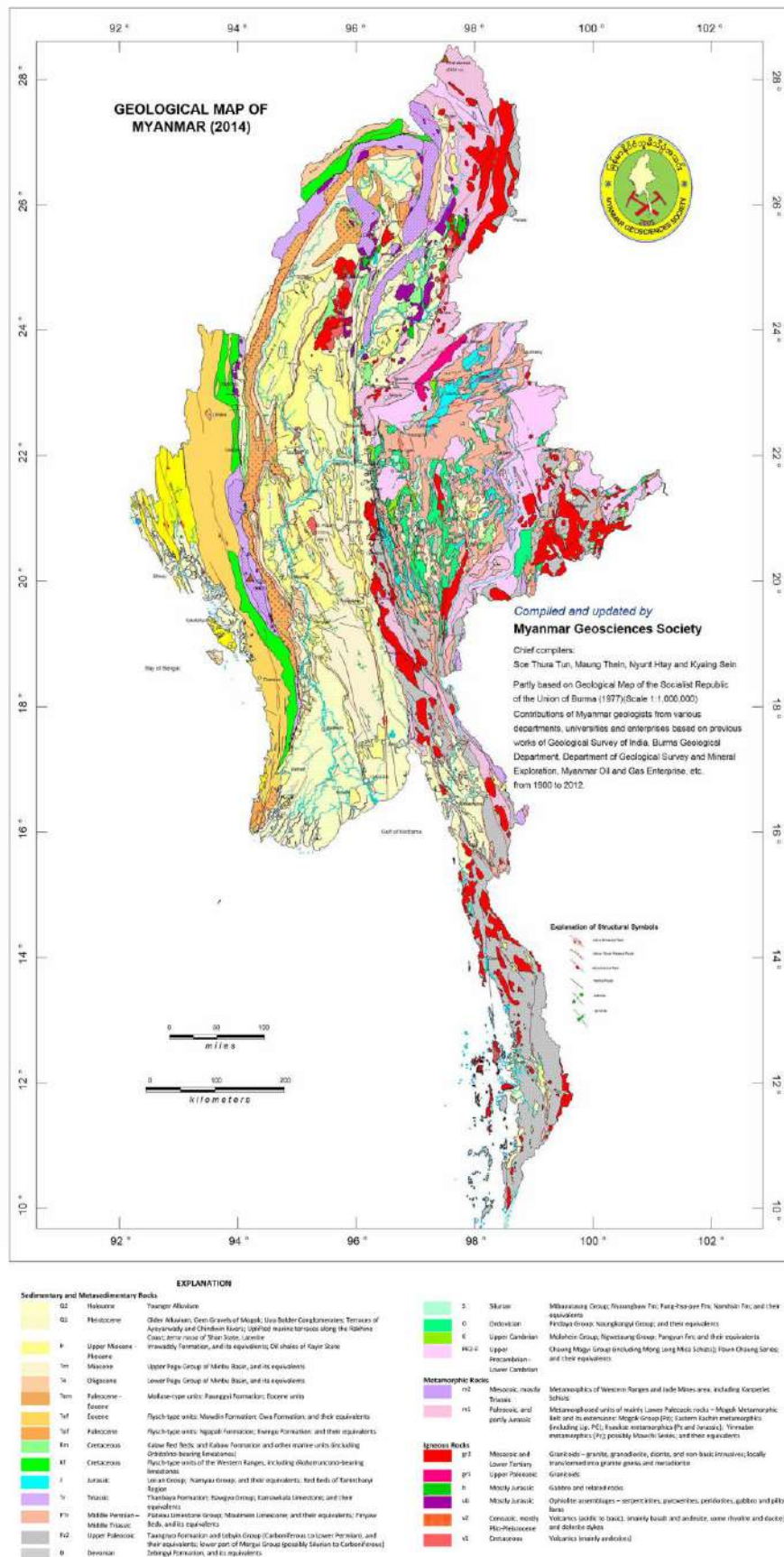


Figure B-1 Geological Map of Myanmar (MGS 2014)

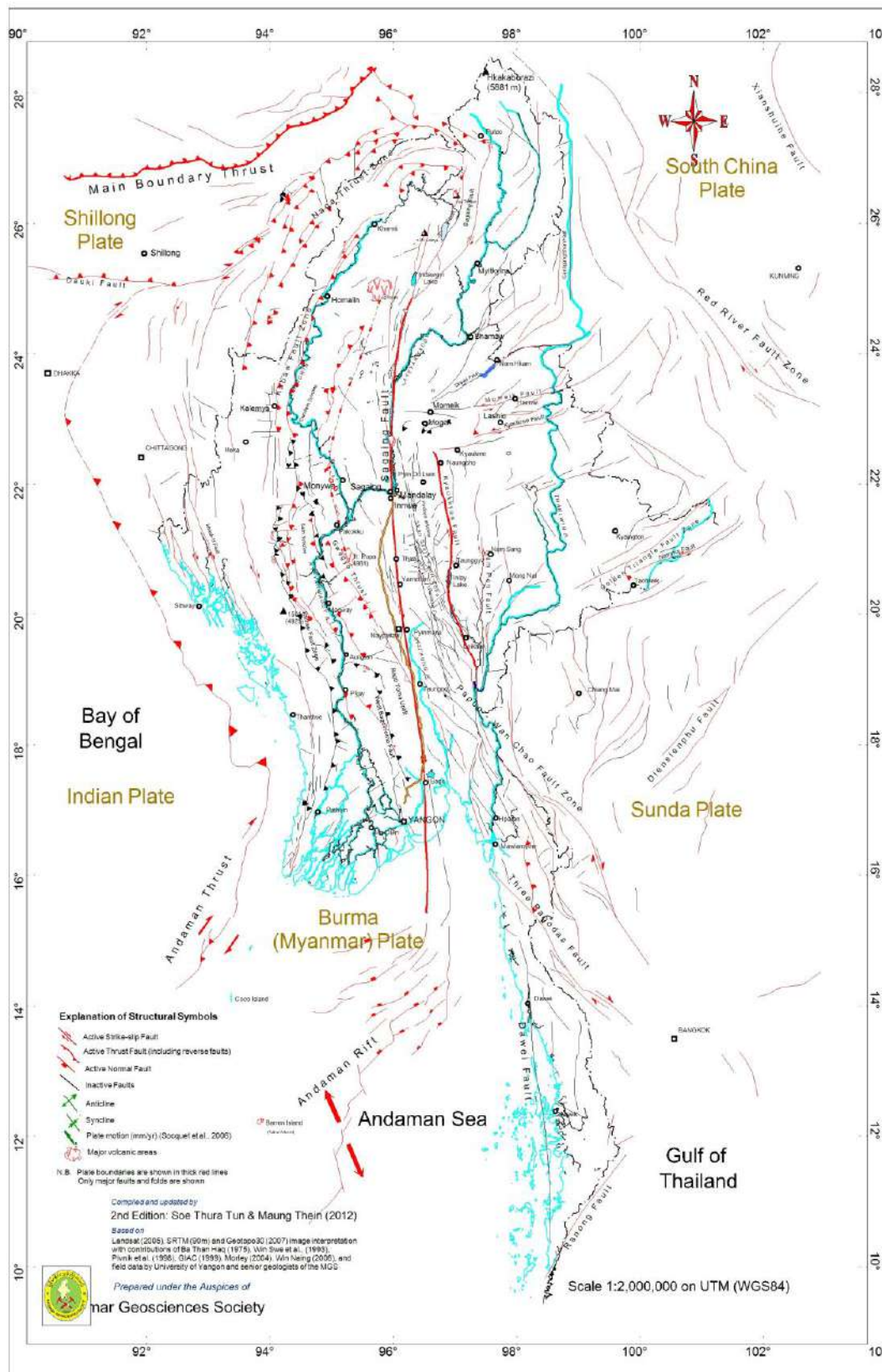


Figure B-2 Tectonic Map of Myanmar and its surrounding (MGS, 2012)

APPENDIX C

Methods of Site Investigation

a) Open Trial Pits (Test Pits) Method

This method consists of excavating trial pits to expose the subsurface soil layers thereby enabling the collection of undisturbed samples from the side-walls and bottom of the pits. Unlike boring, soil can be visually observed from the walls of test pits. Both the material and mass properties of the ground within an excavation must be logged, as well as any observable lateral and vertical variations. Other information to record includes, machine type, make and model, trench or pit size, shape and orientation, bucket size and teeth type. A good photograph can also convey a substantial amount of information.

Test pitting is suitable for all types of formations, but should be used for shallow depths of investigation (up to 3 m or 10 ft.). Safety is a major consideration in the excavation of test pits. Test pits which are excavated in soil materials or loose rock and which are more than 1.5m deep should not be entered unless the excavation is fully supported by engineer designed or specified trench shoring, mesh protection or timber support; or the sides of the excavation have been battered back to a safe angle. It is often impracticable to excavate pits or trenches in areas with groundwater levels near the surface.

Unless specifically requested by the client to do otherwise, conventional practice for backfilling of excavations is to use the machinery that dug the hole to backfill it. Care should therefore be taken to avoid excavating test pits at the exact location of future footings.

Whether test pits are used instead of shallow boreholes depends on the objectives and economics of the investigation.

Test pitting is a suitable means of investigation for low rise buildings of up to two storeys, warehouse, buildings and material surveys for road and airfield construction.

b) Auger Boring (Hand Auger Method)

Various types of hand augers can be used, depending upon the soil conditions, to obtain soil samples to a depth of approximately 30 ft. The holes are typically 0.05m to 0.2m in diameter. A hand auger system consists of an auger bit connected with a bucket type cylinder to a string of rods. The auger may be advanced by rotating and pressing the drilling head down into the soil by means of a "T – Handle" on the upper rod. Depending on the soil characteristics there are various designs of hand augers e.g. sand augers, clay/mud augers, and augers for more typical mixed soils. .

Disturbed samples are typically collected every 2 ft interval and stored in sealed plastic bags. Undisturbed samples may also be obtained by using thin wall steel tubes of 2 inches inner diameter and 1 to 2 ft in length. The recovery of soil samples by hand auger of non-cohesive materials below the water table may not be successful because of the hole's instability or loss of samples upon bit removal from the hole. The recovery of samples of dry sand material or weathered rock materials may not be possible due to the lack of cohesion. In such cases water may be added to the hole in limited amounts to provide a temporary cohesion until the samples are recovered at the surface.

Hand auger boring is a cheap method to take undisturbed and disturbed soil samples. This method may apply to shallow foundations for buildings and it is also suitable to take soil samples for highway and airfield constructions where large sample volumes are not required. This method of investigation may not be suitable in gravelly and boulder soils due to the likelihood of refusal in such soils.

c) Shell and Auger Boring

Portable power-driven helical augers (76 mm to 305 mm in diameter) are available for making deeper boreholes. The soil samples obtained from such boring are highly disturbed. In some non-cohesive soils or soils having low cohesion, the walls of boreholes will not stand unsupported. In such circumstances, a metal pipe is used as a casing to prevent the sides of the hole from caving in.

When power is available, continuous – flight augers are probably the most common method used for advancing a borehole. The power for drilling is delivered by tracked, or tractor – mounted drilling rigs. Boreholes up to 60 – 70 m in depth may easily be drilled by this method. Continuous – flight augers are available in sections of about 1 – 2 m in length with either a solid or hollow stem. Some of the commonly used solid – stem augers have outside diameters of 67 mm, 83mm, 102 mm and 114 mm. Common commercially available hollow – stem augers have dimensions of 63.5 mm ID and 158.75 mm OD, 69.85 mm ID and 177.8 OD, 76.2 mm ID and 203.2 OD, and 82.5 mm ID and 228.6 mm OD.

A cutter head (bit) is attached to the tip of the auger. Auger strings are usually fitted with one of two types of bit, the “V” bit and the tungsten carbide “TC” bit. The “V” bit usually will not penetrate competent rock and for this reason the depth to “V” bit refusal provides useful information. The “TC” bit is used for drilling in rock or to penetrate fill, concrete, boulders etc. During drilling, sections of auger can be added as the hole is extended downwards. The flight of the auger brings the loose soil from the bottom of the hole to the surface. The driller can detect changes in types of soil by noticing changes in the speed and sound of the drilling. When solid – stem augers are used, the augers must be withdrawn at regular intervals to obtain soil samples and also to conduct other operations such as standard penetration tests. Hollow – stem augers have a distinct advantage over solid – stem augers in that they do not have to be removed frequently for sampling and other tests. The outside of the hollow – stem auger acts as a casing supporting the sides of the borehole.

The hollow – stem auger system includes the following components.

Outer component: (a) hollow auger section, (b) hollow auger cap, and (c) drive cap.

Inner component: (a) pilot assembly, (b) center rod column, and (c) rod – to – cap adapter

During drilling, if soil samples are to be collected at a certain depth, the pilot assembly and the center rod are removed. The soil sampler is then inserted through the hollow stem of the auger column to the required sampling depth.

d) Wash Boring

Wash boring is another method of advancing boreholes. In this method, a casing about 6 – 10 ft long is driven into the ground at the collar of the borehole. The soil inside the casing is removed by means of a chopping bit that is attached to a drilling rod. Water is forced through the drilling rod, and it goes out at a very high velocity through the holes at the bottom of the chopping bit. The water and the chopped soil particles rise upward in the drill hole and overflow at the top of the casing through a “T” connection. The wash water is then collected in a container. The casing can be extended with additional pieces as the borehole progresses; however, such extension is not necessary if the borehole can stand without it.

e) Standard Penetration Test

Test Procedure

1. Drill a 2.5 to 8 inches (60-200 mm) diameter exploratory boring to the depth of the first test.

2. Insert the SPT sampler (also known as a split-spoon sampler) into the boring. It is connected via steel rods to a 140 lb (63.5 kg) hammer.
3. Using either a rope and cathead arrangement or an automatic tripping mechanism, raise the hammer a distance of 30 inches (760 mm) and allow it to fall. This energy drives the sampler into the bottom of the boring. Repeat this process until the sampler has penetrated a distance of 18 inches (450 mm), recording the number of hammer blows required for each 6 inches (150 mm) interval. Stop the test if more than 50 blows are required for any of the intervals, or if more than 100 total blows are required. Either of these events is known as refusal and is so noted on the boring log.
4. Compute the N-value by summing the blow counts for the last 12 inches (300 mm) of penetration. The blow count for the first 6 inches (150 mm) is retained for reference purpose, but not used to compute N because the bottom of the boring is likely to be disturbed by the drilling process and may be covered with loose soil that fell from the sides of the boring. Note that the N-value is the same regardless of whether the engineer is using English or SI units.
5. Withdraw the SPT sampler from the borehole; remove and save the soil sample.

Drill the boring to the depth of the next test and repeat steps 2 through 6 as required.

Remarks : N-values may be obtained at intervals no closer than 18 inches (450 mm).

The test results are sensitive to the variations of test procedure and poor workmanship and the principal variants are as follows:

1. Method of drilling
2. How well the bottom of the hole is cleaned before the test
3. Presence or lack of drilling mud
4. Diameter of the drill hole
5. Location of the hammer (surface type or down-hole type)
6. Type of hammer, especially whether it has a manual or automatic tripping mechanism
7. Number of turns of the rope around the cathead
8. Actual hammer drop height (manual types are often as much as 25 percent in error)
9. Mass of the anvil that the hammer strikes
10. Friction in rope guides and pulleys
11. Wear in the sampler drive shoe
12. Straightness of the drill rods
13. Presence or absence of liners inside the sampler (this seemingly small detail can alter the test results by 10-30%)
14. Rate at which the blows are applied

As the result of these variations, the following criteria should be met as a standard approach when carrying out SPT testing in Myanmar:

1. Use the rotary wash method to create a boring that has a diameter between 4 and 5 inches (100-125 mm). The drill bit should provide an upward deflection of the drilling mud (tricone or baffled drag bit).

2. If the sampler is made to accommodate liners, then these liners should be used so the inside diameter is 1.38 inches (35 mm).
3. Use A or AW size drill rods for depths less than 50 feet (15 m) and N or NW size for greater depths.
4. Use a hammer that has an efficiency of 60 %.
5. Apply the hammer blows at a rate of 30 to 40 per minute.

Three types of hammer are recognized:

- (i) Donut Hammer
- (ii) Safety Hammer
- (iii) Automatic Hammer

6. SPT testing should not be carried out below the water table without the borehole being supported by casing or mud. Failure to do this may result in “blowing” on the bottom of the boreholes and a low SPT value recorded in the disturbed material.

Correction of SPT Test Data: Raw SPT N-value can be improved by applying the following equation.

$$N_{60} = \frac{E_m \cdot C_B \cdot C_S \cdot C_R \cdot N}{0.6}$$

Where,

N_{60}	=	SPT N-value corrected for field procedures
E_m	=	hammer efficiency
C_B	=	borehole diameter correction
C_S	=	sampler correction
C_R	=	rod length correction
N	=	measured SPT N-value

$$(N_1)_{60} = N_{60} \times C_N$$

Where ,

$(N_1)_{60}$	=	Corrected N-value
C_N	=	Overburden correction factor

f) Cone Penetration Test

1. Three types of cones are commonly used: the mechanical cone, the electric cone (CPT) and the cone penetration test with pore water pressure measurement (CPTU) often referred to as the piezocone. For detailed information on the operation and interpretation of the cone penetration test see “*Cone Penetration Testing in Geotechnical Practice*” by T Lunne, P.K. Robertson and J.J.M Powell.
2. The test equipment consists of a 60° cone with 10cm² base area (35.7 mm diameter) and a 150cm² friction sleeve (133.7 mm long) located above the cone (15cm² cones are

also being increasingly used). With the CPTu, pore water pressure is measured at typically one, two or three positions, on the cone; behind the cone; and behind the friction sleeve.

3. A hydraulic ram pushes this assembly into the ground and instruments measure the resistance to penetration on the cone tip, friction on the sleeve of the cylinder and in the case of the CPTU, pore water pressure.
4. The mechanical cone is advanced in stages and resistance to penetration is typically measured at intervals of about 20 cm. In homogeneous soils without sharp variations in cone resistance, mechanical cone data can be adequate but the quality of the data is somewhat operator dependent. The electric cone is typically advanced at a rate of about 20mm/sec and includes built-in strain gages enabling measurements to be taken continuously with depth. Most systems are set up to convert the data to digital form at selected intervals of typically 10mm to 50mm.
5. The CPT has many advantages over the SPT, but there are at least two important disadvantages:
 - (i) No soil sample is recovered, so there is no opportunity to inspect the soils.
 - (ii) The test is unreliable or unusable in soils with significant gravel content.

CPT equipment is available to be operated using standard drilling rigs but due to the limited resistance force available from standard truck mounted rigs it is common to mobilize a special rig to perform the CPT. The cost per foot of penetration is less than for boring but, depending on availability, establishment costs for the special rig may be high.

g) Percussion (or) Churn Boring

1. Percussion boring is operated by air or hydraulic-driven hammer-like pistons.
2. This type of boring method consists of breaking the soil and foundation rock by a steel chisel. The chisel is attached to a steel cable which is wound onto the winch drum of the drilling rig.
3. After lifting the chisel, it falls by its weight on the ground.
4. After each blow, the chisel is turned a little so as to bore a circular hole.
5. Previously, a chisel with rods was suspended on a brake-staff which enabled the chisel to be lifted regularly.
6. In shallow boreholes, the tool can be lifted by hand and it can be worked by four to six men.
7. In firm rocks of medium hardness, not strongly jointed, flat straight-edged chisels are generally used.
8. In hard rock, the weight of the chisel is increased by a bar which is inserted between the jar and the chisel.
9. The cuttings and slurry must be removed regularly from the borehole so that percussion blows are not damped.
10. The form of the bit depends on the hardness and character of the rock.
11. Two types of bits are in general use for percussion drilling; button bits and chisel bits.

12. Button bits have a studded face, with the individual studs consisting of cylindrical inserts of tungsten carbide.
13. Chisel bits have chisel-like tungsten carbide inserts arranged in a cross-like pattern, which typically has a waterway at the center.
14. Drive sampling, using thin wall samplers are possible by using cable drill.
15. Deep percussion holes tend to present problem for the use of packers, as the bit undergoes a significant decrease in diameter during drilling.

h) Rotary Boring

Rotary drilling refers to the method of advancing a borehole with a rotary bit and with the removal of cuttings by the circulation of a fluid. It therefore does not include such rotating equipment as bucket or plate augers or continuous flight augers where the removal of cuttings is by mechanical means.

Drilling is effected by the cutting section of the rotating bit which is kept in firm contact with the face of the hole. The bit is carried on hollow jointed drill rods which are rotated by a suitable chuck. The drilling fluid, which may be water or a specially prepared mud is pumped through the hollow rods, discharged at the bit, and returns to the surface in the annular space between the rod and the sides of the hole.

The circulating fluid serves to cool and lubricate the bit and carries the cuttings to the surface.

There are two distinct types of rotary drilling; non-core drilling and core drilling.

1. **Non-core rotary drilling** is used when high rate and output is demanded as in deep oil wells. In this system, the whole bottom of the borehole is ground by a rotating bit so that only crushed rock is obtained, which is washed out by the drilling fluid. Rotary boring offers two advantages over percussion boring, it produces smooth-walled holes of uniform diameter, facilitating the use of packers; and it produces straighter holes than does conventional percussion equipment. The equipment usually consists of a relatively small air-operated drill motor, together with bits and rods. The drill motor can be operated at any one of the three rotational speeds by use of a gear shift, may be mounted on a column. Column-mounted drills advance by a crew-feed. Two types of drills can be recognized: air-track mount and column-mounted. The air-track mount is preferred because the advance of the drill is accomplished by a chain feed, and the rate of advance can be readily controlled by the driller as necessary to accommodate the rock conditions, and enables drilling to be done continuously for the full 10 feet (3 meter) length of the rod, whereas the "stroke" of the column mounted equipment is only about 2 feet (0.61 meter). Diamond bits are used in hard rock, and drag bits faced with tungsten carbide or other relatively economic materials are used in softer rocks. Non-core rotary drilling is the most effective method for penetrating relatively soft materials such as claystones, weathered sandstones and weak shale, where the waterways of percussion bits may tend to become plugged.
2. **Core rotary drilling** is usually carried out in situations where it is important to recover intact rock cores with a high percentage of core recovery to reveal defects and discontinuities such as joint opening and fillings, shear zones and cavities. In core rotary drilling the bit is designed to cut an annular hole leaving a central core which is retained in a core barrel to which the bit is attached. Core barrels used for geotechnical site investigation should at least be of "N" size (nominal hole diameter 76mm). Where weak or fractured rocks occur it is often advantageous to use larger

diameter core barrels which can improve core recovery. Assuming that optimum equipment is used, it is probably the skill of the operator which is the most important element in minimizing core losses by adjusting the controls on the drilling rig to meet different rock conditions. The main variables are the rotation speed of the bit; the pressure exerted on the bit by the weight of the rods plus the feed pressure and the fluid circulation rate of flow which must be high enough to cool the bit and remove cuttings but not so high as to erode the core. Before commencing coring it is preferable to run casing into the upper surface of the rock to provide a seal for the cuttings return.

APPENDIX D

Groundwater Investigation

Water is generally collected and moves in interconnected voids, pore spaces, cracks, fissures, joints, bedding planes and other openings in soil and rock formations beneath the ground surface. The level of the water table is not stationary. It fluctuates according to the rainfall or seasons. During and after the rainy season, it gets raised considerably due to accession of water. This is called natural recharge and during the dry months, it falls. The zone between the maximum and minimum water level is called the zone of intermittent saturation. The zone below the minimum water level is called the zone of permanent saturation. The main types of flows are as follows:

1. The intermediate saturated flows above the near-surface impervious layers. The upper surface of these flows is sometimes described as perched water table.
2. A major saturated flow zone usually defined at the top of the water table by a discharge source and at the bottom by an impermeable layer.
3. An unsaturated flow zone between the surface and the water table through which water percolates or is held by capillary action.

A rough illustration of the flow zones is shown in Figure D-1

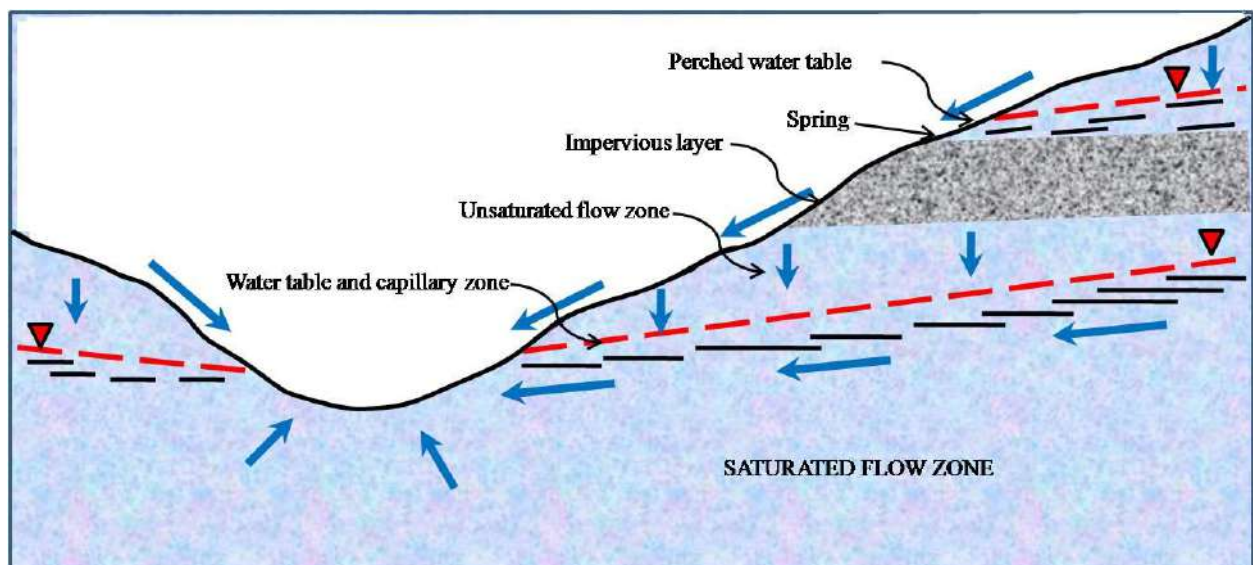


Figure D-1 Major zones of water saturation

APPENDIX E

Geotechnical Instrumentation

The primary requirement of any instrument is that it should be capable of determining a required parameter, such as water pressure, or displacement, without leading to a change in that parameter as a result of the presence of the instrument in the soil. In addition, since most soil instruments will be placed in an hostile environment, it is important that they should be robust and reliable. Most instrumentation cannot be recovered from the ground if it fails, and it will often be abused during installation or during construction of the works.

Pore water pressure and groundwater level measurement

This is the most common form of *in situ* measurement, and fortunately only one measurement is required at any point to define the regime. Quite simple devices are often used to determine water pressure in the ground, but these devices are unsuitable under many conditions.

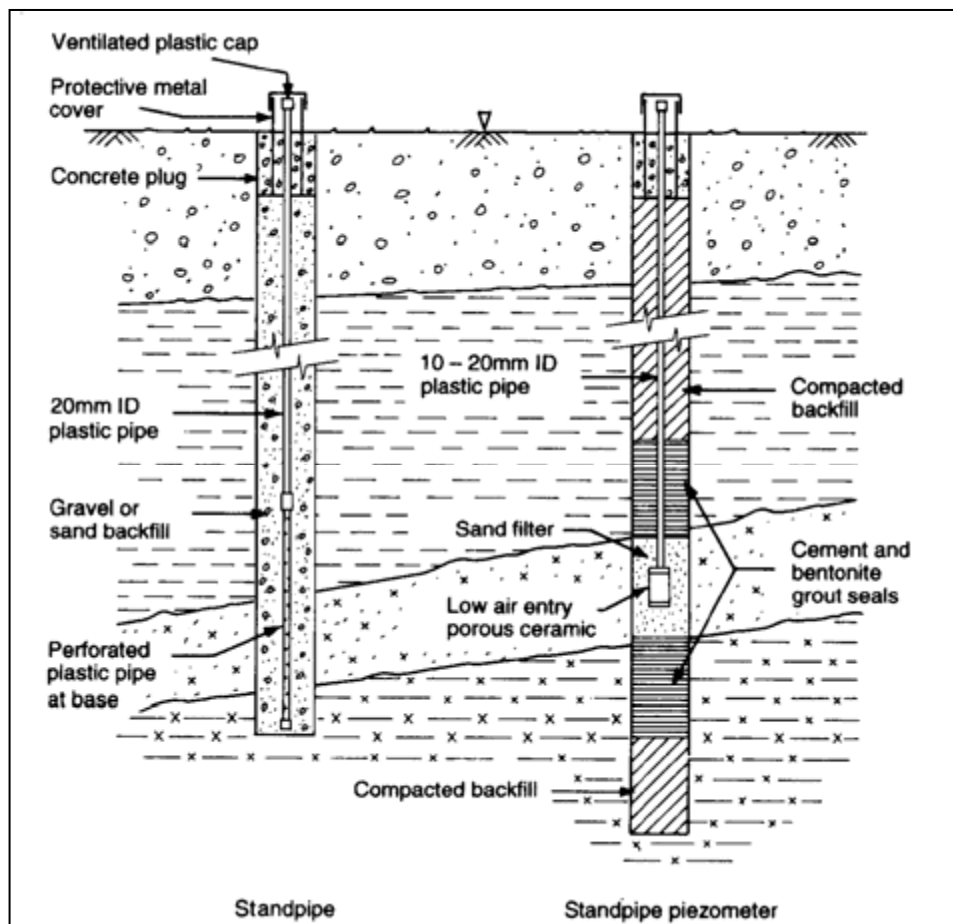


Figure E-1 Installation of standpipe and standpipe (or Casagrande) piezometer

Hanna (1973) has defined the requirements of any piezometer as:

1. to record accurately the pore pressures in the ground;
2. to cause as little interference to the natural soil as possible;
3. to be able to respond quickly to changes in groundwater conditions;
4. to be rugged and remain stable for long periods of time; and
5. to be able to read continuously or intermittently if required.

Displacement measurement

Measurements of displacement may be made relative to time, and to some datum remote from the point of measurement. A straightforward method of monitoring absolute displacement is to use conventional surveying techniques: the type of datum required for such a scheme will depend upon the nature of the structure and the nature of the soil. In most cases, the datum is a fixed point in the ground, such as a bench mark driven to bedrock.

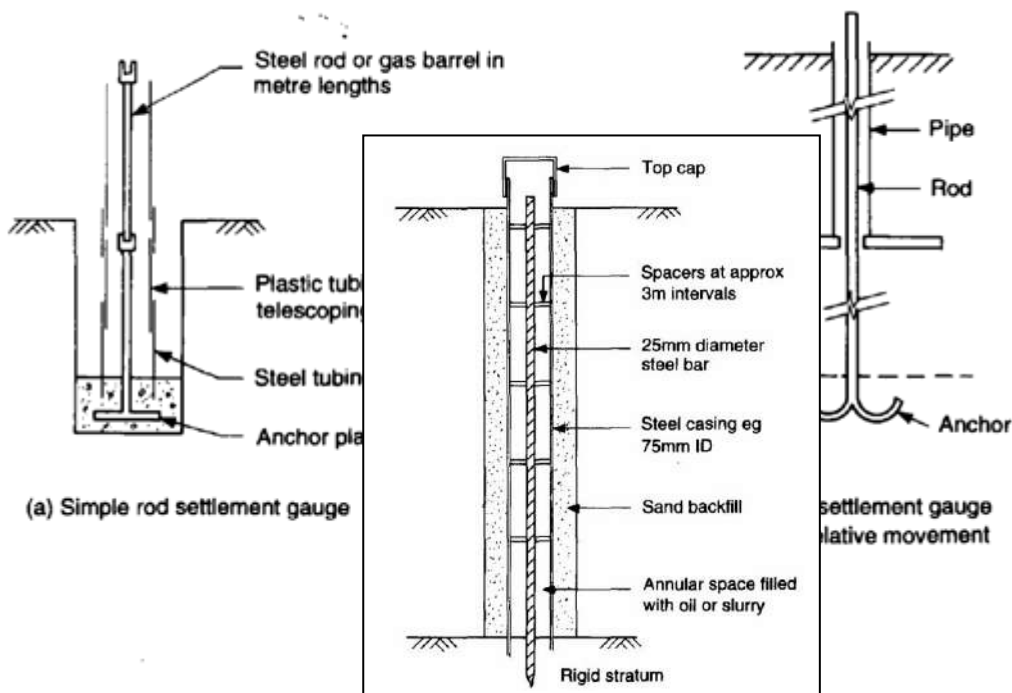


Figure E-2 Bench mark driven to bedrock.

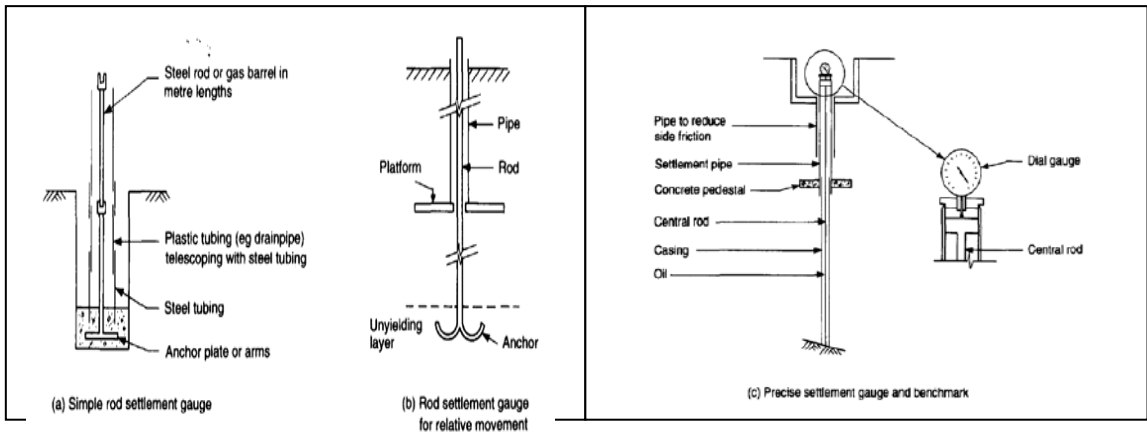


Figure E-3 Rod settlement gauges (from Bjerrum *et al.* 1965; Dunnicliff 1971; Hanna, 1973).

APPENDIX F

a) Seismic Survey

Elastic waves initiated by some energy source travel through geological media at characteristic velocities and are refracted and reflected by material changes or travel directly through the material, finally arriving at the surface where they are detected and recorded by instruments.

Seismic survey investigations are generally divided into three methods as follows:

Refraction survey method

Reflection survey method

Direct survey method

Requirements

Geophones (Vertical and Horizontal)

Energy Source (Blast or Hammer)

Seismograph (12 channels or 24 channels)

Accessories

Interpretation

The interpretation is based on the velocity values.

Seismic refraction techniques are used to measure material velocities from which depths of changes in strata are computed. Seismic reflection methods are used to obtain a schematic representation of the subsurface in terms of time and large amounts of data can be obtained rapidly over large areas. Seismic direct methods are used to obtain data on the dynamic properties of soils and rocks.

For shallow depth investigation, the refraction methods are typically used. This method is particularly valuable for reconnaissance in areas with practically unknown subsurface geology. In engineering practice, the depth to bedrock and the detection of fracture zones in hard rocks and exploration of groundwater are generally conducted by seismic refraction survey.

Table F-1 Compressional wave velocities (V_p) in various medium

Types of medium	V_p (m/s)
Air	330
Water	1400 – 1500
Ice	3000 – 4000
Permafrost	3500 – 4000
Weathered layer	250 – 1000
Alluvium, sand (dry)	300 – 1000
Sand (water saturated)	1200 – 1900
Clay	1100 – 2500
Glacial moraine	1500 – 2600
Coal	1400 – 1600
Sandstone	2000 – 4500

Slate and Shale	2400 – 5000
Limestone and Dolomite	3400 – 6000
Anhydrite	4500 – 5800
Rocksalt	4000 – 5500
Granite and Gneiss	5000 – 6200
Basalt flow top (highly fractured)	2500 – 3800
Basalt	5500 – 6300
Gabbro	6400 – 6800
Dunite	7500 – 8400

Note: For a more extensive compilation of compression and shear wave velocity data, the reader may refer to Bonner and Schock (1981).

Application depths

Up to 60 m depth by hammering

Up to 200 m depth and above by blasting

b) Resistivity Survey

Various subsurface materials have characteristic conductance for direct currents of electricity. Electrolytic action made possible by the presence of moisture and dissolved salts within the soil and rock formation permit the passage of current between the electrodes placed in the surface soils.

An electric current is transmitted into the ground and the resulting potential differences are measured at the surface using electrodes in various configurations. The following different electrode configurations are commonly used in resistivity survey.

Wenner

Gradient

Schlumberger

Pole – Dipole

Dipole – Dipole

Requirements

Resistivity meter

SAS 300 C (ID department)

SAS 4000 (ID department)

Steel electrodes

Accessories

Application depths

100 m to 200 m

APPENDIX H

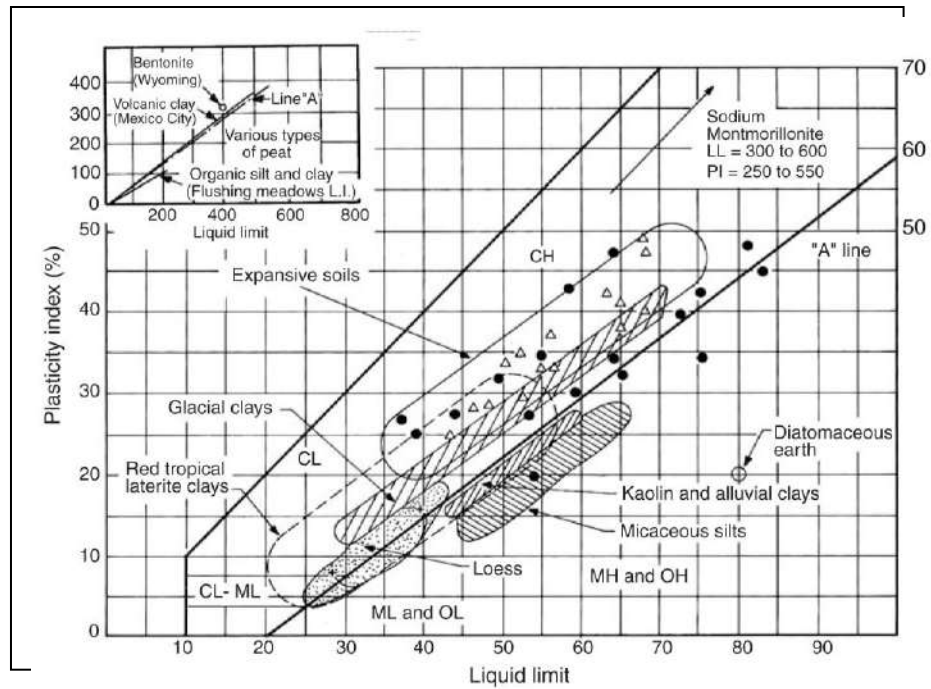


Figure H-1 Plasticity Chart

Table H-1 Unfinied soil classification system and soil symbols ASTM D-2487-00

Major Divisions (1)	Letter (2)	Letter (3)	Symbols (4)	Color (5)	Name (6)	Value for Embankments (7)	Permeability cm per sec (8)
Coarse-Grained Soils	Gravel and Gravelly Soils	GW		Red	Well-graded gravels or gravel-sand mixtures, little or no fines	Very stable, pervious shells of dikes and dams	$k > 10^{-2}$
		GP		Red	Poorly graded gravels or gravel-sand mixtures, little or no fines	Reasonably stable, pervious shells of dikes and dams	$k > 10^{-2}$
		GM		Yellow	Silty gravels, gravel-sand-silt mixtures	Reasonably stable, not particularly suited to shells, but may be used for impervious cores or blankets	$k = 10^{-3}$ to 10^{-6}
		GC		Yellow	Clayey gravels, gravel-sand-clay mixtures	Fairly stable, may be used for impervious core	$k = 10^{-6}$ to 10^{-8}
	Sand and Sandy Soils	SW		Red	Well-graded sands or gravelly sands, little or no fines	Very stable, pervious sections, slope protection required	$k > 10^{-3}$
		SP		Red	Poorly graded sands or gravelly sands, little or no fines	Reasonably stable, may be used in dike section with flat slopes	$k > 10^{-3}$
		SM		Yellow	Silty sands, sand-silt mixtures	Fairly stable, not particularly suited to shells, but may be used for impervious cores or dikes	$k = 10^{-3}$ to 10^{-6}
		SC		Yellow	Clayey sands, sand-silt mixtures	Fairly stable, use for impervious core or flood-control structures	$k = 10^{-6}$ to 10^{-8}
Fine-Grained Soils	Silts and Clays LL < 50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Poor stability, may be used for embankments with proper control	$k = 10^{-3}$ to 10^{-6}
		CL		Green	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Stable, impervious cores and blankets	$k = 10^{-6}$ to 10^{-8}
		OL		Green	Organic silts and organic silt-clays of low plasticity	Not suitable for embankments	$k = 10^{-4}$ to 10^{-6}
	Silts and Clays LL ≥ 50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor stability, core of hydraulic-fill dam, not desirable in rolled-fill construction	$k = 10^{-4}$ to 10^{-6}
		CH		Blue	Inorganic clays of high plasticity, fat clays	Fair stability with flat slopes, thin cores, blankets and dike sections	$k = 10^{-6}$ to 10^{-8}
		OH		Blue	Organic clays of medium to high plasticity, organic silts	Not suitable for embankments	$k = 10^{-6}$ to 10^{-8}
Highly Organic Soils		Pt		Orange	Peat and other highly organic soils	Not used for construction	

APPENDIX I

General procedure of 1D seismic response analysis

1. Construction of subsurface soil model based on borehole data, SPT data and laboratory results.
2. Calculation of shear wave velocity structures of proposed site from SPT data or by measuring geophysical methods.
3. Generation of synthetic bedrock motion for the most suitable seismic sources of proposed site.
4. Performing 1D seismic response analysis by using input parameters from items 1 – 3
5. Final results will be Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV), Peak Ground Displacement (PGD), amplification factor, predominant period and fundamental frequency of proposed site.

APPENDIX J

Basic Design Consideration for Potential Landslide Areas

Myanmar has two mountainous provinces: namely the Western Ranges and the Eastern Highland. These provinces are inherently unstable areas of the country. The steep slopes, unstable geologic conditions, and heavy monsoon rains combine to make these mountainous areas two of the most hazard-prone areas in Myanmar.

More recently there has been an increase in human settlement in hazard-prone areas as a result of rapid population growth, as well as improvement in accessibility by road and the onset of other infrastructure developments. Consequently, natural and man-made disasters are on the increase and each event affects people more than before. Even in central low land between the two mountainous provinces, landslide features occur along the banks of lower Ayeyarwady River and its tributaries.

The main causes that influence landslide hazard in Myanmar are: (i) gravity and the gradient of the slope, (ii) hydrogeological characteristics of the slope, (iii) presence of troublesome earth material, (iv) process of erosion, (v) man-made causes, (vi) geological conditions, and (vii) occurrence of a triggering event.

a) Geotechnical Data Collection and Testing

- 1) Measure the slope height and slope gradient
- 2) Collect disturbed and undisturbed samples of slope material
- 3) Measure field permeability, if possible and determine the ground water table
- 4) Identify the possible recharge sources of surface water near the slope
- 5) Collect the rainfall data of the area
- 6) Perform the following laboratory tests
 - i) Sieve Analysis
 - ii) Permeability Test
 - iii) Direct Shear or Triaxial Test
 - iv) Atterberg's Limit's Tests
 - v) Specific gravity and unit weight of materials

b) Slope Stability Analysis

Various methods can be applied for slope stability analysis. One or two of them should be used according to the data available at the time of analysis. The slopes that should be analyzed may include natural slopes, cutting slopes and artificial embankments. The slope stability analysis is generally performed under the following two main analyses.

- a) Limit Equilibrium Analysis
- b) Stress Deformation Analysis

Some applicable methods for slope stability analysis are as follows:

- 1) Friction Circle Method
- 2) Bishop's Simplified Method of Slices
- 3) Newmark Sliding Block Analysis
- 4) Makdisi – Seed Analysis

d) Potential Landslide Hazard Zone Map of Myanmar

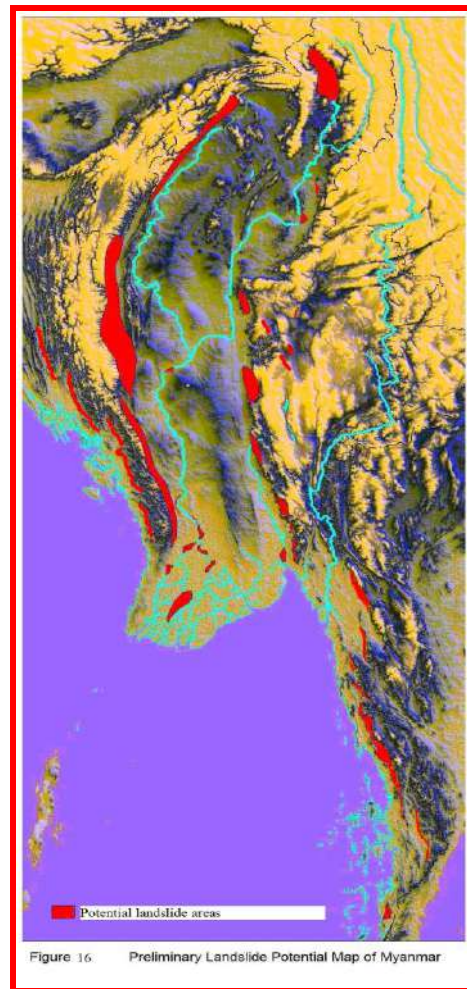


Figure J-1 Potential Landslide Hazard Map of Myanmar (Kyaw Htun, 2011)

c) Stabilization and Prevention

Passive Preventive Intervention

- a) Choose a safe location to build your home, away from steep slopes and places where land-slides have occurred in the past
- b) Prevent deforestation and vegetation removal
- c) Avoid weakening the slope

Active Preventive Intervention

- a) **Reforestation:** Root systems bind materials together and plants do both prevent water percolation and take water up out of the slope. Natural vegetation should be retained where practicable.
- b) **Earthworks:** Retain natural contours where possible. Large scale unsupported cuts and benching should be avoided. Cut and fill heights should be minimized and should be supported by engineer designed retaining walls or battered to an appropriate slope. Vegetation and topsoil should be stripped prior to filling and fill should be keyed into the natural slope by benching.

- c) **Retaining Walls:** Should be engineer designed to resist applied soil and water forces. Walls should be founded on rock where practicable and subsurface drainage should be provided within the wall backfill and surface drainage on the slope above.
- d) **Footings:** Should be founded within rock where practicable. Rows of piers or strip footings should be oriented up and down the slope and should be designed for lateral creep pressure if necessary. Footing excavations should be backfilled to prevent ingress of surface water.
- e) **Proper Surface Drainage** must be ensured, especially where houses and roads have disrupted the natural flow patterns. This can be achieved by providing a proper canalization network. Drains should be provided at the tops of cut and fill slopes and should discharge to street drainage or natural water courses.
- f) **Subsurface Drainage:** good ground drainage is essential to prevent saturation and consequent weakening of the soil and rock structure. Filters should be provided around subsurface drains. Drainage should always be provided when any kind of civil work, like retaining walls, have been constructed. Where possible flexible pipelines should be used with access for maintenance.

MYANMAR

NATIONAL

BUILDING

CODE

2016

PART 5A, PART 5B & PART 5C

MYANMAR

NATIONAL

BUILDING

CODE

2016

PART 5A

**BUILDING SERVICES
(LIGHTING)**

MYANMAR NATIONAL BUILDING CODE

PART 5A BUILDING SERVICES

LIGHTING

C O N T E N T S

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MYANMAR NATIONAL BUILDING CODE

PART 5A BUILDING SERVICES

LIGHTING

5A.1 SCOPE

This Section covers requirements and methods for lighting of buildings.

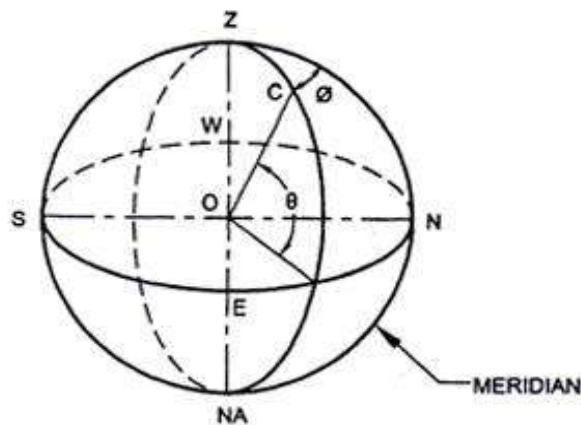
5A.2 TERMINOLOGY

5A.2.0 For the purpose of this Section, the following definitions shall apply.

5A.2.1 Lighting

5A.2.1.1 *Altitude (θ)* — The angular distance of any point of celestial sphere, measured from the horizon, on the great circle passing through the body and the zenith (*see* Figure 1).

5A.2.1.2 *Azimuth (ϕ)* — The angle measured between meridians passing through the north point and the point in question (point C in Figure 1).



REFERENCES

O	-	Observer's station	S	-	Geographical south
C	-	Celestial body	E	-	Geographical east
Z	-	Zenith	W	-	Geographical west
NA	-	Nadir	N	-	Geographical north

Figure 1: Altitude and Azimuth of a Celestial Body

5A.2.1.3 *Brightness Ratio or Contrast* — The variations or contrast in brightness of the details of a visual task, such as white print on blackboard.

5A.2.1.4 *Candela (cd)* —The SI unit of luminous intensity.

Candela = 1 lumen per steradian

5A.2.1.5 Central Field — The area of circle round the point of fixation and its diameter, subtending an angle of about 2° at the eye. Objects within this area are most critically seen in both their details and colour.

5A.2.1.6 Clear Design Sky — The distribution of luminance of such a sky is non-uniform; the horizon is brighter than the zenith, and when L_z is the brightness at zenith, the brightness at an altitude (θ) in the region away from the sun, is given by the expression:

$$L_\theta = L_z \operatorname{cosec} \theta$$

When θ lies between 15° and 90°, and L_θ is constant when θ lies between 0° and 15°.

5A.2.1.7 Colour Rendering Index (CRI) — Measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation.

5A.2.1.8 Correlated Colour Temperature (CCT) (Unit: K) — The temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions.

5A.2.1.9 Daylight Area — The superficial area on the working plane illuminated to not less than a specified daylight factor, that is, the area within the relevant contour.

5A.2.1.10 Daylight Factor — The measure of total daylight illuminance at a point on a given plane expressed as the ratio (or percentage) which the illuminance at the point on the given plane bears to the simultaneous illuminance on a horizontal plane due to clear design sky at an exterior point open to the whole sky vault, direct sunlight being excluded.

5A.2.1.11 Daylight Penetration — The maximum distance to which a given daylight factor contour penetrates into a room.

5A.2.1.12 Direct Solar Illuminance — The illuminance from the sun without taking into account the light from the sky.

5A.2.1.13 External Reflected Component (ERC) — The ratio (or percentage) of that part of the daylight illuminance at a point on a given plane which is received by direct reflection from external surfaces as compared to the simultaneous exterior illuminance on a horizontal plane from the entire hemisphere of an unobstructed clear design sky.

5A.2.1.14 Glare — A condition of vision in which there is discomfort or a reduction in the ability to see significant objects or both due to an unsuitable distribution or range of luminance or due to extreme contrasts in space and time.

5A.2.1.15 Illuminance — At a point on a surface, the ratio of the luminous flux incident on an infinitesimal element of the surface containing the point under consideration to the area of the element.

NOTE — The unit of illuminance (the measurement of illumination) is lux which is 1 lumen per square metre.

5A.2.1.16 Internal Reflected Component (IRC) — The ratio (or percentage) of that part of the daylight illuminance at a point in a given plane which is received by direct reflection or inter-reflection from the internal surfaces as compared to the simultaneous exterior illuminance on a horizontal plane due to the entire hemisphere of an unobstructed clear design sky.

5A.2.1.17 Light Output Ratio (LOR) or Efficiency (η) — The ratio of the luminous flux emitted from the luminaire to that emitted from the lamp(s) (nominal luminous flux). It is expressed in percent.

5A.2.1.18 Lumen (lm) — SI unit of luminous flux. The luminous flux emitted within unit solid angle (one steradian) by a point source having a uniform intensity of one candela.

5A.2.1.19 Luminance (At a point of a Surface in a Given Direction) (Brightness) — The quotient of the luminous intensity in the given direction of an infinitesimal element of the surface containing the point under consideration by the orthogonally projected area of the element on a plane perpendicular to the given direction. The unit is candela per square meter (cd/m^2).

5A.2.1.20 Luminous Flux (Φ)—The quantity characteristic of radiant flux which expresses its capacity to produce visual sensation evaluated according to the values of relative luminous efficiency for the light adapted eye:

(a) *Effective luminous flux (Φ_n)* — Total luminous flux which reaches the working plane.

Nominal luminous flux (Φ_0)— Total luminous flux of the light sources in the interior.

5A.2.1.21 Maintenance Factor (d) — The ratio of the average illuminance on the working plane after a certain period of use of a lighting installation to the average illuminance obtained under the same conditions for a new installation.

5A.2.1.22 Meridian— It is the great circle passing through the zenith and nadir for a given point of observation.

5A.2.1.23 North and South Points — The point in the respective directions where the meridian cuts the horizon.

5A.2.1.24 Orientation of Buildings — In the case of non- square buildings, orientation refers to the direction of the normal to the long axis. For example, if the length of the building is east-west, its orientation is north- south.

5A.2.1.25 Peripheral Field — It is the rest of the visual field which enables the observer to be aware of the spatial framework surrounding the object seen.

NOTE — A central part of the peripheral field, subtending an angle of about 30° on either side of the point of fixation, is chiefly involved in the perception of glare.

5A.2.1.26 Reflected Glare — The variety of ill effects on visual efficiency and comfort produced by unwanted reflections in and around the task area.

5A.2.1.27 Reflection Factor (Reflectance) — The ratio of the luminous flux reflected by a body (with or without diffusion) to the flux it receives. Some symbols used for reflection factor are:

r_c = Reflection factor of ceiling.

r_w = Reflection factor of parts of the wall between the working surface and the luminaires.

r_f = Reflection factor of floor.

5A.2.1.28 Reveal—The side of an opening for a window.

5A.2.1.29 Room Index (k_r)— An index relating to the shape of a rectangular interior, according to the formula:

$$k_r = \frac{L.W}{(L+W) H_m} \quad \text{where } L \text{ and } W \text{ are the length and width respectively of}$$

the interior, and H_m is the mounting height, that is, height of the fittings above the working plane.

NOTES

1 For rooms where the length exceeds 5 times the width, L shall be taken as $L = 5W$.

2 If the reflection factor of the upper stretch of the walls is less than half the reflection factor of the ceiling, for indirect or for the greater part of indirect lighting, the value H_m is measured between the ceiling and the working plane.

5A.2.1.30 Sky Component (SC)—The ratio (or percentage) of that part of the daylight illuminance at a point on a given plane which is received directly from the sky as compared to the simultaneous exterior illuminance on a horizontal plane from the entire hemisphere of an unobstructed clear design sky.

5A.2.1.31 Solar Load — The amount of heat received into a building due to solar radiation which is affected by orientation, materials of construction and reflection of external finishes and colour.

5A.2.1.32 Utilization Factor (Coefficient of Utilization) (μ)— The ratio of the total luminous flux which reaches the working plane (effective luminous flux, ϕ_n) to the total luminous flux of the light sources in the interior (nominal luminous flux, ϕ_0).

5A.2.1.33 Visual Field—The visual field in the binocular which includes an area approximately 120° vertically and 160° horizontally centering on the point to which the eyes are directed. The line joining the point of fixation and the centre of the pupil of each eye is called its primary line of sight.

5A.2.1.34 Working Plane — A horizontal plane at a level at which work will normally be done (see 5A.3.1.3.3 and 5A.3.1.3.4),

5A.3 LIGHTING

5A.3.1 Principles of Lighting

5A.3.1.1 Aims of Good Lighting

Good lighting is necessary for all buildings and has three primary aims. The first aim is to promote work and other activities carried out within the building; the second aim is to promote the safety of the people using the building; and the third aim is to create, in conjunction with the structure and decoration, a pleasing environment conducive to interest of the occupants and a sense of their well-being.

5A.3.1.1.1 Realization of these aims involves

a): careful planning of the brightness and colour pattern within both the working areas and the surroundings so that attention is drawn naturally to the important areas, detail is seen quickly and accurately and the room is free from any sense of gloom or monotony (*see 5A.3.1.3*);

b) using directional lighting where appropriate to assist perception of task detail and to give good modeling;

c) controlling direct and reflected glare from light sources to eliminate visual discomfort;

d) in artificial lighting installations, minimizing flicker from certain types of lamps and paying attention to the colour rendering properties of the light;

e) correlating lighting throughout the building to prevent excessive differences between adjacent areas so as to reduce the risk of accidents; and

f) installation of emergency lighting systems, where necessary.

5A.3.1.2 Planning the Brightness Pattern

The brightness pattern seen within an interior may be considered as composed of three main parts — the task itself, immediate background of the task and the general surroundings of walls, ceiling, floor, equipment and furnishings.

5A.3.1.2.1 In occupations where the visual demands are small, the levels of illumination derived from a criterion of visual performance alone may be too low to satisfy the other requirements. For such situations, therefore, illuminance recommendations are based on standards of welfare, safety and amenity judged appropriate to the occupations; they are also sufficient to give these tasks brightness which ensured that the visual performance exceeds the specified minimum.. Unless there are special circumstances associated with the occupation, it is recommended that the illuminance of all working areas within a building should generally be 150 lux, even though the visual demands of the occupation might be satisfied by lower values.

5A.3.1.2.2 Where work takes place over the whole utilizable area of room, the illumination over that area should be reasonably uniform and it is recommended that the uniformity ratio

(minimum illuminance divided by average illuminance levels) should be not less than 0.7 for the working area.

5A.3.1.2.3 When the task brightness appropriate to an occupation has been determined, the brightness of the other parts of the room should be planned to give a proper emphasis to visual comfort and interest.

A general guide for the brightness relationship within the normal field of vision should be as follows:

(a) For high task brightness (above 100 cd/m ²)	Maximum
1) Between the visual task and the adjacent areas like table tops	3 to 1
2) Between the visual task and the remote areas of the room	10 to 1

(b) For low and medium task brightness (below 100 cd/m²): The task should be brighter than both the background and the surroundings; the lower the task brightness, the less critical is the relationship.

5A.3.1.3 *Recommended Values of Illuminance*

Table 1 gives recommended values of illuminance commensurate with the general standards of lighting described in this section and related to many occupations and buildings; These are valid under most of the conditions whether the illumination is by daylighting, artificial lighting or a combination of the two. The great variety of visual tasks makes it impossible to list them all and those given should be regarded as representing types of task.

5A.3.1.3.1 The different locations and tasks are grouped within the following four sections:

- a) Industrial buildings and process;
- b) Offices, schools and public buildings;
- c) Surgeries and hospitals; and
- d) Hotels, restaurants, shops and homes.

5A.3.1.3.2 The illumination levels recommended in Table 1 are those to be maintained at all time on the task. As circumstances may be significantly different for different interiors used for the same application or for different conditions for the same kind of activity, a range of illuminances is recommended for each type of interior or activity instead of a single value of illuminance. Each range consists of three successive steps of the recommended scale of illuminances. For working interiors the middle value of each range represents the recommended service illuminance that would be used unless one or more of the factors mentioned below apply.

5A.3.1.3.2.1 The higher value of the range should be used when:

- (a) unusually low reflectances or contrasts are present in the task;
- (b) errors are costly to rectify;
- (c) visual work is critical;
- (d) accuracy or higher productivity is of great importance; and
- (e) the visual capacity of the worker makes it necessary.

5A.3.1.3.2.2 The lower value of the range may be used when:

- (a) reflectances or contrast are unusually high;
- (b) speed and accuracy is not important; and
- (c) the task is executed only occasionally.

5A.3.1.3.3 Where a visual task is required to be carried out throughout an interior, general illumination level to the recommended value on the working plane is necessary; where the precise height and location of the task are not known or cannot be easily specified, the recommended value is that on horizontal plane 850 mm above floor level.

NOTE — For an industrial task, working plane for the purpose of general illumination levels is that on a work place which is generally 750 mm above the floor level. For certain purposes, such as viewing the objects of arts, the illumination levels recommended are for the vertical plane at which the art pieces are placed.

5A.3.1.3.4 Where the task is localized, the recommended value is that for the task only; it need not, and sometimes should not, be the general level of illumination used throughout the interior. Some processes, such as industrial inspection process, call for lighting of specialized design, in which case the level of illumination is only one of the several factors to be taken into account.

5A.3.1.4 *Glare*

Excessive contrast or abrupt and large changes in brightness produce the effect of glare. When glare is present, the efficiency of vision is reduced and small details or subtle changes in scene cannot be perceived. It may be

- (a) direct glare due to light sources within the field of vision,
- (b) reflected glare due to reflections from light sources or surfaces of excessive brightness,
- (c) veiling glare where the peripheral field is comparatively very bright.

5A.3.1.4.1 An example of glare sources in day lighting is the view of the bright sky through a window or skylight, especially when the surrounding wall or ceiling is comparatively dark or weakly illuminated. Glare can be minimized in this case either by shielding the open sky from direct sight by louvers, external hoods or deep reveals, curtains or other shading devices or by cross lighting the surroundings to a comparable level. A gradual transition of brightness from one portion to the other within the field of vision always avoids or minimizes the glare discomfort.

5A.3.1.5 Lighting for Movement about a Building

Most buildings are complexes of working areas and other areas, such as passages, corridors, stairways, lobbies and entrances. The lighting of all these areas should be properly correlated to give safe movement within the building at all times.

5A.3.1.5.1 Corridors, passages and stairways

Accidents may result if people leave a well-lighted working area and pass immediately into corridors or on to stairways where the lighting is inadequate, as the time needed for adaptation to the lower level may be too long to permit obstacles or the threads of stairs to be seen sufficiently quickly.

Table 1: Recommended Values of Illuminance
(Clauses 5A.3.1.3, 5A.3.1.3.2, 5A.3.3.2 and 5A.3.3.2.1)

SI No.	Type of Interior or Activity	Range of Service Illuminance in Lux	Quality Class of Direct Glare Limitation	Remarks
(1)	(2)	(3)	(4)	(5)
1	AGRICULTURE AND HORTICULTURE			
1.1	Inspection of Farm Product where Colour is Important	300-500-750	1	Local lighting may be appropriate
	Other Important Tasks	200-300-500	2	Local lighting may be appropriate
1.2	Farm Workshops			
1.2.1	General	50-100-150	3	
1.2.2	Workbench or machine	200-300-500	2	Local or portable lighting may be appropriate
1.3	Milk Premises	50-100-150	3	
1.4	Sick Animal Pets, Calf Nurseries	30-50-100	3	
1.5	Other Firm and Horticultural Buildings	20-30-50	3	
2	COAL MINING (SURFACE BUILDINGS)			
2.1	Coal Preparation Plant			
2.1.1	Walkways, floors under conveyors	30-50-100	3	
2.1.2	Wagon loading, bunkers	30-50-100	3	
2.1.3	Elevators, chute transfer pits, wash box area	50-100-150	3	
2.1.4	Drum filters, screen, rotating shafts	100-150-200	3	
2.1.5	Picking belts	150-200-300	3	Directional and colour properties of lighting may be important for easy recognition of coal and rock
2.2	Lamp Rooms			
2.2.1	Repair section	200-300-500	2	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
2.2.2	Other areas	100-150-200	3	
2.3	Weight Cabins, Fan Houses	100-150-200	3	
2.4	Winding Houses	100-150-200	3	
3	ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION			
3.1	General Plant			
3.1.1	Turbine houses (operating floor)	150-200-300	2	
3.1.2	Boiler and turbine house basements	50-100-150	3	
3.1.3	Boiler houses, platforms, areas around burners	50-100-150	3	
3.1.4	Switch rooms, meter rooms, oil plant rooms, HV substations (indoor)	100-150-200	2	
3.1.5	Control rooms	200-300-500	1	Localized lighting of control display and the control desks may be appropriate
3.1.6	Relay and telecommunication rooms	200-300-500	2	
3.1.7	Diesel generator rooms, compressor rooms	100-150-200	3	
3.1.8	Pump houses, water treatment plant houses	100-150-200	3	
3.1.9	Battery rooms, chargers, rectifiers	50-100-150	3	
3.1.10	Precipitator chambers, platforms, etc	50-100-150	3	
3.1.11	Cable tunnels and basements, circulating water culverts and screen chambers, storage tanks (indoor), operating areas and filling points at outdoor tanks	30-50-100	3	
3.2	Coal Plant			
3.2.1	Conveyors, gantries, junction towers, unloading hoppers, ash handling plants, settling pits, dust hoppers outlets	50-100-150	3	
3.2.2	Other areas where operators may be in attendance	100-150-200	3	
3.3	Nuclear Plants			
	Gas circulation bays, reactor area, boiler platform, reactor charges and discharge face	100-150-200	2	
4	METAL MANUFACTURE			
4.1	Iron Making			
4.1.1	Sinter plant:			

Plant floor	150-200-300	3	
mixer drum, fan house, screen houses, coolers transfer stations	100-150-200	3	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
4.1.2	Furnaces, cupola:			
	General	100-150-200	3	
	Control platforms	200-300-500	2	Local Lighting may be appropriate
	Conveyor galleries, walkways	30-50-100	3	
4.2	Steel Making			
4.2.1	Electric melting shops	150-200-300	3	
4.2.2	Basic oxygen steel making plants			
4.2.2.1	General	100-150-200	3	
4.2.2.2	Convertor floor, teeming bay	150-200-300	3	
4.2.2.3	Control platforms	200-300-500	2	Local Lighting may be appropriate
4.2.2.4	Scrap bays	100-150-200	3	
4.3	Metal Forming and Treatment			
4.3.1	Ingot stripping, soaking pits, annealing and heat treatment bays ,acid recovery plant Picking and cleaning bays, roughing mills, cold mills, finishing mills, tinning and galvanizing lines, cut up and rewind lines	150-200-300	3	
4.3.2	General	100-150-200	3	
4.3.3	Control platforms	200-300-500	2	Local Lighting may be appropriate
4.3.4	Wire mills, product finishing, steel inspection and treatment	200-300-500	3	
4.3.5	Plate/strip inspection	300-500-700	2	
4.3.6	Inspection of tin plate, stainless steel, etc;	-	-	Special lighting to reveal faults in the specular surface of the material will be required
4.4	Foundries			
4.4.1	Automatic Plant			
4.4.1.1	Without manual operation	30-50-100	3	
4.4.1.2	With occasional manual operation	100-150-200	3	
4.4.1.3	With continuous manual operation	150-200-300	3	
4.4.1.4	Control room	200-300-500	1	Localized lighting of the control display and the control desks may be appropriate

4.4.1.5	Control platforms	200-300-500	2
4.4.2	Non-automatic plants		

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
4.4.2.1	Charging floor, pouring, shaking out, cleaning, grinding fettling	200-300-500	3	
4.4.2.2	Rough moulding, rough core making	200-300-500	3	
4.4.2.3	Fine moulding, fine core making	300-500-750	2	
4.4.2.4	Inspection	300-500-750	2	
4.5	Forges (Severe vibration is likely to occur)			
4.5.1	General	200-300-500	2	
4.5.2	Inspection	300-500-750	2	
5	CERAMICS			
5.1	Concrete products			
	Mixing, casting, cleaning	150-200-300	3	
5.2	Potteries			
5.2.1	Grinding, moulding, pressing, cleaning, trimming, glazing, firing	200-300-500	3	
5.2.2	Enamelling, colouring	500-750-1000	1	
5.3	Glass Works			
5.3.1	Furnace rooms, bending ,annealing	100-150-200	3	
5.3.2	Mixing rooms, forming, cutting, grinding polishing, toughening	200-300-500	3	
5.3.3	Beveling, decorative cutting, etching, silvering	300-500-750	2	
5.3.4	Inspection	300-500-750	2	
6	CHEMICALS			
6.1	Petroleum, Chemical and Petrochemical Works			
6.1.1	Exterior walkways, platforms, stairs and ladders	30-50-100	3	
6.1.2	Exterior pump and valve areas	50-100-150	3	
6.1.3	Pump and compressor houses	100-150-200	3	
6.1.4	Process plant with remote control	30-50-100	3	
6.1.5	Process plant requiring occasional manual intervention	50-100-150	3	
6.1.6	Permanently occupied work stations in process plant	150-200-300	3	
6.1.7	Control rooms for process plant	200-300-500	1	
6.2	Pharmaceutia l Manufacturer and Fine Chemicals Manufacturer			

6.2.1	Pharmaceutical manufacturer Grinding, granulating, mixing, drying, tableting, sterilizing, washing, preparation of solutions, filling, capping, wrapping, hardening	300-500-750	2	
ble 1- Continued				
(1)	(2)	(3)	(4)	(5)
6.2.2	Fine chemical manufacture			
6.2.2.1	Exterior walkways, platforms, stairs and ladders	30-50-100	3	
6.2.2.2	Process plant	50-100-150	3	
6.2.2.3	Fine chemical finishing	300-500-750	2	
6.2.2.4	Inspection	300-500-750	1	Local lighting may be appropriate
6.3	Soap Manufacture			
6.3.1	General area	200-300-500	2	
6.3.2	Automatic processes	100-200-300	2	
6.3.3	Control panels	200-300-500	1	Local lighting may be appropriate
6.3.4	Machines	200-300-500	2	
6.4	Paint Works			
6.4.1	General	200-300-500	2	
6.4.2	Automatic processes	150-200-300	2	
6.4.3	Control panels	200-300-500	2	
6.4.4	Special batch mixing	500-750-1000	2	
6.4.5	Colour matching	750-1000-1500	1	
7	MECHANICAL ENGINEERING			
7.1	Structural Steel Fabrication			
7.1.1	General	200-300-500	3	
7.1.2	Marking off	300-500-750	3	Local lighting may be appropriate
7.2	Sheet Metal Works			
7.2.1	Pressing, punching, shearing, stamping, spinning, folding	300-500-750	2	
7.2.2	Bench work, scribing, inspection	500-750-1000	2	
7.3	Machine and Tool Shops			
7.3.1	Rough bench and machine work	200-300-500	3	
7.3.2	Medium bench and machine work	300-500-750	2	
7.3.3	Fine bench and machine work	500-750-1000	2	
7.3.4	Gauge rooms	750-1000-1500	1	Optical aids may be required
7.4	Die Sinking Shops			
7.4.1	General	300-500-750	2	
7.4.2	Fine work	1000-1500-2000	1	Flexible local lighting is desirable
7.5	Welding and Soldering Shops			

7.5.1	Gas and arc welding, rough spot welding	200-300-500	3	Local lighting is desirable
7.5.2	Medium soldering, brazing, spot welding	300-500-750	3	
7.5.3	Fine soldering, fine spot welding	750-1000-1500	2	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
7.6	Assembly Shops			
7.6.1	Rough work for example, frame and heavy machine assembly	200-300-500	3	The lighting of vertical surface may be important
7.6.2	Medium work, for example, engine assembly, vehicle body assembly	300-500-750	2	
7.6.3	Fine work, for example, office machinery assembly	500-750-1000	1	Localized lighting may be useful
7.6.4	Very fine work, for example, instrument assembly	750-1000-1500	1	Local lighting and optical aids are desirable
7.6.5	Minute work, for example, watch making	1000-1500-2000	1	Local lighting and optical aids are desirable
7.7	Inspection and Testing Shops			
7.7.1	Coarse work, for example, using go/no-go gauges, inspection of large sub-assemblies	300-500-750	2	Local or localized lighting may be appropriate
7.7.2	Medium work, for example, inspection of painted surfaces	500-750-1000	1	Local or localized lighting may be appropriate
7.7.3	Fine work, for example, using calibrated scales, inspection of precision mechanisms	750-1000-1500	1	Local or localized lighting may be appropriate
7.7.4	Very fine work, for example, inspection of small intricate parts	1000-1500-2000	1	Local lighting and optical aids are desirable
7.7.5	Minute work, for example, inspection of very small instruments	2000	1	Local lighting and optical aids are desirable
7.8	Paints Shops and Spray Booths			
7.8.1	Dipping, rough spraying	200-300-500	3	
7.8.2	Preparation, ordinary painting, spraying and finishing	200-500-750	2	
7.8.3	Fine painting, spraying and finishing	500-750-1000	2	
7.8.4	Inspection, re-touching and matching	750-1000-1500	2	
7.9	Plating Shops			
7.9.1	Vats and baths	200-300-500	3	Special light to reveal fault in the surface of the material will be required
7.9.2	Buffing, polishing burnishing	300-500-750	2	
7.9.3	Final buffing and polishing	500-750-1000	2	
7.9.4	Inspection	-	-	

8 ELECTRICAL AND ELECTRONIC ENGINEERING

8.1 Electrical Equipment Manufacture

8.1.1	Manufacture of cables and insulated wires, winding, varnishing and immersion of coils, assembly of large machines, simple assembly work	200-300-500	3	
8.1.2	Medium assembly, for example, telephones, small motors	300-500-750	3	Local lighting may be appropriate

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
8.1.3	Assembly of precision components, for example, telecommunication equipment, adjustment, inspection and calibration	750-1000-1500	1	Local lighting is desirable. Optical aids may be useful
8.1.4	Assembly of high precision parts	1000-1500-2000	1	Local lighting is desirable. Optical aids may be useful
8.2	Electronic Equipment Manufacture			
8.2.1	Printed circuit board			
8.2.1.1	Silk screening	300-500-750	1	Local lighting may be appropriate
8.2.1.2	Hand insertion of components, soldering	500-750-1000	1	Local lighting may be appropriate
8.2.1.3	Inspection	750-1000-1500	1	A large, low luminance luminaire overhead ensures specular reflection conditions which are helpful for inspection of printed circuits
8.2.1.4	Assembly of wiring harness, cleating harness, testing and calibration	500-750-1000	1	Local lighting may be appropriate
8.2.1.5	Chassis assembly	750-1000-1500	1	Local lighting may be appropriate
8.2.2	Inspection and testing			
8.2.2.1	Soak test	150-200-300	2	
8.2.2.2	Safety and functional tests	200-300-500	2	
9	FOOD, DRINK AND TOBACCO			
9.1	Slaughter Houses			
9.1.1	General	200-300-500	3	
9.1.2	Inspection	300-500-750	2	
9.2	Canning, Preserving and Freezing			
9.2.1	Grading and sorting of raw materials	500-750-1000	2	Lamp of colour rendering group 1A or 1B will be required, if colour judgement is required
9.2.2	Preparation	300-500-750	3	
9.2.3	Canned and bottled goods			
9.2.3.1	Retorts	200-300-500	3	
9.2.3.2	Automatic processes	150-200-300	3	
9.2.3.3	Labelling and packaging	200-300-500	3	

9.2.4	Frozen foods		
9.2.4.1	Process area	200-300-500	3
9.2.4.2	Packaging and storage	200-300-500	3
9.3	Bottling, Brewing and Distilling		

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
9.3.1	Keg washing and handling, bottle washing	150-200-300	3	
9.3.2	Keg inspection	200-300-500	3	
9.3.3	Bottle inspection	-	-	Special lighting will be
9.3.4	Process areas	200-300-500	3	
9.3.5	Bottle filling	500-750-1000	3	
9.4	Edible Oils and Fats Processing			
9.4.1	Refining and blending	200-300-500	3	
9.4.2	Production	300-500-750	2	
9.5	Mills-Milling, Filtering and Packing	200-300-500	3	
9.6	Bakeries			
9.6.1	General	200-300-500	2	
9.6.2	Hand decorating, icing	300-500-750	2	
9.7	Chocolate and Confectionery Manufacture			
9.7.1	General	200-300-500	3	
9.7.2	Automatic processes	150-200-300	3	
9.7.3	Hand decoration, inspection, wrapping and packing	300-500-750	2	If accurate colour judgements are required, lamps of colour rendering group 1A or 1B are used
9.8	Tobacco Processing	300-500-750	2	
9.8.1	Material preparation, making and packing	500-750-1000	2	
9.8.2	Hand processes			
10	TEXTILES			
10.1	Fibre Preparation			
10.1.1	Bale breaking, washing	200-300-500	3	
10.1.2	Stock dyeing, tinting	200-300-500	3	
10.2	Yarn Manufacture			
10.2.1	Spinning, roving, winding, etc	300-500-750	2	
10.2.2	Healding (drawing in)	750-1000-750	2	
10.3	Fabric Production			
10.3.1	Knitting	300-500-750	2	
10.3.2.	Weaving			

10.3.2.1	Jute and hemp	200-300-500	2
10.3.2.2	Heavy woolens	300-500-750	1
10.3.2.3	Medium worsteds, fine woolens, cottons	500-750-1000	1

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
10.3.2.4	Fine worsteds, fine linens, synthetics	750-1000-1500	1	
10.3.2.5	Mending	1000-1500-2000	1	
10.3.2.6	Inspection	1000-1500-2000	1	
10.4	Fabric Finishing			
10.4.1	Dyeing	200-300-500	3	
10.4.2	Calendaring, chemical treatment, etc	300-500-750	2	
10.4.3	Inspection			
10.4.3.1	'Grey' cloth	750-1000-1500	1	
10.4.3.2	Final	1000-1500-2000	1	
10.5	Carpet Manufacture			
10.5.1	Winding, beaming	200-300-500	3	
10.5.2	Setting pattern, turving cropping, trimming, fringing, latexing and latex drying	300-500-750	2	
10.5.3	Designing, weaving, mending	500-750-1000	2	
10.5.4	Inspection			
10.5.4.1	General	750-1000-1500	1	Local lighting may be appropriate
10.5.4.2	Peace dyeing	500-750-1000	1	Local lighting may be appropriate
11	LEATHER INDUSTRY			
11.1	Leather Manufacture			
11.1.1	Cleaning, tanning and stretching, vats, cutting, fleshing, stuffing	200-300-500	3	
11.1.2	Finishing, scarfing	300-500-750	2	
11.2	Leather Working			
11.2.1	General	200-300-500	3	
11.2.2	Pressing, glazing	300-500-750	2	
11.2.3	Cutting, splitting, scarfing, sewing	500-750-1000	2	Directional lighting may be useful.
11.2.4	Grading, matching		2	Local lighting may be appropriate
12	CLOTHING AND FOOTWEAR			
12.1	Clothing Manufacture			
12.1.1	Preparation of cloth	200-300-500	2	
12.1.2	Cutting	500-750-1000	1	
12.1.3	Matching	500-750-1000	1	
12.1.4	Sewing	750-1000-1500	1	

12.1.5	Pressing	300-500-750	2				
12.1.6	Inspection	1000-1500-2000	1	Local lighting may be appropriate			
Table 1- Continued							
(1)	(2)	(3)	(4)	(5)			
12.1.7	Hand tailoring	1000-1500-2000	1	Local lighting may be appropriate			
12.2	Hosiery and Knitwear Manufacture						
12.2.1	Flat bed knitting machines	300-500-750	2				
12.2.2	Circular knitting machines	500-750-1000	2				
12.2.3	Lockstitch and over locking machine	750-1000-1500	1				
12.2.4	Linking or running on	750-1000-1500	1				
12.2.5	Mending, hand finishing	1000-1500-3000	-	Local lighting may be appropriate			
12.2.6	Inspection	1000-1500-2000	2	Local lighting may be appropriate			
12.3	Glove Manufacture						
12.3.1	Sorting and grading	500-750-1000	1				
12.3.2	Pressing, knitting, cutting	300-500-750	2				
12.3.3	Sewing	500-750-1000	2				
12.3.4	Inspection	1000-1500-2000	-	Local lighting may be appropriate			
12.4	Hat Manufacture						
12.4.1	Stiffening, braiding, refining, forming, sizing, pounding ,ironing	200-300-500	2	12.4.1			
12.4.2	Cleaning, flanging, finishing	300-500-750	2				
12.4.3	Sewing	500-750-1000	2				
12.4.4	Inspection	1000-1500-2000	-	Local lighting may be appropriate			
12.5	Boot and Shoe Manufacture						
12.5.1	Leather and synthetics						
12.5.2	Sorting and grading	750-1000-1500	1				
12.5.3	Clicking, closing	750-1000-1500	2	Local or localized lighting may be appropriate			
12.5.4	Preparatory operations	750-1000-1500	2	Local or localized lighting may be appropriate			
12.5.5	Cutting tables and pressure	1000-1500-2000	1	Local or localized lighting may be appropriate			
12.5.6	Bottom stock preparation, lasting, bottoming finishing, shoe rooms	750-1000-1500	1	Local or localized lighting may be appropriate			
12.5.7	Rubber						
12.5.7.1	Washing, compounding, coating, drying, varnishing, vulcanizing, calendaring, cutting	200-300-500	3				
12.5.7.2	Lining, making and finishing	300-500-750	2				

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
13	TIMBER AND FURNITURE			
13.1	Sawmills			
13.1.1	General	150-200-300	3	
13.1.2	Head saw	300-500-750	2	Localized lighting may be appropriate
13.1.3	Grading	500-750-1000	2	Directional lighting may be useful
13.2	Woodwork Shops			
13.2.1	Rough sawing, bench work	200-300-500	2	
13.2.2	Sizing, planing, sanding, medium machining and bench work	300-500-750	2	
13.2.3	Fine bench and machine work, fine sanding, finishing	500-750-1000	2	Localized lighting may be appropriate
13.3	Furniture Manufacture			
13.3.1	Raw material stores	50-100-150	3	
13.3.2	Finished goods stores	100-150-200	3	
13.3.3	Wood matching and assembly, rough sawing, cutting	200-300-500	2	
13.3.4	Machining, sanding and assembly, polishing	300-500-750	2	Localized lighting may be appropriate
13.3.5	Tool room	300-500-750	2	
13.3.6	Spray booths			
13.3.6.1	Colour finishing	300-500-750	2	
13.3.6.2	Clear finishing	200-300-500	2	
13.3.7	Cabinet making			
13.3.7.1	Veneer sorting and grading	750-1000-1500	1	
13.3.7.2	Marquetry, pressing, patching and fitting	300-500-750	1	
13.3.7.3	Final inspection	500-750-1000	1	Special lighting will be required
13.4	Upholstery Manufacture			
13.4.1	Cloth inspection	1000-1500-2000	1	Special lighting will be required
13.4.2	Filling, covering	300-500-750	2	
13.4.3	Slipping, cutting, sewing	500-750-1000	2	
13.4.4	Mattress making			
13.4.5	Assembly	300-500-750	2	
13.4.6	Tape edging	750-1000-1500	2	Local lighting may be appropriate
14	PAPER AND PRINTING			
14.1	Paper Mills			

14.1.1	Pulp mills, preparation plants	200-300-500	3	
Table 1- Continued				
(1)	(2)	(3)	(4)	(5)
14.1.2	Paper and board making			
14.1.2.1	General	200-300-500	3	
14.1.2.2	Automatic process	150-200-300	3	Supplementary lighting may be necessary for maintenance work
14.1.2.3	Inspection, sorting	300-500-750	1	
14.1.3	Paper converting processes			
14.1.3.1	General	200-300-500	3	
14.1.3.2	Associated printing	300-500-750	2	
14.2	Printing Works -			
14.2.1	Type foundries			
14.2.1.1	Matrix making, dressing type, hand and machine coating	200-300-500	3	
14.2.1.2	Front assembly, sorting	500-750-1000	2	
14.2.2	Composing rooms	-		
14.2.2.1	Hand composing, imposition and distribution	500-750-1000	1	
14.2.2.2	Hot metal keyboard	500-750-1000	1	
14.2.2.3	Hot metal casting	200-300-500	2	
14.2.2.4	Photo composing keyboard or setters	300-500-750	1	
14.2.2.5	Paste up	500-750-1000	1	
14.2.2.6	Illuminated tables-general lighting	200-300-500	-	Dimming may be required
14.2.2.7	Proof presses	300-500-750	2	
14.2.2.8	Proof reading	500-750-1000	1	
14.2.3	Graphic reproduction			
14.2.3.1	General	300-500-750	2	
14.2.3.2	Precision proofing, retouching, etching	750-1000-1500	1	Local lighting may be appropriate
14.2.3.3	Colour reproduction and inspection	750-1000-1500	1	
14.2.4	Printing machine room			
14.2.4.1	Presses	300-500-750	2	
14.2.4.2	Premake ready	300-500-750	2	
14.2.4.3	Printed sheet inspection	750-1000-1500	1	
14.2.5	Binding			
14.2.5.1	Folding, pasting, punching and stitching	300-500-750	2	
14.2.5.2	Cutting, assembling, embossing	500-750-1000	2	
15	PLASTIC AND RUBBER			
15.1	Plastic Products			
15.1.1	Automatic plant			
15.1.1.1	Without manual control	30-50-100	3	
15.1.1.2	With occasional manual control	50-100-150	3	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
15.1.1.3	With continuous manual control	200-300-500	3	
15.1.1.4	Control rooms	200-300-500	1	
15.1.1.5	Control platforms	200-300-500	2	
15.1.2	Non-automatic plant			
15.1.2.1	Mixing, calendaring, extrusion, injection, compression and blow moulding, sheet fabrication	200-300-500	3	
15.1.2.2	Trimming, cutting, polishing, cementing	300-500-750	2	
15.1.2.3	Printing, inspection	750-1000-1500	1	
15.2	Rubber Products			
15.2.1	Stock preparation — plasticizing, milling	150-200-300	3	
15.2.2	Calendaring, fabric preparation, stock-cutting	300-500-750	3	
15.2.3	Extruding, moulding	300-500-750	2	
15.2.4	Inspection	750-1000-1500	-	
16	DISTRIBUTION AND STORAGE			
16.1	Work Stores	100-150-200	3	Avoid glare to drivers of vehicles approaching the loading bay
16.1.1	Unpacking, sorting	150-200-300	3	bay Avoid glare to drivers of vehicles approaching the loading bay
16.1.2	Large item storage	50-100-150	3	Avoid glare to drivers of vehicles approaching the loading bay
16.1.3	Small item rack storage	200-300-500	3	Avoid glare to drivers of vehicles approaching the loading bay
16.1.4	Issue counter, records, storeman's desk	300-500-750	2	Local or localized lighting may be appropriate
16.2	Warehouses and Bulk Stores			
16.2.1	Storage of goods where identification requires only limited preparation of detail	50-100-150	3	
16.2.2	Storage of goods where identification requires perception of details	100-150-200	3	
16.2.3	Automatic high bay rack stores			
16.2.3.1	Gangway	20	-	
16.2.3.2	Control station	150-200-300	3	
16.2.3.3	Packing and dispatch	200-300-500	3	
16.2.3.4	Loading bays	100-150-200	3	Avoid glare to drivers of vehicles approaching the loading bay
16.3	Cold Stores			
16.3.1	General	200-300-500	3	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
16.3.2	Breakdown, make-up and dispatch	200-300-500	3	
16.3.3	Loading bays	100-150-200	3	Avoid glare to drivers of vehicles approaching the loading bay
17	COMMERCE			
17.1	Offices			
17.1.1	General offices	300-500-750	1	
17.1.2	Deep plan general offices	500-750-1000	1	
17.1.3	Computer work stations	300-500-750	1	
17.1.4	Conference rooms, executive offices	300-500-750	1	
17.1.5	Computer and data preparation rooms	300-500-750	1	
17.1.6	Filing rooms	200-300-500	1	
17.2	Drawing Offices			
17.2.1	General	300-500-750	1	
17.2.2	Drawing boards	500-750-1000	1	
17.2.3	Computer aided design and drafting	-	-	Special lighting is required
17.2.4	Print rooms	200-300-500	1	
17.3	Banks and Building Societies			
17.3.1	Counter, office area	300-500-750	1	
17.3.2	Public area	200-300-500	1	
18	SERVICES			
18.1	Garages			
18.1.1	Interior parking areas	20-30-50	3	
18.1.2	General repairs, servicing, washing, polishing	200-300-500	2	
18.1.3	Workbench	300-500-750	1	Local or localized lighting may be appropriate
18.1.4	Spray booths	300-500-750	1	
18.1.5	External apron			
18.1.5.1	General	30-50-100	-	Care should be taken to avoid glare to drivers and Neighbouring residents
18.1.5.2	Pump area (retail sales)	200-300-500	-	See ‘ Retailing
18.2	Appliance servicing			
18.2.1	Workshop			
18.2.1.1	General	200-300-500	2	
18.2.1.2	Workbench	300-500-750	2	Localized lighting may be appropriate
18.2.1.3	Counter	200-300-500	2	Localized lighting may be Appropriate
18.2.1.4	Stores	200-300-500	3	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
18.3	Laundries			
18.3.1	Commercial laundries			
18.3.2	Receiving, sorting, washing, drying, ironing, despatch, dry-cleaning, bulk machine work	200-300-500	3	
18.3.3	Head ironing, pressing, mending, spotting, inspection	300-500-750	3	
18.3.4	Laundrettes	200-300-500	3	
18.4	Sewage Treatment Works			
18.4.1	Walkways	30-50-100	3	
18.4.2	Process areas	50-100-150	3	
19	RETAILING			
19.1	Small Shops with Counters	300-500-750	1	The service illuminance should be provided on the horizontal plane of the counter. Where wall displays are used, a similar illuminance on the walls is desirable
19.2	Small Self-Service Shops with Island Displays	300-500-750	1	
19.3	Super Markets, Hyper-Markets			
19.3.1	General	300-500-750	2	
19.3.2	Checkout	300-500-750	2	
19.3.3	Showroom for large objects, for example, cars, furniture	300-500-750	1	
19.3.4	Shopping precincts and arcades	100-150-200	2	
20	PLACES OF PUBLIC ASSEMBLY			
20.1	Public Rooms, Village Halls, Worship Halls	200-300-500	1	
20.2	Concert Halls, Cinemas and Theatres			
20.2.1	Foyer	150-200-300	-	
20.2.2	Booking office	200-300-500	-	Local or localized lighting may be appropriate
20.2.3	Auditorium	50-100-150	-	Dimming facilities will be necessary. Special lighting of the aisles is desirable
20.2.4	Dressing rooms	200-300-500	-	Special mirror lighting for make-up may be required
20.2.5	Projection room	100-150-200	-	
20.3	Churches			
20.3.1	Body of church	100-150-200	2	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
20.3.2	Pulpit, lectern	200-300-500	2	Use local lighting
20.3.3	Choir stalls	200-300-500	2	Local lighting may be appropriate
20.3.4	Alter, communion table, chancel	100-150-200	2	Additional lighting to provide emphasis is desirable
20.3.5	Vestries	100-150-200	2	
20.3.6	Organ	200-300-500	-	
20.4	Hospitals			
20.4.1	Anaesthetic rooms			
20.4.1.1	General	200-300-500	-	
20.4.1.2	Local	750-1000-1500	-	
20.4.2	Consulting areas			
20.4.2.1	General	200-300-500	-	
20.4.2.2	Examination	750-1000-1500	-	
20.4.3	Corridors			
20.4.3.1	General	100-150-200	-	
20.4.4	Ward corridors		-	
20.4.4.1	Day, screened from bays	150-200-300	-	
20.4.4.2	Day, open to natural light	150-200-300 (total)		
20.4.4.3	Morning/Evening	100-150-200	-	
20.4.4.4	Night	5-10	-	
20.4.5	Cubicles			
20.4.5.1	General	200-300-500	-	
20.4.5.2	Treatment	750-1000-1500	-	
20.4.6	Examination			
20.4.6.1	General	200-300-500	-	
20.4.6.2	Local inspection	750-1000-1500	-	
20.4.7	Intensive therapy			
20.4.7.1	Bed head	30-50	-	
20.4.7.2	Circulation between bed ends	50-100-150	-	
20.4.7.3	Observation	200-300-500	-	
20.4.7.4	Local observation	750-1000-1500	-	
20.4.7.5	Staff base (day)	200-300-500	-	
20.4.7.6	Staff base (night)	30	-	
20.4.8	Laboratories			
20.4.8.1	General	200-300-500	-	
20.4.8.2	Examination	300-500-750	-	
20.4.9	Nurses' stations			
20.4.9.1	Morning/day/evening	200-300-500	-	
20.4.9.2	Night desks	30	-	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
20.4.9.3	Night, medical trolleys	50-100-150	-	
20.4.10	Operating theatres			
20.4.10.1	General	300-500-750	-	
20.4.10.2	Local	10000 to 50000	-	Special operating lights are used
20.4.11	Pathology departments			
20.4.11.1	General	200-300-500	-	
20.4.11.2	Examination	300-500-750	-	
20.4.11.3	Pharmacies	200-300-500	-	
20.4.11.4	Reception/enquiry	200-300-500	-	
20.4.11.5	Recovery rooms	200-300-500	-	
20.4.12	Ward-circulation			
20.4.12.1	Day	50-100-150	-	
20.4.12.2	Morning/Evening	50-100-150	-	
20.4.12.3	Night	3-5	-	
20.4.13	Ward-bed head			
20.4.13.1	Morning/Evening	30-50		
20.4.13.2	Reading	100-150-200		
20.4.14	Night			
20.4.14.1	Adult	0.1-1		
20.4.14.2	Pediatric	1		
20.4.14.3	Psychiatric	1-5		
20.4.14.4	Watch	5		
20.4.15	X-Ray areas			
20.4.15.1	General	150-200-300		
20.4.15.2	Diagnostic	150-200-300		
20.4.15.3	Operative	200-300-500		
20.4.15.4	Process dark room	50		
20.4.16	Surgeries			
20.4.16.1	General	200-300-500	-	
20.4.16.2	Waiting rooms	100-150-200	-	
20.4.17	Dental surgeries			
20.4.17.1	Chair	Special lighting	-	
20.4.17.2	Laboratories	300-500-750	-	
20.4.18	Consulting rooms			
20.4.18.1	General	200-300-500	-	
20.4.18.2	Desk	300-500-750	-	
20.4.18.3	Examination couch	300-500-750	-	
20.4.18.4	Ophthalmic wall and near-vision charts	300-500-750	-	
20.5	Hotels			
20.5.1	Entrance halls	50-100-150		

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
20.5.2	Reception, cashier's and porters' desks	200-300-500		Localized lighting may be appropriate
20.5.3	Bars, coffee base, dining rooms, grill rooms, restaurants, lounges	50-200		The lighting should be designed to create an appropriate atmosphere
20.5.4	Cloak rooms, baggage rooms	50-100-150	3	
20.5.5	Bed rooms	30-50-100	-	Supplementary local lighting at the bed head, writing table should be provided
20.5.6	Bathroom	50-100-150		Supplementary local lighting near the mirror is desirable
20.5.7	Food preparation and stores, cellars, lifts and corridors	-	-	
20.6	Libraries			
20.6.1	Lending library			
20.6.1.1	General	200-300-500	1	
20.6.1.2	Counters	300-500-750	1	Localized lighting may be appropriate
20.6.1.3	Bookshelves	100-150-200	2	The service illuminance should be provided on the vertical face at the bottom of the bookshelves.
20.6.1.4	Reading rooms	200-300-500	1	
20.6.1.5	Reading tables	200-300-500	1	Localized lighting may be appropriate
20.6.2	Catalogues			
20.6.2.1	Card	100-150-200	2	
20.6.2.2	Microfiche/Visual display units	100-150-200	2	
20.6.3	Reference libraries			
20.6.3.1	General	200-300-500	1	
20.6.3.2	Counters	300-500-750	1	Localized lighting may be appropriate
20.6.3.3	Bookshelves	100-150-200	2	The service illuminance should be provided on the vertical face at the bottom of the bookshelves.
20.6.3.4	Study tables, carrels	300-500-750	1	
20.6.3.5	Map room	200-300-500	1	
20.6.4	Display and exhibition areas			
20.6.4.1	Exhibits insensitive to light	200-300-500	-	
20.6.4.2	Exhibit sensitive to light, for example, pictures, prints, rare books in archives	50 to 150	-	
20.6.5	Library workrooms			
20.6.5.1	Book repair and binding	300-500-750	2	
20.6.5.2	Catalogue and sorting	300-500-720	2	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
20.6.5.3	Remote book stores	100-150-200	3	
20.7	Museums and Art Galleries			
20.7.1	Exhibits insensitive to light	200-300-500	-	
20.7.2	Light sensitive exhibits, for example, oil and temper paints, undyed leather, bone, ivory, wood, etc	150	-	This is a maximum illuminance to be provided on the principal plane of the exhibit
20.7.3	Extremely light sensitive exhibits, for example, textiles, water colours, prints and drawings, skins, botanical specimens, etc	50	-	This is the maximum illuminance to be provided on the principal plane of the object
20.7.4	Conservation studies and workshops	300-500-750	1	
20.8	Sports Facilities			
	Multi-purpose sports halls	300-750	-	This lighting system should be sufficiently flexible to provide lighting suitable for the variety of sports and activities that take place in sports halls. Higher illuminance of 1000-2000 lux would be required for television coverage
21	EDUCATION			
21.1	Assembly Halls			
21.1.1	General	200-300-500	3	
21.1.2	Platform and stage	-	-	Special lighting to provide emphasis and to facilitate the use of the platform/ stage is desirable
21.2	Teaching Spaces			
	General	200-300-500	1	
21.3	Lecture Theatres			
21.3.1	General	200-300-500	1	
21.3.2	Demonstration benches	300-500-750	1	Localized lighting may be appropriate
21.4	Seminar Rooms	300-500-750	1	
21.5	Art Rooms	300-500-750	1	
21.6	Needlework Rooms	300-500-750	1	
21.7	Laboratories	300-500-750	1	
21.8	Libraries	200-300-500	1	
21.9	Music Rooms	200-300-500	1	
21.10	Sports Halls	200-300-500	1	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
21.11	Workshops	200-300-500	1	
22	TRANSPORT			
22.1	Airports			
22.1.1	Ticket counters, checking desks, and information desks	300-500-750	2	Localized lighting may be appropriate
22.1.2	Departure lounges, other waiting areas	150-200-300	2	
22.1.3	Baggage reclaim	150-200-300	2	
22.1.4	Baggage handling	50-100-150	2	
22.1.5	Customs and immigration halls	300-500-750	2	
22.1.6	Concourse	150-200-300	2	
22.2	Railway Stations			
22.2.1	Ticket office	300-500-750	2	Localized lighting may be appropriate
22.2.2	Information office	300-500-750	2	Localized lighting over the counter may be appropriate
22.2.3	Parcels office, left			
22.2.4	Luggage office			
22.2.4.1	General	50-100-150	2	
22.2.4.2	Counter	150-200-300	2	
22.2.5	Waiting rooms	150-200-300	2	
22.2.6	Concourse	150-200-300	2	
22.2.7	Time table	150-200-300	2	Localized lighting may be appropriate
22.2.8	Ticket barriers	150-200-300	2	Localized lighting may be appropriate
22.2.9	Platforms (covered)	30-50-100	2	Care should be taken to light and mark the edge of the platform clearly
22.2.10	Platforms (open)	20	-	Care should be taken to light and mark the edge of the platform clearly
22.3	Coach Stations			
22.3.1	Ticket offices	300-500-750	2	Localized lighting over the counter may be appropriate
22.3.2	Information offices	300-500-750	2	Localized lighting over the counter may be appropriate
22.3.3	Left luggage office			
22.3.3.1	General	50-100-150	3	
22.3.3.2	Counter	150-200-300	3	Localized lighting is appropriate
22.3.4	Waiting rooms	150-200-300	2	
22.3.5	Concourse	150-200-300	2	

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
22.3.6	Time tables	150-200-300	2	Localized lighting is appropriate
22.3.7	Loading areas	100-150-200	3	
23	GENERAL BUILDING AREAS			
23.1	Entrance			
23.1.1	Entrance halls, lobbies, waiting rooms	150-200-300	2	
23.1.2	Enquiry desks	300-500-750	2	Localized lighting may be appropriate
23.1.3	Gatehouses	150-200-300	2	
23.2	Circulation Areas			
23.2.1	Lifts	50-100-150	-	
23.2.2	Corridors, passageways, stairs	50-100-150	2	
23.2.3	Escalators, travellers	100-150-200	-	
23.3	Medical and First Aid Centre			
23.3.1	Consulting rooms, treatment rooms	300-500-750	1	
23.3.2	Rest rooms	100-150-200	1	
23.3.3	Medical stores	100-150-200	2	
23.4	Staff Rooms			
23.4.1	Changing, locker and cleaners rooms, cloakrooms, lavatories	50-100-150	-	
23.4.2	Rest room	100-150-200	1	
23.5	Staff Restaurants			
23.5.1	Canteens, cafeterias, dining rooms, mess rooms	150-200-300	2	
23.5.2	Servery, vegetable preparation, washing-up area	200-300-500	2	
23.5.3	Food preparation and cooking	300-500-750	2	
23.5.4	Food stores, cellars	100-150-200	2	
23.6	Communications			
23.6.1	Switchboard rooms	200-300-500	2	
23.6.2	Telephone apparatus rooms	100-150-200	2	
23.6.3	Telex room, post room	300-500-750	2	
23.6.4	Reprographic room	200-300-500	2	
23.7	Building Services			
23.7.1	Boiler houses			
23.7.1.1	General	50-100-150	3	
23.7.1.2	Boiler front	100-150-200	3	
23.7.1.3	Boiler control room	200-300-500	2	Localized lighting of the control display and the control desk may be appropriate

Table 1- Continued

(1)	(2)	(3)	(4)	(5)
23.7.1.4	Control rooms	200-300-500	2	Localized lighting of the control display and the control desk may be appropriate
23.7.1.5	Mechanical plant room	100-150-200	2	
23.7.1.6	Electrical power supply and distribution rooms	100-150-200	2	
23.7.1.7	Store rooms	50-100-150	3	
23.8	Car Parks			
23.8.1	Covered car parks			
23.8.1.1	Floors	5-20	-	
23.8.1.2	Ramps and corners	30	-	
23.8.1.3	Entrances and exits	50-100-150	-	
23.8.1.4	Control booths	150-200-300		
23.8.1.5	Outdoor car parks	5-20		

For the same reason, it is desirable that the illumination level of rooms which open off a working area should be fairly high even though the rooms may be used only occasionally.

It is important, when lighting stairways, to prevent disability from glare caused by direct sight of bright sources to emphasize the edges of the treads and to avoid confusing shadows. The same precautions should be taken in the lighting of cat-walks and stairways on outdoor industrial plants.

5A.3.1.5.2 Entrances

The problems of correctly grading the lighting within a building to allow adequate time for adaptation when passing from one area to another area are particularly acute at building entrances. These are given below:

a) By day, people entering a building will be adapted to the very high levels of brightness usually present outdoors and there is risk of accident if entrance areas, particularly any steps, are poorly lighted. This problem may often be overcome by arranging windows to give adequate natural lighting at the immediate entrance, grading to lower levels further inside the entrance area. Where this cannot be done, supplementary artificial lighting should be installed to raise the level of illumination to an appropriate value.

b) At night it is desirable to light entrance halls and lobbies so that the illumination level reduces towards the exit and so that no bright fittings are in the line of sight of people leaving the building. Any entrance steps to the building should be well-lighted by correctly screened fittings.

5A.3.1.6 For detailed information regarding principles of good lighting, reference may be made to Standard Practice [(1) IS 3646].

5A.3.2 Artificial Lighting

5A.3.2.1 Artificial lighting may have to be provided

- a) where the recommended illumination levels have to be obtained by artificial lighting only,
- b) to supplement daylighting when the level of illumination falls below the recommended value, and
- c) where visual task may demand a higher level of illumination.

5A.3.2.2 *Artificial Lighting Design for Interiors*

For general lighting purposes, the recommended practice is to design for a level of illumination on the working plane on the basis of the recommended levels for visual tasks given in Table 1 by a method called 'Lumen method'. In order to make the necessary detailed calculations concerning the type and quantity of lighting equipment necessary, advance information on the surface reflectances of walls, ceilings and floors is required. Similarly, calculations concerning the brightness ratio in the interior call for details of the interior decor and furnishing. Stepwise guidance regarding designing the interior lighting systems for a building using the 'Lumen method' is given in 5A.3.2.2.1 to 5A.3.2.2.4.

5A.3.2.2.1 *Determination of the illumination level*

Recommended value of illumination shall be taken from Table 1, depending upon the type of work to be carried out in the location in question and the visual tasks involved.

5A.3.2.2.2 *Selection of the light sources and luminous*

The selection of light sources and luminaires depends on the choice of lighting system, namely, general lighting, directional lighting and localized or local lighting.

5A.3.2.2.3 *Determination of the luminous flux*

- a) The luminous flux (Φ) reaching the working plane depends upon the following:

- 1) lumen output of the lamps,
- 2) type of luminaire,
- 3) proportion of the room (room index) (k_r),
- 4) reflectance of internal surfaces of the room,
- 5) depreciation in the lumen output of the lamps after burning their rated life, and
- 6) depreciation due to dirt collection on luminous and room surface.

- b) *Coefficient of Utilization or Utilization Factor*

1) The compilation of tables for the utilization factor requires a considerable amount of calculations, especially if these tables have to cover a wide range of lighting practices. For every luminaire, the exact light distribution has to be measured in the laboratory and their efficiencies have to be calculated and measured exactly. These measurements comprise:

- (i) the luminous flux radiated by the luminaires directly to the measuring surface,
- (ii) the luminous flux reflected and re- reflected by the ceiling and the walls to the measuring surface, and
- (iii) the inter-reflections between the ceiling and wall which result in the measuring surface receiving additional luminous flux.

All these measurements have to be made for different reflection factors of the ceiling and the walls for all necessary room indices. These tables have also to indicate the maintenance factor to be taken for the luminous flux depreciation throughout the life of an installation due to ageing of the lamp and owing to the deposition of dirt on the lamps and luminaires and room surfaces.

2) The values of the reflection factor of the ceiling and of the wall are as follows:

White and very light colours	0.7
Light colours	0.5
Middle tints	0.3
Dark colours	0.1

For the walls, taking into account the influence of the windows without curtains, shelves, almirahs and doors with different colours, etc, should be estimated,

c) Calculation for determining the luminous flux

$$E_{av} = \frac{\mu \phi}{A}$$

or, $\phi = \frac{E_{av} A}{\mu}$ for new condition

and $\phi = \frac{E_{av} A}{\mu d}$ for working condition

where

- ϕ = Total luminous flux of the light sources installed in the room in lumens;
- E_{av} = Average illumination level required on the working plane in lux;
- A = Area of the working plane in m²;
- μ = the utilization factor in new conditions; and
- d = maintenance factor.

In practice, it is easier to calculate straightaway the number of lamps or luminaires from:

$$N_{\text{lamp}} = \frac{E_{av} A}{\mu d \phi_{\text{lamp}}}$$

$$N_{\text{luminaires}} = \frac{E_{av} A}{\mu d \phi_{\text{luminaires}}}$$

where

- ϕ_{lamp} = Luminous flux of each lamp in lumens,
- $\phi_{\text{luminaires}}$ = Luminous flux of each luminaire in lumens,
- N_{lamp} = Total number of lamps, and
- $N_{\text{luminaires}}$ = Total number of luminaires

5A.3.2.2.4 Arrangement of the luminaires

This is done to achieve better uniformly distributed illumination. The location of the luminaires has an important effect on the utilization factor.

- a) In general, luminaires are spaced 'a' metre apart in either direction, while the distance of the end luminaire from the wall is ' $\frac{1}{2}a$ ' metre. The distance 'a' is more or less equal to the mounting height ' H_m ' between the luminaire and the working plane. The utilization factor tables are calculated for this arrangement of luminaires.
- b) For small rooms where the room index (k_r) is less than 1, the distance 'a' should always be less than H_m since otherwise luminaires cannot be properly located. In most cases of such rooms, four or two luminaires are placed for good general lighting. If, however, in such rooms only one luminaire is installed in the middle, higher utilization factors are obtained, but the uniformity of distribution is poor. For such cases, references should be made to the additional tables for $k_r = 0.6$ to 1.25 for luminaires located centrally.

5A.3.2.3 Artificial Lighting to Supplement Day lighting

5A.3.2.3.1 The need for general supplementary artificial lighting arises due to diminution of daylighting beyond design hours, that is, for solar altitude below 15° or when dark cloudy conditions occur.

5A.3.2.3.2 The need may also arise for providing artificial lighting during the day in the inner most parts of the building which cannot be adequately provided with daylighting, or when the outside windows are not of adequate size or when there are unavoidable external obstructions to the incoming day lighting.

5A.3.2.3.3 The need for supplementary lighting during the day arises, particularly when the daylighting on the working plane falls below 100 lux and the surrounding luminance drops below 19 cd/m^2 .

5A.3.2.3.4 The requirement of supplementary artificial lighting increases with the decrease in day lighting availability. Therefore, conditions near sunset or sunrise or equivalent conditions due to clouds or obstructions, etc, represent the worst conditions when the supplementary lighting is most needed.

5A.3.2.3.5 The requirement of supplementary artificial lighting when day lighting

availability becomes poor may be determined from Fig. 2 for an assumed ceiling height of 3.0 m, depending upon floor area, fenestration percentage and room surface reflectance.

Cool daylight fluorescent tubes are recommended with semi-direct luminaires. To ensure a good distribution of illumination, the mounting height should be between 1.5 m and 2.0 m above the work plane for a separation of 2.0 m to 3.0 m between the luminaires. Also the number of lamps should preferably be more in the rear half of the room than in the vicinity of windows. The following steps may be followed for using Fig. 2 for determining the number of fluorescent tubes required for supplementary day lighting.

- a) Determine fenestration percentage of the floor area, that is,

$$\frac{\text{Window Area}}{\text{Floor Area}} \times 100$$

- b) In Figure 2, refer to the curve corresponding to the percent fenestration determined above and the set of reflectances of ceiling, walls and floor actually provided.

- c) For the referred curve of Figure 2 read, along the ordinate, the number of 40 W fluorescent tubes required, corresponding to the given floor area on the abscissa.

5A.3.2.4 For detailed information on the design aspects and principles of artificial lighting, reference may be made to standard practice [(1) IS 3646].

5A.3.2.5 For specific requirements for lighting of special occupancies and areas, reference may be made to Standard practice [(2) IS 1944].

5A.3.2.6 Electrical installation aspect for artificial lighting shall be in accordance with Part 5B 'Building Services, Electrical and Allied Installations'.

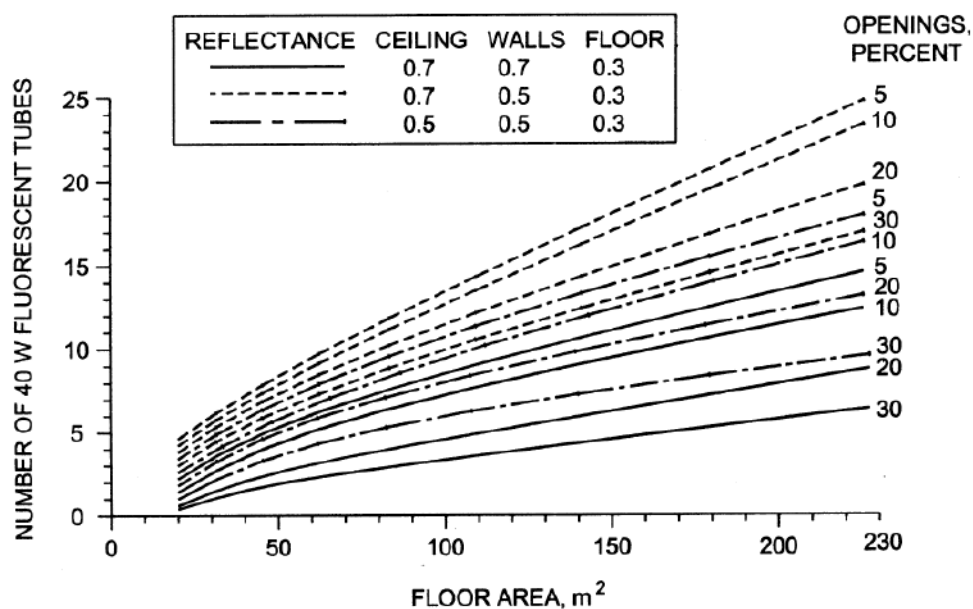


Figure 2: Supplementary Artificial Lighting for 40W Fluorescent Tubes

A.3.3 Energy Conservation in Lighting

5A.3.3.1 A substantial portion of the energy consumed on lighting may be saved by utilization of daylight and rational design of supplementary artificial lights.

5A.3.3.2 Daytime use of artificial lights may be minimized by proper design of windows for adequate daylight indoors.

5A.3.3.3 Fenestration expressed as percentage of floor area required for satisfactory visual performance of a few tasks for different separation to height (S/H) ratio of external obstructions such as opposite buildings may be obtained from the design nomograph (Figure 3). The obstructions at a distance of three times their height or more ($S/H > 3$) from a window facade are not significant and a window facing such an obstruction may be regarded as a case of unobstructed window.

5A.3.3.3.1 The nomograph consists of horizontal lines indicating fenestration percentage of floor area and vertical lines indicating the separation to height ratio of external obstructions such as opposite buildings. Any vertical line for separation to height ratio other than already shown in the nomograph (1.0, 2.0 and 3.0) may be drawn by designer, if required. For cases where there is no obstruction, the ordinate corresponding to the value 3.0 may be used. The value of percentage fenestration and separation to height ratio are marked on left hand ordinate and abscissa respectively. The illumination levels are marked on the right hand ordinate. The values given within brackets are the illumination levels on the work plane at centre and rear of the room. The wattage of fluorescent tubes required per square metre of the floor area for different illumination levels is shown on each curve.

5A.3.3.3.2 Following assumptions have been made in the construction of the nomograph:

An average interior finish with ceiling white, walls off white and floor grey has been assumed.

Ceiling height of 3 m and room depths up to 10 m and floor area between 30 m² and 50 m² have been assumed. For floor area beyond 50 m² and less than 30 m², the values of percent fenestration as well as wattage per m² should be multiplied by a factor of 0.85 and 1.15 respectively.

It is assumed that windows are of metallic sashes with louvers of width up to 600 mm or a *CHHAJJA* (balcony projection) at ceiling level of width up to 2.0 m. For wooden sashes, the window area should be increased by a factor of about 1.1.

Luminaires emanating more light in the downward direction than upward direction (such as reflectors with or without diffusing plastics) and mounted at a height of 1.5 m to 2.0 m above the work plane have been considered.

5A.3.3.3.3 *Method of use*

The following steps shall be followed for the use of nomograph:

Step 1 — Decide the desired illumination level depending upon the task illumination requirement in the proposed room and read the value of watts per square metre on the curve corresponding to the required illumination level.

Step 2 — Fix the vertical line corresponding to the given separation to height ratio of opposite buildings on the abscissa. From the point of intersection of this vertical line and the above curve move along horizontal, and read the value of fenestration percent on the left hand ordinate.

Step 3 — If the floor area is greater than 50 m² and less than 30 m², the value of watts per square metre as well as fenestration percent may be easily determined for adequate day lighting and supplemental artificial lighting for design purposes. However, if the fenestration provided is less than the required value, the wattage of supplementary artificial lights should be increased proportionately to make up for the deficiency of natural illumination.

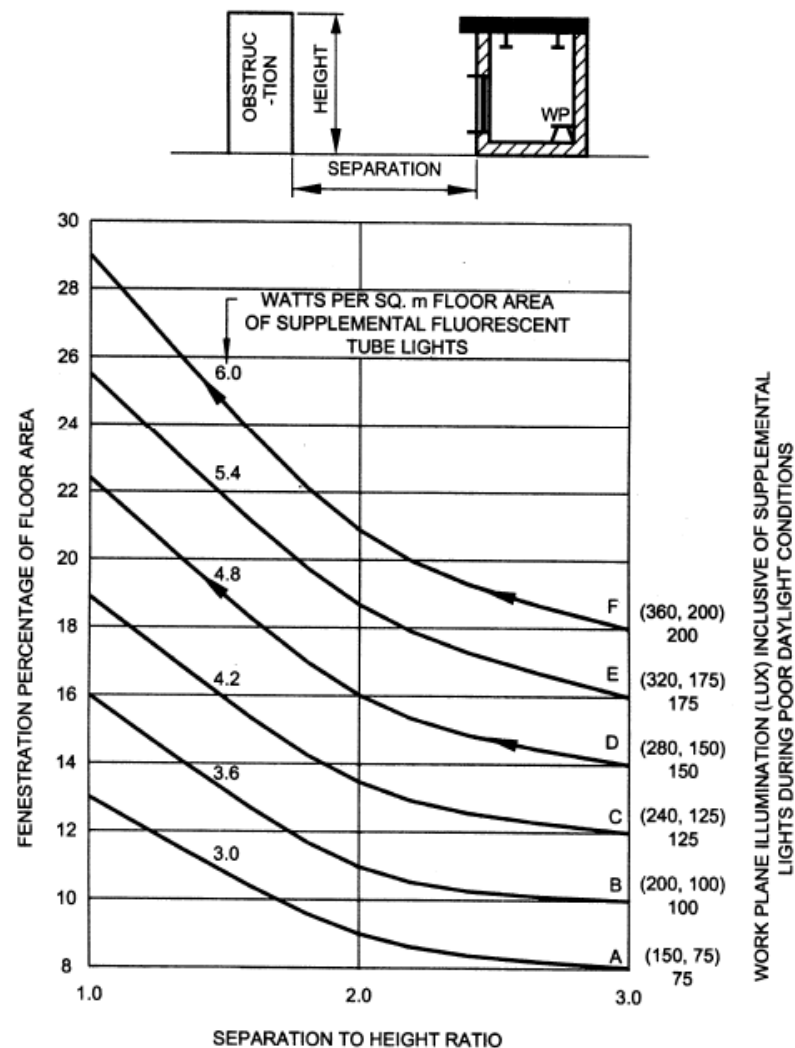


Figure 3: Nomograph for Daylighting and Supplemental Lighting Design of Building

5A.3.3.4 For good distribution of day light on the working plane in a room, window height, window width and height of sill should be chosen in accordance with the following recommendations:

- In office buildings windows of height 1.2 m or more in the center of a bay with sill level at 1.0 to 1.2 m above floor and in residential buildings windows of height 1.0 m to 1.1 m with sill height as 0.9 m to 0.7 m above floor are recommended for good distribution of daylight indoors. Window width can accordingly be adjusted depending upon the required fenestration percentage of the floor area.
- If the room depth is more than 10 m, windows should be provided on opposite sides for bilateral lighting.

c) It is desirable to have a white finish for ceiling and off white (light colour) to white for walls. There is about 7 percent improvement in lighting levels in changing the finish of walls from moderate to white.

5A.3.3.5 For good distribution and integration of daylight with artificial lights the following guidelines are recommended:

- a) Employ cool daylight fluorescent tubes for supplementary artificial lighting.
- b) Distribute luminaires with a separation of 2 m to 3 m in each bay of 3 m to 4 m width.
- c) Provide more supplementary lights such as twin tube luminaires in work areas where daylight is expected to be poor for example in the rear region of a room having single window and in the central region of a room having windows on opposite walls. In the vicinity of windows only single tube luminaires should be provided.

5A.3.3.6 *Artificial Lighting*

Energy conservation in lighting is affected by reducing wastage and using energy effective lamps and luminaires without sacrificing lighting quality. Measures to be followed comprise utilization of daylight, energy effective artificial lighting design by providing required illumination where needed, turning off artificial lights when not needed, maintaining lighter finishes of ceiling, walls and furnishings, and implementing periodic schedule for cleaning of luminaires and group replacement of lamps at suitable intervals. Choice of light sources with higher luminous efficacy and luminaires with appropriate light distribution is the most effective means of energy saving in lighting. However, choice of light sources also depends on the other lighting quality parameters like colour rendering index and colour temperature or appearance. For example, high pressure sodium vapour lamps, which have very high luminous efficacy, are not suitable for commercial interiors because of poor colour rendering index and colour appearance, but are highly desirable in heavy industries. Also the choice of light sources depends on the mounting height in the interiors. For example, fluorescent lamps are not preferred for mounting beyond 7 m height, when high pressure gas discharge lamps are preferred because of better optical control due to their compact size.

5A.3.3.6.1 *Efficient artificial light sources and luminaires*

Luminous efficacy of some of the lamps used in lighting of buildings are given in Table 2 along with average life in burning hours, Colour Rendering Index and Colour Temperature.

Following recommendations may be followed in the choice of light sources for different locations:

- a) For supplementary artificial lighting of work area in office building care should be taken to use fluorescent lamps, which match with colour temperature of the daylight.
- b) For residential buildings fluorescent lamps and/or CFLs of proper CRI and CCT are recommended to match with the colours and interior design of the room.
- c) For commercial interiors, depending on the mounting heights and interior design, fluorescent lamps, CFLs and low wattage metal halide lamps are recommended. For high lighting the displays in show windows, hotels, etc, low wattage tubular or dichroic reflector type halogen lamps can be used.
- d) For industrial lighting, depending on the mounting height and colour consideration fluorescent lamps, high pressure mercury vapour lamps or high pressure sodium vapour lamps are recommended.

5A.3.3.6.2 For the same lumen output, it is possible to save 75 to 80 percent energy if GLS lamps are replaced with CFL and 65 to 70 percent if replaced with fluorescent lamps. Similar energy effective solutions are to be chosen for every application area.

Similarly with white fluorescent tubes recommended for corridors and staircases, the electrical consumption reduces to 1/4.5 of the energy consumption with incandescent lamps.

Table 2: Luminous Efficacy, Life, CRI and CCT of Light Sources

(Clause 5A.3.4.6.1)

SI No.	Light Source	Efficacy lm/W	Average Life h	CRI	CCT
(1)	(2)	(3)	(4)	(5)	(6)
i)	Incandescent Lamps GLS 25 W-1 000W	8-18	1 000	100	2 800
ii)	Tungsten halogen incandescent lamps Mains-voltage types: Low-voltage types with reflector have lower wattages	10% higher than comparable GLS lamp	2 000	100	2 800-3 200
iii)	Fluorescent Lamps (FTL) Standard Lamps 38 mm (T12) 20W-65 W 26mm (T8) 18W-58W Cool daylight Warm white Tri-Phosper lamps 38mm (T12) 20W-65W 26mm (T8) 18W-58W	61 67 88-104	5 000 5 000 12 000- 18 000	72 77 85-95	6 500 3 500 2 700-6 500
iv)	Compact Fluorescent Lamps (CFL) 5W-25W	40-80	8 000	Similar to FTL	
v)	High pressure mercury vapour lamps 80W-400W	36-60	5 000	45	4 000
vi)	Blended __ Light Lamps MLL 100W-500W	11-26	5 000	61	3 600
vii)	High Pressure Sodium Vapour Lamps 50W-1 000W	69-130	10 000- 15 000	23	2 000
viii))	Metal halide lamps 35W-2 000W	69-83	10 000	68-92	3 000-5 600

NOTES

- 1 The table includes lamps and wattages currently in use in buildings .
- 2 Luminous efficacy varies with the wattage of the lamp.
- 3 Average life values given are only indicative.
- 4 CRI and CCT values are only indicative.
- 5 For exact values, it is advisable to contact manufacturers.

5A.3.3.6.3 Efficient luminaire also plays an important role for energy conservation in lighting. The choice of a luminaire should be such that it is efficient not only initially but also throughout its life. Following luminaries are recommended for different locations:

- a) For offices semi-direct type of luminaries are recommended so that both the work plane illumination and surround luminance can be effectively enhanced.
- b) For corridors and staircases direct type of luminaries with wide spread of light distributions are recommended.
- c) In residential buildings, bare fluorescent tubes are recommended. Wherever the incandescent lamps are employed, they should be provided white enamelled conical reflectors at an inclination of about 45° from vertical.
- d) High efficacy lamps are to be used in the lighting fixture wherever as possible or a minimum of 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps as according to IEC 2012.

LIST OF STANDARDS

The following list records those standards which are acceptable as 'standard practice' and 'accepted standards' in the fulfillment of the requirements of the Code. The latest version of a standard shall be adopted at the time of enforcement of the Code. The standards listed may be used by the Authority as a guide in conformance with the requirements of the referred clauses in the Code.

IS No.	Title
(1) IS 3646	Code of practice for interior illumination: Part 1 General requirements and (Part 1): 1992 recommendations for building interiors (<i>first revision</i>)
(2) 1944	Code of practice for lighting of public thoroughfares: Parts 1 and 2 For main and secondary roads (Group A and B)(<i>first revision</i>)
2672 : 1966	Code of practice for library lighting
4347 : 1967	Code of practice for hospital lighting
6665 : 1972	Code of practice for industrial lighting
10894 : 1984	Code of practice for lighting educational institutions
10947 : 1984	Code of practice for lighting for ports and harbours
SP 32 : 1986	Handbook on functional requirements of industrial buildings (lighting and ventilation)
SP 41 : 1987	Handbook on functional requirements of buildings other than industrial buildings

References may be made to the following publications for the common personal protective equipment and tools used.

- [01] International Building Code 2009 (SECTION 1205 - LIGHTING)
- [02] International Energy Conservation Code 2009
- [03] ASHRAE hand book-Fundamentals 2009 (SECTION 15 - FENESTRATION)
- [04] International Energy Conservation Code 2012

Reference

- [01] International building Code 2009: ... SECTION 1205 – Lighting
- [02] International Energy Conservation Code 2009
- [03] ASHRAE hand book – Fundamentals 2009 SECTION 15-FENESTRATION
- [04] International Energy Conservation code 2012 first print (online)

<http://publicecodes.citation.com/icod/iecc/2012/icodiecc2012re4sec004.htm>

Provisions given in India National Lighting Code (under Preparation) may also be referred.

**MYANMAR
NATIONAL
BUILDING
CODE
2016**

**PART5B
BUILDING SERVICES
(ELECTRICAL AND ALLIED INSTALLATIONS)**

MYANMAR NATIONAL BUILDING CODE

PART 5B BUILDING SERVICES

Electrical and Allied Installations

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MYANMAR NATIONAL BUILDING CODE

PART 5B BUILDING SERVICES

Electrical and Allied Installations

5B.1 SCOPE

This Section covers the essential requirements for electrical installations in buildings to ensure efficient use of electricity including safety from fire and shock. This Section also includes general requirements relating to lightning protection of buildings and lighting.

5B.2.0 TERMINOLOGY AND SYMBOLS

5B.2.1 For the purpose of this Section, the following definitions shall apply.

5B.2.1.1 *Accessory*—A device, other than current using equipment, associated with such equipment or with the wiring on an installation.

5B.2.1.2 *Apparatus* —Electrical apparatus including all machines, appliances and fittings in which conductors are used or of which they form a part.

5B.2.1.3 *Appliance*—An item of current using equipment other than a luminaire or an independent motor.

5B.2.1.4 *Bunched* —Cables are said to be 'bunched' when two or more are contained within a single conduit, duct, ducting, or trunking or, if not enclosed, are not separated from each other.

5B.2.1.5 *Cable* —A length of single-insulated conductor (solid or stranded), or two or more such conductors, each provided with its own insulation, which are laid up together. The insulated conductor or conductors may or may not be provided with an overall mechanical protective covering.

5B.2.1.6 *Cable, Armoured*—A cable provided with a wrapping of metal (usually in the form of tape or wire) serving as a mechanical protection.

5B.2.1.7 *Cable, Flexible* —A cable containing one or more cores, each formed of a group of wires, the diameters of the cores and of the wires being sufficiently small to afford flexibility.

5B.2.1.8 *Cable, Metal-Sheathed* - An insulated cable with a metal sheath.

5B.2.1.9 *Cable, PVC Sheathed-Insulated* —A cable in which the insulation of the conductor is a polyvinylchloride (PVC) compound; with PVC sheath also providing mechanical protection to the conductor core or cores in the cable.

5B.2.1.10 *Cable, Weatherproof* —A cable so constructed that when installed in uncovered locations, it will withstand all kinds of weather variations (see **5B.2.1.80**, for definition of Weatherproofing).

5B.2.1.11 *Cable, XLPE* —A cable in which the insulation of the conductor is cross-linked polythene and the mechanical protection is provided for the core or cores by a sheath of a polyvinylchloride compound.

5B.2.1.12 *Ceiling Rose* —A fitting (usually used to attach to the ceiling) designed for the connection between the electrical installation wiring and a flexible cord (which is in turn connected to a lamp holder).

5B.2.1.13 Circuit —An assembly of electrical equipment supplied from the same origin and protected against overcurrent by the same protective device(s). Certain types of circuit are categorized as follows:

- a) *Category 1 Circuit* — A circuit (other than a fire alarm or emergency lighting circuit) operating at low voltage and supplied directly from a mains supply system.
- b) *Category 2 Circuit* — With the exception of fire alarm and emergency lighting circuits, any circuit for telecommunication (for example, radio, telephone, sound distribution, intruder alarm, bell and call and data transmission circuits) which is supplied from a safety source.
- c) *Category 3 Circuit* — A fire alarm circuit or an emergency lighting circuit.

5B.2.1.14 Circuit Breaker —A mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions and also of making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions such as those of short circuit.

NOTE — A circuit breaker is usually intended to operate infrequently, although some types are suitable for frequent operation.

5B.2.1.15 Circuit, Final Sub —An outgoing circuit connected to one-way distribution board and intended to supply electrical energy at one or more points to current, using appliances without the intervention of a further distribution board other than a one-way board. It includes all branches and extensions derived from that particular way in the board.

5B.2.1.16 Cleat —An insulated incombustible support normally used for insulated cable.

5B.2.1.17 Conductor, Aerial —Any conductor which is supported by insulators above the ground and is directly exposed to the weather.

NOTE — Four classes of aerial conductors are recognized:

- a) Bare aerial conductors,
- b) Covered aerial conductors,
- c) Insulated aerial conductors, and
- d) Weatherproof neutral-screened cable.

5B.2.1.18 Conductor, Bare —A conductor not covered with insulating material.

5B.2.1.19 Conductor, Earthed —A conductor with no provision for its insulation from earth.

5B.2.1.20 Conductor, Insulated —A conductor adequately covered with insulating material of such quality and thickness as to prevent danger.

5B.2.1.21 Conductor of a Cable or Core —The conducting portion consisting of a single wire or group of wires, assembled together and in contact with each other or connected in parallel.

5B.2.1.22 Connector —The part of a cable coupler or of an appliance coupler which is provided with female contact and is intended to be attached to the flexible cable connected to the supply.

5B.2.1.23 Connector Box or Joint Box —A box forming a part of wiring installation, provided to contain joints in the conductors of cables of the installations.

5B.2.1.24 Connector for Portable Appliances —A combination of a plug and socket arranged for attachment to a portable electrical appliance or to a flexible cord.

5B.2.1.25 Consumer's Terminals —The ends of the electrical conductors situated upon any consumer's premises and belonging to him at which the supply of energy is delivered from the service line.

5B.2.1.26 Cord, Flexible —A flexible cable having conductor of small cross-sectional area. Two flexible cords twisted together are known as twin 'flexible cord'.

5B.2.1.27 Core of a Cable — A single conductor of a cable with its insulation but not including any mechanical protective covering.

5B.2.1.28 Cut-out —Any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a predetermined amount.

5B.2.1.29 Damp Situation — A situation in which moisture is either permanently present or intermittently present to such an extent as to be likely to impair the effectiveness of an installation conforming to the requirements for ordinary situations.

5B.2.1.30 Dead —A portion of the circuit (normally expected to carry a voltage) at or near about earth potential or apparently disconnected from any live system.

5B.2.1.31 Direct Earthing System —A system of earthing in which the parts of an installation are so earthed as specified but are not connected within the installation to the neutral conductor of the supply system or to earth through the trip coil of an earth leakage circuit-breaker.

5B.2.1.32 Distance Area or Resistance Area (for Earth Electrode only) — The area of ground (around an earth electrode) within which a voltage gradient measurable with ordinary commercial instruments exists when the electrode is being tested.

5B.2.1.33 Discrimination (Over-Current Discrimination) —Co-ordination of the operating characteristics of two or more over-current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the others do not.

NOTES

- 1) Protective devices should have discrimination so that only the affected part (minimum section) of the circuit is isolated, even though a number of protective devices may be in the path of the over current.
- 2) Distinction is made between series discrimination involving different over-current protective devices passing substantially the same over-current and network discrimination involving identical protective devices passing different proportions of the over-current.

5B.2.1.34 Earth —The conductive mass of the earth, whose electric potential at any point is conventionally taken as zero.

5B.2.1.35 Earth Continuity Conductor —The conductor, including any clamp, connecting to the earthing lead or to each other those parts of an installation which are required to be earthed. It may be in whole or in part the metal conduit or the metal sheath or armour of the cables, or the special continuity conductor of a cable or flexible cord incorporating such a conductor.

5B.2.1.36 Earth Electrode — A conductor or group of conductors in intimate contact with and providing an electrical connection to earth.

5B.2.1.37 Earth Fault —Accidental connections of a conductor to earth when the impedance is negligible, the connection is called a dead earth.

5B.2.1.38 Earthing Lead—The final conductor by which the connection to the earth electrode is made.

5B.2.1.39 Earth Leakage Circuit Breaker System — A system of earthing in which the parts of an installation, specified, to be earthed are so earthed through one or more earth leakage circuit-breakers or relays.

5B.2.1.40 Enclosed Distribution Board —An enclosure containing bus bars with one or more control and protected devices for the purpose of protecting, controlling or connecting more than one outgoing circuits fed from one or more incoming circuits.

5B.2.1.41 Exposed Metal —All metal parts of an installation which are easily accessible other than:

- a) parts separated from live parts by double insulation;
- b) metal name-plates, screw heads, covers, or plates, which are supported on or attached or
 - i. connected to substantial non-conducting material only in such a manner that they do not
 - ii. become alive in the event of failure of insulation of live parts and whose means of fixing
 - iii. do not come in contact with any internal metal; and
- c) parts which are separated from live parts by other metal parts which are themselves
 - i. earthed or have double insulation.

5B.2.1.42 Fire resistant cable— A cable which continues in service after exposure to a temperature of 900°C for 20 min or 700°C for 90 min.

5B.2.1.43 Fitting, Lighting —A device for supporting or containing a lamp or lamps (for example, fluorescent or incandescent) together with any holder, shade, or reflector, for example, a bracket, a pendant with ceiling rose, an electrolier, or a portable unit.

5B.2.1.44 Flameproof Enclosure —An enclosure which will withstand without injury any explosion of inflammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated with) and will prevent the transmission of flame which may ignite any inflammable gas that may be present in the surrounding atmosphere.

NOTES

- 1) Hazardous areas are classified into different zones, depending upon the extent to which an explosive atmosphere could exist at that place. In such areas flame proof switchgear, fittings, accessories, have to be used/installed in flameproof enclosure.
- 2) An electrical apparatus is not considered as flameproof unless it complies with the appropriate statutory regulations.
- 3) Other types of fittings are also in vogue in wiring installations, for example, 'increased safety'.

5B.2.1.45 Flame Retardant Cable —Flame retardant cable with reduced halogen evaluation and smoke.

5B.2.1.46 Fuse —A device that, by the fusion of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted when the current through it exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.

5B.2.1.47 Fuse-Element —A part of the fuse-link designed to melt under the action of current exceeding some definite value for a definite period of time.

5B.2.1.48 Harmonics (Current and Voltage) — All alternating current which is not absolutely sinusoidal is made up of a fundamental and a certain number of current harmonics which are the cause of its deformation (distortion) when compared to the theoretical sine-wave.

5B.2.1.49 *Inflammable* —A material capable of being easily ignited.

5B.2.1.50 *Installation (Electrical), of Buildings* — An assembly of associated electrical equipment to fulfill a specific purpose or purposes and having coordinated characteristics.

5B.2.1.51 *Insulated*—Insulated shall mean separated from adjacent conducting material or protected from personal contact by a non-conducting substance or an air space, in either case offering permanently sufficient resistance to the passage of current or to disruptive discharges through or over the surface of the substance or space, to obviate danger or shock or injurious leakage of current.

5B.2.1.52 *Insulation, Basic* —Insulation applied to live parts to provide basic protection against electric shock.

NOTE— Basic insulation does not necessarily include insulation used exclusively for functional purposes.

5B.2.1.53 *Insulation, Double* —Insulation comprising both basic and supplementary insulation.

5B.2.1.54 *Insulation (Electrical)* —Suitable non-conducting material, enclosing, surrounding or supporting a conductor.

5B.2.1.55 *Insulation, Reinforced* —Single insulation applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard.

NOTE — The term 'single insulation' does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

5B.2.1.56 *Insulation, Supplementary* —Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.

5B.2.1.57 *Linked Switch* —Switches linked together mechanically so as to operate simultaneously or in definite sequence.

5B.2.1.58 *Live or Alive* —Electrically charged so as to have a potential different from that of earth.

5B.2.1.59 *Locations, Industrial* — Locations where tools and machinery requiring electrical wiring are installed for manufacture or repair.

5B.2.1.60 *Locations, Non-Industrial* —Locations other than industrial locations, and shall include residences, offices, shops, showrooms, stores and similar premises requiring electrical wiring for lighting, or similar purposes.

5B.2.1.61 *Miniature Circuit Breaker* —Mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions and also making carrying currents for specified times and automatically breaking currents under specified abnormal circuit conditions such as those of overload and short circuits.

5B.2.1.62 *Multiple Earthed Neutral System* —A system of earthing in which the parts of an installation specified to be earthed are connected to the general mass of earth and, in addition, are connected within the installation to the neutral conductor of the supply system.

5B.2.1.63 *Neutral Conductor* —Includes the neutral conductor of a three-phase four-wire system, the conductor of a single-phase or dc installation which is earthed by the supply undertaking (or otherwise at the source of the supply), and the middle wire or common return conductor of a three-wire dc or single-phase ac system.

5B.2.1.64 Plug— A device, provided with contact pins, which is intended to be attached to a Flexible cable, and which can be engaged with a socket outlet or with a connector.

5B.2.1.65 Point (in Wiring) —A termination of the fixed wiring intended for the connection of current using equipment.

5B.2.1.66 Residual Current Circuit Breaker —A mechanical switching device design to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual currents attains a giving value under specified conditions.

5B.2.1.67 Service—The conductors and equipment required for delivering energy from the electric supply system to the wiring system of the premises served.

5B.2.1.68 Socket-Outlet —Accessory having socket contacts designed to engage with the pins of a plug and having terminals for the connection of cable(s).

NOTE — A luminaire track system is not regarded as a socket- outlet system.

5B.2.1.69 Switch —A mechanical switching device capable of making, carrying and breaking current under normal circuit conditions, which may include specified operating overload conditions, and also of carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit.

NOTE —A switch may also be capable of making, but not breaking, short-circuit currents.

5B.2.1.70 Switchboard —An assembly of switchgear with or without instruments, but the term does not apply to a group of local switches in a final circuit.

NOTE — The term 'switchboard' includes a distribution board.

5B.2.1.71 Switch Disconnectors—A device used to open (or close) a circuit when either negligible current is interrupted (or established) or when the significant change in the voltage across the terminals of each of the pole of the disconnectors occurs; in the open position it provides an isolating distance between the terminals of each pole.

5B.2.1.72 Switch Disconnector Fuse —A composite unit, comprising a switch with the fuse contained in or mounted on the moving member of the switch.

5B.2.1.73 Switchgear —A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation, transmission, distribution and conversion of electric energy.

5B.2.1.74 Usable Wall Space—All portions of a wall, except that occupied by a door in its normal open position, or occupied by a fire place opening, but excluding wall spaces which are less than 1 min extent measured along the wall at the floor line.

5B.2.1.75 Voltage, Extra Low (ELV) —The voltage which does not normally exceed 50 Va.c.

5B.2.1.76 Voltage, Low (LV) —The voltage which normally exceed 50 Va.c but not normally exceed 1000 Va.c.

5B.2.1.77 Voltage, Medium (MV) —The voltage which normally exceeds 1000 Va.cbut not exceed 33 kVa.c.

5B.2.1.78 Voltage, High (HT, HV)—The voltage which normally exceeds 33kVa.c but not exceed 230 kVa.c.

5B.2.1.79 Weatherproof —Accessories, lighting fittings, current-using appliances and cables are said to be of the weatherproof type, if they are so constructed that when installed in open situation they will withstand the effects of rain, snow, dust and temperature variations. For definition of other terms reference may be made to accepted standards [(1) IS 8270].

5B.2.2 Symbols

The architectural symbols that are to be used in all drawings, wiring plans, etc, for electrical installations in buildings shall be as given in **Annex A**. For other graphical symbols used in electro-technology, reference may be made to Standard practice [(1) IS 8270].

5B.3 GENERAL REQUIREMENTS

5B.3.1 The installation shall generally be carried out in conformity with the requirements of the Myanmar Electricity Rules and Regulations.

5B.3.2 Materials

All materials, fittings, appliances, etc, used in electrical and allied installations, shall conform to Building Materials' and other related Standards.

5B.3.3 Coordination with Local Supply Authority

- a) In all cases, that is, whether the proposed electrical work is a new installation or extension of an existing one, or a modification involving major changes, the electricity supply undertaking shall be consulted about the feasibility, etc, at an early date.
- b) Addition to an Installation — An addition, temporary or permanent, shall not be made to the authorized load of an existing installation, until it has been definitely ascertained that the current carrying capacity and the condition of existing accessories, conductors, switches, etc, affected, including those of the supply authority are adequate for the increased load. The size of the cable/ conductor shall be suitably selected on the basis of the ratings of the protective devices. Ratings of protective devices and their types shall be based on the installed load, switching characteristics and power factor
 - c) Load assessment and application of suitable diversity factor to estimate the full load current shall be made as a first step. This should be done for every circuit, submain and feeder. Power factor and efficiency of loads shall also be considered. Diversity factor assumed shall be based on one's own experience. Allowance should be made for about 15 percent to 20 percent for extension in near future and the design circuit is calculated for each circuit and submain. The wiring system to be adopted should also be decided in accordance with the environmental requirements. The sizes of wiring cables are decided not merely to carry the load currents, but also to withstand thermal effects of likely over currents and also ensure acceptance level of voltage drop.

5B.3.4 Power Factor Improvement in Consumers' Installation

5B.3.4.1 Conditions of supply of electricity boards or licensees stipulate the lower-limit of power factor which is generally 0.85.

5B.3.4.2 Principal causes of low power factor are many. For guidance to the consumers of electric energy who take supply at low and medium voltages for improvement of power factor, reference shall be made in accordance with Standard practice [(2) IS 7752].

5B.3.5 Execution of Work

Unless otherwise exempted under the appropriate rule of the Myanmar Electricity Rules, the work of electrical installations shall be carried out by a licensed electrical contractor and under the direct supervision of a person holding a certificate of competency and by persons holding a valid permit issued and recognized by any State Government.

5B.3.6 Safety procedures and practices shall be kept in view during execution of the work in accordance with Standard practice [(4) IS 10118].

5B.3.7 Safety provisions given in Part 4 'Fire and Life Safety' shall be followed.

5B.4 PLANNING OF ELECTRICAL INSTALLATIONS

5B.4.1 General

The design and planning of an electrical wiring installation involve consideration of all prevailing conditions, and is usually influenced by the type and requirement of the consumer. A competent electrical design engineer should be involved at the planning stage with a view to providing for an installation that will prove adequate for its intended purpose, and safe and efficient in its use. The information given in **5B.3** shall also be kept in view.

5B.4.1.1 The design and planning of an electrical wiring installation shall take into consideration, some or all of the following:

- a) the type of supply, occupancy, envisaged load and the earthing arrangement available;
- b) the atmospheric condition, such as cooling air temperature, moisture or such other conditions which are likely to affect the installation adversely;
- c) the possible presence of inflammable or explosive dust, vapour or gas;
- d) the degree of electrical and mechanical protection necessary;
- e) the importance of continuity of service including the possible need for standby supply;
- f) the probability of need for modification or future extension;
- g) the probable operation and maintenance cost taking into account the electricity supply tariffs available;
- h) the relative cost of various alternative methods;
- i) the need for radio and telecommunication interference suppression;
- j) ease of maintenance;
- k) safety aspects;
- l) energy conservation
- m) the importance of proper discrimination between protective devices for continuity of supply and limited isolation of only the affected portion; and
- n) reliable and sustainable electricity supply

5B.4.1.2 All electrical apparatus shall be suitable for the services these are intended for.

5B.4.1.3 Co-ordination

Proper co-ordination and collaboration between the architect, civil engineer and the electrical and mechanical engineer shall be effected from the planning stage of the installation. The provisions

that will be needed for the accommodation of substation, transformer, switch rooms, service cable ducts, rising mains and distribution cables, sub-distribution boards, openings and chases in floors and walls for all required electrical installations, etc, shall be specified in advance.

5B.4.1.4 Before starting wiring and installation of fittings and accessories, information should be exchanged between the owner of the building/architect/electrical contractor and the local supply authority in respect of tariffs applicable, types of apparatus that may be connected under each tariff, requirement of space for installing meters, switches, etc, and for total load requirements of lights, fans and power.

5B.4.1.5 While planning an installation, consideration should be taken of the anticipated increase in the use of electricity for lighting, general purpose socket-outlet, kitchen heating, etc. It is essential that adequate provision should be made for all the services which may be required immediately and during the intended useful life of the building, for the householder may otherwise be tempted to carry out extension of the installation himself or to rely upon use of multi-plug adapters and long flexible cords, both of which are not recommended.

5B.4.2 Location and Requirement of Substation

Information on location and requirements of a substation should cover the following:

5B.4.2.1 Location

- a) The substation should preferably be located in separate building and could be adjacent to the generator room, if any. Location of substation in the basement floors should be avoided, as far as possible.
- b) The ideal location for an electrical substation for a group of buildings would be at the electrical load centre on the ground floor.
- c) The floor level of the substation or switch room shall be above the highest flood level of the locality.
- d) Generally the load centre would be somewhere between the geometrical centre and the air conditioning plant room, as air conditioning plant room would normally be the largest chunk of load, if the building is air conditioned.
- e) Substations with oil filled equipment will require great consideration for the fire detection, protection and suppression. Oil cooled transformers require a suitable soak pit with gravity flow to contain the oil in the event of the possibility of oil spillage from the transformer on its failure. Substations with oil filled equipment shall not be located in any floor other than the ground floor or a semi-basement. Such substations with high oil content may be housed in a separate service building or a substation building, which is not the part of a multi-storied building.
- f) In case electric substation has to be located within the main multi-storied building itself for unavoidable reasons, then it should be located on the floor close to ground level, but shall have direct access from the street for operation of the equipments. The provision for installation and removal of substation equipments may be provided from inside the building.
- g) Substations located within a multi-storied building shall not have oil filled transformers, even if it is at the ground level (see Myanmar Fire Department Instruction). Substations with very little combustible material, such as a Dry type transformer, with Vacuum (or SF₆) HT switchgear and ACB or MCCB for MV can be located in the basement as well as upper floors in a building with high load density in the upper floors. (Some functional buildings

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such as hospitals, air traffic control towers, computer centers are likely to have high loading in a few upper floors and in such cases, it may be preferable to provide oil-free substations at upper levels. This measure will decrease the current flow at various points, thereby contributing to reduction of vulnerability to fire).

- h) The power supply control to any such substation or transformer (located at basement levels or upper floors) shall be from a location on ground floor/first basement level having direct access from outside so that in case of fire, the electrical supply can be easily disconnected.
- i) Oil filled transformers may be used only in substations located in separate single or two storied service buildings outside the main building structure and there shall at least 6 meter clear distance between the adjoining buildings and substation such that fire tender is able to pass between the two structures.
- j) If dry type transformer is used, it may be located adjacent to medium voltage switchgear in the form of unit type substation. No separate room or fire barrier for the transformer is required, in a substation with oil free equipment. In such a case the room size will decrease. Layout of equipment has to keep the requirement that any one piece of equipment or sub-assembly can be taken out of service and out of the installed location, while keeping the remaining system in service.
- k) The emergency power supply (such as Generating Sets) should not be allowed to be installed above ground floor or below first basement level of building. There shall be provision of separate direct escape and entry into these areas from outside so that in case of fire, electrical supplies can be disconnected to avoid additional losses which may be caused due to electrical supply, present at the time of fire.

Note:

In unavoidable circumstances emergency generators, power transformers, chiller units, water pumps and other heavy equipment machineries can also be installed in the intermediate floor level of a tall building, designated as mechanical service floors, provided that the building can safely withstand both static and dynamic load of the said installed equipment in the event of seismic vibration and similar ones, and that shall be certified by the authority concerned. So also in such a case acoustics and environmental disturbances together with ease of maintenance and access for the people shall be considered and it shall be within the acceptable limits. Standard fire protection system shall be provided in respective equipment rooms also.

- l) For transformers having large oil content (more than 2 000 litres) Myanmar Electricity Rules shall apply.
- m) Facility for connection from substation to adjoining building to feed essential emergency load in that building, such as escape route lighting, fire or sprinkler pumps, emergency communication systems shall be provided. Similarly, the essential emergency load switchboard of this building or building complex should be so as to be capable of receiving power for such loads from the adjoining building or building complex, with its own substation/DG sets shut off due to crisis conditions such as fire,
- n) The availability of power lines nearby may also be kept in view while deciding the location of the substation,
- o) For detailed information regarding location of transformers reference may be made to Standard practice [(3) IS 5216].
- p) All door openings from substation, electrical rooms, etc should open towards outside.

5B.4.2.2 Type of Building for Substations

The substations enclosure, that is, walls, floor, ceiling, openings, doors, etc shall have 2 hour fire rating (See Myanmar Fire Department Instructions).

5B.4.2.3 Layout of Substation

In allocating the area of substation, it is to be noted that the flow of electric power is from supply company's room to HV room, then to transformer and finally to the medium voltage switchgear room. The layout of the room shall be in accordance with this flow, so as to optimize the cables, bus-trunking etc. Visibility of equipment controlled from the operating point of the controlling switchgear is also a desirable feature, though it may not be achievable in case of large substation.

5B.4.2.4 Room /Spaces Required

Generally the following rooms /spaces are required in a substation:

- a) Supply company's switchgear room and/or space for meters.
- b) Capacity and Size — The capacity of a substation depends upon the area of the building and its type. The capacity of substation may be determined based on the following load requirements:

After calculating the electrical load on the above basis, a load factor of 70-90 percent is to be applied to arrive at the minimum capacity of substation. The area required for substation and transformer room for different capacities is given in **Annex B** for general guidance. For reliability, it would be necessary to split the load into more than one transformer and also provide for standby transformer as well as multiple sources, bus-section, etc.

- c) *High Voltage Switch Room*— In case of substation having one transformer and one source of supply, the owner is required to provide one high voltage switch. In case of single point supply with two or more transformers the number of switch required will be one for incoming supply and one for each transformer. In case of duplicate supply two switches shall be provided with mechanical/electrical interlocking arrangement where necessary in cables with switches. In case the number of incoming and outgoing switches exceed five, bus coupler of suitable capacity should invariably be provided. The floor area required in case of a single switch is roughly 4 m x 4 m and for every additional switch the length would be increased by 1 m.
- d) Facility for connection from substation of adjoining building to feed emergency loads shall be permitted for feeding escape route and signage lighting as well as selected section of the fire protection system. Similarly on a reciprocal basis facility to feed the adjoining building for such emergency loads may be provided by necessary switchgear.
- e) *Medium Voltage Switch Room* — The floor area required in respect of medium voltage switchgear room may be determined keeping in view the number and type of incoming/outgoing bus coupler switches including likely expansion in future.
- f) *Room for Standby Generator* — It is preferable to install the standby generator in service building. If installed in main building it shall be at the ground floor or at the semi basement, alternatively, in the first basement with facilities for forced ventilation. Adequate space shall be provided for storing of fuel. Compartmentation for fire protection with detection and first-aid protection measures is essential. Different type of requirements exist for the diesel engine and generator for the oil storage area and for the switchgear.

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Table of Typical Allowances for Diversity

Purpose of Final Circuit Fed from Conductors or Switchgear to which Diversity Applies	Individual Household Installations, including Individual Dwelling of a Block	Type of Premises Small, Shops, Stores Offices and Business Premises	Type of Premises Small Hotels, Boarding Houses etc.
(1)	(2)	(3)	(4)
Lighting	66% of total demand	90% of total current demand	75% of total current demand
Heating and power	80% of total current demand up to 10 A +40% of any current demand in excess of 10A	80% full load of largest appliance +60% of remaining appliances	80% full load of largest appliance +60% of second largest appliances +40% of remaining appliances
Cooking appliances	10A +30% full load of connected cooking appliances in excess of 10 A + 5 A if socket-outlet incorporated in unit	80% full load of largest appliance +60% full load of second largest appliance +50% full load of remaining appliances	80% of largest appliance +60% full load of second largest appliance +50% full load of remaining appliances
Motors (other than lift motors which are subject to special consideration)		80% full load of largest motor +60% full load of second largest motor +50% full load of remaining motors	80% full load of largest motor + 50% full load of remaining motors
Water heater	80% full load of largest appliance +50% of second largest appliance +25% full load of remaining appliances	80% full load of largest appliance +60% of second largest appliance +25% full load of remaining appliances	80% full load of largest appliance +60% of second largest appliance +25% full load of remaining appliances
Floor warming Installations	50%		
Water heaters thermal storage space heating installations	50%		
Standard arrangements of final circuits	80% of current demand of largest circuit +40% of current demand of every other circuit	80% of current demand of largest circuit +50% of current demand of every other circuit	
Socket outlets other than those included above and stationary equipment other than those listed above	80% of current demand of largest point of +40% of current demand of every other point of.	80% of current demand of largest point of +60% of current demand of every other point of	80% of current demand of largest point of +60% of current demand of every point in main rooms (dinning rooms, etc) +40% of current demand of every other point of

Note:

1. For the purpose of the table an instantaneous water heater is deemed to be a water heater of any loading which heats water only while the tap is turned on and therefore uses electricity intermittently.
2. It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity.
3. Diversity factor shall apply according to the specific requirement.

- g) Facilities including space at appropriate positions, relative to the location of the installed equipment has to be kept in the layout design for removal of equipment or sub-assemblies for repair or maintenance. When it is located, other than the ground level with direct equipment access, a hatch or ramp shall be required.
- h) Other environmental requirements under the provisions of Standard Environment Protection Rules, from the aspect of engine emissions including regarding the height of exhaust pipe and permitted noise levels/noise control.
- i) The capacity of standby generating set shall be chosen on the basis of essential light load, essential air conditioning load, essential equipment load and essential services load, such as one lift out of the bank of lifts, one or all water pumps, etc. Having chosen the capacity and number of generating sets, required space may be provided for their installation (see **Annex C** for general guidance).
- j) The generating set should preferably be housed adjacent to MV switchgear in the substation building to enable transfer of electrical load quickly as well as to avoid transfer of vibration and noise to the main building. Acoustics lining of the room shall be in line with the Standard requirement. If DG Set is located outdoor, it shall be housed in acoustics enclosure. The generator house should have proper ventilation, fire-fighting equipment, etc (see Myanmar Fire Department Instruction).
- k) *Requirements of Room*
 - 1) The areas given above in respect of the different categories of rooms holds good if they are provided with windows and independent access doors in accordance with local regulations.
 - 2) All the rooms shall be provided with partitions up to the ceiling and shall have proper ventilation. Special care should be taken to ventilate the transformer rooms and where necessary louvers at lower level and exhaust fans at higher level shall be provided at suitable locations.
 - 3) In order to prevent storm water entering the transformer and switch rooms through the soak-pits, the floor level, the substation shall be at least 15 cm above the highest flood water level that may be anticipated in the locality. Also, facility shall be provided for automatic removal of water.
 - 4) The minimum height of high voltage switchgear room shall be 3.6 m below the soffit of the beam.
- l) *Fire Compartmentation*— It is advisable to provide fire compartmentation of buildings and segregation of associated wiring. Busbar trunking of horizontal and vertical distribution type in place of cable based distribution system shall be used.

5B.4.3 Location of Switch Room

In large installations other than where a substation is provided, a separate switch room shall be provided; this shall be located as closely as possible to the electrical load centre preferably near the entrance of the building on the ground floor or on the first basement level, and suitable ducts shall be laid with minimum number of bends from the points of entry of the main supply cable to the position of the main switchgear. The switch room shall also be placed in such a position that rising ducts may readily be provided there from to the upper floors of the building in one straight vertical run. In larger buildings, more than one rising duct may be required and then horizontal ducts may also be required for running cables from the switch room to the foot of each rising main. Such cable ducts shall be either be reserved for the electrical services only or provided with

a means of segregation for medium and low voltage installations, such as call-bell systems; telephone installations, fire detection and alarm system, announcement or public address system. Cables for essential emergency services such as those related to fire detection, alarm, announcement should use either metal conduit in addition to physical segregation from power cables or use fire resistant cables, so that the service is maintained even in the event of a fire at least for a period of about 2 hrs.

5B.4.4 Location and Requirements of Distribution Panels

The electrical control gear distribution panels and other apparatus, which are required on each floor may conveniently be mounted adjacent to the rising mains, and adequate space should be provided at each floor for this purpose.

5B.4.5 Substation Safety

The owner or the operator of any substation shall be collectively and severally be responsible for any lapse or neglect leading to an accident or an incidence of an avoidable abnormality and shall take care of the safety requirements as follows:

- a) enclose the substation where necessary to prevent, so far as is reasonably practicable, danger or unauthorized access;
- b) enclose any part of the substation, which is open to the air and contains live equipment which is not encased, with a fence or wall not less than 2.4 m in height to prevent, so far as is reasonably practicable, danger or unauthorized access;
- c) ensure that, so far as is reasonably practicable, there are at all times displayed:
- d) sufficient safety signs of such size and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances;
- e) a notice which is placed in a conspicuous position and which gives the location or identification of the substation, the name of each generator or distributor who owns or operates the substation equipment making up the substation and the telephone number where a suitably qualified person appointed for this purpose by the generator or distributor will be in constant attendance; and
- f) such other signs, which are of such size and placed in such positions, as are necessary to give due warning of danger having regard to the sitting of, the nature of, and the measures taken to ensure the physical security of, the substation equipment; and
- g) take all reasonable precautions to minimize the risk of fire associated with the equipment.

5B.4.6 Overhead Lines, Wires and Cables

5B.4.6.1 Height Requirement

While overhead lines may not be relevant within buildings, regulations related to overhead lines are of concern from two different angles.

- a) Overhead lines may be required in building complexes, though use of underground cables is the preferred alternative.
- b) Overhead lines may be passing through the site of a building. In such a case the safety aspects are important for the construction activity in the vicinity of the overhead line as well as portions of low height buildings that may have to be constructed below the overhead lines. For minimum distance (vertical and horizontal) of electric lines/wires/cables from buildings, reference may be made to the Myanmar Electricity Rules and Regulations.

- c) Any person responsible for erecting an overhead line will keep informed the authority(s) responsible for services in that area for telecommunication, gas distribution, water and sewage network, roads so as to have proper co-ordination to ensure safety. He shall also publish the testing, energizing programme for the line in the interests of safety.

5B.4.6.2 *Position, Insulation and Protection of Overhead Lines*

Any part of an overhead line which is not connected with earth and which is not ordinarily accessible shall be supported on insulators or surrounded by insulation. Any part of an overhead line which is not connected with earth and which is ordinarily accessible shall be:

- a) made dead; or
- b) so insulated that it is protected, so far it is reasonably practicable, against mechanical damage or interference; or
- c) adequately protected to prevent danger.

Any person responsible for erecting a building or structure which will cause any part of an overhead line which is not connected with earth to become ordinarily accessible shall give reasonable notice to the generator or distributor who owns or operates the overhead line of his intention to erect that building or structure.

Any bare conductor not connected with earth, which is part of a low voltage overhead line, shall be situated throughout its length directly above a bare conductor which is connected with earth.

No overhead line shall, so far as is reasonably practicable, come so close to any building, tree or structure as to cause danger.

In this regulation the expression "ordinarily accessible" means the overhead line could be reached by hand if any scaffolding, ladder or other construction was erected or placed on/in, against or near to a building or structure.

5B.4.6.3 *Precautions Against Access and Warnings of Dangers*

Every support carrying a high voltage overhead line shall, if the circumstances reasonably require, be fitted with devices to prevent, so far it is reasonably practicable, any unauthorized person from reaching a position at which any such line would be a source of danger.

Every support carrying a high voltage overhead line, and every support carrying a low voltage overhead line incorporating bare phase conductors, shall have attached to it sufficient safety signs and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances.

Poles supporting overhead lines near the road junction and turnings shall be protected by a masonry or earth fill structure or metal barricade, to prevent a vehicle from directly hitting the pole, so that the vehicle, if out of control, is restrained from causing total damage to the live conductor system, likely to lead to a hazardous condition on the road or foot path or building.

5B.4.6.4 *Fitting of Insulators to Stay Wires*

Every stay wire which forms part of, or is attached to, any support carrying an overhead line incorporating bare phase conductors (except where the support is a lattice steel structure or other structure entirely of metal and connected to earth) shall be fitted with an insulator no part of which shall be less than 3 m above ground or above the normal height of any such line attached to that support.

5B.4.7 Maps of Underground Networks

5B.4.7.1 Any person or organization or authority laying cables shall contact the local authority in charge of that area and find out the layout of

- a) water distribution pipe lines in the area;
- b) sewage distribution network;
- c) telecommunication network; and
- d) gas pipeline network and plan the cable network in such a manner that the system is compatible, safe and non interfering either during its installation or during its operation and maintenance. Plan of the proposed cable installation shall be brought to the notice of the other authorities referred above.

5B.4.7.2 Suitable cable markers and danger sign as would be appropriate for the safety of the workmen of any of the systems shall be installed along with the cable installation. Notification of testing and energizing of the system shall also be suitably published for ensuring safety.

5B.4.7.3 Any person or organization or authority laying cables shall have and, so far it is reasonably practicable, keep up to date, a map or series of maps indicating the position and depth below surface level of all networks or parts there of which he owns or operates.

Any map prepared or kept shall be available for inspection by any of the municipal authority, other service providers, general public provided they have a reasonable cause for requiring to inspect any part of the map.

5B.5 DISTRIBUTION OF SUPPLY AND CABLING

5B.5.0 General

In the planning and design of an electrical wiring installation, due consideration shall be made of all the prevailing conditions. It is recommended that advice of a competent electrical engineer be sought at the initial stage itself with a view to providing an installation, that will prove adequate for its intended purpose be reliable and safe and efficient.

A certain redundancy in the electrical system is necessary and has to be built in from the initial design stage itself. The extent of redundancy will depend on the type of load, its criticality, normal hours of use, quality of power supply in that area, co-ordination with the standby power supply, capacity to meet the starting current requirements of large motors etc.

5B.5.1 System of Supply

5B.5.1.1 All electrical apparatus shall be suitable for the voltage and frequency of supply.

5B.5.1.2 In case of connected load of 100 kVA and above, the relative advantage of medium voltage three-phase supply should be considered. Though the use of high voltage supply entails the provisions of space for the capital cost of providing suitable transformer substation at the consumer's premises, the following advantages are gained:

- a) advantage in tariff;
- b) more effective earth fault protection;
- c) elimination of interference with supplies to other consumers permitting the use of large size motors, welding plant, etc; and
- d) better control of voltage regulation and more constant supply voltage.

NOTE — Additional safety precautions required to be observed in HV installations shall also be kept in view.

In many cases there may be no choice available to the consumer, as most of the licensees have formulated their policy of correlating the supply voltage with the connected load or the contract demand. Generally the supply is at 400/230 volts, 11 kV for loads up to 1 MVA and 33 kV or 66 kV for consumers of more than 1 MVA.

5B.5.1.3 In very large industrial buildings where heavy electric demands occur at scattered locations, the economics of electrical distribution at high voltage from the main substation to other subsidiary transformer substations or to certain items of plant, such as large motors and furnaces, should be considered. The relative economy attainable by use of medium or high voltage distribution and high voltage plant is a matter for expert judgement and individual assessment in the light of experience by a professionally qualified electrical engineer.

5B.5.2 Substation Equipment and Accessories

Substations require an approval by the Electrical Inspectorate. Such approval is mandatory before energizing the substation. It is desirable to get the approval for the general layout, schematic layout, protection plan etc, before the start of the work from the Inspectorate. All substation equipment and accessories and materials, etc, shall conform to relevant Standards wherever they exist, otherwise the consumer (or his consultant) has to specify the standards to which the equipment to be supplied confirms and that shall be approved by the authority. Manufacturers of equipment have to furnish certificate of conformity as well as type test certificates for record, in addition to specified test certificates for acceptance tests and installation related tests for earthing, earth continuity, load tests and tests for performance of protective gear.

5B.5.2.1 High Voltage Switchgear

5B.5.2.1.1 The selection of the type of high voltage switchgear for any installation inter alia depends upon the following:

- a) voltage of the supply system;
- b) the prospective short-circuit current at the point of supply;
- c) the size and layout of electrical installation;
- d) the accommodation available; and
- e) the nature of industry.

Making and breaking capacity of switchgear shall be commensurate with short-circuit potentialities of the supply system and the supply authority shall be consulted on this subject.

5B.5.2.1.2 Guidelines on various types of switchgear equipment and their choice for a particular application shall be in accordance with International Standard (IEC) practice.

5B.5.2.1.3 In extensive installations of switchgear (having more than four incoming supply cables or having more than 12 circuit breakers), banks of switchgears shall be segregated from each other by means of fire resisting barriers having 2h fire resistance rating in order to prevent spreading of the risk of damage by fire or explosion arising from switch failure. Where a bus-bar section switch is installed, it shall also be segregated from adjoining banks in the same way [(5)IS1646]. Except main LT panel, it would be preferable to locate the sub panels/distribution boards near load centre. Further, it should be ensured that these panels are easily approachable. The preferable location of panels shall be near the exitways.

5B.5.2.1.4 It should be possible to isolate any section from the rest of the switchboards such that work might be undertaken on this section without the necessity of making the switchboard dead. Isolating switches used for the interconnection of sections or for the purpose of isolating circuit-

breakers of other apparatus, shall also be segregated within its compartment so that no live part is accessible when work in a neighbouring section is in progress.

5B.5.2.1.5 In the case of duplicate or ring main supply, switchgears with interlocking arrangement shall be provided to prevent simultaneous switching of two different supply sources. Electrical and/or mechanical interlocks may preferably be provided.

5B.5.2.2 *Cables*

5B.5.2.2.1 The smallest size of the cable that shall be used, will depend upon the method of laying cable permissible maximum temperature it shall withstand, voltage drop over the length of the cable, the prospective short-circuit current to which the cable may be subjected, the characteristics of the overload protection gear installed, load cycle and thermal resistivity of the soil[(6) IS 732].

NOTE — Guidelines for correlation of the ratings of cables and characteristics of protective devices are under consideration. Continuous current carrying capacity (thermal limit leading to permanent change in properties of the insulation) under the installed conditions, voltage drop under required load and the fault current withstand ability of the cable for the duration that the protective device controlling the cable installation will let go the fault current, operating voltage are the prime considerations.

5B.5.2.2.2 The advice of the cable manufacturer with regard to installation, jointing and sealing shall be followed.

5B.5.2.2.3 The LV cables shall either be laid on the cable rack/built-up concrete trenches/tunnel/basement or directly buried in the ground depending upon the specific requirement. It is preferable to use four core cable in place of three and half core to minimize heating of neutral core due to harmonic content in the supply system and also avoidance of overload failures. All cables shall be installed in accordance with Standard practice [(6) IS 732].

5B.5.2.2.4 *Colour identification of cores of non-flexible cables*

<i>Function</i>	<i>Colour Identification of Core of Rubber or PVC Insulated Non flexible Cable, or of Sleeve or Disc to be Applied to Conductor or Cable Code</i>
Protective or earthing	Green and yellow or Green with yellow stripes ¹⁾
Neutral of a.c. single or three phase circuit	Blue
Phase R of 3-phase a.c. circuit	Brown
Phase Y of 3-phase a.c. circuit	Black
Phase B of 3-phase a.c. circuit	Grey
Positive of d.c. 2-wire circuit	Brown
Negative of d.c. 2-wire circuit	Grey
Outer (positive or negative) of d.c. 2-wire circuit derived from 3-wire system	Brown/Grey
Positive of 3-wire system positive of 3-wire d.c. circuit)	Brown
Middle wire of 3-wire d.c. circuit	Blue
Negative of 3-wire d.c. circuit	Grey
Functional Earth-Telecommunication	Cream

¹⁾Bare conductors are also used for earthing and earth continuity conductors. But it is preferable to use insulated

conductors with green insulation with yellow stripes.

5B.5.2.2.5 Colour, identification of cores of flexible cables and flexible cords

<i>Number of Cores</i>	<i>Function of Core</i>	<i>Colour(s) of Core</i>
1	Phase	Brown ¹⁾
	Neutral	(Light) Blue
	Protective or Earthing	Green & yellow
2	Phase	Brown
	Neutral	(Light) Blue ¹⁾
3	Phase	Brown
	Neutral	(Light) Blue ¹⁾
	Protective or Earthing	Green & yellow
4 or 5	Phase	Brown, Black ¹⁾ , Grey
	Neutral	(Light) Blue ¹⁾
	Protective or Earthing	Green & yellow

¹⁾ Certain alternative are allowed in Wiring Regulations.

5B.5.2.3 High Voltage Bus bar Trunking/Ducting

High voltage busbar trunking system is a type-tested switchgear and control gear assembly in the form of an enclosed system. HV busbar system is used for transporting power between HV Generators, transformers and the infeed main switchgear of the main HV switchgear.

Generally three types of bus ducts namely non-segregated, segregated and isolated phase bus duct shall be used. The non-segregated bus ducts consists of three phase busbars running in a common enclosure made of steel or aluminium. The enclosure shall provide safety for the operational personnel and reduces chances of faults. The enclosures shall be effectively grounded.

Segregated phase bus duct are similar to non-segregated phased duct except that metal or insulation barriers are provided between phase conductors to reduce chances of phase to phase faults. However, it is preferable to use metal barriers.

In the case of isolated bus ducts, each phase conductor shall be housed in a separate non-magnetic enclosures. The bus duct shall be made of sections which are assembled together at site to make complete assembly. The enclosure shall be of either round or square shape and welded construction. The enclosures of all phases in general to be supported on a common steel structure. Provision of fire protection shall be provided in all openings' [see Myanmar Fire Department Instruction]. Fire separation in openings shall be provided using materials having 2h fire resistance rating.

5B.5.2.4 MV/LV Busbar Trunking/Rising Mains

Where heavy loads are to be carried, busbar systems are preferred. The busbars are available for continuous run from point to point or with tap offs at standard intervals and have to be chosen as per specific requirement. MV/LV busbar trunking shall be a type-tested switchgear and control gear assembly in the form of an enclosed system. There are two types of MV/LV bus duct system for power distribution system:

- Conventional type.
- Compact and sandwich type.

Conventional type bus duct is used for large power handling between transformer and switchgear or between switchgear and large power loads, such as compressor drive motor etc. This type is generally used in plant rooms, riser shafts, substations etc.

Compact type is available either air insulated or sandwich type for use within areas of the building which are put to other higher (aesthetic) level of use. They could be used in false ceiling spaces or even in corridors and shafts for distribution without any false ceiling as they provide an aesthetically acceptable finish to merge with other building elements such as beams, ducts or pipes in functional buildings.

The class of protection shall be specific depending on the requirement at the place of installation. Protection class (IP xx) will automatically identify the ventilation, protection from weather, water, dust etc.

In modern building technology, high demands are made of the power distribution system and its individual components:

- a) Long life and good service quality,
- b) Safe protection in the event of fire,
- c) Low fire load,
- d) Low space requirement, and
- e) Minimum effort involved in carrying out retrofits.

The high load density in modern large buildings and high rise buildings demands compact and safe solution for the supply of power. The use of busbartrunking system is ideal for such applications.

Busbar trunking can be installed in vertical risers ducts or horizontally in passages for transmission and distribution of power. Busbar trunking systems allow electrical installations to be planned in a simple and clear fashion. In the building complexes, additional safety demands with respect to fire barriers and fire load and use of bus bar trunking meets this requirement.

Busbar trunking system reduces the combustible material near the area with high energy in comparison with other distribution systems such as cables and makes the building safe from the aspect of vulnerability to fire of electrical origin. In addition, unlike cable systems the reliability of a busbar trunking system is very high. These systems also require very little periodic maintenance.

Choice of busbar trunking for distribution in building scan be made on the basis of

- a) reduced fire load (drastically reduced in comparison to the cable system),
- b) reduced maintenance over its entire lifetime,
- c) longer service lifetime in comparison with a cable distribution
- d) enhanced reliability due to rigid bolted joints and terminations and extremely low possibility of insulation failure.

5B.5.2.5 Transformers

5B.5.2.5.1 General design objective while selecting the transformer(s) for a substation would be to provide at least two or more transformers, so that a certain amount of redundancy is built in, even if a standby system is provided. The total installed transformation capacity would be marginally higher than the anticipated maximum demand. With growing emphasis on energy conservation, the system design is made for both extremes of loading. During the periods of

lowest load in the system, it would be desirable to operate only one transformer and switch in additional transformers as the load variation takes place in a day. The minimum size of a transformer would quite often depend on the minimum load that is anticipated over a period of about 4h in a day. Total transformer capacity is generally selected on the basis of present load, possible future load, operation and maintenance cost and other system conditions and selection of the maximum size(capacity) of the transformer is guided by short-circuit making and breaking capacity of the switchgear used in the medium voltage distribution system. Maximum size limitation is important from the aspect of feed to a down stream fault.

For feeding final single phase domestic type of loads or general office loads it is advisable to even use transformers of capacity much lower than what the switchgear can handle, so that lower fault MVA is available in such areas and use of hand held equipment fed through flexible cords is safe.

For reasons of reliability and redundancy it is normal practice to provide at least two transformers for any important installation. Interlinking by tie lines is an alternative to enhance reliability /redundancy in areas where there are a number of substations in close vicinity, such as a campus with three or four multi-storied blocks each with a substation.

Ring main type of distribution is preferred for complexes having a number of substations.

5B.5.2.5.2 Where two or more transformers are to be installed in a substation to supply a medium voltage distribution system, the distribution system shall be divided into separate sections each of which shall be normally fed from one transformer only unless the medium voltage switchgear has the requisite short circuit capacity. Provision may, however, be made to interconnect separate sections, through a bus coupler in the event of failure or disconnection of one transformer. See **5B.4.2** for details of location and requirements of substation.

The transformers, that may at any time operate in parallel, shall be so selected as to share the load in proportion to their respective load ratings. While the general practice is to avoid operation of transformers in parallel for feeding final distribution in buildings, it is possible to use transformers with slightly different impedance or voltage taps to operate in parallel, but with appropriate protection. Installations designed for parallel operation of transformers shall have protection for avoiding circulating current between transformers, avoid overload of any one transformer due to reactance mismatch and the system shall be so arranged as to trip the secondary breaker in case the primary breaker of that transformer trips.

5B.5.2.6 *Switchgear*

5B.5.2.6.1 Switchgear (and its protective device) shall have breaking capacity not less than the anticipated fault level in the system at that point. System fault level at a point in distribution system is predominantly dependent on the transformer size and its reactance. Parallel operation of transformers naturally increases the fault level.

5B.5.2.6.2 Isolation and controlling circuit breaker shall be interlocked so that the isolator cannot be operated unless the corresponding breaker is in open condition. The choice between alternative types of equipment maybe influenced by the following considerations:

- a) In certain installations supplied with electric power from remote transformer substations, it may be necessary to protect main circuits with circuit-breakers operated by earth fault, in order to ensure effective earth fault protection.
- b) Where large electric motors, furnaces or other heavy electrical equipment is installed, the main circuits shall be protected from short circuit by switch disconnector fuse or circuit breakers. For motor protection, the combination of contactor overload device and fuse or circuit breakers shall be Type-2 coordinated in accordance with accepted standards[(7)IS

13947]. Wherever necessary, backup protection and earth fault protection shall be provided to the main circuit.

- c) Where mean of isolating main circuits is separately required, switch disconnector fuse or switch disconnector may form part of main switchboards.

5B.5.2.6.3 It shall be mandatory to provide power factor improvement capacitor at the substation bus. Suitable capacitor may be selected in consultation with the capacitor as well as switchgear manufacture depending upon the nature of electrical load anticipated on the system. Necessary switchgear/feeder circuit breaker shall be provided for controlling of capacitor bank.

Power factor of individual motor may be improved by connecting individual capacitor banks in parallel. For higher range of motors, which are running continuously without much variation in load, individual power factor correction at load end is advisable.

NOTE — Care should be taken in deciding the kVA rating of the capacitor in relation to the magnetizing kVA of the motor. Over rating of the capacitor may cause injury to the motor and capacitor bank. The motor still rotating after disconnection from the supply, may act as generator by self-excitation and produce a voltage higher than supply voltage. If the motor is again switched on before the speed has fallen to about 80 percent of the normal running speed, the high voltage will be superimposed on the supply circuits and will damage both the motor and capacitor.

As a general rule, the kVAr rating of the capacitor should not exceed the no-load magnetizing kVA of the motor.

Generally it would be necessary to provide an automatic control for switching in capacitors matching the load power factor and the bus voltage. Such a scheme would be necessary as capacitors permanently switched in the circuit may cause over voltage at times of light load.

5B.5.2.6.4 Sufficient additional space shall be allowed in substations and switch rooms to allow operation and maintenance and proper means shall be provided for isolating the equipment to allow access for servicing, testing and maintenance. Sufficient additional space shall be allowed for temporary location and installation of standard servicing and testing equipment. Space should also be allowed to provide for anticipated future extensions.

5B.5.2.6.5 Electrical installations in a room or cubicle or in an area surrounded by wall fence, access to which is controlled by lock and key shall be considered accessible to authorized persons only.

A wall or fence less than 1.8 m in height shall not be considered as preventing access unless it has other features that provide a degree of isolation equivalent to a 1.8 m fence.

5B.5.2.6.6 Harmonics on the supply systems are becoming a greater problem due to the increasing use of electronic equipments, computer, fluorescent, mercury vapour and sodium vapour lighting, controlled rectifier and inverters for variable speed drives, power electronics and other non-linear loads. Harmonics may lead to almost as much current in the neutral as in the phases. This current is almost entirely third harmonic. Phase rectification devices may be considered for the limits of harmonic voltage distortion may be considered at the planning stage in such cases.

With the wide spread use of thyristor and rectifier based loads there is necessity of providing a full size neutral; but this requirement is limited to the 3-phase 4-wire distribution generally in the 400/230V system. As a result it is not desirable to use half-size neutral conductor, as possibility of neutral conductor overload due to harmonics is likely.

5B.5.3 Reception and Distribution of Main Supply

5B.5.3.1 Control at Point of Commencement of Supply

5B.5.3.1.1 There shall be a circuit-breaker or miniature circuit-breakers or a load break switch fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no switch or fuse unit in the earthed neutral of conductor. The neutral shall also be distinctly marked.

5B.5.3.1.2 The main switch shall be easily accessible and situated as near as practicable to the termination of service line.

5B.5.3.1.3 On the main switch, where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor or a multi-wire system or a conductor which is to be connected thereto, an indication of a permanent nature shall be provided to identify the earthed neutral conductor.

5B.5.3.1.4 *Energy meters*

Energy meters shall be installed in residential buildings at such a place which is readily accessible to the owner of the building and the Authority. These should be installed at a height where it is convenient to note the meter reading, it should preferably not be installed below one metre from the ground. The energy meters should either be provided with a protecting covering, enclosing it completely except the glass window through which the readings are noted or should be mounted inside a completely enclosed panel provided with hinged or sliding doors with arrangement for locking.

In multi-storied buildings meters shall be installed with tapping point for meters of the rising main (bustrunking) on individual floors (Energy Meter Installed Location subject to the requirement of Electricity Supply Authority).

5B.5.3.2 *Main Switches and Switchboard*

5B.5.3.2.1 All main switches shall be either of metal-clad enclosed pattern or of any insulated enclosed pattern which shall be fixed at close proximity to the point of entry of supply. Every switch shall have an environmental protection level rating (IP), so that its operation is satisfactory in the environment of the installation.

NOTE — Woodwork shall not be used for the construction or mounting of switches and switch boards installed in' a building.

5B.5.3.2.2 *Location*

- a) The location of the main board should be such that it is easily accessible for fireman and other personnel to quickly disconnect the supply in case of emergencies. If the room is locked for security, means of emergency access, by schemes such as break glass cupboard, shall be incorporated.
- b) Main switch board shall be installed in rooms or cupboards so as to safeguard against operation by unauthorized personnel.
- c) Switchboards shall be placed only in dry situations and in ventilated rooms and they shall not be placed in the vicinity of storage batteries or exposed to chemical fumes.
- d) In damp situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switchboard shall be totally enclosed and shall have adequate degree of protection. In some cases flameproof enclosure may be necessitated by particular circumstances [(8) IS 2148].
- e) Switchboards shall not be erected above gas stoves or sinks, or within 2.5 m or any washing unit in the washing rooms or laundries, or in bathrooms, lavatories or toilets, or kitchens.

- f) In case of switchboards unavoidably fixed in places likely to be exposed to weather, to drip, or to abnormal moist temperature, the outer casing shall be weatherproof and shall be provided with glands or bushings or adopted to receive screwed conduit, according to the manner in which the cables are run.
- g) Adequate illumination shall be provided for all working spaces about the switchboards when installed indoors.

5B.5.3.2.3 Metal-clad switchgear shall preferably be mounted on any of the following types of boards:

- a) *Hinged-type metal boards* — These shall consist of a box made of sheet metal not less than 2 mm thick and shall be provided with a hinged cover to enable the board to swing open for examination of the wiring at the back. The joints shall be welded. There shall be a clear distance of not less than 2.5 cm between the teak wood board and the cover, the distance being increased for larger boards in order that on closing of the cover, the insulation of the cables is not subjected to damage and no excessive twisting or bending in any case. The board shall be securely fixed to the wall by means of rag bolts, plugs, or wooden plugs and shall be provided with a locking arrangement and an earthing stud. All wires passing through the metal board shall be protected by a rubber or wooden bush at the entry hole. The earth stud should commensurate with the size of earth lead/leads. Alternatively, metal boards may be made of suitable size angle iron of minimum size 35 mm x 35 mm x 6 mm or channel iron of minimum size 35 mm x 25 mm x 6 mm frames work suitably mounted on front with a 3 mm thick mild steel plate and on back with 1.5 mm thick mild steel sheet. No apparatus shall project beyond any edge of panel. No fuse body shall be mounted within 2.5 cm of any edge of the panel.

NOTE — Such type of boards are particularly suitable for small switchboard for mounting metal-clad switchgear connected to supply at low voltages.

- b) *Fixed-type metal boards* — These shall consist of an angle or channel iron frame fixed on the wall or on floor and supported on the wall at the top, if necessary. There shall be a clear distance of 1 m in front of the switchboards. If there are any attachments of bare connections at the back of the switchboard *Myanmar Electricity Rules* shall apply. The connections between the switchgear mounting and the outgoing cable up to the wall shall be enclosed in a protection pipe.

NOTE — Such type of boards are particularly suitable for large switchboards for mounting large number of switchgears or high capacity metal-clad switchgear or both.

- c) *Protected-type switchboard* — A protected switchboard is one where all of the conductors are protected by metal or other enclosures. They may consist of a metal cubicle panel, or an iron frame upon which is mounted metal clad switchgear. They usually consist of a main switch, busbars and circuit breakers or fuses controlling outgoing circuits.
- d) *Open-type switchboard* — An open type switchboard is one, which has exposed current carrying parts on the front of the switchboard. This type of switchboard is rarely used nowadays but where this exists, a hand rail or barrier has to be provided to prevent unintentional or accidental contact with exposed live parts. They must be located in a special switch room or enclosure and only a competent person may have access to these switchboards.

NOTE — These boards may be existing in old installations. It is recommended that they be phased out. With the continuously increasing fault power feed due to increases in generation and strengthening of distribution systems, these open boards are a source of accidents.

5B.5.3.2.4 Recessing of boards

Where so specified, the switchboards shall be recessed in the wall. Ample room shall be provided at the back for connection and at the front between the switchgear mountings.

5B.5.3.2.5 Marking of apparatus [see (9) IS 5578]

- a) Where a board is connected to voltage higher than 250 V, all the apparatus mounted on it shall be marked on the following colors to indicate the different poles or phases to which the apparatus or its different terminals may have been connected:

Alternating Current

Three-phases — Brown, Black, Grey

1 Neutral — Blue

Direct Current

Three-wire system — 2 outer wire,
positive Brown and negative Grey

1 Neutral — Blue

- b) Where four-wire three-phase wiring is done, the neutral shall be in one colour and the other three wires in another colour as mentioned above or shall be suitably tagged or sleeved for full proof identification.
- c) Where a board has more than one switch, each such switch shall be marked to indicate which section of the installation it controls. The main switch shall be marked as such and where there is more than one main switch in the building, each such switch shall be marked to indicate which section of the installation it controls.

All markings shall be clear and permanent.

5B.5.3.2.6 Drawings

Before proceeding with the actual construction, a proper drawing showing the detailed dimensions and design including the disposition of the mountings of the boards, which shall be symmetrically and neatly arranged for arriving at the overall dimensions, shall be prepared along the building drawing. Such drawings will show the mandatory clearance spaces if any, and clear height below the soffit of the beam required to satisfy regulations and safety considerations, so that other designers or installers do not get into such areas or spaces for their equipment.

5B.5.3.2.7 Where a board has more than one switch, each such switch shall be marked to indicate which section of the installation it controls. The main switch shall be marked as such and where there is more than one main switch in the building, each such switch shall be marked to indicate which section of the installation it controls.

All markings shall be clear and permanent.

5B.5.3.2.8 MV/LV Bus bar chambers (400 V/230 V)

Busbar chambers, which feed two or more circuits, must be controlled by a main disconnector (TP & N), or Isolating links or TPN MCB to enable them to be disconnected from the supply.

5B.5.3.3 Distribution Boards

A distribution board comprises of one or more protective devices against over current and ensuring the distribution of electrical energy to the circuits. Distribution board shall provide

plenty of wiring space, to allow working as well as to allow keeping the extra length of connecting cables, likely to be required for maintenance.

5B.5.5.3.1 Main distribution board shall be provided with a circuit breaker on each pole of each circuit, or a switch with a fuse on the phase or live conductor and a link on the neutral or earthed conductor of each circuit. The switches shall always be linked.

All incomers should be provided with surge protection devices.

5B.5.3.4 *Branch Distribution Boards*

5B.5.3.4.1 Branch distribution boards shall be provided, along with earth leakage protective device (ELCB)(incoming), with a fuse or a miniature circuit breaker or both of adequate rating/setting chosen on the live conductor of each sub-circuit and the earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes. At least one spare circuit of the same capacity shall be provided on each branch distribution board. Further, the individual branching circuits (outgoing) shall be protected against over-current with miniature circuit breaker of adequate rating. In residential/industrial lighting installations, the various circuits shall be separated and each circuit shall be individually protected so that in the event of fault, only the particular circuit gets disconnected.

5B.5.3.4.2 Circuits shall be separate for installations at higher level such as those in the ceiling and at higher levels, above 1 m, on the walls and for installations at lower level such as sockets for portable or stationery plug in equipments. For devices consuming high power and which are to be supplied through supply cord and plug, separate wiring shall be done. For plug-in equipment provisions shall be made for providing ELCB protection in the distribution board.

5B.5.3.4.3 It is preferable to have additional circuit for kitchen and bathrooms. Such sub-circuit shall not have more than a total of ten points of light and fans. The load of such circuit shall be restricted to 800 W. If a separate fan circuit is provided, the number of fans in the circuit shall not exceed ten. Power sub-circuit shall be designed according to the load but in no shall there be more than two 16A outlets on each sub-circuit.

5B.5.3.4.4 The circuits for lighting of common area shall be separate. For large halls 3-wire control with individual control and master control installed near the entrance shall be provided for effective conservation of energy.

5B.5.3.4.5 Where daylight would be available, particularly in large halls, lighting in the area near the windows, likely to receive daylight shall have separate controls for lights, so that they can be switched off selectively when daylight is adequate, while keeping the lights in the areas remote from the windows on.

5B.5.3.4.6 Circuits for socket outlets may be kept separate circuits feeding fans and lights. Normally, fans and lights may be wired on a common circuit. In large spaces circuits for fans and lights may also be segregated. Lights may have group control in large halls and industrial areas. While providing group control consideration may be given for the nature of use of the area lit by a group. Consideration has to be given for the daylight utilization, while grouping, so that a group feeding areas receiving daylight can be selectively switched off during daylight period.

5B.5.3.4.7 The load on any low voltage sub-circuit shall not exceed 3000 W. In case of a new installation, all circuits and sub-circuits shall be designed with an initial load of about 2 500 W, so as to allow a provision of 20percent increase in load due to any future modification. Power sub-circuits shall be designed according to the load, where the circuit is meant for a specific equipment. Good practice is to limit a circuit to a maximum of four sockets, where it is expected that there will be diversity due to use of very few sockets in large spaces (example sockets for use

of vacuum cleaner). General practice is to limit it to two sockets in a circuit, in both residential and non-residential buildings and to provide a single socket on a circuit for a known heavy load appliance such as air conditioner, cooking range etc.

5B.5.3.4.8 In wiring installations at special places like construction sites, stadium, shipyards, open yards in industrial plants, etc, where a large number of high wattage lamp may be required, there shall be no restriction of load on any circuit but conductors used in such circuits shall be of adequate size for the load and proper circuit protection shall be provided.

5B.5.3.5 *Location of Distribution Boards*

- a) The distribution boards shall be located as near as possible to the centre of the load they are intended to control.
- b) These shall be fixed on suitable stranchion or wall and shall be accessible for replacement/reset of protective devices, and shall not be more than 1.8 m from floor level.
- c) These shall be of either metal-clad type, or air insulated type. But, if exposed to weather or damp situations, these shall be of the weatherproof type and, if installed where exposed to explosive dust, vapour or gas, these shall be of flameproof type in accordance with accepted Standards[(10) IS1777]. In corrosive atmospheres, these shall be treated with anti-corrosive preservative or covered with suitable plastic compound.
- d) Where two and/or more distribution boards feeding low voltage circuits are fed from a supply of medium voltage, the metal case shall be marked 'Danger 400 V' and identified with proper phase marking and danger marks.
- e) Each shall be provided with a circuit list giving diagram of each circuit which it controls and the current rating of the circuit and size of fuse element.
- f) In wiring branch distribution board, total load of consuming devices shall be divided as far as possible evenly between the number of ways in the board leaving spare circuits for future extension.

5B.5.3.6 *Protection of Circuits*

- a) Appropriate protection shall be provided at switchboards, distribution boards and at all levels of panels for all circuits and sub-circuits against short circuit, over-current and other parameters as required. The protective device shall be capable of interrupting maximum prospective short circuit current that may occur, without danger. The ratings and settings of fuses and the protective devices (ACB, MCCB, MCB) shall be co-ordinate so as to afford selectivity in operation and in accordance with accepted standards [(1) IS 8270].
- b) Where circuit-breakers are used for protection of a main circuit and of the sub-circuits derived there from, discrimination in operation may be achieved by adjusting the protective devices of the sub-main circuit-breakers to operate at lower current settings and shorter time-lag than the main circuit-breaker.
- c) Where HRC type fuses are used for back-up protection of circuit-breakers, or where HRC fuses are used for protection of main circuits, and circuit-breakers for the protection of sub-circuits derived there from, in the event of short-circuits protection exceeding the short circuits capacity of the circuit-breakers, the HRC fuses shall operate earlier than the circuit-breakers; but for smaller overloads within the short-circuit capacity of the circuit breakers, the circuit-breakers shall operate earlier than the HRC fuse blows.
- d) If rewirable type fuses are used to protect sub-circuits derived from a main circuit protected by HRC type fuses, the main circuit fuse shall normally blow in the event of a

short-circuit or earth fault occurring on sub-circuit, although discrimination may be achieved in respect of overload currents. The use of rewirable fuses is restricted to the circuits with short-circuit level of 4 kA; for higher level either cartridge or HRC fuses shall be used. However, use of rewirable fuses not desirable, even for lower fault level areas. MCB's provide a better and dependable protection, as their current setting is not temperable.

- e) A fuse carrier shall not be fitted with a fuse element larger than that for which the carrier is designed.
- f) The current rating of a fuse shall not exceed the current rating of the smallest cable in the circuit protected by the fuse.
- g) Every fuse shall have its own case or cover for the protection of the circuit and an indelible indication of its appropriate current rating in an adjacent conspicuous position.

5B.5.4 Voltage and Frequency of Supply

It should be ensured that all equipment connected to the system including any appliances to be used on it are suitable for the voltage and frequency of supply of the system. The nominal values of low and medium voltage systems in Myanmar are 230 V and 400 V ac, respectively, and the frequency 50 Hz.

5B.5.5 Rating of Cables and Equipments

5B.5.5.1 The current-carrying capacity of different types of cables shall be chosen in accordance with Standard practice [(12) IS 3961].

5B.5.5.2 The current ratings of switches for domestic and similar purposes are 6A and 16A.

5B.5.5.3 The current ratings of isolators and normal duty switches and composite units of switches and fuses shall be selected from one of the following values:

16, 25, 32, 63, 100, 160, 200, 320, 400, 500, 630, 800, 1 000 and 1 250 A etc. up to applicable limit.

5B.5.5.4 The ratings of rewirable and HRC fuses shall be in accordance with Standard practice [(13) IS 2086].

5B.5.5.5 The current ratings of miniature circuit-breakers shall be chosen from the values given below:

6, 8, 10, 13, 16, 20, 25, 32, 40, 50, 63, 80, 100 and 125 A.

5B.5.5.6 The current ratings of moulded-case circuit breakers shall be chosen from the values given below:

100, 125, 160, 200, 250, 315, 400, 630, 800, 1 000, 1250, 1600 A and applicable range as practically possible.

5B.5.5.7 The current ratings of air circuit-breakers shall, be chosen from the values given below:

630, 800, 1000, 1250, 1600, 2000, 2500, 3200, 4000 A and applicable range as practically possible.

NOTES

The design of the wiring system and the sizes of the cables should be decided taking into account two factors.

- a) *Voltage Drop*— This should be kept as low as economy permits to ensure proper functioning of all electrical appliances and equipment including motors; and

- b) First cost against operating losses.

5B.5.5.8 The current ratings of the distribution fuse board shall be selected from one of the following values:

6,16,25,63 and 100A

5B.5.6 Installation Circuits

<i>Type of Circuit</i>	<i>Wire Size (Minimum)</i>	<i>Number of Circuits</i>
Lighting	1.0 mm ²	2 or more
Socket-outlets 10 A	2.5 mm ²	Areas such as kitchens and laundries 3x double socket outlets per circuit. Other areas up to 6 double socket outlets
Socket-outlets 15 or 20 A	2.5 mm ²	1
Water heater 3 kW	2.5 mm ²	1
Water heater 3-6 kW	4.0 mm ²	1
Free standing electric range	6.0 mm ²	1
Separate oven and/ or cook top	4.0 mm ²	1
Permanently connected appliances including dish-washers, heaters, etc	2.5 mm ²	1 above 10 A. Up to 10 A can be wired as part of a socket-outlet circuit
Sub mains to garage or out-building	2.5 mm ²	1 for each
Mains cable	16 mm ²	1

5B.5.6.1 Selecting and Installing Cables

5B.5.6.1.1 Cable insulation types

For installation wiring	Polyvinyl chloride (PVC) cables
For main earth or main equipotential wire	Polyvinyl chloride (PVC) insulated conduit wire
Underground installation and installation in cable trench, feeders between buildings etc.,	PVC insulated, PVC sheathed armoured cables or XLPE insulated, PVC sheathed cables armoured cables
Installation in plant rooms, switch rooms etc, on cable tray or ladder or protected trench, where risk of mechanical damage to cable does not exist.	PVC insulated, PVC sheathed or XLPE insulated, PVC sheathed unarmoured cable

For the purposes of this Code cables above 1mm² must have stranded conductors. All cables when installed, must be adequately protected against mechanical damage. This can be carried out by either having additional protection, such as being enclosed in PVC conduit or metal pipes, or placing the cables in a suitable location that requires no additional protection. The cables for wiring circuits in electrical installation must have the appropriate wire size matching the requirement of the loads and the following table gives the recommendations for different types of loads.

BUILDING SERVICES (ELECTRICAL AND ALLIED INSTALLATIONS)

5B.5.6.1.2 Circuit wire sizes

<i>Circuits</i>	<i>Minimum Wire Size</i>	<i>Wire Colour</i>
1-way lighting	2 + E cable wires 1.5 mm ²	Brown-Blue-Green or Green/Yellow
2-way lighting control (straps between the 2 switches)	3-wire cable 1.5 mm ²	Brown –Brown- Blue
Storage water heaters up to 3 kW	2+E cable 1.5 mm ² (stranded conductors)	Brown-Blue-Green or Green/Yellow
Storage water heaters between 3 kW and 6 kW	2 + E cable 2.5 mm ² (stranded conductors)	Brown-Blue-Green or Green/Yellow
Socket-outlets and permanent and permanent connection units	2 + E cable 2.5 mm ² (stranded conductors)	Brown-Blue-Green or Green/Yellow
Submains to garages or outbuildings	2 + E cable 2.5 mm ² (stranded conductors)	Brown-Blue-Green or Green/ Yellow
Cooking hobs	2 + E cable 4 mm ²	Brown-Blue-Green or Green/Yellow
Separate ovens	2 + E cable 4 mm ² (stranded conductors)	
Electric range	2 + E cable 6 mm ² (stranded conductors)	Brown-Blue-Green or Green/Yellow
Mains	2 wire cable 16 mm ² (stranded conductors)	Brown-Blue
Main equipotential bonding wire	Conduit wire 4 mm ² (stranded conductors)	Green or Green/Yellow
Main earth wire	Conduit wire 6 mm ² (stranded conductors) 2 + E is also known as twin and earth	Green or Green/Yellow

Switch or isolator controlling a water heater or geyser should not be located within 1m from the location of a shower or bath tub, to avoid a person in wet condition reaching the switch or isolator. It is preferable to provide the control switch outside the bathroom near the entrance and provide an indication at the water heater. A socket or a connector block with suitable protection against water spray should be provided to connect the water heater. The above considerations apply to switches for outdoor lights and other appliances, with the object of avoidance of operation of a switch when a person is wet. Sockets in kitchen, bathroom, toilet, garage etc, should not be provided within a height of 1 m from the ground level. Similar care has to be taken for installations involving fountains, swimming pools etc. Light fittings in such areas should be fed at low voltage, preferably through an isolating transformer with a proper earth leakage protection.

5B.5.6.2 Requirements for Physical Protection of Underground Cables

<i>Protective Element</i>	<i>Specifications</i>
Bricks	a) 100mm minimum width b) 25 mm thick

	c) sand cushioning 100 mm and sand cover 100 mm.
Concrete slabs	at least 50 mm thick.
Plastic slabs(polymeric cover strips) Fiber reinforced plastic	at least 10 mm thick, depending on properties and has to be matched with the protective cushioning and cover.
PVC conduit or PVC pipe or stoneware pipe or hume pipe	The pipe diameter should be such so that the cable is able to easily slip down the pipe
Galvanized pipe	The pipe diameter should be such so that the cable is able to easily slip down the pipe.

The trench shall be backfilled to cover the cable initially by 200 mm of fill; and then a plastic marker strip over the full length of cable in the trench. Fill the trench shall be laid before filling the full trench. The marker signs where any cable enters or leaves a building shall be put. This will identify that there is a cable located underground near the building. If the cables rise above ground to enter a building or other structure, a mechanical protection such as a GI pipe or PVC pipe for the cable from the trench depth to a height of 2.0 m above ground shall be provided.

5B.5.7 Lighting and Levels of Illumination

5B.5.7.1 General

Lighting installation shall take into consideration the many factors on which the quality and quantity of artificial lighting depends. The modern concept is to provide illumination with the help of a large number of light sources not of higher illumination level. Also much higher levels of illumination are called for, than in the past, often necessitating the use of fluorescent lighting suitably supplemented with incandescent fittings, where required (PART 5A, Building Services (Lighting)).

5B.5.7.2 Future Demand

However, if for financial reasons, it is not possible to provide a lighting installation to give the recommended illumination levels, the wiring installation at least should be so designed that at a later date, it will permit the provision for additional lighting fittings or conversion from incandescent to fluorescent lighting fittings or high efficient LED light to bring the installation to the required standard. It is essential that adequate provisions should be made for all the electrical services which may be required immediately and during the intended useful life of the building.

5B.5.7.3 Principles of Lighting

When considering the function of artificial lighting, attention shall be given to the following principle characteristics before designing an installation:

- a) illumination and its uniformity;
- b) special distribution of light. This includes a reference to the composition of diffused and directional light, direction of incidence, the distribution of luminances and the degree of glare; and
- c) colour temperature of the light and colour rendition.

5B.5.7.4 The variety of purposes which have to be kept in mind while planning the lighting installation could be broadly grouped as:

- a) industrial buildings and processes;
- b) offices, schools and public buildings;
- c) surgeries and hospitals; and

d) hostels, restaurants, shops and residential buildings.

5B.5.7.4.1 It is important that appropriate levels of illumination for these and the types and positions of fittings determined to suit the task and the disposition of the working planes.

5B.5.7.5 For specific requirements for lighting of special occupancies, reference shall be made to Standard practice [(14) IS 2672].

5B.5.7.6 *Energy Conservation*

Energy conservation may be achieved by using the following:

- a) Energy efficient lamps, chokes, ballast, etc for lighting equipment.
- b) Efficient switching systems such as remote sensors, infrared switches, master switches, remote switches, etc for switching ON and OFF of lighting circuits.
- c) Properly made/connected joints/contacts to avoid loose joints leading to loss of power.

5B.5.8 In locations where the system voltage exceeds 650V, as in the case of industrial locations, for details of design and construction of wiring installation, reference may be made to Standard practice [(15) IS 732].

5B.5.9 Guideline for Electrical Layout in Residential Buildings

For guidelines for electrical installation in residential buildings, reference may be made to Standard practice [(16) IS 4648].

A typical distribution scheme in a residential building with separate circuits for lights and fans and for power appliances is given in Figure 1.

5B.5.10 For detailed information regarding the installation of different electrical equipments, reference may be made to Standard Practice [(17) IS 900].

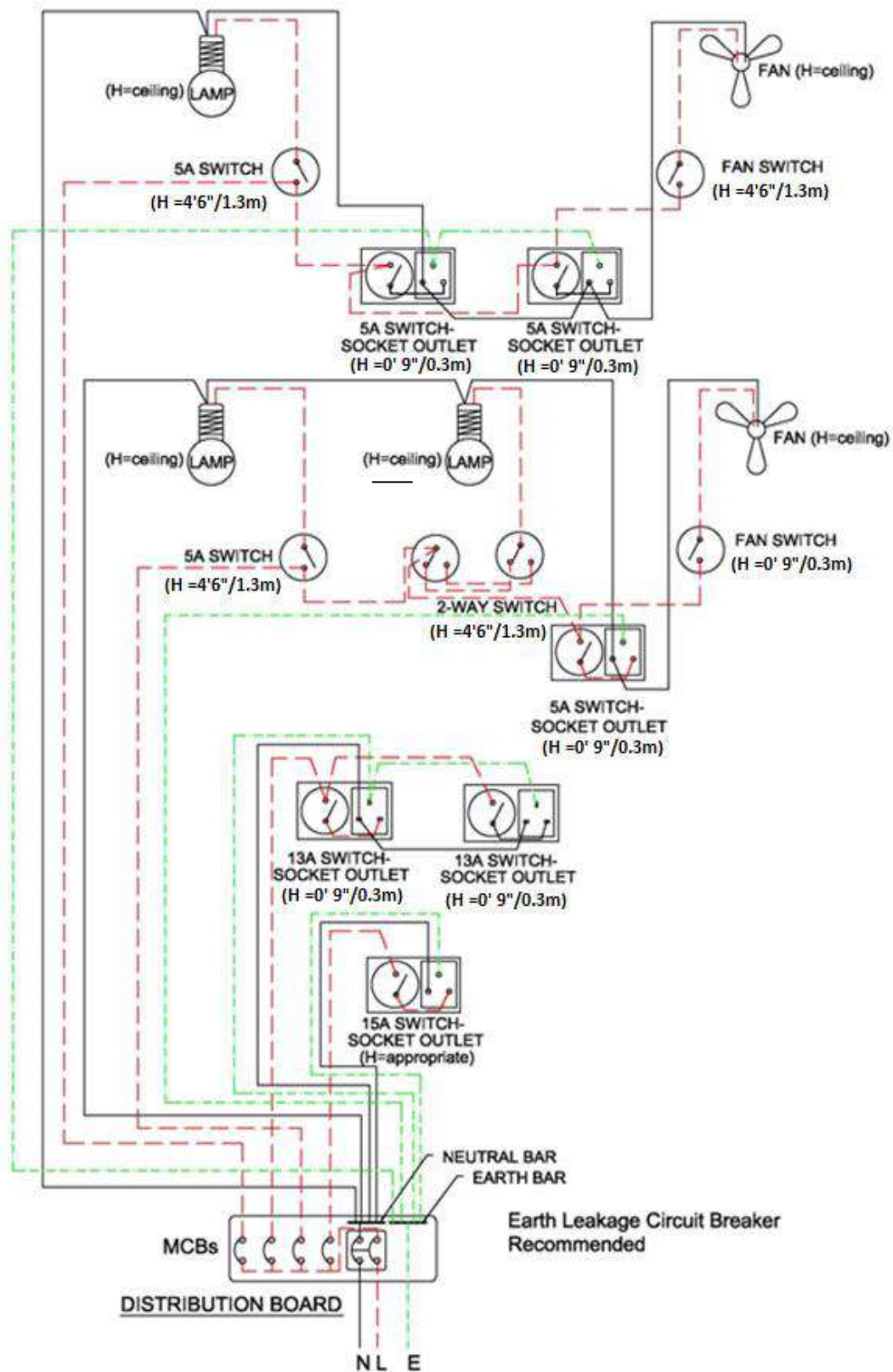


Figure 1: Wiring Diagram for a Typical Distribution Board Scheme in a Residential Building Flat

5B.6 WIRING

5B.6.1 Provision for Maximum Load

All conductors, switches and accessories shall be of such size as to be capable of carrying, without their respective ratings being exceeded, the maximum current which will normally flow through them.

5B.6.1.1 Estimation of Load Requirements

In estimating the current to be carried by any conductor the following ratings shall be taken, unless the actual values are known or specified for these elements:

<i>Element</i>	<i>Rating (in W)</i>
Incandescent lamps	60
Ceiling fans	100
Table fans	
Ordinary socket outlet points	100
Fluorescent tubes:	
Length: 600 mm	25
1 200mm	50
1 500 mm	90
Power socket-outlet	1 000
Air-conditioner	2 500

5B.6.1.2 Electrical installation in a new building shall normally begin immediately on the completion of the main structural building work and before finishing work such as plastering has begun except in the case of surface wiring which can be carried out after the plaster work. Usually, no installation work should start until the building is reasonably weatherproof, but where electric wiring is to be concealed within the structures as may be the case with a reinforced concrete building, the necessary conduits and ducts shall be positioned firmly by tying the conduit to the reinforcement before concreting. When shutters are removed after concreting, the conduits ends shall be given suitable anti-corrosive treatment and holes blocked off by putties or caps to protect conduits from getting blocked. All conduit openings and junction box openings, etc shall be properly protected against entry of mortar, concrete, etc during construction.

5B.6.2 Selection of Size of Conductors

The size of conductors of circuits shall be so selected that the drop in voltage from consumer's terminals in a public supply (or from the busbars of the main switchboard controlling the various circuits in a private generation plant) to any point on the installation does not exceed four percent of the voltage at the consumer's terminals (or at two busbars as these maybe) when the conductors are carrying the maximum current under the normal conditions of service.

5B.6.2.1 If the cable size is increased to avoid voltage drop in the circuit, the rating of the cable shall be the current which the circuit is designed to carry. In each circuit or sub-circuit the fuse shall be selected to match the cable rating to ensure the desired protection.

5B.6.3 Branch Switches

Where the supply is derived from a three-wire or four wire source, and distribution is done on the two-wire system, all branch switches shall be placed in the outer or live conductor of the circuit and no single phase switch or protective device shall be inserted in the middle wire, earth or earthed neutral conductor of the circuit. Single-pole switches (other than for multiple control) carrying not more than 16 A may be of tumbler type or flush type which shall be on when the handle or knob is down.

5B.6.4 Layout and Installation Drawing

5B.6.4.1 The electrical layout should be drawn indicating properly the locations of all outlets for lamps, fans, appliances both fixed and transportable, motors, etc, and best suit for wiring.

5B.6.4.2 All runs of wiring and the exact positions of all points of switch-boxes and other outlets shall be first marked on the plans of the building and approved by the engineer-in-charge or the owner before actual commencement of the work.

5B.6.4.3 Industrial layout drawings should indicate the relative civil and mechanical details.

5B.6.4.4 *Layout of Wiring*

The layout of wiring should be designed keeping in view disposition of the lighting system to meet the illumination levels. All wirings shall be done on the distribution system with main and branch distribution boards at convenient physical and electrical load centres. All types of wiring, whether concealed or unconcealed should be as near the ceiling as possible. In all types of wirings due consideration shall be given for neatness and good appearance.

5B.6.4.5 Balancing of circuits in three-wire or poly-phase installation shall be arranged beforehand. Proper Balancing can be done only under actual load conditions. Conductors shall be so enclosed in earthed metal or incombustible insulating material that it is not possible to have ready access to them. Means of access shall be marked to indicate the voltage present.

Where terminals or other fixed live parts between which a voltage exceeding 250 V exists are housed in separate enclosures or items of apparatus which, although separated are within reach of each other, a notice shall be placed in such a position that anyone gaining access to live parts is warned of the magnitude of the voltage that exists between them.

Where loads are single phase, balancing should be for the peak load condition based on equipment usage. Facility for change should be built into the distribution design.

NOTE — The above requirements apply equally to three-phase circuits in which the voltage between lines or to earth exceeds 250 V and to groups of two or more single-phase circuits, between which medium voltage may be present, derived therefrom. They apply also to 3-wire dc or 3-wire single-phase ac circuits in which the voltage between lines or to earth exceeds 250 V and to groups of 2-wire circuits, between which medium voltage may be present, derived therefrom.

5B.6.4.6 Medium voltage wiring and associated apparatus shall comply, in all respects, with the requirements of Myanmar Electricity Rules.

5B.6.5 Conductors and Accessories

5B.6.5.1 *Conductors*

Conductors for all the internal wiring shall be of copper. Conductors for power and lighting circuits shall be of adequate size to carry the designed circuit load without exceeding the permissible thermal limits for the insulation. The conductor for final sub-circuit for fan and light wiring shall have a nominal cross sectional area not less than 1.50 mm² copper. The cross-

sectional area of conductor for power wiring shall be not less than 4.0 mm² copper. The minimum cross sectional area of conductor of flexible cord shall be 1.50 mm² copper.

In existing buildings where aluminium wiring has been used for internal electrification, changeover from aluminium conductor to copper conductor may be made once the former goes beyond economical repairs.

NOTE — It is advisable to replace wiring, which is more than 30 years old as the insulation also would have deteriorated, and will be in a state to cause failure on the slightest of mechanical or electrical disturbance.

5B.6.5.2 Flexible Cables and Flexible Cords

Flexible cables and cords shall be of copper and stranded and protected by flexible conduits or tough rubber or PVC sheath to prevent mechanical damage.

5B.6.5.3 Cable Ends

When a stranded conductor having a nominal sectional area less than 6 mm² is not provided with cable sockets, all strands at the exposed ends of the cable shall be soldered together or crimped using suitable sleeve or ferrules

5B.6.5.4 Special Risk

Special forms of construction, such as flameproof enclosures, shall be adopted where there is risk of the fire or explosion

5B.6.5.5 Connection to Ancillary Buildings

Unless otherwise specified, electric connections to ancillary buildings, such as out-houses, garages, etc, adjacent to the main building and when no roadway intervenes shall be taken in an earthed GI pipe or heavy-duty PVC or HDPE pipe of suitable size in the exposed portion at a height of not less than 5.8 m or by buried underground cables. This applies to both runs of mains or sub-mains or final sub-circuit wiring between the buildings.

5B.6.5.6 Expansion Joints

Distribution boards shall be so located that the conduits shall not normally be required to cross expansion joints in a building. Where such crossing is found to be unavoidable, special care shall be taken to ensure that the conduit runs and wiring are not in any way put to strain or damaged due to expansion of building structure. Any one of the standard methods of connection at a structural expansion joint shall be followed:

- a) Flexible conduit shall be inserted at place of expansion joint.
- b) Oversized conduit overlapping the conduit.
- c) Expansion box.

5B.6.5.7 Low Voltage (Types of Wires/Cables)

Low voltage services utilize various categories of cables/wires, such as Fibre optic cable, co-axial, etc. These shall be laid at least minimum specified distance of 300 mm from any power wire or cable. Special care shall be taken to ensure that the conduit runs and wiring are laid properly for low voltage signal to flow through it.

5B.6.6 Joints and Looping Back

5B.6.6.1 Where looping back system of wiring is specified, the wiring shall be done without any junction or connector boxes on the line. Where joint box system is specified, all joints in conductors shall be made by means of suitable mechanical connectors in suitable joint boxes.

Wherever practicable, looping back system should be preferred. Whenever practicable, only one system shall be adopted for a building, preferably a looping back system.

5B.6.6.2 In any system of wiring, no bare or twist joints shall be made at intermediate points in the through run of cables unless the length of a final sub-circuit, sub-main or main or more than the length of the standard coil as given by the manufacturer of the cable. If any jointing becomes unavoidable such joint shall be made through proper cutouts or through proper junction boxes open to easy inspection, but in looping back system no such junction boxes shall be allowed.

5B.6.6.3 Joints are a source of problems in reliability and are also vulnerable to fire. They should be avoided or at least minimized. Where joints in cable conductors or bare conductors are necessary, they shall be mechanically and electrically sound. Joints in non-flexible cables shall be accessible for inspection; provided that this requirement shall not apply to joints in cables buried underground, or joints buried or enclosed in non-combustible building materials. Joints in non-flexible cables shall be made by soldering, brazing, welding or mechanical clamps, or be of the compression type; provided that mechanical clamps shall not be used for inaccessible joints buried or enclosed in the building structure. All mechanical clamps and compression type sockets shall securely retain all the wires of the conductors. Any joint in a flexible cable of flexible cord shall be effected by means of a cable coupler.

For flexible cables for small loads less than 1 kW, while it would be desirable to avoid joints, if unavoidable, joints can be made either by splicing by a recognized method or by using a connector and protecting the joint by suitable insulating tape or sleeve or straight joint. For application of flexible cable for loads of 1 kW or more, if joint is unavoidable, crimped joint would be preferred. Spliced joint should not be used for large loads.

There are different standard joints such as epoxy resin based joint, heat shrinkable plastic sleeve joint etc, and each one has its advantage and disadvantage. Selection has to be made on the basis of application, site conditions and availability of skilled licensed workmen.

5B.6.6.4 Every joint in a cable shall be provided with insulation not less effective than that of the cable cores and shall be protected against moisture and mechanical damage. Soldering fluxes which remain acidic or corrosive at the completion of the soldering operation shall not be used.

For joints in paper-insulated metal-sheathed cables, a wiped metal sleeve or joint box, filled with insulating compound, shall be provided.

Where an aluminium conductor and a copper conductor are joined together, precautions shall be taken against corrosion and mechanical damage to the conductors.

5B.6.6.5 *Pull at Joints and Terminals*

Every connection at a cable termination shall be made by means of a terminal, soldering socket, or compression type socket and shall securely contain and anchor all the wires of the conductor, and shall not impose any appreciable mechanical strain on the terminal or socket.

Flexible cords shall be so connected to devices and to fittings that tension will not be transmitted to joints or terminal screws. This shall be accomplished by a knot in the cord, by winding with tape, by a special fitting designed for that purpose, or by other approved means which will prevent a pull on the cord from being directly transmitted to joints or terminal screws.

5B.6.7 *Passing Through Walls and Floors*

5B.6.7.1 Where conductors pass through walls, one of the following methods shall be employed. Care shall be taken to see that wires pass freely through protective pipe or box and that the wires pass through in a straight-line without any twist or cross in wires on either ends of such holes:

- a) The conductor shall be carried either in a rigid steel conduit or a rigid non-metallic conduit conforming to accepted standards [(19) IS 2667].

b) *Conduit colour coding*

The conduits shall be colourcoded as per the purpose of wire carried in the same. The colour coding may be in form of bands of colour (4 inch thick, with centre-to-centre distance of 12 inches) or coloured throughout in the colour. The colour scheme shall be as follows:

<i>Conduit Type</i>	<i>Colour Scheme</i>
Power conduit	Black
Security conduit	Blue
Fire alarm conduit	Red
Low voltage conduit	Brown
UPS conduit	Green

c) *Cable trunking/cable ways*

For the smaller cables, enclosures such as conduit and trunking, may be employed and PVC-insulated, with or without sheath, single core cables installed following completion of the conduit/trunking system. As these cables are usually installed in relatively large groups, care must be taken to avoid overheating and to provide identification of the different circuits.

d) *Tray and ladder rack*

As tray provides continuous support, unless mounted on edge or in vertical runs (when adequate strapping or clipping is essential), the mechanical strength of supported cable is not as important as with ladder-racking or structural support methods. Consequently, tray is eminently suitable for the smaller unarmoured cabling while racks and structural support, except for short lengths, call for armoured cables as they provide the necessary strength to avoid sagging between supports. Both tray and ladder racks can be provided with accessories to facilitate changes of route, and as PVC and similar insulating materials are non-migratory (unlike the older types of impregnated cables) they provide no difficulty in this respect on vertical runs,

Insulated conductors while passing through floors shall be protected from mechanical injury by means of rigid steel conduit, non-metal conduit or mechanical protection to a height not less than 1.5 m above the floors and flush with the ceiling below. This steel conduit shall be earthed and securely bushed. Power outlets and wiring in the floor shall be generally avoided. If not avoidable, use false floor or floor trunking. False floor shall be provided where density of equipment and interconnection between different pieces of equipment is high. Examples are: Mainframe Computer station, Telecommunication switch rooms, etc.

Floor trunking shall be used in large halls, convention centres, open plan offices, laboratory, etc.

In case of floor trunking drain points shall be provided, as there could be possibility of water seepage in the case of wiring passing through the floors. Proper care should be taken for suitable means of draining of water. Possibility of water entry exists from: (1) floor washing, (2) condensation in some particular weather and indoor temperature conditions. At the design stage, these aspects have to be assessed and an appropriate means of avoiding, or reducing, and draining method will have to be built in.

Floor outlet boxes are generally provided for the use of appliances, which require a signal, or communication connection. The floor box and trunking system should cater to serve both power distribution and the signal distribution, with appropriate safety and non-interference.

5B.6.7.2 Where a wall tube passes outside a building so as to be exposed to weather, the outer end shall be bell-mouthed and turned downwards and properly bushed on the open end.

5B.6.8 Wiring of Distribution Boards

5B.6.8.1 All connections between pieces of apparatus or between apparatus and terminals on a board shall be neatly arranged in a definite sequence, following the arrangements of the apparatus mounted thereon, avoiding unnecessary crossings.

5B.6.8.2 Cables shall be connected to a terminal only by soldered or welded or crimped lugs using suitable sleeve, lugs or ferrules unless the terminal is of such a form that it is possible to securely clamp them without the cutting away of cables stands. Cables in each circuit shall be bunched together.

5B.6.8.3 All bare conductors shall be rigidly fixed in such a manner that a clearance of at least 25 mm is maintained between conductors of opposite polarity or phase and between the conductors and any material other than insulation material.

5B.6.8.4 If required, a pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus-bars of the board.

5B.6.8.5 In a hinged type board, the incoming and outgoing cables shall be fixed at one or more points according to the number of cables on the back of the board leaving suitable space in between cables, and shall also, if possible, be fixed at the corresponding points on the switchboard panel. The cables between these points shall be of such length as to allow the switchboard panel to swing through on angle of not less than 90°. The circuit breakers in such cases shall be accessible without opening the door of distribution board. Also, circuit breakers or any other equipment (having cable size more than 1.5 sq. mm multi strand wire) shall not be mounted on the door.

NOTE — Use of hinged type boards is discouraged, as these boards lead to deterioration of the cables in the hinged portion, leading to failures or even fire.

5B.6.8.6 Wires terminating and originating from the protective devices shall be properly lugged and taped.

5B.6.9 PVC-Sheathed Wiring System

5B.6.9.1 General

Wiring with PVC-sheathed cables is suitable for medium voltage installation and may be installed directly under exposed conditions of sun and rain or damp places.

5B.6.9.2 PVC Clamps/PVC Channel

Link clips had been the common system for wiring on wooden batten, which is now phased out. PVC clamps/PVC channel shall conform accepted standards. The clamps shall be used for temporary installations of 1-3 sheathed wires only. The clamps shall be fixed on wall at intervals of 100 mm in the case of horizontal runs and 150 mm in the case of vertical runs.

PVC channel shall be used for temporary installations in case more than 3 wires or wires or unsheathed wires. The channel shall be clamped on wall at intervals not exceeding 300 mm.

5B.6.9.3 Protection of PVC-Sheathed Wiring from Mechanical Damage

- a) In cases where there are chances of any damage to the wirings, such wirings shall be covered with sheet metal protective covering, the base of which is made flush with the

plaster or brickwork, as the case may be, or the wiring shall be drawn through a conduit complying with all requirements of conduit wiring system (see 6.10).

- b) Such protective coverings shall in all cases be fitted on all down-drops within 1.5 m from the floor.

5B.6.9.4 Bends in Wiring

The wiring shall not in any circumstances be bent so as to form a right angle but shall be rounded off at the corners to a radius not less than six times the overall diameter of the cable.

5B.6.9.5 Passing Through Floors

All cables taken through floors shall be enclosed in an insulated heavy gauge steel conduit extending 1.5 m above the floor and flush with the ceiling below, or by means of any other approved type of metallic covering. The ends of all conduits or pipes shall be neatly bushed with porcelain, wood or the approved material.

5B.6.9.6 Passing Through Walls

The method to be adopted shall be according to good practice. There shall be one or more conduits of adequate size to carry the conductors [see **5B.6.10.1(a)**]. The conduits shall be neatly arranged so that the cables enter them straight without bending.

5B.6.9.7 Stripping of Outer Covering

While cutting and stripping of the outer covering of the cables, care shall be taken that the sharp edge of the cutting instrument does not touch the rubber or PVC-sheathed insulation of conductors. The protective outer covering of the cables shall be stripped off near connecting terminals, and this protective covering shall be maintained up to the close proximity of connecting terminals as far as practicable. Care shall be taken to avoid hammering on link clips with any metal instruments, after the cables are laid. Where junction boxes are provided, they shall be made moisture-proof with an approved plastic compound.

5B.6.9.8 Painting

If so required, the tough rubber-sheathed wiring shall, after erection, be painted with one coat of oil-less paint or distemper of suitable colour over a coat of oil-less primer, and the PVC-sheathed wiring shall be painted with a synthetic enamel paint of quick drying type.

5B.6.10 Conduit Wiring System

5B.6.10.1 Surface Conduit Wiring System with Rigid Steel Conduits

- a) *Type and size of conduit*— All conduit pipes shall conform to accepted standards [(19)IS2667], finished with galvanized or stove enameled surface. All conduit accessories shall be of threaded type and under no circumstance pin grip type or clamp type accessories be used. No steel conduit less than 16 mm in diameter shall be used. The number of insulated conductors that can be drawn into rigid conduit are given in Tables 1 and 2.
- b) *Bunching of cables*— Unless otherwise specified, insulated conductors of ac supply and dc supply shall be bunched in separate conduits. For lighting and small power outlet circuits phase segregation in separate conduits is recommended.
- c) *Conduit joints*— Conduit pipes shall be joined by means of screwed couplers and screwed accessories only [(19)IS2667]. In long distance straight runs of conduit, inspection type couplers at reasonable intervals shall be provided or running threads with couplers and jam-nuts (in the latter case the bare threaded portion shall be treated with anti-corrosive

preservative) shall be provided. Threaded on conduit pipes in all cases shall be between 11 mm to 27 mm long sufficient to accommodate pipes to full threaded portion of couplers or accessories. Cut ends of conduit pipes shall have no sharp edges nor any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

- d) *Protection against dampness*— In order to minimize condensation or sweating inside the tube, all outlets of conduit system shall be properly drained and ventilated, but in such a manner as to prevent the entry of insects as far as possible.
- e) *Protection of conduit against rust*— The outer surface of the conduit pipes, including all bends, unions, tees, conduit system shall be adequately protected against rust particularly when such system is exposed to weather. In all cases, no bare threaded portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anti-corrosive preservative or covered with suitable plastic compound.
- f) *Fixing of conduit*— Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable wood plugs or other plugs with screws in an approved manner at an interval in an approved manner at an interval of not more than 1 m, but on either side of couplers or bends or similar fittings, saddles shall be fixed at a distance of 300 cm from the centre of such fittings.
- g) *Bends in conduit*— All necessary bends in the system including diversion shall be done by bending pipes; or by inserting suitable solid or inspection type normal bends, elbows or similar fittings; or fixing cast iron, thermoplastic or thermosetting plastic material inspection boxes whichever is more suitable. Conduit fittings shall be avoided as far as possible on conduit system exposed to weather; where necessary, solid type fittings shall be used. Radius of such bends in conduit pipes shall be not less than 7.5 cm. No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlets not being counted,
- h) *Outlets*— All outlets for fittings, switches, etc, shall be boxes of suitable metal or any other approved outlet boxes for either surface mounting system.
- i) *Conductors*— All conductors used in conduit wiring shall preferably be stranded. No single-core cable of nominal cross-sectional area greater than 130 mm² enclosed along in a conduit and used for alternating current,
- j) *Erection and earthing of conduit*— The conduit of each circuit or section shall be completed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirements as already specified by means of suitable earthing clamp efficiently fastened to conduit pipe in a workman like manner for a perfect continuity between each wire and conduit. Gas or water pipes shall not be used as earth medium. If conduit pipes are liable to mechanical damage they shall be adequately protected.
- k) Inspection type conduit fittings, such as inspection boxes, draw boxes, bends, elbows and tees shall be so installed that they can remain accessible for such purposes as to withdrawal of existing cables or the installing of traditional cables.

5B.6.10.2 Recessed Conduit Wiring System with Rigid Steel Conduit

Recessed conduit wiring system shall comply with all the requirements for surface conduit wiring system specified in **5B.6.10.1 (a) to (j)** and in addition, conform to the requirements specified below:

- a) *Making of chase*— The chase in the wall shall be nearly made and be of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, chases shall be provided. In the wall, ceiling, etc., at the time of their construction and shall be filled up neatly after reaction of conduit and brought to the original finish of the wall. In case of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work.
- b) *Fixing of conduit in chase*— The conduit pipe shall be fixed by means of staples or by means of saddles not more than 600 mm apart. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with a long radius which will permit easy drawing-in of conductors. All threaded joints of rigid steel conduit shall be treated with preservative compound to secure protection against rust.
- c) *Inspection boxes*— Suitable inspection boxes shall be provided to permit periodical inspection and to facilitate removal of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating holes shall be provided in the inspection box covers. The minimum sizes of inspection boxes shall be 75 mm x 75 mm.
- d) *Types of accessories to be used*— All outlet, such as switches and wall sockets, may be either of flush mounting type or of surface mounting type.
 - 1) *Flush mounting type*— All flush mounting outlets shall be of cast-iron or mild steel boxes with a cover of insulating material or shall be a box made of a suitable insulating material. The switches and other outlets shall be mounted on such boxes. The metal box shall be efficiently earthed with conduit by a suitable means of earth attachment.
 - 2) The switches/socket outlets shall be adequately rated IP for various utilizations.
 - 3) *Surface mounting type*— If surface mounting type outlet box is specified, it shall be of any suitable insulating material and outlets mounted in an approved manner.

5B.6.10.3 Conduit Wiring System with Rigid Non-Metallic Conduits

Rigid non-metallic conduits are used for surface, recessed and concealed conduit wiring. Cable trunking and ducting system of insulating material are used for surface wiring.

5B.6.10.3.1 Type and size

All non-metallic conduits used shall conform to accepted standards [(19)IS 2667]. The conduit may be either threaded type or plain type in accordance with accepted standards [(19)IS 2667] and shall be used with the corresponding accessories. The conduits shall be circular or rectangular cross-sections.

5B.6.10.3.2 Bunching of cables

Conductors of ac supply and dc supply shall be bunched in separate conduits. For lighting and small power outlet circuits phase segregation in separate circuits is recommended. The number of insulated cables that may be drawn into the conduits are given in **Table 1** and **Table 2**. In these tables the space factor does not exceed 40 percent.

5B.6.10.3.3 Conduit joints

Conduits shall be joined by means of screwed or plain couplers depending on whether the conduits are screwed or plain. Where there are long runs of straight conduit, inspection type couplers shall be provided at intervals. For conduit fittings and accessories reference may be made to the Standard practice [(19) IS 2667].

Table 1: Maximum Permissible Number of Single-Core Cables up to and Including 1100 V that can be Drawn into Rigid Steel and Rigid Non-Metallic Conduits

(Clauses 5B.6.10.1 and 5B.6.10.3.2)

Size of Cable		Size of Conduit(mm)													
Nominal Cross Section Area mm ²	Number and Diameter(in mm)of Wires	(Number of Cable, Max)													
		16		20		25		32		40		50		60	
		S	B	S	B	S	B	S	B	S	B	S	B	S	B
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1.0	1/1.12 ¹⁾	5	4	7	5	13	10	20	14	-	-	-	-	-	-
1.5	1/1.40	4	3	7	5	12	10	20	14	-	-	-	-	-	-
2.5	1/1.80	3	2	0	5	10	8	18	12	-	-	-	-	-	-
	3/1.06 ¹⁾														
4	1/2.24	3	2	4	3	7	8	12	10	-	-	-	-	-	-
	7/0.85 ¹⁾														
6	1/2.80	2	-	3	2	6	5	10	8	-	-	-	-	-	-
	7/1.06 ¹⁾														
10	7/1.40 ¹⁾	-	-	2	-	4	3	6	5	8	6	-	-	-	-
16	7/1.70	-	-	-	-	2	-	4	3	7	6	-	-	-	-
25	7/2.24	-	-	-	-	-	-	3	2	5	4	8	6	9	7
35	7/2.50	-	-	-	-	-	-	2	-	4	3	7	5	8	6
50	19/1.80														

NOTES

1 The table shows the maximum capacity of conduits for the simultaneously drawing of cables. The columns headed S apply to runs of conduit which have distance not exceeding 4.25 m between draw-in boxes, and which do not deflect from the straight by an angle of more than 15°. The columns headed B apply to runs of conduit which deflect from the straight by an angle of more than 15°.

2 In case an inspection type draw-in box has been provide and if first drawn through one straight conduit, then through the draw in box, and then through the second straight conduit, such systems may be considered as that of a straight conduit even if the conduit deflects through the straight by more than 15°

¹⁾ For copper conductor only.

Table 2: Maximum Permissible Number of Single-Core Cables that can be Drawn into Cable Tunneling/Trunking and Ducting System (Casing and Capping)

(Clauses 5B.6.10.1 and 5B.6.10.3.2)

Normal Cross- Sectional Area of Conductor in mm ²	10/15mm x 10mm	20mm x 10mm	25mm x 10mm	30mm x 10mm	40mm x 20mm	50mm x 20mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.5	3	5	6	8	12	18
2.5	2	4	5	6	9	15
4	2	3	4	5	8	12
6	-	2	3	4	6	9
10	-	1	2	3	5	8
16	-	-	1	2	4	6
25	-	-	-	1	3	5
35	-	-	-	-	2	4
50	-	-	-	-	1	3
70	-	-	-	-	1	2

5B.6.10.3.4 *Fixing of conduits*

The provisions of **5B.6.10.1(f)** shall apply except that the spacing between saddles or supports is recommended to be 600 cm for rigid non-metallic conduits.

5B.6.10.3.5 *Bends in conduits*

Wherever necessary, bends or diversions may be achieved by bending the conduits (see **5B.6.10.3.8**) or by employing normal bends, inspection bends, inspection boxes, elbows or similar fittings.

5B.6.10.3.6 Conduit fittings shall be avoided, as far as possible, on outdoor systems

5B.6.10.3.7 *Outlets*

In order to minimize condensation or sweating inside the conduit, all outlets of conduit system shall be properly drained and ventilated, but in such a manner as to prevent the entry of insects.

5B.6.10.3.8 Heat may be used to soften the conduit for bending and forming joints in case of plain conduits. As the material softens when heated, sitting of conduit in close proximity to hot surfaces should be avoided. Caution should be exercised in the use of this conduit in locations where the ambient temperature is 50°C or above. Use of such conduits in places where ambient temperature is 60°C or above is prohibited.

5B.6.10.3.9 Non-metallic conduit systems shall be used only where it is ensured that they are:

- a. suitable for the extremes of ambient temperature to which they are likely to be subjected in service,
- b. resistant to moisture and chemical atmospheres, and
- c. resistant to low temperature and sunlight effects.

For use underground, the material shall be resistant to moisture and corrosive agents.

NOTE — Rigid PVC conduits are not suitable for use where the normal working temperature of the conduits and fittings may exceed 55°C. Certain types of rigid PVC conduits and their associated fittings are unsuitable for use where the ambient temperature is likely to fall below -5°C.

5B.6.10.4 *Non-Metallic Recessed Conduit Wiring System*

5B.6.10.4.1 Recessed non-metallic conduit wiring system shall comply with all the requirements of surface nonmetallic conduit wiring system specified in **5B.6.10.3.1** to **5B.6.10.3.9** except **5B.6.10.3.4**. In addition, the following requirements **5B.6.10.4.2** to **5B.6.10.4.5** also shall be complied with.

5B.6.10.4.2 *Fixing of conduit in chase*

The conduit pipe shall be fixed by means of staples or by means of non-metallic saddles placed at not more than 80 cm apart or by any other approved means of fixing. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves shall be maintained by sending the conduit pipe itself with along radius which will permit easy drawing in of conductors. At either side of bends, saddles/staples shall be fixed at a distance of 15 cm from the centre of bends.

5B.6.10.4.3 *Inspection boxes*

Suitable inspection boxes to the nearest minimum requirements shall be provided to permit periodical inspection and to facilitate replacement of wires, if necessary. The inspection/junction boxes shall be mounted flush with the wall or ceiling concrete. Where necessary deeper boxes of suitable dimensions shall be used. Suitable ventilating holes shall be provided in the inspection box covers, where required.

5B.6.10.4.4 The outlet boxes such as switch boxes, regulator boxes and their phenolic laminated sheet covers shall be as per requirements of **5B.6.10.1(h)**,

They shall be mounted flush with the wall.

5B.6.10.4.5 *Types of accessories to be used*

All outlets such as switches, wall sockets, etc, maybe either flush mounting type or of surface mounting type.

5B.7 FITTINGS AND ACCESSORIES

5B.7.1 Ceiling Roses and Similar Attachments

5B.7.1.1A ceiling rose or any other similar attachment shall not be used on a circuit the voltage of which normally exceeds 250 V.

5B.7.1.2 Normally, only one flexible cord shall be attached to a ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.

5B.7.1.3A ceiling rose shall not embody fuse terminal as an integral part of it.

5B.7.2 Socket-Outlets and Plugs

Each 16A socket-outlet provided in buildings for the use of domestic appliances such as air conditioner, water cooler, etc, shall be provided with its own individual fuse, with suitable discrimination with backup fuse or miniature circuit-breaker provided in the distribution/sub-distribution board. The socket-outlet shall not necessarily embody the fuse as an integral part of it.

5B.7.2.1 Each socket-outlet shall also be controlled by a switch which shall preferably be located immediately adjacent thereto or combined therewith.

5B.7.2.2 The switch controlling the socket-outlet shall be on the live side of the line.

5B.7.2.3 Ordinary socket-outlet may be fixed at any convenient place at a height above 20 cm from the floor level and shall be away from danger of mechanical injury.

NOTE — In situations where a socket-outlet is accessible to children, it is necessary to install an interlocked plug and socket or alternatively a socket-outlet which automatically gets screened by the withdrawal of plug. In industrial premises socket-outlet of rating 20 A and above shall preferably be provided with interlocked type switch.

5B.7.2.4 In an earthed system of supply, a socket-outlet with plug shall be of three-pin type with the third terminal connected to the earth. When such socket outlets with plugs are connected to any current consuming device of metal or any non-insulating material or both, conductors connecting such current consuming devices shall be of flexible cord with an earthing core and the earthing core shall be secured by connecting between the earth terminal of plug and the body of current-consuming devices.

In industrial premises three-phase and neutral socket-outlets shall be provided with a earth terminal either of pin type or scrapping type in addition to the main pins required for the purpose.

5B.7.2.5 In wiring installations, metal clad switch, socket outlet and plugs shall be used for power wiring.

NOTE —A recommended schedule of socket-outlets in a residential building is given below:

<i>Location</i>	<i>Number of 5A Socket-Outlets</i>	<i>Number of 15A Socket-Outlets</i>
Bed room	2 to 3	1
Living room	2 to 3	2
Kitchen	1	2
Dining room	2	1
Garage	1	1
For refrigerator	-	1
For air conditioner	-	(one for each)
VERANDAH	1 per 10m ²	1
Bathroom	1	1

5B.7.3 Lighting Fittings

5B.7.3.1 A switch shall be provided for control of every lighting fitting or a group of lighting fittings. Where control at more than one point is necessary as many two way or intermediate switches may be provided as there are control points.

5B.7.3.2 In industrial premises lighting fittings shall be supported by suitable pipe/conduits, brackets fabricated from structural steel, steel chains or similar materials depending upon the type and weight of the fittings.

5B.7.3.3 No flammable shade shall form a part of lighting fittings unless such shade is well protected against all risks of fire. Celluloid shade or lighting fittings shall not be used under any circumstances.

5B.7.3.4 General and safety requirements for electrical lighting fittings shall be in accordance with Standard practice [(20) IS 1913].

5B.7.3.5 The lighting fittings shall conform to accepted standards [(10) IS 1777].

5B.7.4 Fitting-Wire

The use of fittings-wire shall be restricted to the internal wiring of the lighting fittings. Where fittings-wire is used for wiring fittings, the sub-circuit loads shall terminate in a ceiling rose or box with connectors from which they shall be carried into the fittings.

5B.7.5 Lampholders

Lampholders for use on brackets and the like shall be in accordance with accepted standards [(21)IS1258] and all those for use with flexible pendants shall be provided with cord grips. All lampholders shall be provided with shade carriers. Where centre-contact Edison screw lampholders are used, the outer or screw contacts shall be connected to the 'middle wire', the neutral, the earthed conductor of the circuit.

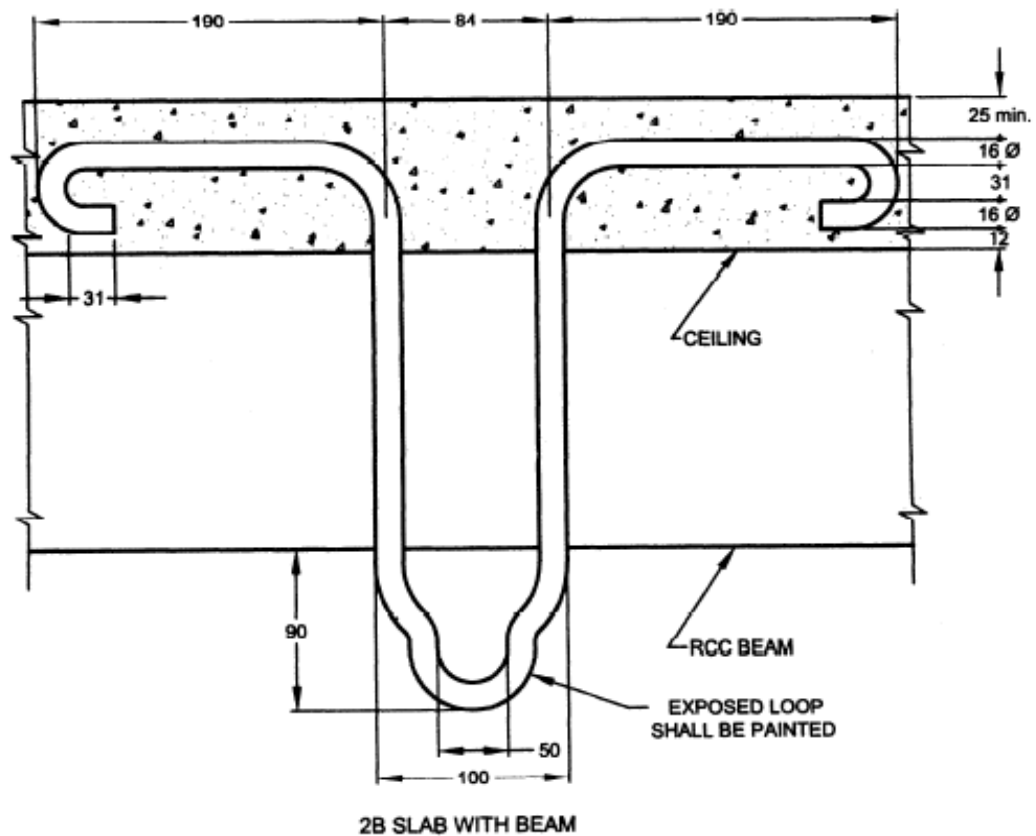
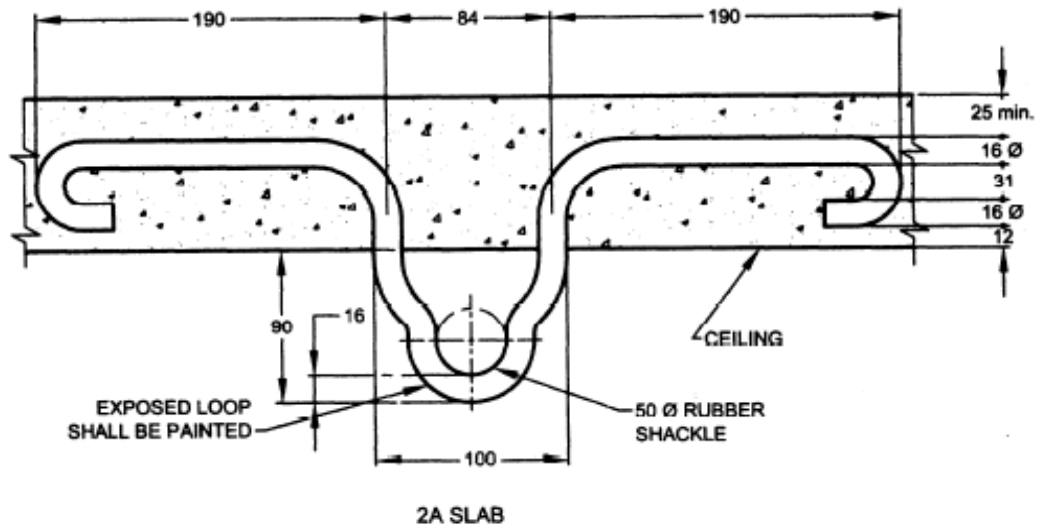
5B.7.6 Outdoor Lamps

External and road lamps shall have weatherproof fittings of approved design so as to effectively prevent the ingress of moisture and dust. Flexible cord and cord grip lampholders shall not be used where exposed to weather. In VERANDAHS and similar exposed situations where pendants are used, these shall be of fixed rod type.

5B.7.7 Lamps

All lamps unless otherwise required and suitably protected, shall be hung at a height of not less than 2.5 m above the floor level. All electric lamps and accessories shall conform to accepted standards[(22)IS 418]

- a) Portable lamps shall be wired with flexible cord. Hand lamps shall be equipped with a handle of moulded composition or other material approved for the purpose. Hand lamps shall be equipped with a substantial guard attached to the lampholder or handle. Metallic guards shall be earthed suitably.
- b) A bushing or the equivalent shall be provided where flexible cord enters the base or stem of portable lamp. The bushing shall be of insulating material unless a jacketed type of cord is used.
- c) All wiring shall be free from short-circuits and shall be tested for these defects prior to being connected to the circuit.
- d) Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least 125 mm between live parts and the mounting plane of the fixture.



a) All dimensions in millimetres

NOTES

- 1) RCC slab steel reinforcement not shown.
- 2) Fan clamp shall be placed in position such that its projecting arms in the line of length of beam.

Figure 2: Typical Design of Fan Clamps

5B.7.8 Fans, Regulators and Clamps**5B.7.8.1 Ceiling Fans**

Ceiling fans including their suspension shall conform to accepted standards[(23) IS 374] and to the following requirements:

- a) Control of a ceiling fan shall be through its own regulator as well as a switch in series.
All ceiling fans shall be wired with normal wiring to ceiling roses or to special connector boxes to which fan rod wires shall be connected and suspended from hooks or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension rod, but if joints are unavoidable then such joints shall be screwed to special couplers of 5 cm minimum length and both ends of the pipes shall touch together within the couplers, and shall in addition be secured by means of split pins; alternatively, the two pipes may be welded. The suspension rod shall be of adequate strength to withstand the dead and impact forces imposed on it. Suspension rods should preferably be procured along with the fan.
- b) Fan clamps shall be of suitable design according to the nature of construction of ceiling on which these clamps are to be fitted. In all cases fan clamps shall be fabricated from new metal of suitable sizes and they shall be as close fitting as possible. Fan clamps for reinforced concrete roofs shall be buried with the casting and due care shall be taken that they shall serve the purpose. Fan clamps for wooden beams, shall be of suitable flat iron fixed on two sides of the beam and according to the size and section of the beam one or two mild steel bolts passing through the beam shall hold both flat irons together. Fan clamps for steel joist shall be fabricated from flat iron to fit rigidly to the bottom flange of the beam. Care shall be taken during fabrication that the metal does not crack while hammer to shape. Other fan clamps shall be made to suit the position, but in all cases care shall be taken to see that they are rigid and safe.
- c) Canopies on top and bottom of suspension rods shall effectively conceal suspensions and connections to fan motors, respectively.
- d) The lead-in-wire shall be of nominal cross sectional area not less than 1.5 mm² copper and shall be protected from abrasion.
- e) Unless otherwise specified, the clearance between the bottom most point of the ceiling fan and the floor shall be not less than 2.4 m. The minimum clearance between the ceiling and the plane of the blades shall be not less than 300 mm.

Atypical arrangement of a fan clamp is given in Figure 2.

NOTE – All fan clamps shall be so fabricated that fans revolve steadily.

5B.7.8.2 Exhaust fans

For fixing of an exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame which shall be fixed by means of rag-bolts embedded in the wall. The hole shall be nearly plastered with cement and brought to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.

5B.7.9 Attachment of Fittings and Accessories

5B.7.9.1 In wiring other than conduit wiring, all ceiling roses, brackets, pendants and accessories attached to walls or ceilings shall be mounted on substantial teakwood blocks twice varnished

after all fixing holes are made in them. Blocks shall not be less than 4 cm deep. Brass screws shall only be used for attaching fittings and accessories to their base blocks.

5B.7.9.2 Where teak or hardwood boards are used for mounting switches, regulators, etc, these boards shall be well varnished with pure shellac on all four sides(both inside and outside), irrespective of being painted to match the surroundings. The size of such boards shall depend on the number of accessories that could conveniently and neatly be arranged. Where there is danger of attack by white ants, the boards shall be treated with suitable anti-termite compound and painted on both sides.

5B.7.10 Interchangeability

Similar part of all switches, lampholders, distribution fuse-boards, ceiling roses, brackets, pendants, fans and all other fittings shall be so chosen that they are of the same type and interchangeable in each installation.

5B.7.11 Equipment

Electrical equipment which form integral part of wiring intended for switching or control or protection of wiring installations shall conform to the relevant Standards wherever they exist.

5B.7.12 Fanning

5B.7.12.1 Where ceiling fans are provided, the bay sizes of a building, which control fan point locations, play an important part.

5B.7.12.2 Fans normally cover an area of 9 m^2 to 10 m^2 and therefore in general purpose office buildings, for every part of a bay to be served by the ceiling fans, it is necessary that the bays shall be so designed that full number of fans could be suitably located for the bay, otherwise it will result in ill-ventilated pockets. In general, fans in long halls may be spaced at 3 m in both the directions. If building modules do not lend themselves for proper positioning of the required number of ceiling fans, such as air circulators or bracket fans would have to be employed for the areas uncovered by the ceiling fans. For this, suitable electrical outlets shall be provided although result will be disproportionate to cost on account of fans.

5B.7.12.3 Proper air circulation could be achieved either by larger number of smaller fans or smaller number of larger fans. The economics of the system as a whole should be a guiding factor in choosing the number and type of fans and their locations.

5B.7.12.4 Exhaust fans are necessary for spaces, such as community toilets, kitchens and canteens, and godowns to provide the required number of air changes.

5B.7.12.5 Positioning of fans and light fittings shall be chosen to make these effective without causing shadows and stroboscopic effect on the working planes.

5B.8 EARTHING

5B.8.1 General

Earthing shall generally be carried out in accordance with the requirements of Myanmar Electricity Rules.

The main earthing system of an electrical installation must consist of:

- a) An earth electrode;
- b) A main earthing wire;

- c) An earth bar (located on the main switchboard) for the connection of the main earthing wire, protective earthing wires and/or bonding wires within the installation; and
- d) A removable link, which effectively disconnects the neutral bar from the earth bar.

NOTE — The requirements of (c) and (d) above must be carried out by the licensed electrician as part of the switchboard installation.

The main earthing wire termination must be readily accessible at the earth electrode.

The main earthing wire connection must:

- a) be mechanically and electrically sound;
- b) be protected against damage, corrosion, and vibration;
- c) not place any strain on the various parts of the connection;
- d) not damage the wire or fittings; and
- e) be secured at the earth electrode

Use a permanent fitting (like a screwed-down plastic label or copper label, or one that can be threaded onto the cable) at the connection point that is clearly marked with the words: "EARTHING LEAD — DO NOT DISCONNECT" or "EARTHING CONDUCTOR — DO NOT DISCONNECT".

5B.8.1.1 All medium voltage equipment shall be earthed by two separate and distinct connections with earth.

Medium voltage systems of 400/230 V, 4-wire, 3-phase, systems are normally operated with the neutral solidly earthed at source. At medium voltage, Myanmar Electricity Regulations require that the neutral be earthed by two separate and distinct connections with earth. Source in the case of a substation (such as 11kV/400 V) would be the neutral(s) of the transformer(s). Neutral conductor of half the size of the phase conductor was permitted in earlier installations. But with the proliferation of equipment using non-linear devices and consequent increase in harmonics, the neutral will carry a current more than the notional out-of-balance current and as such neutral conductor shall be of the same size as the phase conductor.

In the case of high and extra high voltages, the neutral points shall be earthed by not less than two separate and distinct connections with earth, each having its own electrode at the generating station or substation and may be earthed at any other point provided no interference is caused by such earthing. The neutral may be earthed through suitable impedance. Neutral earthing conductor shall be sized at to have a current carrying capacity not less than the phase current.

5B.8.1.2 As far as possible, all earth connections shall be visible for inspection.

5B.8.1.3 Earth system shall be so devised that the testing of individual earth electrode is possible. It is recommended that the value of any earth system resistance shall be such as to conform with the degree of shock protection desired.

5B.8.1.4 It is recommended that a drawing showing the main earth connection and earth electrodes be prepared for each installation.

5B.8.1.5 No addition to the current-carrying system, either temporary or permanent, shall be made which will increase the maximum available earth fault current or its duration until it has been ascertained that the existing arrangement of earth electrodes, earth busbar, etc, are capable of carrying the new value of earth fault current which may be obtained by this addition.

5B.8.1.6 No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and the live conductors, shall be inserted on any supply system. This, however, does not include the case of a switch for use in controlling a generator or a transformer or a link for test purposes.

5B.8.1.7 All materials, fittings, etc, used in earthing shall conform to Standard specifications, wherever these exist.

5B.8.1.8 Earthing associated with current-carrying conductor is normally essential for the security of the system and is generally known as system earthing, while earthing of non-current carrying metal work and conductor is essential for the safety of human life, of animals and of property and it is generally known as equipment earthing.

5B.8.2 Earth Electrodes

Earth electrode either in the form of pipe electrode or plate electrode should be provided at all premises for providing an earth system. Details of typical pipe and plate earth electrodes are given in **Fig.3** and **Fig.4**.

Although electrode material does not affect initial earth resistance, care should be taken to select a material which is resistant to corrosion in the type of soil in which it is used. Under ordinary conditions of soil, use of copper, iron or mild steel electrodes is recommended. In case where soil condition leads to excessive corrosion of the electrode, and the connections, it is recommended to use either copper electrode or copper clad electrode or zinc coated galvanized iron electrode. The electrode shall be kept free from paint, enamel and grease. It is recommended to use similar material for earth electrodes and earth conductors or otherwise precautions should be taken to avoid corrosion.

5B.8.3 As far as possible, all earth connections shall be visible for inspection and shall be carefully made; if they are poorly made or inadequate for the purpose for which they are intended, loss of life and property or serious personal injury may result.

To obtain low overall resistance the current density should be as low as possible in the medium adjacent to the electrodes; which should be so designed as to cause the current density to decrease rapidly with distance from the electrode. This requirement is met by making the dimensions in one direction large compared with those in the other two, thus a pipe, rod or strip has a much lower resistance than a plate of equal surface area. The resistance is not, however, inversely proportional to the surface area of the electrode.

5B.8.4 Equipment and Portions of Installations which shall be Earthed

5B.8.4.1 *Equipment to be Earthed*

Except for equipment provided with double insulation, all the non-current carrying metal parts of electrical installations are to be earthed properly. All metal conduits, trunking, cable sheaths, switchgear, distribution fuse boards, lighting fittings and all other parts made of metal shall be bent together and connected by means of two separate and distinct conductors to an efficient earth electrode.

5B.8.4.2 *Structural Metal Work*

Earthing of the metallic parts shall not be effected through any structural metal work which houses the installation. Where metallic parts of the installation are not required to be earthed and are liable to become alive should the insulations of conductors become defective, such metallic parts shall be separated by durable non-conducting material from any structural work.

5B.8.5 Neutral Earthing

To comply with Myanmar Electricity Rules no fuses or circuit breakers other than a linked circuit breaker shall inserted in an earthed neutral conductor, a linked switch or linked circuit breaker shall be arranged to break or the neutral either with or after breaking all the related phase conductors and. shall positively make (or close) the neutral before making (or closing) the phases.

If this neutral point of the supply system is connected permanently to earth, then the above rule applies throughout the installation including 2-wire final circuits. This means that no fuses may be inserted in the neutral or common return wire. And the neutral should consist of a bolted solid link, or part of a linked switch, which completely disconnects the whole system from the supply. This linked switch must be arranged so that the neutral makes before, and break after the phases.

5B.8.6 System of Earthing

Equipment and portions of installations shall be deemed to be earthed only if earthed in accordance with either the direct earthing system, the multiple earthed neutral system or the earth leakage circuit breaker system. In all cases, the relevant provisions of Myanmar Electricity Rules shall be complied with.

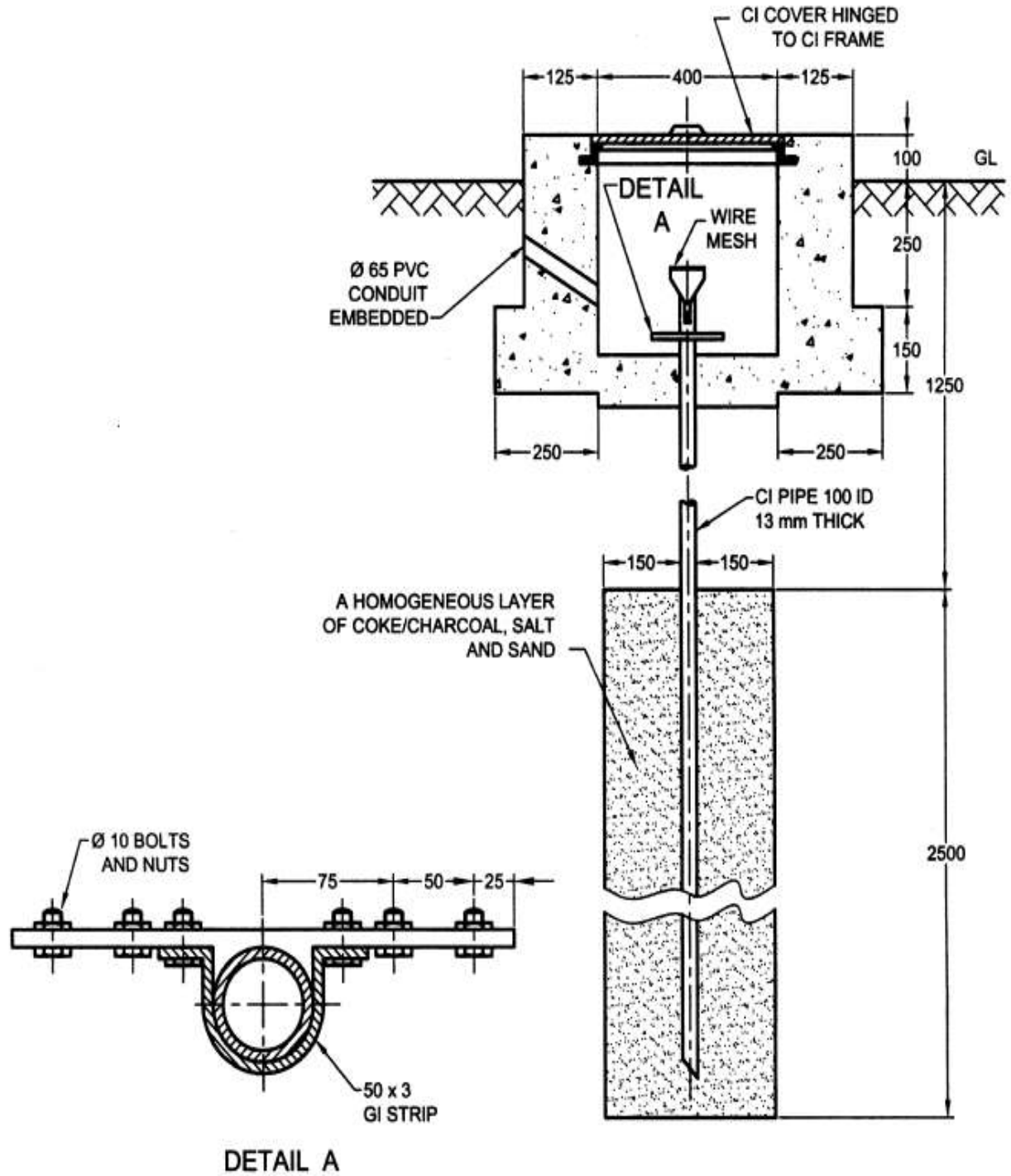
The earthing of electrical installations for nonindustrial and industrial buildings shall be done in accordance with Standard practice [(24) IS 3043].

5B.8.7 Classification of Earthing System

The earthing systems are classified as follows:

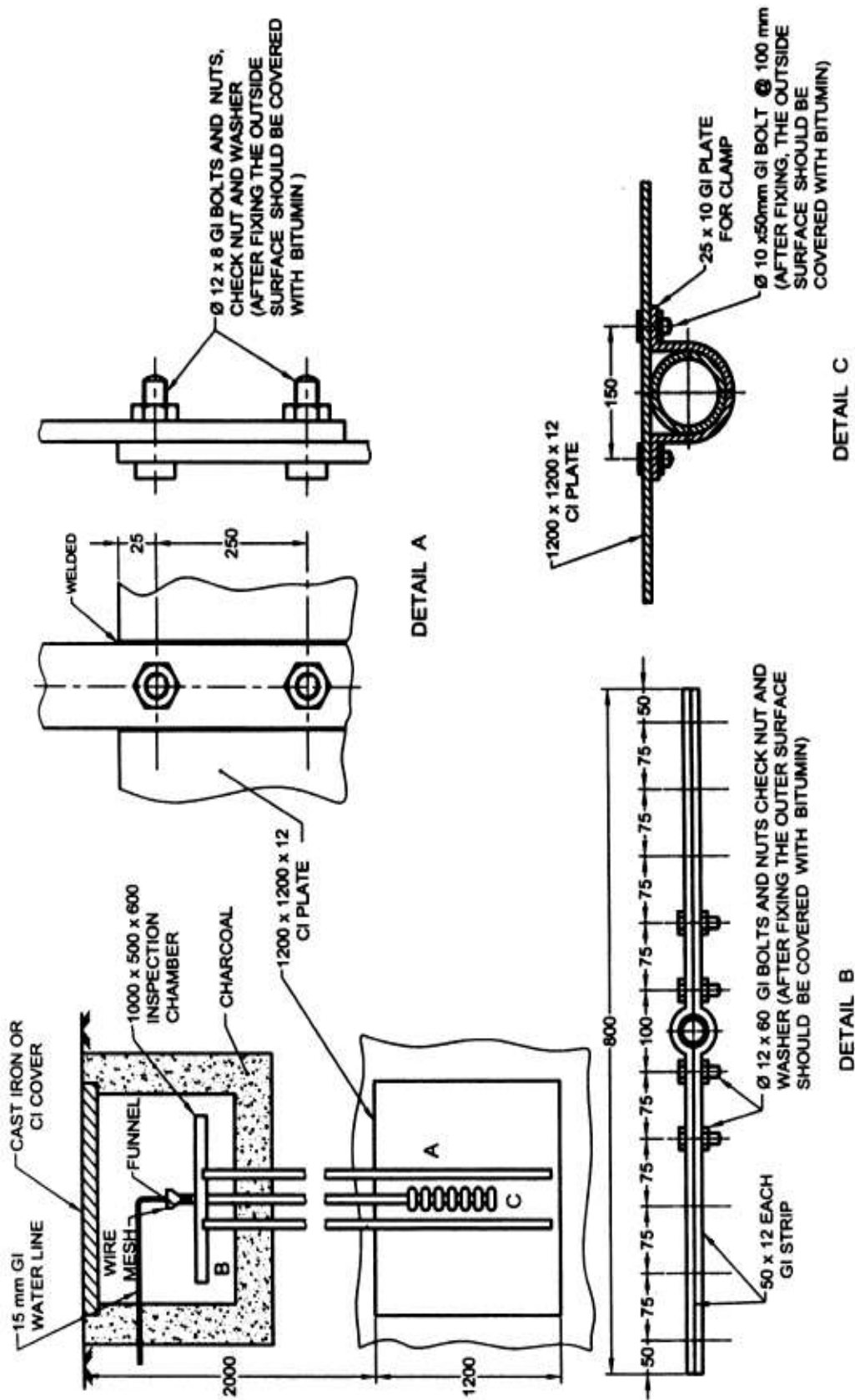
- a) *TN System*— A system which has one or more points of the source of energy directly earth, and the exposed and extraneous conductive parts of the installation are connected by means of protective conductors to the earth points of the source, that is, currents to flow from the installation to the earth points of the source.
- b) *TT System*— A system which has one or more points of the source of energy directly earth, and the exposed and extraneous conductive parts of the installation are connected to a local earth electrodes or electrodes electrically independent of the source earth.

IT System— A system which has source either unearthed or earthed through a high impedance and the exposed conductive parts of the installations are connected to electrically independent earth electrodes.



All dimensions in millimeters

Fig. 3 Typical Arrangement of Pipe Earthing



All dimensions in millimeters

Fig.4 Typical Arrangement of Plate Earthing

5B.9 INSPECTION AND TESTING OF INSTALLATION

5B.9.1 General Requirements

5B.9.1.1 Before the completed installation, or an addition to the existing installation, is put into service, inspection and testing shall be carried out in accordance with the Myanmar Electricity Rules. In the event of defects being found, these shall be rectified, as soon as practicable and the installation retested.

5B.9.1.2 Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting into service.

5B.9.1.3 Where an addition is to be made to the fixed wiring of an existing installation, the latter shall be examined for compliance with the recommendations of the Code.

5B.9.1.4 The individual equipment and materials which form part of the installation shall generally conform to the relevant Standard Specification wherever applicable.

5B.9.1.5 Completion Drawings

On completion of the electric work, a wiring diagram shall be prepared and submitted to the engineer-in-charge or the owner. All wiring diagrams shall indicate clearly, the main switch board, the runs of various mains and submains and the position of all points and their controls. All circuits shall be clearly indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit in which they are electrically connected. Also the location and number of earth points and the run of each load should be clearly shown in the completion drawings.

5B.9.2 Inspection of the Installation

5B.9.2.1 General

On completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of this Code and that of Myanmar Electricity Rules, have been complied with. This, among other things, shall include checking whether all equipments, fittings, accessories, wires/cables, used in the installation are of adequate rating and quality to meet the requirement of the load. General workmanship of the electrical wiring with regard to the layout and finish shall be examined for neatness that would facilitate easy identification of circuits of the system, adequacy of clearances, soundness, contact pressure and contact area. A complete check shall also be made of all the protective devices, with respect to their ratings, range of settings and co-ordination between the various protective devices.

5B.9.2.2 Item to be Inspected

5B.9.2.2.1 Substation installations

In substation installation, it shall be checked whether:

- 1) The installation has been carried out in accordance with the approved drawings;
- 2) Phase-to-phase and phase to earth clearances are provided as required;
- 3) All equipments are efficiently earthed and properly connected to the required number of earth electrodes;
- 4) The required ground clearance to live terminals is provided;
- 5) Suitable fencing is provided with gate with lockable arrangements;

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- 6) The required number of caution boards fire-fighting equipments, operating rods, rubber mats, etc, are kept in the substation;
- 7) In case of indoor substation sufficient ventilation and draining arrangements are made;
- 8) All cable trenches are provided with non-inflammable covers;
- 9) Free accessibility is provided for all equipments for normal operation;
- 10) All name plates are fixed and the equipments are fully painted;
- 11) All construction materials and temporary connections are removed;
- 12) Oil-level, busbar tightness, transformer tap position, etc, are in order;
- 13) Earth pipe troughs and cover slabs are provided for earth electrodes/earth pits and the neutral and LA earth pits are marked for easy identification;
- 14) Earth electrodes are of GI pipes or CI pipes or copper plates. For earth connections, brass bolts and nuts with lead washers are provided in the pipes/plates;
- 15) Earth pipe troughs and oil sumps/pits are free from rubbish and dirt and stone jelly and the earth connections are visible and easily accessible;
- 16) HT and LT panels switchgears are all vermin and damp-proof and all unused openings or holes are blocked properly;
- 17) The earth bus bars have tight connections and corrosion-free joint surfaces;
- 18) Operating handle of protective devices are provided at an accessible height from ground;
- 19) Adequate headroom is available in the transformer room for easy topping-up of oil, maintenance, etc;
- 20) Safety devices, horizontal and vertical barriers, bus bar covers/shrouds, automatic safety shutters/doors interlock, handle interlock are safe and in reliable operation in all panels and cubicles;
- 21) Clearances in the front, rear and sides of the main HV and MV and sub-switch boards are adequate;
- 22) The switches operate freely; the 3 blades make contact at the same time, the arcing horns contact in advance; and the handles are provided with locking arrangements;
- 23) Insulators are free from cracks, and are clean;
- 24) In transformers, there is any oil leak;
- 25) Connections to bushing in transformers for tightness and good contact;
- 26) Bushings are free from cracks and are clean;
- 27) Accessories of transformers like breathers, vent pipe, Buchholz relay, etc, are in order;
- 28) Connections to gas relay in transformers are in order;
- 29) Oil and winding temperature are set for specific requirements in transformers;
- 30) In case of cable cellars, adequate arrangements to pump out water that has entered due to see page or other reasons;
- 31) All incoming and outgoing circuits of HV and MV panels are clearly and indelibly labeled for identifications;

- 32) No cable is damaged;
- 33) There is adequate clearance around the equipments installed; and
- 34) Cable terminations are proper.

5B.9.2.2.2 Medium voltage installation

In medium voltage installations, it shall be checked whether:

- 1) All blocking materials that are used for safe transportation in switchgears, contactors, relays, etc, are removed;
- 2) All connections to be earthing system are feasible for periodical inspection;
- 3) Sharp cable bends are avoided and cables are taken in a smooth manner in the trenches or alongside the walls and ceilings using suitable support clamps at regular intervals;
- 4) Suitable linked switch or circuit breaker or lockable push button is provided near the motors/apparatus for controlling supply to the motor/apparatus in an easily accessible location;
- 5) Two separate and distinct earth connections are provided for the motor/apparatus;
- 6) Control switch-fuse is provided at an accessible height from ground for controlling supply to overhead travelling crane, hoists, overhead bus bar trunking;
- 7) The metal rails on which the crane travels are electrically continuous and earthed and bonding of rails and earthing at both ends are done;
- 8) Four core cables are used for overhead travelling crane and portable equipments, the fourth core being used for earthing, and separate supply for lighting circuit is taken;
- 9) If flexible metallic hose is used for wiring to motors and other equipment, the wiring is enclosed to the full lengths, and the hose secured properly by approved means;
- 10) The cables are not taken through areas where they are likely to be damaged or chemically affected;
- 11) The screens and armours of the cables are earthed properly;
- 12) The belts of the belt driven equipments are properly guarded;
- 13) Adequate precautions are taken to ensure that no live parts are so exposed as to cause danger;
- 14) Ammeters and voltmeters are tested;
- 15) The relays are inspected visually by moving covers for deposits of dusts or other foreign matter;
- 16) Wherever bus ducts/rising mains/overhead bus trucking are used, special care should be taken for earthing the system. All tap off points shall be provided with adequately rated protective device like MCB, MCCB, fuses, ELCB, RCCB, etc;
- 17) All equipments shall be weather, dust and vermin proof; and
- 18) Any and all equipments having air insulation as media shall maintain proper distances between phases; phase to neutral; phase to earth and earth to neutral.

5B.9.2.2.3 Overhead lines

For overhead lines it shall be checked whether:

- 1) All conductors and apparatus including live parts thereof are inaccessible;
- 2) The types and size of supports are suitable for the overhead lines/conductors used and are in accordance with approved drawing and standards;
- 3) Clearances from ground level to the lowest conductor of overhead lines, sag conditions, etc, are in accordance with the relevant standard;
- 4) Where overhead lines cross the roads or cross each other or are in proximity with one another, suitable guarding is provided at road crossings and also to protect against possibility of the lines coming in contact with one another;
- 5) Every guard wire is properly earthed;
- 6) The type, size and suitability of the guarding arrangement provided is adequate;
- 7) Stays are provided suitably on the over-headlines as required and are efficiently earthed or provided with suitably stay insulators of suitable voltages;
- 8) Anti-climbing devices and Danger Board/Caution Board Notices are provided on all HT supports;
- 9) Clearances along the route are checked and all obstructions such as trees/branches and shrubs are cleared on the route to the required distance on either side;
- 10) Clearance between the live conductor and the earthed metal parts are adequate;
- 11) For the service connections tapped-off from the overhead lines, cut-outs of adequate capacity are provided;
- 12) All insulators are properly and securely mounted; also they are not damaged.
- 13) All poles are properly grouted/insulated so as to avoid bending of pole towards tension; and
- 14) Steel poles, if used shall be properly earthed.

5B.9.2.2.4 *Lighting circuits*

The lighting circuits shall be checked whether:

- 1) Wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls, etc;
- 2) Neutral links are provided in double poles switch-fuses which are used for lighting control, and no protective devices (such as MCB, MCCB, fuses, ELCB, etc) is provided in the neutral;
- 3) The plug points in the lighting circuit are all of 3-pin type, the third pin being suitably earthed;
- 4) Tamper-proof interlocked switch socket and plug are used for locations easily accessible;
- 5) Lighting wiring in factory area is taken enclosed in conduit and conduit properly earthed, or alternatively, armoured cable wiring is used;
- 6) A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipments;
- 7) Proper connectors and junction boxes are used wherever joints are to be made in conductors or crossover of conductors takes place;
- 8) Cartridge fuse units are fitted with cartridge fuses only;

- 9) Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary;
- 10) The polarity having been checked and all protective devices (such as MCB, MCCB, fuses, ELCB, etc) and single pole switches are connected on the phase conductor only and wiring is correctly connected to socket outlets;
- 11) Spare knockouts provided in distribution boards and switch fuses are blocked;
- 12) The ends of conduits enclosing the wiring leads are provided with ebonite or other suitable bushes;
- 13) The fittings and fixtures used for outdoor use are all of weather-proof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area, are of flame-proof application;
- 14) Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals;
- 15) Flat ended screws are used for fixing conductor to the accessories;
- 16) Use of flat washers backed up by spring washers for making end connections is desirable; and
- 17) All metallic parts of installation such as conduits, distribution boards, metal boxes, etc have been properly earthed.

5B.9.3 Testing of Installation

5B.9.3.1 General

After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation in an already existing installation shall commence after obtaining permit to work from the engineer-in-charge and after ensuring the safety provisions.

5B.9.3.2 Testing

5B.9.3.2.1 Switchboards

HV and MV switchboards shall be tested in the manner indicated below:

- a) All high voltage switchboards shall be tested for dielectric test as per Standard practice[(25) IS 8623]
- b) All earth connections shall be checked for continuity.
- c) The operation of the protective devices shall be tested by means of secondary or primary injection tests.
- d) The operation of the breakers shall be tested from all control stations.
- e) Indication/signaling lamps shall be checked for proper working.
- f) The operation of the breakers shall be tested for all interlocks.
- g) The closing and opening timings of the breakers shall be tested wherever required for auto-transfer schemes.
- h) Contact resistance of main and isolator contacts shall be measured.
- i) The specific gravity and the voltage of the control battery shall be measured.

5B.9.3.2.2 Transformers

Transformers are tested in the manner indicated below:

- a) All commissioning tests shall be in accordance with Standard practice [(26) IS 10028].
- b) Insulation resistance on HV and MV windings shall be measured at the end of 1 min as also at the end of 10 min of measuring the polarization index. The absolute value of insulation resistance should not be the sole criterion for determining the state of dryness of the insulation. Polarization index values should form the basis for determining the state of dryness of insulation. For any class of insulation, the polarization index should be greater than 1.5.

5B.9.3.2.3 Cables

Cable installations shall be checked as below:

- a) It shall be ensured that the cables conform to the relevant Standards. Tests shall also be done in accordance with Standard practice[(6) IS 732].The insulation resistance before and after the tests shall be checked.
- b) The insulation resistance between each conductor and against earth shall be measured. The insulation resistance varies with the type of insulation used and with the length of cable. The following empirical rule gives reasonable guidance:

Insulation resistance in megaohms

$$= \frac{10 \times \text{Voltage in kV}}{\text{Length in km}}$$

- c) Physical examination of cables shall be carried out.
- d) Cable terminations shall be checked.
- e) Continuity test shall be performed before charging the cable with current.

5B.9.3.2.4 Motors and other equipments

The following test is made on motor and other equipment:

The insulation resistance of each phase winding against the frame and between the windings shall be measured. Megger of 500 V or 1 000 V rating shall be used. Star points should be disconnected. Minimum acceptable value of the insulation resistance varies with the rated power and the rated voltage of the motor.

The following relation may serve as a reasonable guide:

$$R_i = \frac{20 \times E_n}{1\,000 + 2P}$$

where

R_i = Insulation resistance in megaohms at 25 °C.

E_n = Rated phase to phase voltage.

P = Rated power in kW.

If the resistance is measured at a temperature different from 25°C, the value shall be corrected to 25°C.

The insulation resistance as measured at ambient temperature does not always give a reliable value, since moisture might have been absorbed during shipment and storage. When the temperature of such a motor is raised, the insulation resistance will initially drop considerably, even below the acceptable minimum. If any suspicion exists on this score, motor winding must be dried out.

5B.9.3.2.5 *Wiring installation*

The following tests shall be done:

- a) The insulation resistance shall be measured by applying between earth and the whole system of conductor or any section thereof with all fuses in place and all switches closed, and except in earthed concentric wiring, all lamps in position or both poles of installation otherwise electrically connected together, a dc voltage of not less than twice the working voltage, provided that it does not exceed 500 V for medium voltage circuits. Where the supply is derived from three –wire (ac or dc) or a poly-phase system, the neutral pole of which is connected to earth either direct or through added resistance the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.
- b) The insulation resistance in megaohms of an installation measured as in **(a)** shall be not less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one megaohm.
- c) Control rheostats, heating and power appliances and electric signs, may, if desired, be disconnected from the circuit during the test, but in that event the insulation resistance between the case of framework, and all live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Standard specification or where there is no such specification, shall be not less than half a megaohm.
- d) The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the neutral on to the other pole of phase conductors of the supply. Such a test shall be made after removing all metallic connections between the two poles of the installation and in these circumstances the insulation resistance between conductors of the installation shall be not less than that specified in **(b)**.

5B.9.3.2.6 *Completion certificate*

On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, counter-signed by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in a prescribed form as required by the local electric supply authority. One such recommended form is given in **Annex D**.

5B.9.3.2.7 *Earthing*

For checking the efficiency of earthing, the following tests are done:

- a) The earth resistance of each electrode shall be measured.
- b) Earth resistance of earthing grid shall be measured.
- c) All electrodes shall be connected to the grid and the earth resistance of the entire earthing system shall be measured.

These tests shall preferably be done during the summer months.

5B.10 TELECOMMUNICATION AND OTHER MISCELLANEOUS SERVICES

15B.0.1 Telecommunication Service

5B.10.1.1 House wiring of telephone subscribers offices in small buildings is normally undertaken by the relevant Telecommunications service provider on the surface of walls. And the user (subscriber) likes to have extension or place to another location inside the same apartment/house; the work should be undertaken with the instruction from the Auto Telephone Department. But in large multi- storied buildings intended for commercial, business and office use as well as for residential purposes, wiring for telephone connections is generally done in a concealed manner through conduits. The telephone wiring diagrams of the multi-storied building should be consulted and appalled for the permission to use to the Auto Telephone Department in prior to the completion of building construction.

5B.10.1.2 The requirements of telecommunication facilities like Telephone connections, Private Branch Exchange, Intercommunication facilities, Telex and Telephone lines and Fibre cables are to be planned well in advance so that suitable provisions are made in the building plan in such a way that the demand for telecommunication services in any part of the building at any floor are met at any time during the life of the building.

5B.10.1.3 Layout arrangements, methods for internal block wiring and other requirements regarding provisions of space including room for Telecommunication facilities and equipments etc, may be decided depending as the number of phone outlets and other details in consultation with Engineer/Architect and user. Those arrangement//methods & requirements should be consulted with respective Telecommunications service provider for the safety and effectiveness of the materials usage.

5B.10.2 Public Address System — See Fire Department Instructions.

5B.10.3 Common Antenna System for TV Receivers

5B.10.3.1 In multi-storied apartments, houses and hotels where many TV receivers are located, a common master antenna system may preferably be used to avoid mushrooming of individual antennas.

5B.10.3.2 Master antenna is generally provided at the top most convenient point in any building and a suitable room on the top most floors or terrace for housing the amplifier unit, etc, may also be provided in consultation with the architect/engineer.

5B.10.3.3 From the amplifier rooms, conduits are laid in recess to facilitate drawing co-axial cable to individual flats. Suitable 'Tap Off' boxes may be provided in every room/flat as required.

5B.10.4 UPS System

An electrical device providing an interface between the main power supply and sensitive loads (computer systems, instrumentation, etc). The UPS supplies sinusoidal ac power free of disturbances and within strict amplitude and frequency tolerances. It is generally made up of a rectifier/charger and an inverter together with a battery for backup power in the event of a mains failure with virtually no time lag.

In general UPS system shall be provided for sensitive electronic equipments like computers, printers, fire alarm panel, public address system equipment, access control panel, EPABX, etc with the following provisions:

- a) Provisions of isolation transformers shall be provided where the capacity exceeds 5 kVA.
- b) UPS shall have dedicated neutral earthing system.

- c) Adequate rating of protective devices such as MCB, MCCB, fuses, ELCB, etc, shall be provided at both incoming and outgoing sides.
- d) UPS room shall be provided with adequate ventilation and/or air conditioning as per requirement.

5B.10.5 Inverter

In general inverter system shall be provided for house lighting, shop lighting, etc, with the following provisions:

- a) Adequate rating of protective devices such as MCB, MCCB, fuses, ELCB, etc, shall be provided at both incoming and outgoing sides.
- b) Earthing shall be done properly.
- c) Adequate ventilation space shall be provided around the battery section of the inverter.
- d) Care in circuit design to keep the connected load in such a manner that the demand at the time of mains failure is within the capability of the inverter. (If the inverter fails to take over the load at the time of the mains failure, the purpose of providing the inverter and battery backup is defeated.)
- e) Circuits which are fed by the UPS or Inverter systems should have suitable marking to ensure that a workman does not assume that the power is off, once he has switched off the mains from the DB for maintenance.
- f) UPS systems and Inverter systems have a very limited fault feeding capacity in comparison to the mains supply from the licensee's network. The low fault current feed may cause loss of discrimination in the operation of MCB's, if the Inverter or UPS system feeds a number of circuits with more than one over current protective device in series (such as incoming MCB at the DB and a few outgoing MCB'S). The choice of MCB's in such cases has to be done keeping the circuit operating and fault condition parameters under both (mains operation and UPS operation) conditions.

5B.10.6 Diesel Generating Set (less than 5 kVA)

In general small diesel generating sets shall be provided for small installations such as offices, shops, small scale industry, hostels, etc, with the following provisions:

- a) These shall be located near the exit or outside in open areas.
- b) They shall be in reach of authorized persons only.
- c) Adequate fire-fighting equipment shall be provided near such installations.
- d) Exhaust from these shall be disposed in such a way so as not to cause health hazard.
- e) These shall have acoustic enclosure, or shall be placed at a location so as not to cause noise pollution.
- f) Adequate ventilation shall be provided around the installation.
- g) Adequate rating of protective devices such as MCB, MCCB, fuses, ELCB, etc shall be provided.
- h) Separate and adequate body and neutral earthing shall be done.

5B.10.7 Building Management System

A building management/automation system may be considered to be provided for controlling and monitoring of all parameters of HVAC, electrical, plumbing, fire fighting, low voltage system such as telephone, TV, etc. This not only lead to reduction of energy consumption, it shall also generate data leading to better operation practice and systematic maintenance scheduling. The total overview provided by a Building Automation System, with a capability to oversee a large

number of operating and environmental parameters on real time basis leads to introduction of measures which lead to further reduction in energy consumption.

It shall also help in reduction of skilled manpower required for operation and maintenance of large complexes. This system can further linked to other systems such as Fire alarm system, public address system, etc for more effective running of services.

This system can be used for analysis and controlling of all services in a particular complex, leading efficient and optimum utilization of available services.

5B. 10.8 Security System

Security System may be defined as an integrated Closed Circuit Television System, Access Control System, Perimeter Protection Systems, movement sensors, etc. These have a central control panel, which has a defined history storage capacity. This main control panel may be located near to the fire detection and alarm system.

These may be considered for high security areas or large crowded areas or complexes. High security areas may consider uncoded, high-resolution, black and white cameras in place of colored cameras. These may be accompanied with movement sensors.

Access control may be provided for entry to high security areas. The systems may have proximity card readers, magnetic readers, etc.

5B. 10.9 Computer Networking

Networking is the practice of linking computing devices together with hardware and software that supports data communications across these devices.

5B. 10.10 Car Park Management System

The Car Management System may be provided in multi-level parking or other parking lots where number of vehicles to be parked exceeds 1000 vehicles. The Car Park Management System may have features of Pay and Display Machines and Parking Guidance System. The Pay and Display Machines may be manned and unmanned type. Parking guidance system needs to display number of car spaces vacant on various floors, direction of entry and exit, etc. This system can be of great benefit in evaluating statistical data's such as number of cars in a day or month or hour, stay time of various vehicles, etc.

5B.11 LIGHTNING PROTECTION OF BUILDINGS

5B.11.1 Basic Considerations for Protection

Before proceeding with the detailed design of a lightning protecting system, the following essential steps should be taken:

- a) Decide whether or not the structure needs protection and, if so, what are the special requirements (*see 5B.11.1.1*) {*see International Standard practice for details [IEC 62305]*}
- b) Ensure a close liaison between the architect, the builder, the lightning protective system engineer, and the appropriate authorities throughout the design stages.
- c) Agree the procedures for testing, commissioning and future maintenance.

5B. 11.1.1 Need for Protection

Structures with inherent explosive risks; for example, explosives factories, stores and dumps and fuel tanks; usually need the highest possible class of lightning protective system.

For all other structures, the standard of protection recommended in the remainder of the Code is applicable and the only question remaining is whether to protect or not.

In many cases, the need for protection may be self-evident, for example:

- where large numbers of people congregate;
- where essential public services are concerned;
- where the area is one in which lightning strokes are prevalent;
- where there are very tall or isolated structures; and
- where there are structures of historic or cultural importance.

However, there are many cases for which a decision is not so easy to make. Various factors effecting the risk of being struck and the consequential effects of a stroke in these cases are discussed in **5B.11.1.2** to **5B.11.1.8**.

It must be understood, however, that some factors cannot be assessed, and these may override all other considerations. For example, a desire that there should be no avoidable risk to life or that the occupants of a building should always feel safe, may decide the question in favour of protection, even though it would normally be accepted that there was no need. No guidance can be given in such matters, but an assessment can be made taking account of the exposure risk (that is the risk of the structure being struck) and the following factors:

- a) Use to which the structure is put,
- b) Nature of its construction,
- c) Value of its contents or consequential effects,
- d) The location of the structure, and
- e) The height of the structure (in the case of composite structures the overall height).

5B.11.1.2 *Estimation of Exposure Risk*

The probability of a structure or building being struck by lightning in any one year is the product of the 'lightning flash density' and the 'effective collection area' of the structure. The lightning flash density, N_g , is the number of (flashes to ground) per km² per year.

NOTE — For the purposes of this Code, the information given in Figure 5 on thunderstorm days per year would be necessary to be translated in terms of estimated average annual density N_g

The table below which indicates the relationship between thunderstorm days per year and lightning flashes per square kilometer per year:

Thunderstorm		Lightning Flashes per km ² per Year	
days/year			
Mean	Limits		
5		0.2	0.1-0.5
10		0.5	0.15-1
20		1.1	0.3-3
30		1.9	0.6-5
40		2.8	0.8-8
50		3.7	1.2-10
60		4.7	1.8-12
80		6.9	3-17
100	9.24 – 20		

The effective collection area of a structure is the area on the plan of the structure extended in all directions to take account of its height. The edge of the effective collection area is displaced from the edge of the structure by an amount equal to the height of the structure at that point. Hence, for a simple rectangular building of length L, width W and height H meters, the collection area has length (L + 2H) meters and width (W + 2 H) meters with four rounded corners formed by quarter circles of radius H meters. This gives a collection area, A_c (in m²):

$$A_c = (L \times W) + 2 (L \times H) + 2 (W \times H) + \pi H^2 \quad \dots (1)$$

The probable number of strikes (risk) to the structure per year is:

$$P = A_c \times N_g \times 10^{-6} \quad \dots (2)$$

It must first be decided whether this risk P is acceptable or whether some measure of protection is thought necessary.

5B.11.1.3 Suggested Acceptable Risk

For the purposes of this Code, the acceptable risk figure has been taken as 10^{-5} , that is, 1 in 100000 per year.

5B.11.1.4 Overall Assessment of Risk

Having established the value of P, the probable number of strikes to the structure per year [see equation (2) in 5B.11.1.2] the next step is to apply the 'weighting factors' in **Tables 3** and **4**.

This is done by multiplying P by the appropriate factors to see whether the result, the overall weighting factors, exceeds the acceptable risk of $P = 10^{-5}$ per year.

5B.11.1.5 Weighting Factors

In Tables 3A to 3E, the weighting factor values are given under headings 'A' to 'E', denoting a relative degree of importance or risk in each case. The tables are mostly self-explanatory but it may be helpful to say something about the intention of **Table 3C**.

Table 3: Overall Assessment of Risk

(Clauses 11.1.4 and 11.1.5)

Table 3A: Weighting Factor 'A'

(Use of Structure)

Use to Which Structure is Put	Value of 'A'
Houses and other buildings of comparable size	0.3
Houses and other buildings of comparable size with outside aerial	0.7
Factories, workshops and laboratories	1.0
Office blocks, hotels, blocks of flats and other residential buildings other than those included below	1.2
Places of assembly, for example, churches, halls, theatres, museums, exhibitions, departmental stores, post offices, stations, airports, and stadium structures	1.3
Schools, hospitals, children's and other homes	1.7

Table 3B: Weighting Factor 'B'

(Type of Construction)

Type of Construction	Value of 'B'
Steel framed encased with any roof other than metal ¹⁾	0.2
Reinforced concrete with any roof other than metal	0.4
Steel framed encased or reinforced concrete with metal roof	0.8
Brick, plain concrete or masonry with any roof other than metal or thatch	1.0
Timber framed or clad with any roof other than metal or thatch	1.4
Brick, plain concrete, masonry, timber framed but with metal roofing	1.7
Any building with a thatched roof	2.0

¹⁾ A structure of exposed metal which is continuous down to ground level is excluded from these tables as it requires no lightning protection beyond adequate earthing arrangements.

Table 3C: Weighting Factor 'C'
(Contents or Consequential Effects)

Contents or Consequential Effects	Value of 'C'
Ordinary domestic or office buildings, factories and workshops not containing valuable or specially susceptible contents	0.3
Industrial and agricultural buildings with specially susceptible ¹⁾ contents	0.8
Power stations, gas works, telephone exchanges, radio stations	1.0
Industrial key plants, ancient monuments and historic buildings, museums, art galleries or other buildings with specially valuable contents	1.3
Schools, hospitals, children's and other homes, places of assembly	1.7
¹⁾ This means specially valuable plant or materials vulnerable to fire or the results of fire	

Table 3D: Weighting Factor 'D'
(Degree of Isolation)

Degree of Isolation	Value of 'D'
Structure located in a large area of structures or trees of the same or greater height, for example, in a large town or forest	0.4
Structure located in an area with few other structures or trees of similar height	1.0
Structure completely isolated or exceeding at least twice the height of surrounding structures or trees	2.0

Table 3E: Weighting Factor 'E'
(Type of Country)

Type of Country	Value of 'E'
Flat country at any level	0.3
Hill country	1.0
Mountain country between 300 m and 900 m	1.3
Mountain country above 900 m	1.7

The effect of the value of the contents of a structure is clears the term 'consequential effect' is intended to cover not only material risks to goods and property but also such aspects as the disruption of essential services of all kinds, particularly in hospitals.

The risk to life is generally very small, but if a building is struck, fire or panic can naturally result. All possible steps should, therefore, be taken to reduce these effects, especially among children, the old, and the sick.

5B.11.1.6 *Interpretation of Overall Risk Factor*

The risk factor method put forward here is to be taken as giving guidance on what might, in some cases, be a difficult problem. If the result obtained is considerably less than 10^{-5} (1 in 100 000) then, in the absence of other overriding considerations, protection does not appear necessary; if the result is greater than 10^{-5} , say for example 10^{-4} (1 in 10 000) then sound reasons would be needed to support a decision not to give protection.

When it is thought that the consequential effects will be small and that the effect of a lightning stroke will most probably be merely slight damage to the fabric of the structure, it may be economic not to incur the cost of protection but to accept the risk. Even though, this decision is made, it is suggested that the calculation is still worthwhile as giving some idea of the magnitude of the calculated risk being taken.

5B.11.1.7 *Anomalies*

Structures are so varied that any method of assessment may lead to anomalies and those who have to decide on protection must exercise judgement. For example, a steel-framed building may be found to have a low risk factor but, as the addition of an air termination and earthing system will give greatly improved protection, the cost of providing this may be considered worthwhile.

A low risk factor may result for chimneys made of brick or concrete. However, where chimneys are free standing or where they project for more than 4.5 m above the adjoining structure, they will require protection regardless of the factor. Such chimneys are, therefore, not covered by the method of assessment. Similarly, structures containing explosives or flammable substances are also not covered.

Results of calculations for different structures are given in **Table 4** and a specific case is worked through in **5B.11.1.8**.

5B.11.1.8 *Sample Calculation of Need for Protection*

A hospital building is 10 m high and covers an area of 70 m x 12 m. The hospital is located in flat country and isolated from other structures. The construction is of brick and concrete with a non-metallic roof. Is lightning protection needed?

a) *Flashes/km²/year* — Let us say, for the protection of the hospital a value for N_g is 0.7.

b) *Collection area*— Using equation (1) in **5B.11.1.2**:

$$\begin{aligned} A_c &= (70 \times 12) + 2 (70 \times 10) + 2 (12 \times 10) + (\pi \times 100) \\ &= 840 + 1\,400 + 240 + 314 \\ &= 2\,794 \text{ m}^2 \end{aligned}$$

c) *Probability of being struck*— Using equation (2) in **5B.11.1.2**:

$$\begin{aligned} P &= A_c \times N_g \times 10^{-6} \text{ times per year} \\ &= 2\,794 \times 0.7 \times 10^{-6} \\ &= 2.0 \times 10^{-3} \text{ approximately} \end{aligned}$$

Table 4: Examples of Calculations for Evaluating the Need for Protection*(Clauses 5B.11.1.4 and 5B11.1.7)*

Sl No.	Description of Structure	Risk of Being Struck(p)			Weighting Factors					Overall Multi-Playing Factor (Product Of Clos6-10)	Overall Risk Factor (Product Of Cols 5 and 11)	Recommendation.
		Collection Area A_c	Flash Density N_g	P $A_c \times N_g \times 10^{-6}$	'A' Use of Structure (Table3A)	'B' Type of Const ruction (Table 3B)	'C' Contents or Consequen tial Effects (Table3C)	'D' Degree of Isolation (Table 3D)	'E' Type of Country (Table 3E)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
i)	Malsonette, reinforced concrete and brick built non-metallic roof	3 327	0.6	2×10^{-3}	1.2	0.4	0.3	0.4	0.3	0.02	4×10^{-5}	Protection required
ii)	Office building reinforced concrete construction, non-metallic roof	4 296	0.6	2.6×10^{-3}	1.2	0.4	0.3	0.4	0.3	0.02	5.2×10^{-5}	Protection required
iii)	School, brick built	1 456	0.7	1×10^{-3}	1.7	1.0	1.7	0.4	0.3	0.3	3×10^{-4}	Protection Required
iv)	3 bedroom detached dwelling house , brick built	405	0.4	1.6×10^{-4}	0.3	1.0	0.3	0.4	0.3	0.01	1.6×10^{-4}	No Protection Required
v)	Village church	5 027	0.6	3×10^{-3}	1.3	1.0	1.7	2.0	0.3	1.3	3.9×10^{-3}	Protection Required

NOTE — The risk of being struck, (col 5), is multiplied by the product of the weighting factors (col 6 to 10) to yield an overall risk factor (col 12). This should be compared with the acceptable risk (1×10^{-5}) for guidance on whether or not to protect.

d) Applying the weighting factors

$$A = 1.7$$

$$B = 1$$

$$C = 1.7$$

$$D = 2.0$$

$$E = 0.3$$

The overall multiplying factor= $A \times B \times C \times D \times E$

$$= 1.7$$

Therefore, the overall risk factor

$$= 2.0 \times 1.7 \times 10^{-3}$$

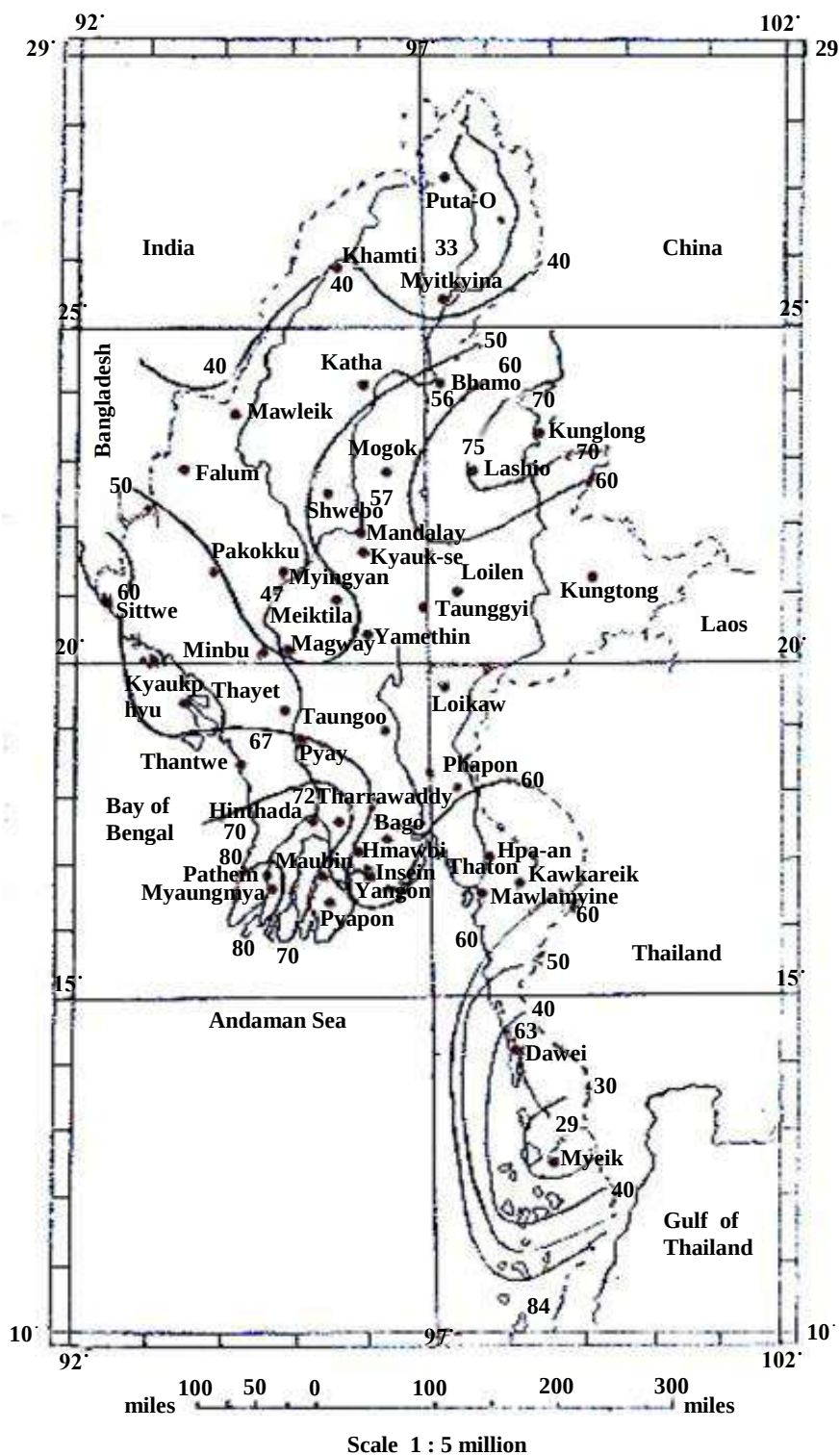
$$= 3.4 \times 10^{-3}$$

Conclusion: Protection is necessary.

5B.11.2 For detailed requirements of lightning protection of various structures, reference may be made to Standard practice [(27) IS 2309].

MYANMAR

PLACES FOR AVERAGE NUMBER OF THUNDERSTORMS DAYS IN A YEAR



(CONTOUR MAP NEED TO BE UP-DATED)

ANNEX A

[Clause (2.2)]

DRAWING SYMBOLS FOR ELECTRICAL INSTALLATION IN BUILDING

A-Lighting Apparatus

SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
1		LAMP	7		CHANDELIER LIGHT
2		FLUORESCENT LAMP, SINGLE, BARE TYPE	8		SPOT LIGHT
3		FLUORESCENT LAMP, DOUBLE, BARE TYPE	9		FLOOD LIGHT
4		DOWN LIGHT	10		BULK HEAD LAMP
5		WALL BRACKET LIGHT	11		EMERGENCY LAMP
6		LIGHTING OUTLET	12		WATER TIGHT LIGHT FITTING

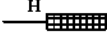
B-Fans

SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
1		CEILING FAN	7		TELEPHONE OUTLET
2		OSCILLATING FAN, CEILING TYPE	8		TELEVISION OUTLET
3		OSCILLATING FAN, WALL TYPE	9		DATA NETWORK OUTLET
4		EXHAUST FAN, WALL TYPE	10		AMPLIFYING EQUIPMENT
5		EXHAUST FAN, CEILING TYPE	11		SIREN
6		FAN REGULATOR	12		HORN OR HOOTER

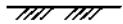
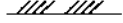
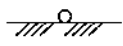
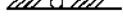
D- Electrical Circuit Diagram

SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
1		TRANSFORMER	18		CONNECTING LINK, open
2		AUTO TRANSFORMER	19		JUNCTION, CONNECTION POINT
3		CURRENT TRANSFORMER	20		TERMINAL
4		FUSE	21		JUNCTION OF CONDUCTOR
5		MINIATURE CIRCUIT BREAKER	22		TERMINAL BLOCK
6		MOULDED CASE CIRCUIT BREAKER	23		CONDUCTOR
7		SWITCH (Mechanical)	24		THREE CONDUCTOR
8		CIRCUIT BREAKER	25		THREE PHASE CIRCUIT, 50Hz, 380V, Three conductors of 120mm ² with neutral of 50mm ²
9		DISCONNECTOR (Isolator)	26		THREE CONDUCTOR IN CABLE
10		2 WAY DISCONNECTOR (Isolator) with off position in the centre	27		CABLE SEALING END, Show with 1no 3core cable
11		SWITCH DISCONNECTOR (Onload isolating switch)	28		CABLE SEALING END, Show with 3nos one core cable
12		CONTACTOR (Contact open in the unoperated position)	29		MOTOR STARTER, General symbol
13		CONTACTOR (Contact close in the unoperated position)	30		STARTER, Operated in steps
14		FUSE SWITCH	31		STARTER, Operated with star-delta
15		FUSE DISCONNECTOR (Fuse Isolator)	32		STARTER, Operated with auto transformer
16		FUSE SWITCH DISCONNECTOR (Onload isolating fuse switch)	33		STARTER, Operated in direct on line with contactor
17		CONNECTING LINK, closed	34		STARTER, Operated with starter regulator with thyristors
35		MACHINE, General symbol *Star mark shall be replaced by a letter designation as follow C Synchronous convertor G Generator GS Synchronous generator M Motor MS Synchronous motor	41		FAULT
			42		FLASH OVER
			43		CLOCK
36		FAN	44		SIGNAL LAMP
37		HEATER	45		SWITCH, General

BUILDING SERVICES (ELECTRICAL AND ALLIED INSTALLATIONS)

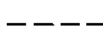
SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
38		STORAGE WATER HEATER	46		SWITCH WITH PILOT LAMP
39		BELL	47		SWITCH, two pole
40		EARTH, GROUND	48		EARTH POINT

E- Wiring and Distribution

SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
1		GENERAL WIRING	7		WIRING GOING DOWNWARDS
2		WIRING ON SURFACE	8		WIRING GOING THROUGH
3		WIRING UNDER SURFACE	9		CIRCUIT MAIN
4		WIRING IN CONDUIT ON SURFACE	10		DISTRIBUTION BOARD
5		WIRING IN CONDUIT UNDER SURFACE (CONCEALED)	11		SUB-DISTRIBUTION BOARD
6		WIRING GOING UPWARDS	12		MAIN PANEL

F- Lightning Protection Apparatus G-Fire Alarm Apparatus

BUILDING SERVICES (ELECTRICAL AND ALLIED INSTALLATIONS)

SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
1		LIGHTNING FINAL	1		SMOKE DETECTOR
2		TEST TERMINAL BOX	2		HEAT DETECTOR
			3		MANUAL OPERATED FIRE ALARM
3		EARTH FOR LIGHTNING SYSTEM	4		AUTOMATIC FIRE DETECTOR SWITCH
			5		FIRE ALARM BELL
4		CONDUCTOR	6		FIRE ALARM INDICATOR

H- Wiring Accessories

SR NO	SYMBOL	DESCRIPTION	SR NO	SYMBOL	DESCRIPTION
1		SINGLE POLE SWITCH	10		5-10A SOCKET OUTLET
2		DOUBLE POLE SWITCH	11		5-10A SWITCHED SOCKET OUTLET
3		PULL-CORD SWITCH	12		13A SOCKET OUTLET
4		2 WAY SWITCH	13		13A SWITCHED SOCKET OUTLET
5		INTERMEDIATE SWITCH	14		15A SOCKET OUTLET
6		DIMMER SWITCH	15		15A SWITCHED SOCKET OUTLET
7		TIME SWITCH	16		5-10A INTERLOCKING SWITCHED SOCKET OUTLET
8		PUSH BUTTON	17		13A INTERLOCKING SWITCHED SOCKET OUTLET
9		BELL	18		15A INTERLOCKING SWITCHED SOCKET OUTLET

ANNEX B*[Clause 5B.4.2.4(b)]***AREA REQUIRED FOR TRANSFORMER ROOM AND SUBSTATION FOR
DIFFERENT CAPACITIES**

B-I The requirement for area for transformer room and substation for different capacities of transformers is given below for guidance:

Sl No	Capacity of Transformer(s) KVA	Total Transformer Room Area Minimum, m ²	Total Substation Area (In Coming, HV, MV Panels, Transformer Room but Without Generators), Minimum, m ²	Suggested Minimum Face Width , m
i)	1 x 160	14.0	90	9.0
ii)	2 x 160	28.0	118	13.5
iii)	1 x 250	15.0	91	9.0
iv)	2 x 250	30.0	121	13.5
v)	1 x 400	16.5	93	9.0
vi)	2 x 400	33.0	125	13.5
vii)	3 x 400	49.5	167	18.0
viii)	2 x 500	36.0	130	14.5
ix)	3 x 500	54.0	172	19.0
x)	2 x 630	36.0	132	14.5
xi)	3 x 630	54.0	176	19.0
xii)	2 x 800	39.0	135	14.5
xiii)	3 x 800	58.0	181	14.0
xiv)	2 x 1000	39.0	149	14.5
xv)	3 x 1000	58.0	197	19.0

NOTES

1 The above dimensions are overall area required for substation excluding generating set.

2 The clear height required for substation equipment shall be minimum of 3.0 m below the soffit of the beam.

ANNEX C*[Clause 5B.4.2.4(i)]***ADDITIONAL AREA REQUIRED FOR GENERATOR IN ELECTRIC SUBSTATION**

C-I The requirement of additional area for generator in electric substation for different capacities of generators is given below for guidance:

Sr. No	Capacity	Area	Clear Height below the soffit of the Beam
	KW	m ²	m
(1)	(2)	(3)	(4)
i)	25	56	3.6
ii)	48	56	3.6
iii)	100	65	3.6
iv)	150	72	4.6
v)	248	100	4.6
vi)	350	100	4.6
vii)	480	100	4.6
viii)	600	110	4.6
ix)	800	120	4.6
x)	1000	120	4.6
xi)	1250	120	4.6
xii)	1600	150	4.6

NOTE — The area and height required for generating set room given in the above table are for general guidance only and may be finally fixed according to actual requirements.

ANNEX D

(Clause 5B. 9.3.2.6)

FORM OF COMPLETION CERTIFICATE

I/We certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with *MYANMAR Electricity Rules*,

Electrical Installation at -----

Voltage and system of supply

Particulars of Works:

a) Internal Electrical Installation

No.	Total Load	Type of system of wiring
i) Light point		
ii) Fan point		
iii) Plug point		
3-pin 6 A		
3-pin 16 A		

b) Others Description hp/kW Type of starting

1) Motors:

i)

ii)

iii)

2) Other plants:

c) If the work involves installations of over head line and/or underground cable

1) i) Type and description of over headline.

ii) Total length and number of spans.

iii) No. of street lights and its description.

2) i) Total length of underground cable and its size:

ii) No. of joints:

End joint:

Tee joint:

Straight through joint:

Earthing:

i) Description of earthing electrode

ii) No. of earth electrodes

iii) Size of main earth lead

Test Results:

a) Insulation Resistance

i) Insulation resistance of the whole system of conductors to earth-----Megaohms.

ii) Insulation resistance between the phase conductor and neutral

Between phase R and neutral Megaohms.

Between phase Y and neutral Megaohms.

Between phase B and neutral Megaohms.

iii) Insulation resistance between the phase conductors in case of polyphase supply.

Between phase R and phase Y Megaohms

Between phase Y and phase B Megaohms

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Between phase B and phase R Megaohms

b) Polarity test:

Polarity of non-linked single pole branch switches

c) Earth continuity test:

Maximum resistance between any point in the earth continuity conductor including metal conduits and main earthing lead----- Ohms.

d) Earth electrode resistance:

Resistance of each earth electrode.

i) Ohms.

ii) Ohms.

iii) Ohms.

iv) Ohms.

e) Lightning protective system.

Resistance of the whole of lightning protective system to earth before any bonding is effected with earth electrode and metal in/on the structure Ohms.

Signature of Supervisor

Name and Address

.....
.....
.....
.....

Signature of Contractor

Name and Address

.....
.....
.....
.....

LIST OF STANDARD

The following list records those standards which are acceptable standards 'in the fulfillment of the requirements of the Code. The latest version of a standard shall be adopted at the time of the enforcement of the Code. The standards listed may be used by the Authority as a guide in conformance with the requirements of the referred clauses in the Code.

- (i) Myanmar Electricity Rules.
- (ii) Indian Electricity Rules 1956

	<i>IS No.</i>	<i>Title</i>
(1)	8270 (Part 1):1976	Guide for preparation of diagrams ,charts and tables for electro technology: Part1 Definitions and classification
	1885 (Part 16/ Sec3) 1967	Electro technical vocabulary: Lighting, Section 3 Lamps and auxiliary apparatus
	(Part 17):1979	Switchgear and control gear (first revision)
	(Part 32):1993	Electrical cables (First Revision)
	(Part 78):1993	Generation , transmission and distribution of electricity General
	12032 (Part 6):1987	Graphical symbols for diagrams in the field of electro technology: Protection and conversion of electrical energy
	(Part 7):1987	Switchgear, control gear and protective devices
(2)	7752 (Part 1):1975	Guide for improvement of power factor in consumer installation: Part 1 Low and medium supply voltages
(3)	5216 (Part 1):1982 (Part 2):1982	Recommendations on safety procedures and practices in electrical work: General (first revision) Life saving techniques (first revision)
(4)	10118 (Part 2):1982	Code of practice for selection, installation and maintenance of switchgear and control gear: Part 2 Selection.
(5)	1646:1997	Code of practice for fire safety of buildings (general):Electrical installations(second revision)
(6)	732:1989 1255:1983	Code of practice for electrical wiring installation (third revision) Code of practice for installation and maintenance of power cables (up to and including 33kV rating)(second revision)
(7)	13947:1993	Specification for low-voltage switchgear and control gear
(8)	2148:1981	Specification for flame-proof enclosures of electrical apparatus (second revision)

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(9)	5578:1985	Guide for marking of insulated conductors (first revision)
(10)	1777:1978	Industrial luminaire with metal reflectors (first revision)
	2206	Flameproof electric lighting fittings:
	(part 1):1984	Well –glass and bulkhead types (first revision)
	(Part 2):1976	Fittings using glass tubes
	3287:1965	Industrial lighting fittings with plastic reflectors
	3528:1966	Waterproof electric lighting fittings
	3553:1966	Specification for watertight electric lighting fittings
	4012:1967	Specification for dust-proof electric lighting fittings
	4013:1967	Dust-tight electric lighting fittings
	5077:1969	Decorative lighting outfits
	10322(Part 5/ Sec 5): 1987	Luminaries: Part 5 Particular requirements , Section 5 Flood lights
(11)	8828:1996	Electrical accessories – Circuit – breakers for over current protection for household and similar installations (second revision)
	13947	Specification for low –voltage switchgear and control gear:
	(Part 1):1993	General rules
	(Part 2):1993	Circuit –breakers
	(Part 3):1993	Switches , disconnectors, switch disconnectors and fuse combination units
	(Part4/Sec1):1993	Contactors and motor –starters, section 1 Electro-technical contactors and motor starters
	(Part5/Sec1):1993	Control circuit devices and switching elements , section 1Electro-technical control circuit devices
(12)	3961	Recommended current ratings for cables:
	(Part 1):1967	Paper insulated lead sheathed cables
	(Part 2):1967	PVC insulated and PVC sheathed heavy duty cables
	(Part 3):1968	Rubber insulated cables
	(Part 5):1968	PVC insulated light duty cables
(13)	2086:1993	Specification for carriers and bases used in rewirable type electric fuses for voltages up to 650 V (third revision)
	13703	LV fuses for voltages not exceeding 1000 V ac or 1500 dc: Part
	(Part 1):1993	1 General requirement
(14)	2672:1966	Code of practice for library lighting

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4347:1967	Code of practice for hospital lighting
6665:1972	Code of practice for industrial lighting
8030:1976	Specification for luminaries for hospitals
(15) 732:1989	Code of practice for electrical wiring installations (third revision)
(16) 4648:1968	Guide for electrical layout in residential buildings
(17) 900:1992	Code of practice for installation and maintenance of induction motors (second revision)
(18) 2412:1975	Link clips for electrical wiring (first revision)
(19) 2667:1988	Fittings for rigid steel conduits for electrical wiring (first revision)
3419:1989	Fittings for rigid non-metallic conduits (second revision)
9537	Conduits for electrical installations:
(Part 1):1980	General requirements
(Part 2):1981	Rigid steel conduits
(Part 3):1983	Rigid plain conduits of insulating materials
14772:2000	Specification for accessories for household and similar fixed electrical installations
(20) 1913	General and safety requirements for luminaires: Part 1 Tubular fluorescent lamps (second revision)
Part 1):1978	
(21) 1258:1987	Bayonet lamp holders (third revision)
(22) 418:1978	Tungsten filament general service electric lamps (third revision)
1534	Ballast for fluorescent lamp:Part1 for switch start circuits (second revision)
(Part 1):1977	
1569:1976	Capacitors for use in tubular fluorescent high pressure mercury and low pressure sodium vapour discharge lamp circuit (first revision)
2215:1983	Specification for starters for fluorescent lamps (third revision)
2418	Specification for tubular fluorescent lamps for general lighting service:
(Part 1):1977	Requirements and tests (first revision)
(Part 2):1977	Standard lamp data sheets (first revision)
(Part 3):1977	Dimensions of G-5 and G-13 lc –pin caps (first revision)
(Part 4):1977	Go and no-go gauges for G-5 and G-13 lc –pin caps (first revision)
3323:1980	Bi-pin lampholders for tubular fluorescent lamps (first revision)
3324:1982	Holders for starters for tubular fluorescent lamps (first revision)
9900	Basic environmental testing procedures for electronic and electrical items:
(Part 1):1981	General

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(Part 2):1981	Cold test
(Part 3):1981	Dry heat test
(Part 4):1981	Damp test (steady state)
(23) 374:1979	Electric ceiling type fans and regulators (third revision)
(24) 3043:1987	Code of practice for earthing
(25) 8623 Part 1):1993	Specification for low-voltage switchgear and control gear assemblies:Part1Requirements for type-tested and partially type-tested assemblies (first revision)
(26) 10028 (Part 2):1981	Code of practice for selection, installation and maintenance of transformers: Part2 Installation
11353:1985	Guide for uniform system of marking and identification of conductors and apparatus terminals
(27) 2309:1989	Code of practice for the protection of buildings and allied structures against lightning (second revision)

References may be made to the following publications for better applying and understanding of the requirements of the Code

IEC 60079	Electrical apparatus for explosive gas atmospheres
IEC 60085	Electrical insulation-Thermal classification
IEC 60127	Miniature fuses
IEC 60189	Low-frequency cables and wires with PVC insulation and PVC sheath
IEC 60227	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V
IEC 60228	Conductors for insulated cables
IEC 60238	Edison screw lampholders
IEC 60245	Rubber insulated cables of rated voltages up to and including 450/750V
IEC 60269	Low-voltage fuse
IEC 60309	Plugs, socket-outlets and couplers for industrial purposes
IEC 60364	Low-voltage electrical installations /Electrical installation of building
IEC 60423	Conduit systems for cable management-Outside diameters of conduits for electrical installation and threads for conduits and fittings
IEC 60439	Low-voltage switchgear and control gear assemblies
IEC 60529	Degree of protection provided by enclosures (IP Code)
IEC 60617	Graphical symbols for diagrams

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IEC	60669	Switches for household and similar fixed electrical installations
IEC	60702	Mineral insulated cables and their terminations with a rated voltage not exceeding 750V
IEC	60755	General requirements for residual current operated protective devices
IEC	60898	Electrical accessories-Circuit-breakers for overcurrent protection for household and similar installations
IEC	60947	Low-voltage switchgear and control gear
IEC	60950	Information technology equipment-Safety
IEC	61008	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)
IEC	61009	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
IEC	61084	Cable trunking and ducting systems for electrical installations
IEC	61140	Protection against electric shock-Common aspects for installation and equipment
IEC	61386	Conduit system for cable management
IEC	61643	Low-voltage surge protective devices
IEC	62305	Protection against lightning
IEE	519	IEEE recommended practices and requirement for harmonic control in electrical power system.
BS EN	50266	Common test method for cables under fire conditions- Test for vertical flame spread of vertically- mounted bunched wires or cables
BS EN	50310	Application of equipotential bonding and earthing in buildings with information technology equipment
BS EN	60332-1-2	Tests on electric and optical fibre cables under fire conditions-Test for vertical flame propagation for a single insulated wire or cable- Procedure for 1 KW pre-mixed flame
BS EN	60598	Luminaires
BS EN	61034-2	Measurement of smoke density of cables burning under defined conditions-Test procedure and requirements
BS EN	61534	Power track systems
BS EN	61558	Safety of power transformers, power supply ,supplies, reactors and similar products
BS EN	61558-2-5	Safety of power transformers, power supply units and similar-Particular requirements for shaver transformers and shaver supply units

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BS	31	Specification-steel conduit and fittings for electrical wiring
BS	88	Low-voltage fuses/Cartridge fuses for voltages up to and including 1000V a.c and 1500V d.c
BS	88 Part 2	Low-voltage fuses. Supplementary requirements for fuses for use by authorized persons fuses mainly for industrial application).Examples of standardized systems of fuses AtoI
BS	88 Part 6	Cartridge fuses for voltages up to and including 1000V a.c. and 1500V d.c Specification of supplementary requirements for fuses of compact dimensions for use in 240/415V a.c. industrial and commercial electrical installations.
BS	196	Specification for protected-type non-reversible plugs, socket-outlets, cable-couplers and appliance-couplers with earthing contacts for single-phase a.c. circuits up to 250 volts
BS	476 Part20	Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction(general principles)
BS	546	Specification-Two-pole and earthing-pin plugs, socket-outlets and socket-outlet adaptors
BS	1361	Specification for cartridge fuses for a.c. circuits in domestic and similar premises
BS	1363	13A plugs, socket-outlets, adaptors and connection units
BS	3036	Specification-Semi-enclosed electric fuses (ratings up to 100 amperes and 240 volts to earth)
BS	3676	Switches for household and similar fixed electrical installations
BS	4444	Guide to electrical earth monitoring and protective conductor proving
BS	4568	Specification-for steel conduit and fittings with metric threads of ISO form for electrical installations
BS	4607	Non-metallic conduits and fittings for electrical installations
BS	4662	Boxes for flush mounting of electrical accessories requirements and test methods and dimensions
BS	5266	Emergency lighting
BS	5839	Fire detection and fire alarm systems for buildings
BS	6004	Electric cables.PVC insulated, non-armoured cables for voltages up to and including 450/750V, for electric power, lighting and internalwiring
BS	6007	Electric cables. Single core unsheathed heat resisting cables for voltage up to and including 450/750 V for internal wiring
BS	6231	Electrical cables. Single core PVC insulated flexible cables for rated voltage 600/1000 V for switchgear and control gear wiring
BS	6346	Electric cables.PVC insulated, armoured cables for voltage of

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		600/1000V and 1900/3300V
BS	6387	Specification for performance requirements for cables required to maintain circuit integrity under fire conditions
BS	6500	Electric cables, Flexible cords rated up to 300/500V, for use with appliances and equipment intended for domestic, office and similar environments
BS	6701	Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance
BS	6724	Electric cables, Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300V, having low emission of smoke and corrosive gases when affected by fire
BS	7211	Electric cables. Thermosetting insulated, nonarmoured cables for voltages up to and including 450/750V, for electric power, lighting and internal wiring, and having low emission of smoke and corrosive gases when affected by fire
BS	7629	Specification for 300/500V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire
BS	7671	Requirements for electrical installations. IEE Wiring Regulations. Seventeenth Edition
BS	7919	Electric cable. Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments.
AS/NZS	1768	Lightning protection
NFPA	780	Standard for the installation of lightning protection systems

References may be made to the following publications for the common personal protective equipment and tools used for electrical work.

BS EN	60900	Live working – Hand tools for use up to 1000V a.c. and 1500 V d.c
BS EN	60903	Live working – Gloves of insulating material
BS IEC	ISO 20345	Personal protective equipment – Safety footwear
BS IEC	61111	Matting of insulating material for electrical purposes
BS EN	61112	Blankets of insulating material for electrical purposes
ASTM	F1506	Standard performance specification for flame resistant textile materials for wearing apparel for use by electrical workers exposed to momentary electric arc and related thermal hazards

References

International Energy Conservation Code 2009

International Green Construction Code 2010

**MYANMAR
NATIONAL
BUILDING
CODE
2016**

**PART5C
INSTALLATION OF LIFTS AND
(ESCALATORS)**

MYANMAR NATIONAL BUILDING CODE

TWG No.5 BUILDING SERVICES

Installation of Lifts and Escalators

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MYANMAR NATIONAL BUILDING CODE
TWG No.5C BUILDING SERVICES
Installation of Lifts and Escalators

5C.1 SCOPE

5C.1.1 This Section covers the essential requirements for the installation, operation and maintenance and also inspection of lifts (passenger lifts, goods lifts, hospital lifts, service lifts and dumb waiters) and escalators so as to ensure safe and satisfactory performance.

5C.1.2 This Section gives information that should be exchanged among the architect, the consulting engineer and the lift / escalator manufacturer from the stage of planning to installation including maintenance.

5C.2 TERMINOLOGY

For the purpose of this Section, the following definitions shall apply.

5C.2.1 A lift (Elevator) , is a Type of vertical transport equipment that efficiently moves people or goods between floor of a building , vessel or other structures .

5C.2.1.1 Automatic Rescue Device – A device meant to bring a lift stuck between floors due to loss of power, to the nearest level and open the doors in order to allow trapped passengers to be evacuated. Such a device may use some form of internal auxiliary power source for such purpose, complying with all the safety requirements of a lift during normal run. The speed of travel is usually lower than the normal speed. In the case of manual doors on reaching the level, the device shall allow the door to be opened and in case of power operated doors the device shall automatically open the door.

5C.2.1.2 Bottom Car Runby – The distance between the car buffer striker plate and the striking surface of the car buffer when the car is in level with the bottom terminal landing.

5C.2.1.3 Bottom Counterweight Runby – The distance between the counter weight buffer striker plate and the striking surface of the counterweight buffer when the car is in level with the top terminal landing.

5C.2.1.4 Buffer – A device designed to stop a descending car or counter weight beyond its normal limit of travel by storing or by absorbing and dissipating the kinetic energy of the car or counterweight.

5C.2.1.5 Oil Buffer – A buffer using oil as a medium which absorbs and dissipates the kinetic energy of the descending car or counterweight.

5C.2.1.6 Oil buffer stroke – The oil displacing movement of the buffer plunger or piston, excluding the travel of the buffer plunger accelerating device.

5C.2.1.7 Spring Buffer – A buffer which stores in a spring the kinetic energy of the descending car or counterweight.

5C.2.1.8 Spring buffer load rating – The load required to compress the spring by an amount equal to its stroke.

5C.2.1.9 Spring buffer stroke – The distance, the contact end of the spring can move under a compressive load until the spring is compressed solid.

5C.2.1.10 Call Indicator – A visual and audible device in the car to indicate to the attendant the lift landings from which calls have been made.

5C.2.1.11 Car Bodywork – The enclosing bodywork of the lift car which comprises the sides and roof and is built upon the car platform.

5C.2.1.12 Car Door Electric Contact – An electric device, the function of which is to prevent operation of the driving machine by the normal operating device unless the car door is in the closed position.

5C.2.1.13 Car Frame – The supporting frame or sling to which the platform of the lift car, its safety gear, guide shoes and suspension ropes are attached.

5C.2.1.14 Car Platform – The part of the lift car which forms the floor and directly supports the load.

5C.2.1.15 Bottom Car Clearance – The clear vertical distance from the pit floor to the lowest structural or mechanical part, equipment or device installed beneath the car platform aprons or guards located within 300mm, measured horizontally from the sides of the car platform when the car rests on its fully compressed buffers.

5C.2.1.16 Top Car Clearance – The shortest vertical distance between the top of the car crosshead, or between the top of the car where no crosshead is provided, and the nearest part of the overhead structure or any other obstruction when the car floor is level with the top terminal landing.

5C.2.1.17 Top Counterweight Clearance – The shortest vertical distance between any part of the counterweight structure and the nearest part of the overhead structure or any other obstruction when the car floor is level with the bottom terminal landing.

5C.2.1.18 Control – The system governing starting, stopping direction of motion, acceleration, speed and retardation of moving member.

5C.2.1.19 Single-Speed Alternating Current Control – A control for a driving machine induction motor which is arranged to run at a single-speed.

5C.2.1.20 Two-speed Alternating Current Control – A control for a two-speed driving machine induction motor which is arranged to run at two different synchronous speeds either by pole changing of a single motor or by two different armatures.

5C.2.1.21 Rheostatic Control – A system of control which is accomplished by varying resistance or reactance or both in the armature or field circuit or both of the driving machine motor.

5C.2.1.22 Variable Voltage Motor Control (Generator Field Control) – A system of control which is accomplished by the use of an individual generator for each lift wherein the voltage applied to the driving machine motor is adjusted by varying the strength and direction of the generator field.

5C.2.1.23 Electronic Devices – A system of control which is accomplished by the use of electronic devices for driving the lift motor at variable speed.

5C.2.1.24 Alternating Current Variable Voltage (ACVV) Control – A system of speed control which is accomplished by varying the driving and braking torque by way of voltage variation of the power supply to the driving machine induction motor.

5C.2.1.25 Alternating Current Variable Voltage Variable Frequency (ACVVVF) Control – A system of speed control which is accomplished by varying the voltage and frequency of the power supply to the driving machine induction motor.

5C.2.1.26 Solid-State d.c, Variable Voltage Control – A solid state system of speed control which is accomplished by varying the voltage and direction of the power supply to the armature of driving machine d.c motor.

5C.2.1.27 Counterweight – A weight or series of weights to counter-balance the weight of the lift car and part of the rated load.

5C.2.1.28 Deflector Sheave – An idler pulley used to change the direction of a rope lead.

5C.2.1.29 Door, Centre, Opening Sliding – A door which slides horizontally and consists of two or more panels which open from the centre and are usually so interconnected that they move simultaneously.

5C.2.1.30 Door, Mid-Bar Collapsible – A collapsible door with vertical bars mounted between the normal vertical members.

5C.2.1.31 Door, Multipanel – A door arrangement whereby more than one panel is used such that the panels are connected together and can slide over one another by which means the clear opening can be maximized for a given shaft width. Multipanels are used in centre opening and two sliding doors.

5C.2.1.32 Door, Single Slide – A single panel door which slides horizontally.

5C.2.1.33 Door, Two Speed Sliding – A door which slides horizontally and consists of two or more panels, one of which moves at twice the speed of the other.

5C.2.1.34 Door, Vertical Bi-parting – A door which slides vertically and consists of two panels or sets of panels that move away from each other to open and are so interconnected that they move simultaneously.

5C.2.1.35 Door, Vertical Lifting – A single panel door, which slides in the same plane vertically up to open.

5C.2.1.36 Door, Swing – A swinging type single panel door which is opened manually and closed by means of a door closer when released.

5C.2.1.37 Door Closer – A device which automatically closes a manually opened door.

5C.2.1.38 Door Operator – A power-operated device for opening and closing doors.

5C.2.1.39 Dumb Waiters – A lift with a car which moves in guides in a vertical direction; has a net floor area of 1sqm meter, total inside height of 1.2 meter, whether or not provided with fixed or removable shelves; has a capacity not exceeding 250kg and is exclusively used for carrying materials and shall not carry any person.

5C.2.1.40 Electrical and Mechanical Interlock – A device provided to prevent simultaneous operation of both up and down relays.

5C.2.1.41 Electro – Mechanical Lock – A device which combines in one unit, electrical contact and a mechanical lock jointly used for the landing and /or car doors.

5C.2.1.42 Emergency Stop Push or Switch – A push button or switch provided inside the car designed to open the control circuit to cause the lift car to stop during emergency.

5C.2.1.43 Gearless Machine – A lift machine in which the motive power is transmitted to the driving sheave from the motor without intermediate reduction gearing and has the brake drum mounted directly on the motor shaft.

5C.2.1.44 Goods Lift – A lift designed primarily for the transport of goods, but which may carry a lift attendant or other person necessary for the loading or unloading of goods.

5C.2.1.45 Guide Rails – The members used to guide the movement of a lift car or counterweight in a vertical direction.

5C.2.1.46 Guide Rails Fixing – The complete assy comprising the guide rails bracket and its fastenings.

5C.2.1.47 Guide Rails Shoe – An attachment to the car frame or counterweight for the purpose of guiding the lift car or counterweight frame.

5C.2.1.48 Hoisting Beam – A beam, mounted immediately below the machine room ceiling, to which lifting tackle can be fixed for raising or lowering parts of the lift machine.

5C.2.1.49 Hospital lift – A lift normally installed in a hospital/dispensary clinic and designed to accommodate one number bed / stretcher along its depth, with sufficient space around to carry a minimum of three attendants in addition to the lift operator.

5C.2.1.50 Landing Call Push – A push button fitted at a lift landing, either for calling the lift car, or for actuating the call indicator.

5C.2.1.51 Landing Door – The hinged or sliding portion of a lift well enclosure, controlling access to a lift car at a lift landing.

5C.2.1.52 Landing Zone – A space extending from a horizontal plane 400 mm below a landing to a plane 400 mm above the landing.

5C.2.1.53 Levelling Device, Lift Car – Any mechanism which either automatically or under the control of the operator, moves the car within the Levelling zone towards the landing only, and automatically stops it at the landing.

5C.2.1.54 Levelling Device, One Way Automatic – A device which corrects the car level only in case of under run of the car but will not maintain the level during loading and unloading.

5C.2.1.55 Levelling Device, Two Way Automatic Maintaining – A device which corrects the car level on both under run and over-run and maintains the level during loading and unloading.

5C.2.1.56 Levelling Device, Two Way Automatic Non-Maintaining – A device which corrects the car level on both under run and over run but will not maintain the level during loading and unloading.

5C.2.1.57 Levelling Zone – The limited distance above or below a lift landing within which the Levelling device may cause movement of the car towards the landing.

5C.2.1.58 Lift – An appliance designed to transport persons or materials between two or more levels in a vertical or substantially vertical direction by means of a guided car or platform. The word 'elevator' is also synonymously used for 'lift'.

5C.2.1.59 Lift Car – The load carrying unit with its floor or platform, car frame and enclosing body work.

5C.2.1.60 Lift Landing - That portion of building or structure used for discharge of passengers or goods or both into or from a lift car.

5C.2.1.61 Lift Machine – The part of the lift equipment comprising the motor and the control gear therewith, reduction gear (if any), brake(s) and winding drum or sheave, by which the lift car is raised or lowered.

5C.2.1.62 Lift Pit – The space in the lift well below the level of the lowest lift landing served.

5C.2.1.63 Lift Well – The unobstructed space within an enclosure provided for the vertical movement of the lift car(s) and any counterweight(s), including the lift pit and the space for top clearance.

5C.2.1.64 Lift Well Enclosure – Any structure which separates the lift well from its surroundings.

5C.2.1.65 Operation – The method of actuating the control of lift machine.

5C.2.2 Operation

5C.2.2.1 Automatic Operation – A method of operation in which by a momentary pressure of a button the lift car is set in motion and caused to stop automatically at any required lift landing.

5C.2.2.2 Non-Selective Collective Automatic Operation – Automatic operation by means of one button in the car for each landing level served and one button at each landing, wherein all stops registered by the momentary actuation of landing or car buttons are made irrespective of the number of buttons actuated or of the sequence in which the buttons are actuated. With this type of operation, the car stops at all landings for which buttons have been actuated making the stops in the order in which the landings are reached after the buttons have been actuated but irrespective of its direction of travel.

5C.2.2.3 Selective Collective Automatic Operation – Automatic operation by means of one button in the car for each landing level served and by up and down buttons at the landings, wherein all stops registered by the momentary actuation of the car made as defined under non-selective collective automatic operation, but wherein the stops registered by the momentary actuation of the landing buttons are made in the order in which the landings are reached in each direction of travel after the buttons have been actuated. With this type of operation, all 'up' landing calls are answered when the car is travelling in the up direction and all 'down' landing calls are answered when the car is travelling in the down direction, except in the case of the uppermost or lowermost calls which are answered as soon as they are reached irrespective of the direction of travel of the car.

5C.2.2.4 Single Automatic Operation – Automatic operation by means of one button in the car for each landing level served and one button at each landing so arranged that if any car or landing button has been actuated, the actuation of any other car or landing operation button will have no effect on the movement of the car until the response to the first button has been completed.

5C.2.2.5 Group Automatic Operation – Automatic operation of two or more non-attendant lifts equipped with power-operated car and landing doors. The operation of the car is co-ordinated by a supervisory operation system including automatic dispatching means whereby selected car at designated dispatching points automatically close their doors and proceed on their trips in a regulated manner.

Typically, it includes one button in each car for each floor served and up and down buttons at each landing (single button at terminal landings). The stops set up by the momentary actuation of the car buttons are made automatically in succession as a car reaches the corresponding landings irrespective of its directions of travel or the sequence in which the buttons are actuated. The stops set up by the momentary actuation of the landing buttons may be accomplished by any lift in the group, and are made automatically by the first available car that approaches the landing in the corresponding direction.

5C.2.2.6 Car Switch Operation – Method of operation by which the movement of lift car is directly under the operation of the attendant by means of a handle.

5C.2.2.7 Signal Operation – Same as collective operation, except that the closing of the door is initiated by the attendant.

5C.2.2.8 Double Button (Continuous Pressure) Operation – Operation by means of buttons or switches in the car and the landings any of which may be used to control the movement of the car as long as the button or switch is manually pressed in the actuating position.

5C.2.2.9 Operating Device – A car switch, push button or other device employed to actuate the control.

5C.2.3 Others:

5C.2.3.1 Overhead Beams – The members, usually of steel, which immediately support the lift equipment at the top of the lift well.

5C.2.3.2 Over Speed Governor – An automatic device which brings the lift car and /or counter weight to rest by operating the safety gear in the event of the speed in a descending direction exceeding a predetermined limit.

5C.2.3.3 Passenger Lift – A lift designed for the transport of passengers.

5C.2.3.4 Position and/or Direction Indicator – A device which indicates on the lift landing or in the lift car or both, the position of the car in the lift well or the direction or both in which the lift car is travelling.

5C.2.3.5 Rated Load (Lift) – The maximum load for which the lift car is designed and installed to carry safely at its rated speed.

5C.2.3.6 Rated Load (Escalator) – The load which the escalator is designed and installed to lift at the rated speed.

5C.2.3.7 Rated Speed (Lift) – The mean of the maximum speed attained by the lift car in the upward and downward direction with rated load in the lift car.

5C.2.3.8 Retiring Cam – A device which prevents the landing doors from being unlocked by the lift car unless it stops at a landing.

5C.2.3.9 Roping Multiple – A system of roping where, in order to obtain a multiplying the factor from the machine to the car, multiple falls of rope are run around sheave on the car or counterweight or both. It includes roping arrangement of 2 to 1, 3 to 1 etc.

5C.2.3.10 Safety Gear – A mechanical device attached to the lift car or counterweight or both, designed to stop and to hold the car or counterweight to the guides in the event of free fall, or, if governor operated, of over-speed in the descending direction. Any anticipated impact force shall be added in the general drawing or layout drawing.

5C.2.3.11 Service Lift – A passenger cum goods lift meant to carry goods along with people.

Typically in an office building this may be required to carry food or stationeries, in a residential building to carry a bureau or accommodate a stretcher and in a hotel to be used for food trolleys or baggage. There is a need in such lifts, to take care of the dimensions of the car and the door clear opening in line with the type of goods that may have to be carried based on mutual discussion between supplier and customer. Also, such lifts shall have buffer railings in the car at suitable height to prevent damage to the car panels when the goods are transported. Typically such lifts, if provided with an automatic door, may use some means to detect trolleys and stretcher movement in advance to protect the door against damage. The car floor load calculations and car area of such a lift is as in the case of a passenger lift except that these are not meant to carry heavy concentrated loads.

5C.2.3.12 Sheave – A rope wheel, the rim of which is grooved to receive the suspension ropes but to which the ropes are not rigidly attached and by means of which power is transmitted from the lift machine to the suspension ropes.

5C.2.3.13 Slack Rope Switch – Switch provided to open the control circuit in case of slackening of rope(s).

5C.2.3.14 Suspension Ropes – The ropes by which the car and counter weight are suspended.

5C.2.3.15 Terminal Slow Down Switch – A switch when actuated shall compulsorily cut off the high speed and switch on the circuitry to run the lift in Levelling speed before reaching on terminal landings.

5C.2.3.16 Terminal Stopping Switch Normal – Switch for cutting all the energizing current in case of car travelling beyond the top bottom landing or a switch cuts off the energizing current so as to bring the car to stop at the top and bottom level.

5C.2.3.17 Terminal Stopping Device Final – A device which automatically cause the power to be removed from an electric lift driving machine motor and brake, independent of the functioning of the normal terminal stopping device, the operating device or any emergency terminal stopping device, after the car has passed a terminal landing.

5C.2.3.18 Total Headroom – The vertical distance from the level of the top lift landing to the bottom of the machine room slab.

5C.2.3.19 Travel – The vertical distance between the bottom and top lift landing served.

5C.2.3.20 Geared Machine – A machine in which the power is transmitted to the sheave through worm or worm and spur reduction gearing.

5C.3 GENERAL

5C.3.1 The appropriate aspect of lift and escalator installation shall be discussed during the preliminary planning of the building with all the concerned parties, namely, client, architect, consulting engineer and/or lift/escalator manufacturer. This enables the lift/escalator manufacturer to furnish the architect and/or consulting engineer with the proposed layout on vice-versa.

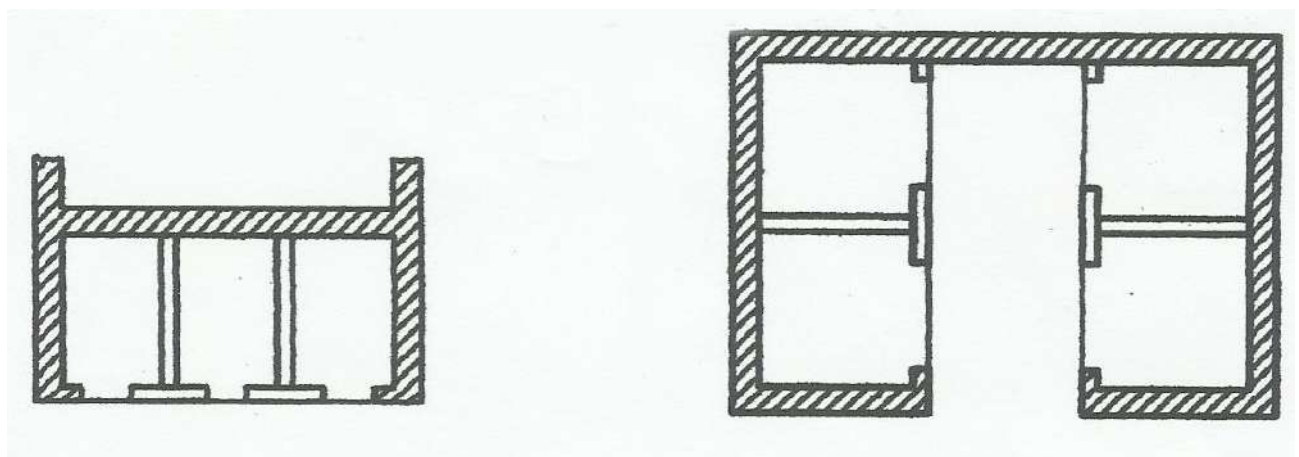
5C.3.2 Exchange of Information

5C.3.2.1 If the proposed installation is within the scope of 6, the guidelines laid down together with Fig.1 will enable the preliminary scheme for the installation to be established.

Figure 1 shows only some of the typical arrangements and variations are possible with respect to number of lifts and the layout.

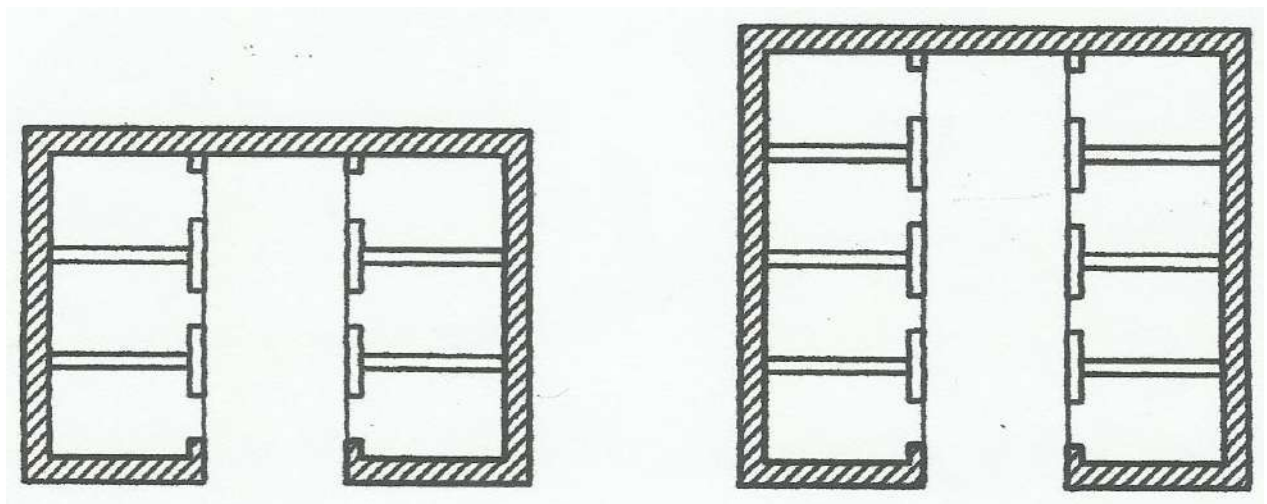
Although the recommended outline for the various classes of lifts given in 6 enables the general planning details to be determined by the architect, these should be finally settled at the earliest possible stage by detailed investigation with the purchaser's representative reaching agreement with the lift maker where necessary before an order is finally placed. This will enable a check to be made and information to be exchanged on such vital matters as:

- a) Capacity, speed the number, and disposition of the lifts necessary to give adequate lift service in the proposed building.
- b) The provision of adequate access to the machine room.
- c) The loads which the lift will impose on the building structure, and the holes to be left in the machine room floor and cut-outs for wall boxes for push-buttons and signals.
- d) The necessity for and type of insulation to minimize the transmission of vibration and noise to other parts of the building.



**1A STRAIGHT LINE
ARRANGEMENT FOR THREE LIFTS**

**1B ALCOVE ARRANGEMENT FOR
FOUR LIFTS**



1C ARRANGEMENT FOR SIX LIFTS

1D ARRANGEMENT FOR EIGHT LIFTS

Fig -1 ARRANGEMENT OF LIFTS

- e) The special requirements of local authorities and other requirements set out in the 'planning permit'.
- f) The need for the builder to maintain accuracy of building as to dimensions and in plumb.
- g) The periods of time required for preparation and approval of relevant drawings for manufacturing and the installation of the lift equipment.
- h) The requirements for fixing guide brackets to the building structure; and brackets spacing is not more than 2500 mm.
- i) The time at which electric power will be required before completion to allow for testing.
- j) Lift well shall be adequately ventilated at the top of the shaft to the external air by means of one or more permanent openings having a total unobstructed area of at least 1% of the horizontal section of the well and not less than 0.1 m² for each lift in the shaft.
- k) Where the depth of a pit, measured from the lower terminal landing exceeds 1000 mm and where no other means of access exists, a ladder shall be fixed permanently within reach of the lower terminal landing door. The pit ladder or the handholds for the pit ladder shall extend up to 1500 mm above the bottom terminal floor to enable safe descent into the pit. Where more than one lift is operating in the same pit, pit ladder shall be installed for every lift.
- l) Pits shall be waterproofed before installation of the lift equipment by the use of tanking, membranes or other positive means and where required, shall have a covered sump located therein. The sump cover shall be a non-slip type and shall be not easily displaced. The sump shall not be connected to any closed drainage system; but may be connected into an open-ended drain below the sump level so that it cannot be flooded.
- m) Where pumps are required, they shall be installed outside the lift well. Pump shall be effectively partitioned from the lift well and separate access for maintenance. The level of any external sump shall be such that water cannot flow back into the lift well. Drains shall not run into pits.
- n) The requirements for electrical supply feeders, etc.
- o) The requirements for scaffolding in the lift well and protection of the lift well prior to and during installation of equipment and

- p) Delivery and storage of equipment.

5C.3.2.2 Information to be Provided by Architect or Engineer

As a result of preliminary discussion the drawings of the building should give the following particulars and finished sizes;

- a) Number, type and size of lifts and position of lift well
- b) Particulars of lift well enclosure
- c) Size, position, number and type of landing doors
- d) Number of floors served by the lift
- e) Height between floor levels
- f) Number of entrances
- g) Total headroom
- h) Provision of access to machine room
- i) Provision of ventilation and, if possible, natural lighting of machine room
- j) Height of machine room; not less than 2100 mm
- k) Depth of lift pit
- l) Position of lift machine, above or below lift well
- m) Size and position of any trimmer joists or stanchions adjacent to the lift well at each floor
- n) Size and position of supporting steel work at roof levels
- o) Size and position of any footings or grillage foundations, if these are adjacent to the lift pit and
- p) In the case of passenger lifts whether the lift cage is required to carry household luggage, such as refrigerator, steel almirah, etc.

5C.3.2.2.1 The lift lobby should be designed appropriately since this has bearing on the traffic handling especially when more number of lifts are involved. In a dual line arrangement (lifts opposite to each other) the lobby can be between 1.5 times to 2.5 times the depth of one car. Typically the more the number of lifts the bigger the multiple to be used. As an example a quadruplex may use 1.5 to 2 times whereas an octoplex will need 2 to 2.5 times. For in line (single line) arrangements, the lobby can be typically half of the above recommendations.

It is preferable that the lift lobby is not used as a thoroughfare but in such cases the lift corridor shall take into account space for people who are moving.

5C.3.2.2.2 The architect/engineer should advise the lift manufacturer, if the Authority has any special requirements regarding lifts in buildings in the administrative area concerned.

5C.3.2.2.3 The architect/engineer should inform the lift/escalator manufacturer of the dates when the erection of the lift/escalator may be commenced and is to be completed so that sufficient time is allowed for the manufacture and erection of the lift/escalator.

5C.3.2.2.4 When submitting application for a building permit to the local Authority, the building plans shall include the details of lifts (number of lifts duly numbered, location, type, type of doors, passenger capacity and speed).

5C.3.2.3 Working Drawings to be Prepared by the lift/Escalator Manufacturer

The lift/escalator manufacturer requires sufficient information for the preparation of working drawings and is usually obtained from architect's drawings supplemented by any information obtained from the site and by collaboration with the other contractors.

5C.3.2.3.1 Working drawings showing the layout of lift/escalator duly numbered, details of builders works, for example, holes in walls for guide fixing, holes in machine room floor for ropes and conduits, recesses for landing sills, supports for lift/escalator machine and loads imposed on the building should be submitted by the lift/escalator manufacturer to the architect/engineer for written approval.

5C.3.3 Electrical Requirement

For information of the electrical engineer, the lift/escalator a manufacturer should advise the architect/engineer of his electrical requirements. This information should be available early in planning stage so that the electrical supply requirements of the lift(s)/escalator(s) may be included in the electrical provisions of the buildings and that suitable cables and switchgear may be provided.

5C.3.4 The requirements given under 4 to 13 deal with installation of lifts and 14 deal with the installation of escalators.

5C.4 ESSENTIAL REQUIREMENTS

5C.4.1 Conformity with Lift/ Escalator Rule and Regulation

The installation shall be generally carried out in conformity with Myanmar Electricity (Lift/ Escalator) Rule and Regulation there under, wherever they are in force.

5C.4.1.1 It is the responsibility of the owner of the premises where the lift/escalator will be installed, to obtain necessary permission from the Authority before and after the erection of lift/ escalator and for subsequent operation of lift/ escalator.

5C.4.2 Conformity with Myanmar Electricity Rule and Regulation

All electrical work in connection with installation of electric lift/escalator shall be carried out in accordance with the provisions of Myanmar Electricity (lift/escalator) Rule – 1985 and the provisions framed there under as amended from time to time, and shall also comply with the other provisions of Part 5 A&B 'Buildings Service, Electrical and Allied Installations'. MNBC 2012 or Latest version.

5C.4.3 Conformity with Myanmar Standards

5C.4.3.1 The materials shall be approved by the competent authority. For detailed specification for lift/escalator, reference shall be made to accepted standard as according to CP 2 2009 & EN-81-1- 1998 or latest version and EN-115-1:2008 or latest version.

5C.4.4 Conformity with Fire Regulations

5C.4.4.1 The installation shall be carried out in conformity with 'Myanmar Fire Safety code of practices' and local fire regulations and rules there under wherever they are in force.

5C.4.5 Factor of Safety

The minimum factor of safety for any part of the lift shall not be less than five. Higher factor of safety for various parts shall be applicable in accordance with CP 2 2009, EN – 81 – 1 – 1998, Myanmar Electricity Rule & Regulation 1985.

5C.4.6 Additional Requirements for Passenger and Goods Lifts

5C.4.6.1 Bottom and Top Car Clearances

5C.4.6.1.1 Bottom car clearance

When the car rests on its fully compressed buffer there shall be vertical clearance of not less than 600mm between the pit floor and the buffer striker plate or the lowest structural or mechanical part equipment or device installed. The clearance shall be available beneath the whole area of the platform except for:

- a) 0 mm measured horizontally from the sides of the car platform and
- b) Compensating sheaves, guide shoes or rollers, safety jaw blocks, platform aprons, guards of other equipment located within 30.

Provided that in all the cases, including small cars, a minimum clearance of 600 mm is available over a horizontal area of 800 mm x 500 mm.

Provided also that in all the cases, when the car rests on its fully compressed buffers, there shall be a vertical clearance of not less than 50 mm between any part of the car and any obstruction of device mounted in the pit.

5C.4.6.1.2 Top car clearance

The vertical clearance between the car cross-head and the nearest overhead obstruction within 500mm measured horizontally to the nearest part of the crosshead when the car platform is level with the top landing, shall be not less than the sum of the following;

- a) The bottom counterweight runby.
- b) The stroke of the counterweight buffer used.
- c) One-half of the gravity stopping distance based on:
 - 1) 115 percent of the rated speed where oil buffers are used and no provision is made to prevent the jump of the car at counterweight buffer engagement and
 - 2) Governor tripping speed where spring buffers are used.

NOTE - The gravity stopping distance based on the gravity retardation from any initial velocity may be calculated according to the following formula.

$$S = 51 V^2$$

where

S = Free fall in mm (gravity stopping distance), and

V = Initial velocity in m/s

- d) 600 mm

Where there is a projection below the ceiling of the well and the projection is more than 500 mm, measured horizontally from the centre line of the cross-head but over the roof of the car, a minimum vertical clearance not less than that calculated above shall also be available between the roof of the car and the projection.

Provided that the vertical clearance between any equipment mounted on top of the car and the nearest overhead obstruction shall be not less than the sum of the three items (a), (b) and (c) as calculated above plus 150 mm.

5C.4.6.2 Bottom Runby for Cars and Counterweights

5C.4.6.2.1 The bottom runby of cars and counterweights shall be not less than the following:

- a) 150 mm where oil buffers are used;
- b) Where spring-buffers are used;
 - (1) 150 mm for controls as in 5C. 2.1.23 to 5C. 2.1.27.
 - (2) Not less than the following for controls as in 5C.2.1.20 to 5C. 2.1.22.

Rated Speed	Runby
m/s	mm
Up to 0.125	75
0.125 to 0.25	150
0.25 to 0.50	225
0.50 to 1	300

5C.4.6.3 Maximum Bottom Runby

In no case shall the maximum bottom runby exceed the following:

- a) 600 mm for cars and
- b) 900 mm for counterweights.

5C.4.6.4 Top Counterweight Clearances

The top counterweight clearances shall be not less than the sum of the following four items:

- a) The bottom car runby
- b) The stroke of the car buffer used
- c) 150 mm and
- d) One-half the gravity stopping distance based on
 - 1) One hundred and fifteen percent of the rated speed where oil buffers are used and no provision is made to prevent jump of the counterweight at car buffer engagement and
 - 2) Governor tripping speed where spring buffers are used.

5C.4.7 Additional Requirements for Service Lifts

5C.4.7.1 Top and Bottom Clearances for Car and Counterweights

5C.4.7.1.1 Top car clearance

The top car clearance shall be sufficient to avoid any protruding part fixed on the top of the car coming in direct contact with the ceiling or diverting sheave.

The clearance shall be calculated taking into account the following and shall not be less than the sum of the following four items:

- a) The bottom counterweight runby
- b) The stroke of the counterweight buffer used
- c) The dimensions of the portion of the diverting sheave hanging underneath the ceiling in the lift well and
- d) 150 mm for compensating for gravity stopping distance and future repairs to the rope connections at counterweight and at the car or at the suspension points

5C.4.7.1.2 Bottom car clearance

The bottom car clearance shall be maintained in such a way that the counterweight shall not come in contact with the ceiling or any part hanging underneath the ceiling, when the car completely rests on fully compressed buffers, provided the buffers are spring type mounted on solid concrete or steel bed.

In case of wooden buffers the bottom car clearance shall be maintained in such a way that the total downward travel of the car from the service level of the immediate travel of the car from the service level the immediate floor near the pit, shall not be more than the top counterweight clearance, when the wooden buffers are completely crushed.

5C.4.7.1.3 Top counterweight clearance

The top clearance for the counterweight can be calculated taking into account the following and shall not be less than the sum of the following three items:

- a) Car runby
- b) Compression of the buffer spring or height of the wooden block used as buffer and
- c) 150 mm to compensate for gravity stopping distance for counterweight and any future repairs to rope connections at the counterweight at the car ends or at the suspension points.

5C.4.7.1.4 Runby for Cars and Counterweights

5C.4.7.1.5 The bottom runby for cars and counterweights shall not be less than 150 mm.

5C.4.7.1.6 Maximum bottom runby

In no case shall the maximum bottom runby exceed 300 mm.

5C.4.8 In order to maintain a safe work environment, and to avoid potential hazards, the following shall be provided:

- a) Caution sign shall be installed in the areas listed below where potential hazard exists:
 - 1) Trip hazard in machine room and
 - 2) Caution notice against unauthorized use of rescue devices (for example, brake release device).
- b) Use the hard hats for entry in pit and car top during construction period.
- c) Warning sign shall be provided on the controller so also eliminate, the possibility of contact with any exposed or concealed power circuit.
- d) Car top barricade system shall be provided as primary protection against fall, on car top.
- e) Whenever work is carried out on the lift and lift is not required to be moved on power, notice shall be put on electrical main switch indicating requirement of de-energized condition.
- f) During lift installation/maintenance, protection against fall shall be provided with suitable barricades for all open landing entrances.

5C.4.9 Planning for Dimensions

5C.4.9.1 General

The dimensions of lift well have been chosen to accommodate the door inside the well which is the normal practice. In special cases, the door may be accommodated in a recess in the front wall, for which prior consultation shall be made with the lift manufacturer.

5C.4.9.2 Plan Dimensions

5C.4.9.2.1 All plan dimensions of lift well are the minimum clear plumb sizes. The architect/engineer, in conjunction with the builder, shall ensure that adequate tolerances are included in the building design so that the specified minimum clear plumb dimensions are obtained in the finished work.

5C.4.9.2.2 Rough opening in concrete or brick walls to accommodate landing doors depend on design of architrave. It is advisable to provide sufficient allowances in rough opening width to allow for alignment errors of opening at various landings.

5C.4.9.2.3 When more than one lift is located in a common well, a minimum allowance of 100 mm for separator beams shall be made in the widths shown in Table 1 to 4.

5C.4.9.2.4 For outline dimensions of lifts having more than one car entrance, lift manufacturers should be consulted.

5C.4.9.3 Outline Dimensions

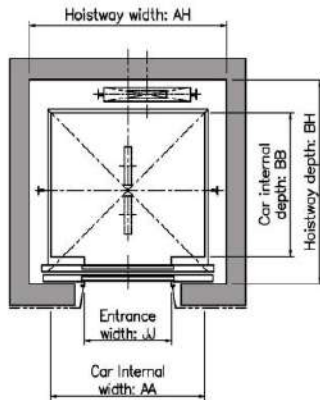
5C.4.9.3.1 The outline dimensions of machine-room, pit depth, total headroom, overhead distance and sill for four classes of lifts to which the standard applies are specified in Tables 1 to 4 as indicated below.

1. Recommended Dimensions of Passenger Lifts and Service Lifts

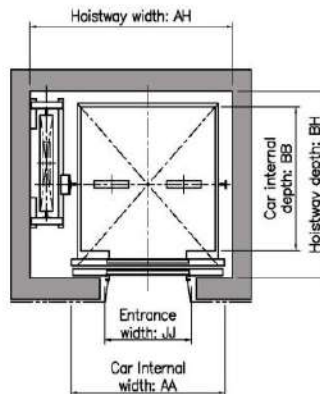
(Machine Room System)

All dimensions in millimeters

Hoistway Plan

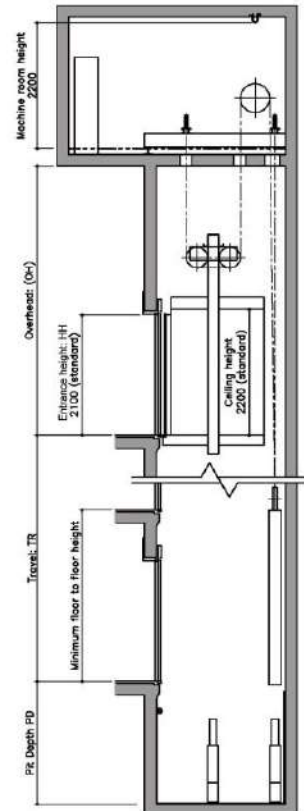


Shown for CO doors
Counterweight rear drop

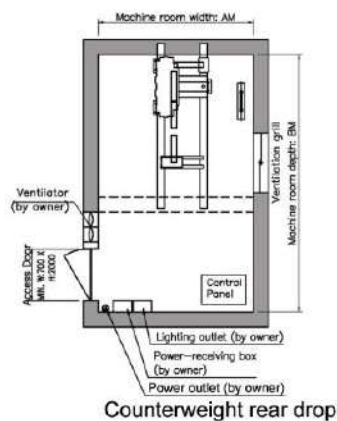


Shown for CO doors
Counterweight side drop

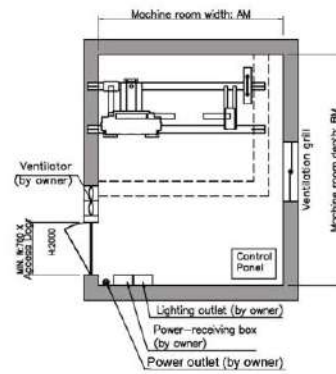
Hoistway Section



Machine Room Plan



Counterweight rear drop



Counterweight side drop

Table-1(a)

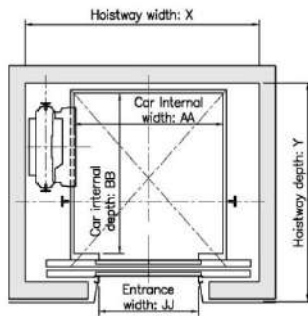
Number of persons	Rated Capacity (kg)	Rated Speed (m/sec)	Door Type	Entrance Width (mm) JJ	Car internal dimensions (mm) AA x BB	Counter-weight position	Minimum hoistway dimensions (mm) AH x BH /car	Minimum machine room dimensions (mm) AM x BM /car
6	450	1.0	CO	800	1400x850	Rear	1750x1400	2000x3250
						Side	2100x1200	2500x2900
8	550	1.0			1400x1030	Rear	1750x1590	2000x3350
		1.5						2000x3600
		1.0				Side	2100x1380	2500x3000
9	600	1.0			1400x1100	Rear	1750x1660	2000x3550
		1.0				Side	2100x1450	2500x3000
10	700	1.0			1400x1250	Rear	1750x1810	2000x3600
		1.5						2000x3650
						Side	2100x1600	2500x3100
11	750				1400x1350	Rear	1750x1910	2000x3700
						Side	2100x1700	2500x3100
13	900			900	1600x1350	Rear	2050x1910	2100x3700
						Side	2400x1730	2500x3100
15	1000				1600x1500	Rear	2050x2060	2100x3850
						Side	2400x1880	2500x3200
17	1150	1.0		1000	1800x1300	Rear	2250x1860	2300x3700
		1.5				Side	2600x1680	2600x3000
		1.75			1800x1500	Rear	2250x2110	2300x3900
						Side	2650x1880	2900x3100
20	1350			1100	2000x1350	Rear	2450x1960	2500x3450
						Side	2850x1730	3100x3000
				1000	1800x1700	Rear	2250x2310	2300x4100
						Side	2650x2080	3000x3200
				1100	2000x1550	Rear	2450x2160	2500x3650
						Side	2850x1930	3200x2800

Table 1(b)

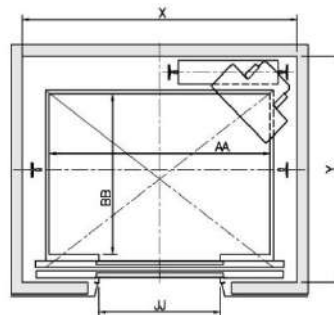
Rated Speed (m/sec)	Maximum travel (m) TR	Maximum number of Stops	Minimum overhead (mm) OH	Minimum pit depth (mm) PD	Minimum machine room clear height (mm)	Minimum floor to floor height (mm)
1	60	30	4400	1360	2200	2500
1.5	90		4560	1410		
1.75			4630	1410		

2. Recommended Dimensions of Passenger Lift and Service Lift (Machine Room Less System) All dimensions in millimeters

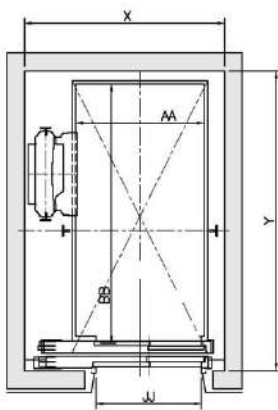
Hoistway Plan



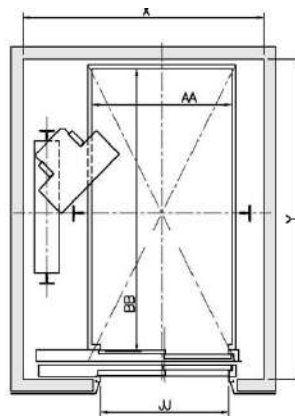
Shown for CO doors
Counterweight side drop
(Capacity 630kg ~ 1050kg)



Shown for CO doors
Counterweight rear drop
(Capacity 1275kg ~ 1600kg)

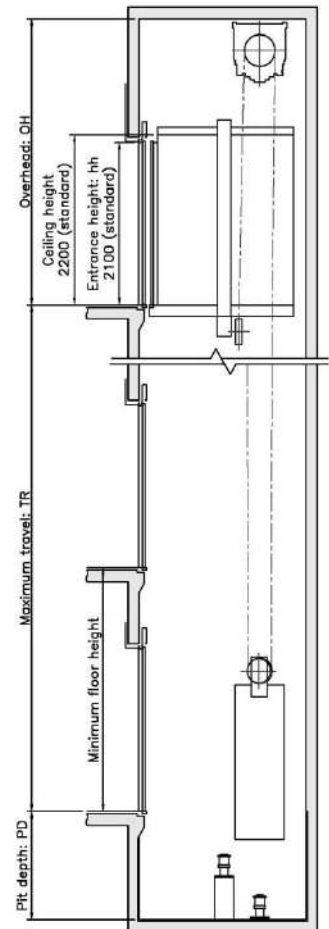


Shown for 2S doors
Counterweight side drop
(Capacity 450kg ~ 1050kg)



Shown for 2S doors
Counterweight side drop
(Capacity 1275kg ~ 1600kg)

Hoistway Section



Note: History Section for capacity of 1275 ~ 1600 kg is slightly different from this section

Table -2(a)

Code Number	Number of Persons	Rated Cap (Kg)	Door Type	Counter Weight Position	Car Internal Dimensions (mm) AA x BB	Entrance with(mm) JJ	Hoistway Dimensions (mm) X x Y
P 6	6	450	Co	Side	$\frac{930 \times 1300}{1000 \times 1200}$	800	1550 x 1700
P 8	8	550	Co	Side	$\frac{1100 \times 1300}{1030 \times 1400}$	800	1650 x 1700
P 9	9	600	Co	Side	1100 x 1400	800	1950 x 1720
P 10	10	700	Co	Side	1250 x 1400	800	2100 x 1720
P 11	11	750	Co	Side	1350 x 1400	900	2200 x 1720
P13	13	900	Co	Side	1350 x 1600	900	2350 x 1950
P 15	15	1000	Co	Side	1500 x 1600	900	2500 x 1950

Table -2(b)

Rated Speed (m/s)	Rated Capacity (Kg)	Maximum overhead (OH)	Maximum pit depth (mm) PD	Minimum Floor Height (mm)
1.0	450 - 750	3600	1300	2500
	900-1000	4100	1550	
1.6	450 - 750	3750	1400	
	900 – 1000	4250	1650	
1.75	450 - 750	3850	1450	
	900 – 1000	4350	1700	

3. Recommended Dimensions of Hospital Lifts

All dimensions in millimeters

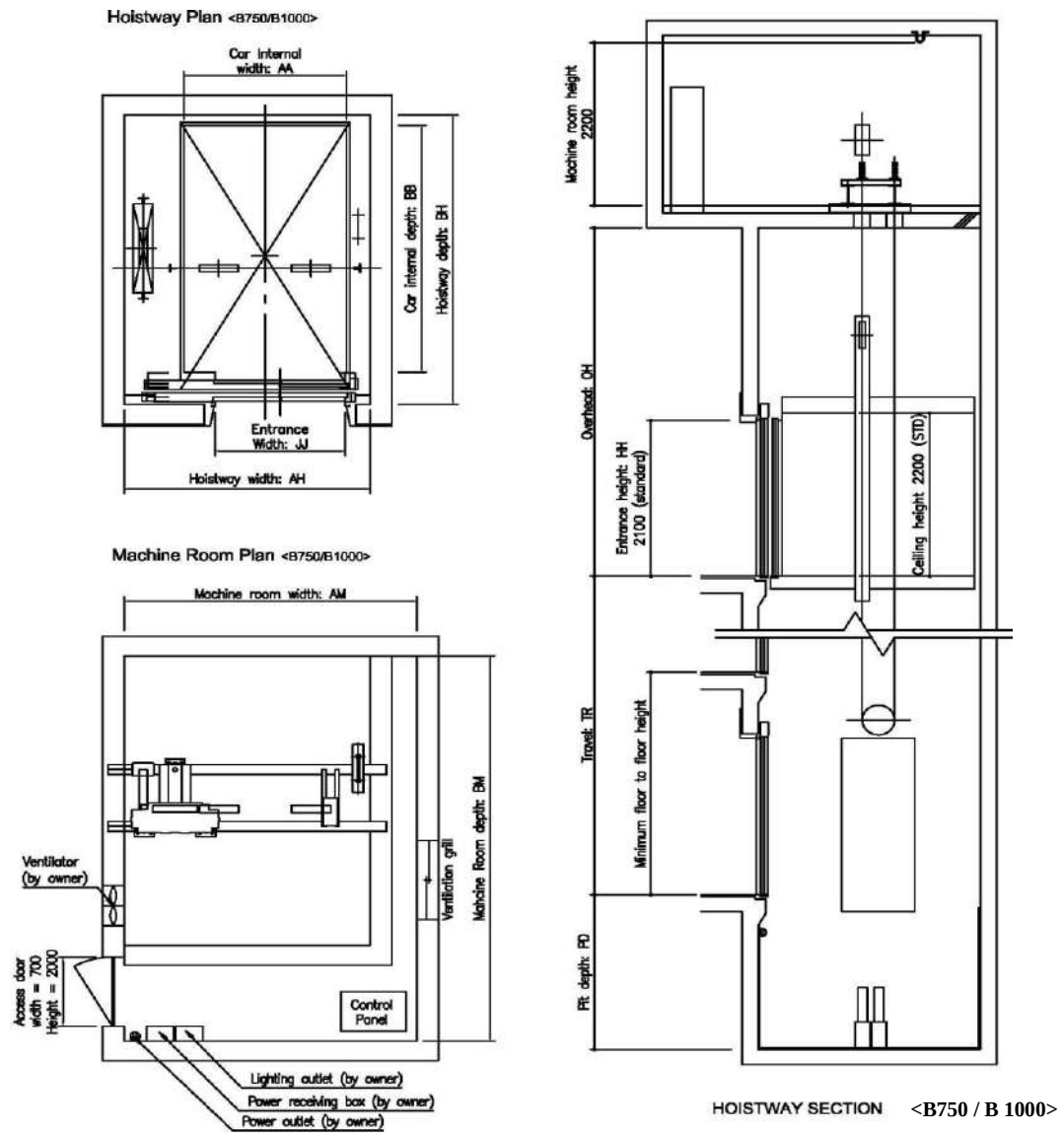


Table -3(a)

Number of persons	Rated Capacity (kg)	Rated Speed (m/sec)	Door Type	Counter-weight position	Car internal dimensions (mm) AA x BB	Entrance Width (mm) JJ	Minimum hoistway dimensions (mm) AH x BH /car	Minimum machine room dimensions (mm) AM x BM /car
11	750	1.0	2S	Side	1300x2300	1100	2135x2730	2600x3900
		1.5						
15	1000	1.75			1500x2500	1200	2335x2930	2700x3900

Table -3(b)

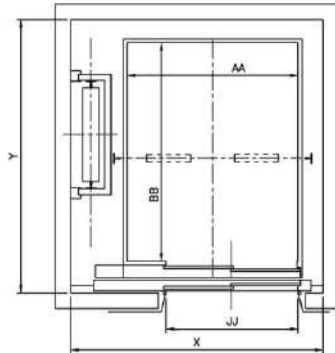
Rated Speed (m/sec)	Maximum travel (m) TR	Maximum number of Stops	Minimum overhead (mm) OH	Minimum pit depth (mm) PD	Minimum machine room clear height (mm)	Minimum floor to floor height (mm)
1	60	30	4400	1360	2200	2500
1.5	90		4560	1410		
1.75			4630	1410		

4. Recommended Dimensions of Good / Cargo / Freight Lift

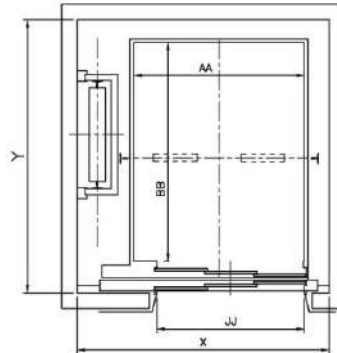
All dimensions in millimeters

Hoistway Plan

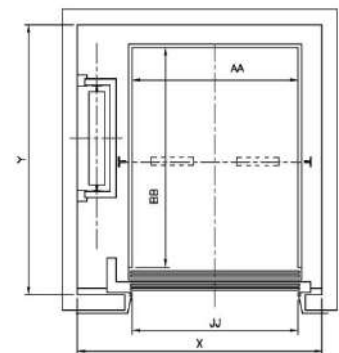
Hoistway Plan for 2-panel side opening door (2S)



Hoistway Plan for 3-panel side opening door (3S)



Hoistway Plan for 2-panel side opening door (2U)



Machine Room Plan

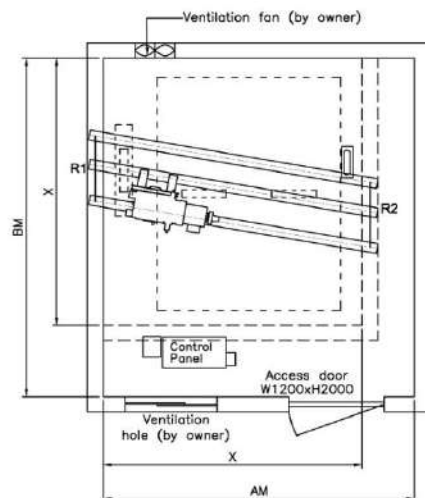


Table -4

Capacity (kg)	Speed (m/sec)	Motor (kW)	Machine room (mm)	Pit depth PD (mm)	Door type	Hoistway (mm)	Min. floor height (mm)	Overhead OH (mm)	Reaction loads (kN)			
									Machine room		Pit	
			AM x BM			X x Y			R1	R2	R3	R4
750	0.75	7.5	2600 x 3950	1250	2S	2200 x 2900	2800	4450	57.9	41.2	70.6	55.4
	1	9.5		1550				4650			71.6	55.4
1000	0.75	7.5	3150 x 3950	1250	2S	2600 x 2900	2800	4450	74.6	43.1	80.4	66.2
	1	9.5		1550				4650			84.8	73.1
1500	0.75	9.5	3600 x 4050	1250	2S	3150 x 3000	2800	4450	101	53.9	119.6	82.4
	1	13		1550				4650			129.4	88.3
2000	0.75	13	3600 x 4250	1250	2S	3150 x 3400	2800	4450	121.6	63.7	139.2	103
	1	18.5		1550				4650			150	109.8
2500	0.75	18.5	4000 x 4400	1250	3S	3600 x 3700	3300	4850	148.1	81.4	192.2	144.2
	1	22		1550				5050			206	154
	0.75	18.5	4000 x 4400	1250	2U	3600 x 3700	4500	4850	155.9	80.4	192.2	144.2
	1	22		1550				5050			206	154
	0.75	18.5	4000 x 4400	1250	3U	3600 x 3700	3950	4850	155.9	80.4	192.2	144.2
	1	22		1550				5050			206	154
3000	0.75	18.5	4100 x 4800	1250	3S	3750 x 4100	3300	4850	166.7	92.2	208	154
	1	26		1800				5050			223	165
	0.75	18.5	4100 x 4800	1250	2U	3750 x 4100	4500	4850	174.5	92.2	208	154
	1	26		1800				5050			223	165
	0.75	18.5	4100 x 4800	1250	3U	3750 x 4100	3950	4850	174.5	92.2	208	154
	1	26		1800				5050			223	165

5. Recommended Dimensions of Dumb Waiter

5.(a) Table Type

Hoistway Plan

FIGURE 1

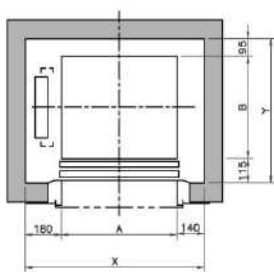


FIGURE 2

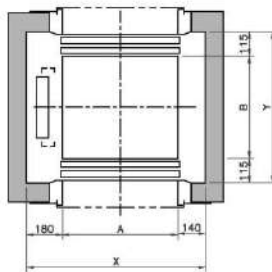


FIGURE 3

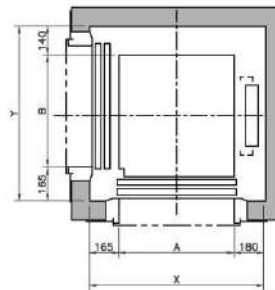


FIGURE 4

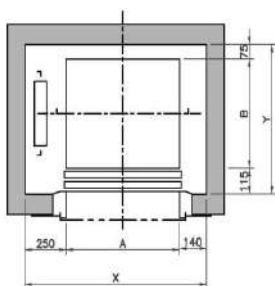
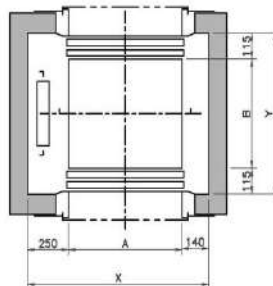
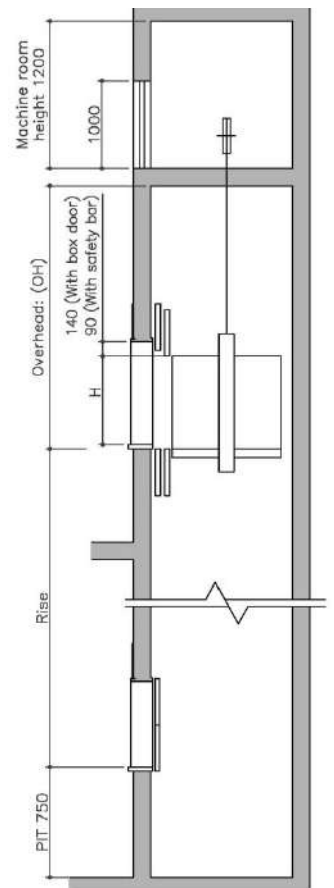


FIGURE 5



Hoistway Section



Load capacity (Kgs)	Speed (m/sec)	Kind of Equipment	Figure	Dimension (mm)							Motor Rating (KW)
				A	B	H	X	Y	OH		
									With Box Door	With Safety Bar	
50	0.5	M-50-O-5	1	550	550	750	870	760	1525	1425	0.75
		M-50-P-5	2					780			
		M-50-R-5	3					895			
100	0.5	M -100-O-5	1	700	700	900	1020	910	1750	1650	0.75
		M -100-P-5	2					930			
		M -100-R-5	3					1045			
150	0.5	M -150-O-5	4	800	800	1000	1190	990	1900	1800	0.75
		M -150-P-5	5					1030			

Hoistway Plan

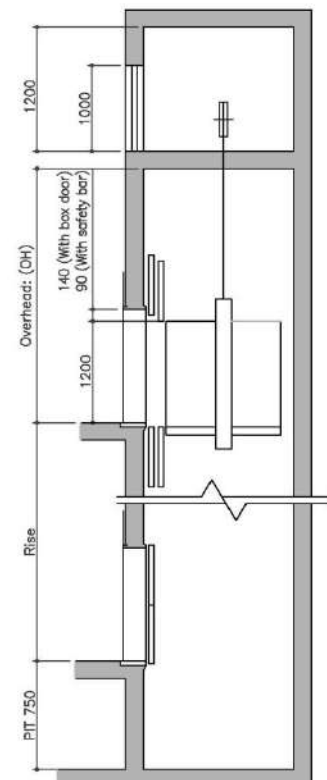


Table 5.(b)

Load Capacity (Kgs)	Speed (m/sec)	Kind of Equipment	Figure	Dimension (mm)		Motor Rating (KW)
				OH		
				With Box Door	With Safety Bar	
200	0.35	OF-200-O-3.5	1	2200	2100	1.5
		OF-200-P-3.5	2			
300	0.35	OF-200-O-3.5	1	2200	2100	2.5
		OF-300-P-3.5	2			

5C.4.9.3.2 Travel

The tables have been established for a maximum travel of 30m. For travels above 30m, the lift manufacturer should be consulted.

5C.4.9.3.3 Pit

The pit depth of the lifts will normally accommodate compensating chains. If compensating ropes are required, pit depth shall be increased for all loads and speeds and lift manufacturer should be consulted.

5C.4.9.3.4 Minimum floor to floor height

Minimum floor to floor height for landings on same side for horizontally sliding door is $f + 750$ mm and for vertically bi-parting doors is $1.5f + 250$ mm, where 'f' is clear entrance heights in mm.

5C.4.10 Lift Wells and Lift Well Enclosures**5C.4.10.1 Lift wells**

5C.4.10.1.1 No equipment except that forming a part of the lift or necessary for its operation and maintenance shall be installed in the lift well. For this purpose, the main supply lines shall be deemed to be a part of the lift and the underground cable, if laid along the lift well shaft, shall be properly clamped to the wall.

5C.4.10.1.2 Sufficient space shall be provided between the guides for the cars and the side walls of the lift well enclosure to allow safe and easy access to the parts of the safety gears for their maintenance and repairs; safety gears provided shall be in accordance with Part 5 A&B Electrical and Allied Installation MNBC 2012 or latest version.

5C.4.10.1.3 Lift wells, together with the whole of the contained equipment and apparatus, shall be rendered fire resistant to the greatest possible extent.

5C.4.10.1.4 Every counterweight shall travel in juxtaposition to its car in the same lift well.

5C.4.10.1.5 It is undesirable that any room, passage or thoroughfare be permitted under any lift well. If unavoidable spaces for other uses may be permitted under the lift well, with the prior approval of the lift Inspectorate Authority and the following provisions shall be made:

- a) Spring or Oil buffers shall be provided for lift car and counterweight.
- b) The pit shall be sufficiently strong to withstand successfully the impact of the lift car with rated load or the impact of the counterweight when either is descending at rated speed or at governor tripping speed.
- c) The car and the counterweight shall be provided with a governor-operated safety gear and
- d) The forces required on the structure in the event of car buffering directly without safety gear application to be indicated in the general arrangement drawing.

5C.4.10.2 Lift Well Enclosures

5C.4.10.2.1 Lift well enclosures shall be provided and shall extend on all sides from floor-to-floor or stair-to-stair, and shall have requisite strength and in proper plumb. Liftwell enclosures are made concrete wall or Brick wall in up to 9 stop but more than 9 stop, must be do concrete wall only.

5C.4.10.2.2 The inner sides of the lift well enclosures facing any car entrances shall, as far as practicable form a smooth, continuous flush surface devoid of projections or recesses.

NOTE – This requirement may be met in existing lift wells by filling any recesses or spaces between projections or alternatively by covering them with suitable sheet material. If it is not possible to render flush any objection or tops of recesses, they should be beveled on the under side to an angle of 60°, from the horizontal by means of metal plates, cement rendering or other fire-resisting materials. Where a car-Levelling device is operative with car door opening, such interior surfaces shall always form a smooth flush surface below each landing level for a depth to at least the depth of the car-Levelling zone plus the distance through which the lift car may travel of its own momentum when the power is cut-off.

5C.4.10.2.3 Where an open lift well would increase the fire risk in a building, the lift well enclosure shall be fire-resisting construction (see 'Myanmar Fire Safety code of practices').

5C.4.10.2.4 Where wire grill or similar constructions is used, the mesh or opening shall be such that the opening between the bars shall reject the ball of 30 mm in diameter and the lift well enclosure shall be of sufficient strength to resist accidental impact by users of the staircase or adjoining floor or by materials or trucks being moved in the vicinity.

5C.4.10.2.5 Where the clearance between the inside of an open-type lift well enclosure and any moving or movable part of the lift equipment of apparatus is less than 50 mm, the openings in the enclosure shall be further protected by netting of square mesh of aperture not greater than one centimeter and of wire not smaller than one mm. (The provisions of this clause need not be adhered to for lift wells in factory premises, coming under the preview of Factories Rule and Regulation. In such cases provisions of 5C. 4.10.2.4 is sufficient.)

5C.4.10.2.6 There shall be no opening in the lift well enclosure permitting access to the lift car by passing under the counterweight.

5C.4.10.2.7 In case of a completely enclosed lift well, a notice with the word 'Lift' may be placed outside of each landing door.

5C.4.10.2.8 Indicator

Where lifts are installed in totally enclosed wells, position indicators are recommended to be provided at each floor; however, where position indicators are not provided, at least direction indicators or 'In Use' indicators shall be provided at each landing.

5C.4.10.2.9 Landing doors

Every lift well shall, on each side from which there is access to a car, be fitted with a door. Such a door shall be fitted with efficient electromechanical locking so as to ensure that it cannot be opened except when the lift car is at landing and that the lift car cannot be moved away from the landing until the door is closed and locked. If the door is mechanically locked, means should be provided for opening the same by means of special key during emergency or inspection.

5C.4.10.2.10 Automatic devices for cutting off power

An efficient automatic device shall be provided and maintained in each lift whereby all power shall be cut off from the motor before the car or counterweight lands on buffer.

5C.4.10.3 Lift Pits

5C.4.10.3.1 A lift pit shall be provided at the bottom of every lift.

5C.4.10.3.2 Pits shall be of sound construction and maintained in a dry and clean condition. Where necessary, provision shall be made for permanent drainage and where the pit depth exceeds 1.5m suitable descending arrangement shall be provided to reach the lift pit. And a suitable fixed ladder or other descending facility in the form of permanent brackets grouted in the wall extending to a height of 0.75m above the lowest floor level shall be provided. A light point with a switch shall also be provided for facility of maintenance and repair work.

5C.4.11 Machine Rooms and Overhead Structures

5C.4.11.1 The lift machine, controller and all other apparatus and equipment of a lift installation, excepting such apparatus and equipments as function in the lift well or other positions, shall be placed in the machine room which shall be adequately lighted and rendered fire-proof and weather-proof.

5C.4.11.2 The motor generators controlling the speed of multi-voltage or variable voltage machines, secondary sheaves, pulleys, governors, floor selecting equipment may be placed in a place other than the machine room, but such position shall be adequately lighted, ventilated and rendered fire-proof and weather – proof.

5C.4.11.3 The machine room shall have sufficient floor area as well as permit free access to all parts of the machines and equipment located therein for purposes of inspection, maintenance or repair.

5C.4.11.4 The room shall be kept closed, except to those who are concerned with the operation and maintenance of the equipment. When the electrical voltage exceeds 220/230 V ac, a danger notice plate shall be displayed permanently on the outside of the door and on or near the

machinery. Where standby generator is provided, it is necessary to connect fireman lift to the standby generator. Depending upon the capacity of the standby generator one or more other lifts may also be connected to the supply.

Rescue instruction with required tools and tackles if any shall be made available in the machine room.

All lift which do not have any automatic transfer facility to an alternate supply, such as generator, shall be equipped with Battery Operated Automatic Rescue Device to bring the lift to the nearest floor and open the door in the event of power failure.

5C.4.11.5 The machine room shall be equipped with an insulated portable hand lamp provided with flexible cord for examining the machinery.

5C.4.11.6 If any machine room floor or platform does not extend to the enclosing walls, the open sides shall be provided with hand rails or otherwise suitably guarded.

5C.4.11.7 The machine room shall not be used as a store room or for any purpose other than housing the lift machinery and its associated apparatus and equipment.

5C.4.11.8 Machine room floor shall be provided with a trap door, if necessary. The size of the trap door shall be as per manufacturer's recommendation.

5C.4.11.9 The height of the machine room shall be sufficient to allow any portion of equipment to be accessible and removable for repair and replacement and shall be not less than 2m clear from the floor or the platform of machine whichever is higher.

5C.4.11.10 It will be noted that generally lifts have machine rooms immediately over the lift well, and this should be arranged whenever possible without restricting the overhead distance required for normal safety precautions. In case where machine room provision on top is a limitation, either machine room less lift or basement drive or side drive lift can be considered.

5C.4.11.11 For detailed information regarding nomenclature of floors and storeys, reference may be made to Myanmar electricity rule and Regulation.

5C.4.11.12 There should be a proper access planned for approach to the machine room taking into account need for maintenance personnel to access the machine room at all times of day and night and also the need to take heavy equipment. Any fixture such as a ladder provided should be secured permanently to the structure and should have railings to reduce the risk of falling.

5C.4.11.13 It is desirable that emergency exit may be provided in case of large machine rooms having four or more lifts.

5C.4.11.14 Where the machine room occupies a prominent position on roof of a building, provision should be made for lightning protection in accordance with Part 5 A&B Electrical and Allied Installation MNBC 2012 or Latest version and Myanmar electricity Rule and Regulation.

5C.4.11.15 Wherever the machine room is placed, it should be properly ventilated. The ambient temperature of machine room shall be maintained between +5°C and +40°C.

5C.4.11.16 If located in the basement, it should be separated from the lift well by a separation wall.

5C.4.12 Essential Features Required

5C.4.12.1 Power operated car doors on automatically operated lifts shall be so designed that their closing and opening is not likely to injure a person. The power operated car door shall be provided with a sensitive device which shall automatically initiate reopening of the door in the event of a passenger being struck or is about to be struck by the door, while crossing the entrance during closing movement. The effect of the device may be neutralized:

- a) During the last 58 mm of travel of door panel in case of side opening doors
- b) When panels are within 58 mm of each other in case of center opening doors.

The force needed to prevent the door from closing shall not exceed 150 N and this measurement shall not be made in the first third of the travel of the door.

In order to achieve this it is desirable that all power operated doors have a full length (covering at least 80 percent of the car door height from the bottom) infrared light curtain safety to retract the door in the event of coming across any obstacle during closing of the door.

5C.4.12.2 Single speed and two speed drives which are poor in Levelling accuracy and energy consumption shall not be used for new lifts in view of availability of latest technology energy efficient Variable Voltage Variable Frequency drive systems with improved Levelling accuracy.

5C.4.12.3 For passenger lifts with car call button control in car and with capacities of 16 passenger and above, it is recommended to have an additional car operating panel with call buttons on the opposite side to main panel for ease of access to buttons.

5C.4.12.4 Passenger lifts shall be provided with power operated doors which are imperforate.

5C.5 DIMENSIONAL TOLERANCES

5C.5.1 Lift Well Dimensions

Plan dimensions of lift wells given by the lift maker represent the minimum clear plumb sizes. The purchaser's representative, in conjunction with the builder, should ensure that adequate tolerances are included in the building design so that the specified minimum plumb dimensions are obtained in the finished work.

Dimensions in excess of these minimum plumb dimensions for lift well and openings (but not less) can be accommodated by the lift maker up to certain maximum values beyond which changes in design may be necessary involving additional expense or work by the builder. The purchaser's representative should take these factors into account when specifying the lift well structural dimensions on the basis of the constructional tolerance appropriate to the building technique.

5C.5.2 Landing Door Openings

It is very important that finished landing openings should be accurate to design size and plumb one above the other for the full travel of the lift. In constructing the structural openings in concrete walls to lift wells it is not possible to achieve a degree of accuracy vertically which will allow doors and frames to be inserted in the opening without some form of masking or packing to overcome inaccuracies. Provisions should therefore be made in design by increasing the nominal height from design finished floor level and width of openings to each jamb and head.

In addition, the alignment of the outer face of the front wall of the lift well is of importance when architrave of fixed dimensions are called for, and in this case the alignment of the outer face from

floor to floor should not vary to a greater extent than can be accommodate by the subsequent front wall finish, the architrave being set accurately plumb.

To facilitate accurate alignment of landing sills it is common practice to provide at each landing an independent threshold, the position of which can be adjusted.

5C.5.3 Structural Limits for Lift Wells at any Level

If the net plumb well (dimensions A and B of Fig-2) and the nominal structural entrance openings (dimensions C and D of Fig.2) are defined by plumb lines, the actual wall should not encroach on these dimensions.

Dimension K (inside face of wall of Fig .2) should fall within the following limits:

For wells up to 30 m	-	0.25 mm
For wells up to 60 m	-	0.35 mm
For wells up to 90 m	-	0.50 mm

When architrave are to be supplied by the lift maker dimension L (side of structural opening of Fig.2) should fall within the limits of 0 and 25 mm and dimension M (outer face of the front wall of Fig.2) should not vary to a greater extent than can be accommodated by the subsequent front wall finish, the architrave being set accurately plumb.

When the entrance linings are supplied by the builder, corresponding provision should be made for the finished openings to be accurately plumb one above the other for the full travel of the lift end to design size.

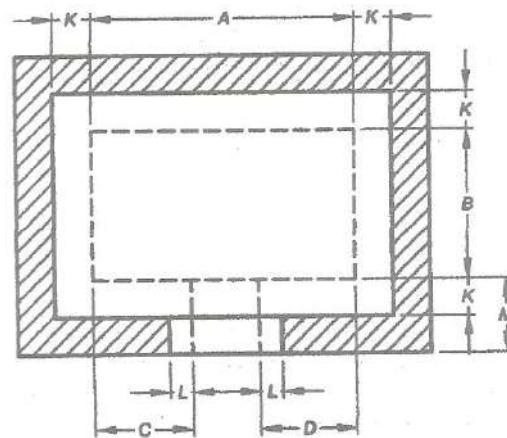


FIG. 2 LIFE WELL TOLERANCE

5C.6 PRELIMINARY DESIGN

5C.6.1 Number of Lifts and Capacity

5C.6.1.1 Two basic considerations, namely, the quantity of service required and the quality of service desired, determine the type of lifts to be provided in a particular building. Quantity of service gives the passenger handling capacity of the lifts during the peak periods and the quality of service is measured in terms of waiting time of passengers at various floors. Both these basic factors require proper study into the character of the building, extent and duration of peak periods, frequency of service required, type and method of control, type of landing doors etc. In busy cities patience, coefficient being low satisfaction cannot be obtained if lifts with adequate capacities and speed are not provided. In view of many variables, no simple formula is possible for determining the most suitable lifts.

NOTE – It is recommended to do Traffic Analysis Study to ensure optimum provision of lifts for the building in consultation with lift manufactures. In view of the dynamic situation it is recommended that a computerized software is used for Traffic Analysis Study.

5C.6.1.2 The number of passenger lifts and their capacities, that is load and speed, required for a given building depend on the characteristics of the building. The most important of these are:

- a) Number of floors to be served by the lifts
- b) Floor to floor distance
- c) Population of each floor to be served and
- d) Maximum peak demand; this demand may be unidirectional, as in up and down peak periods, or a two-way traffic movement.

It should be appreciated that all calculations on the traffic handling capabilities of lifts are dependent on a number of factors which vary according to the design of lift and the assumptions made on passenger actions. It follows, therefore, that the result of such calculations can only be put to limited use of a comparative nature. For instance, they can with advantage be used to compare the capabilities of lifts in a bank with different loads and speeds provided the same set of factors are used for all cases. On the other hand, they cannot be used to compare the capabilities of different makes of lift used for a given bank of lifts.

Different authorities and manufacturers differ widely in their methods of calculation, due to the variations in lift performance, especially with regard to rates of acceleration and deceleration and door operation times which form the components of performance time. Therefore, the calculations made by different organizations will not necessarily agree.

5C.6.2 Preliminary Lift Planning

5C.6.2.1 General

Methods of calculating the traffic handling capabilities of lifts were first devised for office buildings. In due course detailed modifications were devised to suit other applications without altering the basic principles. The application to office buildings is still the most frequently used.

Therefore, the following method may be used as general guidance on preliminary lift planning for offices, bearing in mind the differences set out in 5C .6.1.2.

A lift installation for office building is normally designed to populate the building at a given rate and the three main factors to be considered are:

- a) Population or the number of people who require lift service.
- b) Handling capacity of the maximum flow rate required by these people.
- c) Interval or the quality of service required.

5C.6.2.2 Population

The first point to be ascertained from the eventual occupier is the total building population and whether this is likely to increase in the future.

If a definite population figure is unobtainable an assessment should be made from the net area and probable population density. Average population density can vary from about one person per 4 m² to one person per 20 m². It is essential, therefore, that some indication of the probable population density should be obtained from the building owner. If no indications is possible (a speculative development for example) population in the region of 5m² per person for general office buildings is usually assumed.

5C.6.2.3 Quantity of Service

The quantity of service is a measure of the passenger handling capacity of a vertical transportation system. It is measured in terms of the total number of passenger handled during each five-minute peak period of the day. A five-minute base period is used as this is the most practical time over which the traffic can be averaged.

The recommended passenger handling capacity for various buildings is as follows:

Type of Building	Handling Capacity
Office – Diversified tenants	10 to 15 percent
Office – Single tenant	15 to 25 percent
Residential	7.5 percent

5C.6.2.4 Quality of Service

The quality of service on the other hand is generally measured by the passenger waiting time at the various floors. The following shall be the guiding factor for determining this aspect.

Quality of Service or Acceptable Interval

20 to 25 seconds	Excellent
26 to 35 seconds	Good
36 to 40 second s	Fair

41 to 45 seconds

Poor

Over 45 seconds

Unsatisfactory

NOTE – For residential buildings longer intervals should be permissible.

5C.6.2.5 Traffic Peaks

The maximum traffic flow during the up peak period is usually used as a measure of the vertical transportation requirement in an office building. The employees of all offices are subject to discipline and are required to be at their place in time. Consequently, the incoming traffic flow is extremely high and the arrival time is over a short period.

Sometimes it becomes necessary to reduce the maximum traffic flow by staggering the arrival of the employees so that different groups arrive at different times. This reduces the peak and also the requirement of lifts. However, many organizations may object to staggering and prefer to have all employees arrive at the same time since it is claimed that staggering will affect the proper co-ordination of business.

5C.6.2.6 Capacity

The minimum size of car recommended for a single purpose buildings is one suitable for a duty load of 884 kg. Generally, for large office buildings cars with capacities up to 2040 kg are recommended according to the requirements.

5C.6.2.7 Speed

It is dependent upon the quantity of service required and the quality of service desired (see 5C.6.2.3 and 5C.6.2.4). Therefore, no set formulae for indicating the speed can be given. However, the following general recommendations are made:

No. of Floors	Speed
4 to 5	0.5 to 0.75 m/s
6 to 12	0.75 to 1.5 m/s
13 to 20	1.5 m/s to 2.5 m/s
Above 20	2.5 m/s and above

5C.6.2.8 Layout

The shape and size of the passenger lift car bears a distinct relation to its efficiency as a medium of traffic handling. A study of the most suitable proportions for these lifts reveal that the width of the lift well entrance is in reality, the basic element in the determination of the best proportions. In other words, the width of the car is determined by the width of the entrance and the depth of the car is regulated by the loading per square metre permissible under this Code. Centre opening doors are more practicable and efficient entrance units for passenger lifts.

5C.6.2.9 Determination of Transportation or Handling Capacity During the Up Peak

5C.6.2.9.1 The handling capacity is calculated by the following formula:

$$H = \frac{300 \times Q \times 100}{T \times P}$$

Where

H = Handling capacity as the percentage of the peak population handled during 5 min period,

Q = Average number of passengers carried in a car,

T = Waiting interval in seconds, and

P = Total population to be handled during peak morning period. (It is related to the area served by a particular bank of lifts.)

The value of Q depends on the dimensions of the car. It may be noted that the car is not loaded always to its maximum capacity during each trip and, therefore, for calculating H the value of Q is taken as 80 percent of the maximum carrying capacity of the car.

The waiting interval is calculated by the following formula:

$$T = \frac{RTT}{N}$$

where

T = Waiting interval in seconds,

N = Number of lifts, and

RTT = Round trip time, that is, the average time required by each lift in taking one full load of passengers from ground floor, discharging them in various upper floors and coming back to ground floor for taking fresh passengers for the next trip.

RTT is the sum of the time required in the following process:

- a) Entry of the passengers on the ground floor,
- b) Exit of the passengers on each floor of discharge,
- c) Door closing time before each starting operation,
- d) Door opening time on each discharging operation,
- e) Acceleration periods,
- f) Stopping and Levelling periods,
- g) Periods of full rated speeds between stops going up, and
- h) Periods of full rated speeds between stops going down.

It is observed that the handling capacity is inversely proportional to waiting interval which in turn is proportional to RTT. Reducing the RTT of a lift from 120 to 100 increases its handling capacity by 20 percent.

The round trip time can be decreased not only by increasing the speed of the lift but also by improving the design of the equipment related to opening and closing of the landing and car doors, acceleration, deceleration, Levelling and passenger movement. These factors are discussed below:

- a) The most important factor in shortening the time consumed between the entry and the exit of the passengers to the lift car is the correct design of the doors and the proper car width. For comfortable entry and exist for passengers it has been found that most suitable door width is 1000 mm and that of car width is 2000 mm.
- b) The utilization of centre opening doors has been a definite factor in improving passenger transfer time, since when using this type of door the passengers, as a general rule, begin to move before the doors have been completely opened. On the other hand, with a side opening door the passengers tend to wait until the door has completely opened before moving.

The utilization of centre opening doors also favours the door opening and closing time periods. Given the same door speed, the centre opening door is much faster than the side opeing type. It is beyond doubt that the centre opening door represents an increase in transportational capacity in the operation of a lift.

5C.6.2.9.2 An example illustrating the use of the above consideration is given below:

Gross area per floor	1100 m ²
Net usable area per floor	950 m ²
No. of landings including ground	15
Assuming population density	9.5 m ² per person
Probable population in	

$$P = \frac{14 \times 950}{9.5}$$

Upper floors 1400 persons

Taking 20 passengers lift with 2.5 m/s the calculated RTT = 165 s

$$Q = 20 \times 0.8 = 16$$

a) Taking No. of lifts, N = 4

$$T = \frac{RTT}{N} = \frac{165}{4} = 41s$$

$$H = \frac{300 \times Q \times 100}{T \times P} = \frac{300 \times 16 \times 100}{41 \times 1400} = 8.3 \text{ percent}$$

b) Taking No. of lifts, N = 6

$$T = \frac{165}{6} = 27.6s$$

$$H = \frac{300 \times Q \times 100}{T \times P} = \frac{300 \times 16 \times 100}{27.6 \times 1400} = 12 \text{ percent}$$

5C.6.3 Quiet Operation of Lifts

Every precaution should be taken with passenger lifts to ensure quiet operation of the lift doors and machinery. The insulating of the lift machine and any motor generator from the floor by rubber cushions or by a precast concrete slab with rubber cushions, prevents transmission of most of the noise.

5C.6.4 Positioning of Lifts

A thorough investigation should be made for assessing the most suitable position for lift(s) while planning the building. It should take into account future expansions, if any. Though each building has to be considered individually for purposes of location of lifts, factors influencing the locations of passenger and goods lifts are given in 5C. 6.4.2 to 5C. 6.4.4.

The location of lifts may also conform to the travel distance requirements specified in 'Myanmar Fire Safety code of practices'.

5C.6.4.1 Arrangement of Lifts

The lifts should be easily accessible from all entrances to the building. For maximum efficiency, they should be grouped near the centre of the building. It is preferably not to have all the lifts out in straight line and, if possible, not more than three lifts should be arranged in this manner. It has to be kept in mind that the corridor should be wide enough to allow sufficient space for waiting passengers as well as through passengers.

5C.6.4.1.1 In some cases when there are more than three lifts, the alcove arrangement is recommended. With this arrangement, the lift alcove lead off the main corridor so that there is no interference by traffic to other groups or to other parts of the ground floor. This arrangement permits the narrowest possible corridors and saves space on the upper floors. Walking distance to the individual lift is reduced and passenger standing in the center of the group can readily see all the lift doors and landing indicators. The ideal arrangement of the lifts depends upon the particular layout of the respective building and should be determined in every individual case. Some typical recommended arrangements are given in Fig. 1.

5C.6.4.2 Passenger Lifts

5C.6.4.2.1 Low and medium class flats

Where a lift is arranged to serve two, three or four flats per floor, the lift may be placed adjoining a staircase, with the lift entrances serving direct on to the landings. Where the lift is to serve a considerable number of flats having access to balconies or corridors, it may be conveniently placed in a well ventilated tower adjoining the building.

5C.6.4.2.2 Office buildings, hotels and high class flats

In general the arrangement as recommended in 5C 6.4.1 is to be followed. However, in case this is not possible, it is desirable to have at least a battery of two lifts at two or more convenient points of a building. If this is not possible, it is advisable to have at least two lifts side by side at the main entrance and one lift each at different sections of the building for intercommunication. When two lifts are installed side by side, the machine room shall be suitably planned with sufficient space for housing the machine equipment. The positioning of lifts side by side gives the following advantages:

- a) All machine and switch gear may be housed in one machine room
- b) The lifts can be inter-connected more conveniently from an installation point of view and
- c) Greater convenience in service owing to the landing openings and each floor being adjacent.

5C.6.4.2.3 Shops and departmental stores

Lifts in shops and stores should be situated so as to secure convenient and easy access at each floor.

5C.6.4.2.4 For buildings with more than 12 floors, it is recommended to have provision of one stretcher/service lift in addition to the passenger lifts.

5C.6.4.2.5 For buildings with more than 12 floors, where passenger and service lifts are provided in one lobby it is recommended to have group control for all the lifts.

5C.6.4.3 Goods Lifts

The location of lifts in factories, warehouses and similar buildings should be planned to suit the progressive movement of goods throughout the buildings, having regard to the nature of position of the loading platforms, railway sidings, etc. The placing of a lift in a fume or dust laden atmosphere or where it may be exposed to extreme temperatures, should be avoided wherever possible. Where it is impossible to avoid installing a lift in an adverse atmosphere, the electrical equipment should be of suitable design and construction to meet the conditions involved.

5C.6.4.3.1 Normally goods lifts have lower speeds than passenger lifts for the same travel because traffic conditions are less demanding, and more time is required for loading and unloading.

5C.6.4.3.2 As loads for goods lifts increase in size and weight, so the operation of loading and unloading becomes more difficult. Therefore, it is usual to require greater accuracy of levelling as the capacity of the goods lift increases.

5C.6.4.3.3 A large capacity goods lift at high speed is often a very uneconomical proposition. The inherent high cost is enhanced due to the very small demand for such equipment, much of which is custom made. The high capital cost of the lift, building work and electrical supply equipment usually shows a much smaller return as an investment than more normal sizes of lifts.

5C.6.4.4 Hospital Bed Lifts

Hospital bed lifts should be situated conveniently near the ward and operating theatre entrances. There shall be sufficient space near the landing door for easy movement of stretcher.

It is convenient to place the passenger lifts in a hospital, near the staircases.

5C.6.5 Structural Considerations

5C.6.5.1 Lift well enclosures, lift pits, machine rooms and machine supports besides conforming to the essential requirements given in 4, should form part of the building construction and comply with the lift manufacturer's drawings.

5C.6.5.2 Machine Room

Floors shall be designed to carry a load of not less than 350 kg/m^2 over the whole area and also any load which may be imposed there on by the equipment used in the machine room or by any reaction from any such equipment both during periods of normal operation and repair.

5C.6.5.3 The side wall of the lift well may be made of reinforced cement concrete at least 150 mm thick so as to provide satisfactory anchoring arrangement for fixing. Reference shall also be made to 'Structural Design,

5C.6.5.4 The total load on overhead beams shall be assumed as equal to all equipment resting on the beams plus twice the maximum load suspended from the beams.

5C.6.5.5 The factor of safety for all overhead beams and supports based on ultimate strength of the material and load in accordance with 5C 6.5.4 shall be not less than the following:

For Steel 5

For Reinforced Concrete 7

The deflection of the overhead beams under the maximum static load calculated in accordance with above shall not exceed 1/1500 of the span.

5C.6.6 Access to Machine Room and Lift Pits

5C.6.6.1 Access to machine room above a lift well may be either from the roof or by an internal staircase with a proper arrangement for fixing.

5C.6.6.2 Access between a secondary floor and a machine room may be by ladder. Where a machine room entrance is less than 1.5 m above or below the adjacent floor or roof surfaces, a substantial permanently attached ladder may be used. Ladders shall be fixed at least 150 mm clear of any wall, beam or obstruction and shall extend at least to the landing level. Above the landing level and for a height of at least 1.15m, either the ladder stringers shall be extended or suitable hand grips shall be provided.

5C.6.6.3 Where the machine room entrance is 1.5 m or more above or below the adjacent floor or roof surface, access shall be provided by means of stairs in accordance with the requirements given in 5C 6.6.3.1 to 5C 6.6.3.6.

5C.6.6.3.1 The angle of inclination of the stair shall not exceed 50° from the horizontal and the clear width of the stair shall be not less than 600 mm.

5C.6.6.3.2 The tread shall have a non-slip surface which shall be not less than 150 mm wide for open stair construction and not less than 20cm wide for closed stair construction.

5C.6.6.3.3 The rise of the stair shall not exceed 250 mm.

5C.6.6.3.4 A hand rail shall be provided on the outer stringer of all stairways fixed at a convenient height, but not less than 500 mm high measured vertically from the nosings, and not less than 1m high on landings and platforms. Such hand rail shall have at least 50 mm clearance between nearest permanent object at the corresponding side of the stair.

5C.6.6.3.5 Headroom clearance of not less than 2 m measured from the nosings of the stairway, shall be provided on every stairway.

5C.6.6.3.6 Heights of stairs over 5 m in length shall be provided with intermediate landings.

NOTE – Where compliance with any of the requirements specified in 5C.6.6.1 to 5C.6.6.3 is impracticable, applications for variation shall be made to the Authority, who may, vary such requirements.

5C.6.6.4 Access to a machine room in a basement may be provided from a corridor.

5C.6.6.5 Access to a machine room via the lift well shall be prohibited.

5C.6.6.6 The lift pit should be capable of being examined by a separate access. In the case of a battery of two lifts, it is possible to examine the lift pit through the adjoining one.

5C.6.7 Fire Protection

To prevent fire from spreading by means of the lift well, lift well enclosures shall conform to the requirements given in 'Myanmar Fire Safety code of practices'. The machine room should be

constructed of a suitable grade of fire-resisting material and precautions should be taken to minimize spread of fire from the machine room into the lift well see also 5C.7.3.14.

5C.6.8 Requirements for Fireman's Lift

5C.6.8.1 For buildings having height of 24 m or more atleast one lift shall meet the requirements of fireman's lift as given in 5C.6.8.2.

5C.6.8.2 The fireman's lift shall have the following minimum requirements:

- a) Lift car shall have floor area of not less than 1.44 square meters. It shall also have a loading capacity of not less than 550 kg (8 persons).
- b) Lift landing doors shall have a minimum of fire resistance of one hour.
- c) Doors shall be of automatic operation for car and landing.

5C.6.8.3 Fireman's lifts in a building having more than 24 m or more height, shall work at or above the speed of 1.0 m/s so as to reach the top floor from ground level within one minute.

5C.6.8.4 Operation Requirements of Fireman's Lift

The lift shall be provided with the following as a minimum:

- a) A two position switch at evacuation floor (normally main entrance floor) (ON/OFF), and
- b) Buzzer and 'Fireman's lift' – light in car

5C.6.8.4.1 Sequence of operation:

a) Return to evacuation floor (Phase 1):

- 1) Shall start when the switch at the evacuation floor is turned to the "ON" position or the signal from smoke detector (if provided by the Building Management System) is on. All lift(s) controlled by this switch shall cancel all existing car calls and separate from landing calls and no landing or car calls shall be registered. The buzzer and "fireman's lift" light shall be turned on. All heat and smoke sensitive door reopening devices shall be rendered inoperative.
- 2) If the lift is travelling towards the evacuation floor, it shall continue driving to that floor.
- 3) If the lift is travelling away from the evacuation floor, it shall reverse its direction at the nearest possible floor without opening its doors and return non-stop to the evacuation floor.
- 4) If the lift is standing at a floor other than the evacuation floor, it shall close the door and start travelling non-stop to the evacuation floor.
- 5) When at the evacuation floor the lift shall park with doors open.
- 6) The buzzer is turned off after this return drive.

b) Fireman's service (Phase 2):

The phase 2 operation of the lift shall be as defined below.

- 1) The phase 2 is started after phase 1, if the switch is "ON".
- 2) The lift does not respond to landing calls but registers car calls. All heat and smoke sensitive door reopening devices are rendered inoperative.
- 3) When the car call button is pressed the doors start closing. If the button is released before the doors are fully closed, they re-open. The car calls is registered only when the doors are fully closed.
- 4) After registering a car call the lift starts driving to the call. If more than one car call is registered, only the nearest call is answered and the remaining calls will be cancelled at the first stop.
- 5) At the floor the doors are opened by pushing the door open button. If the button is released before the doors are fully open, they re-close.
- 6) The lift returns to normal service when it stands at the evacuation floor with doors open and the switch is "OFF".

5C.6.9 Supply Cables and Switches

Each lift should be provided with a main switch or circuit breaker of a capacity determined by the lift manufacturer and the incoming supply cable should terminate in this switch. For a single lift, this switch should be fixed adjacent to the machine room entrance inside the machine room. In a machine room common to more than one lift, each main switch should be conveniently situated with respect to the lift it controls. Switches and fuses (which may form part of a distribution switch-board) should be provided for isolating the supply cables to the machine room.

5C.6.10 The detailed design considerations for different types and selection of the lifts shall be done in accordance with Part 5 A&B Electrical and Allied Installation MNBC 2012 or Latest version .

5C.7 POWER AND CONTROL SYSTEMS

5C.7.1 Features Associated with Power Systems

5C.7.1.1 Industrial Switchgear

Switchgear for controlling lift power systems is characterized by its high duty cycle and its high rupturing capacity. Switchgear must be robust enough and shall be so designed as to withstand the high duty cycle and high rupturing capacity introduced during the operation of the lifts.

5C.7.1.2 Levelling Accuracy

The Levelling tolerances in not more than $\pm 5\text{mm}$, are those which can be reasonably expected between no load and full load in either direction.

Where greater Levelling accuracy is required, careful examination should be made to see whether such increased precision is justified or practical. Advice should also be obtained, as additional apparatus and cost may be involved, and in some cases the requirement may not be practicable.

5C.7.1.3 Overload Tests

A lift is designed to operate and transport the contract load at the required duty cycle, and should not by intention or habitually be used to carry overloads. During test as a safeguard to cover variable supply and temperature conditions a lift is checked for the car to complete one round trip with contract load plus 10 percent at nominal supply voltage and nominal ambient temperature.

There is also static test with contract load plus 25 percent to check that the brake will sustain the car.

It is unnecessary to specify an additional overload test or capacity and in fact it is detrimental to the normal running efficiency and safety of the lift to do so.

5C.7.1.4 Occasional Extra Load

It is not good practice to request that a lift should be designed to carry an occasional extra load. It is tantamount to specifying an excessive overload test which is detrimental to the normal running efficiency and safety of the lift.

5C.7.2 Description of Operation Systems

5C.7.2.1 Methods of Control Systems

The methods of control systems are as follows:

- a) Attendant and dual control (see 5C.7.2.2) and
- b) Automatic push button operation (see 5C.7.2.2).

5C.7.2.1.1 Types of control systems

- a) Collective control (see 5C.7.2.3)
- b) Single push button collective control (see 5C.7.2.4)
- c) Down collective control (see 5C.7.2.5)
- d) Directional collective control for one car (see 5C.7.2.6)
- e) Directional collective control for two or three cars (see 5C.7.2.7)
- f) Group supervisory control (see 5C.7.2.8)

Features of control systems are described in 5C. 7.3.

5C.7.2.2 Automatic Push Button Operation

Automatic control is a method of operation by which a momentary pressure on a push button sets the car in motion and causes it to stop automatically at any required lift landing. This is the simplest control system and it is sometimes referred to as push button control.

A car answers a landing or car call whichever is actuated first by momentary pressure provided the lift is not in use. Momentary pressure of a car push button will send the car to the designated floor. The car always responds to a car push button in preference to a landing push button.

With this type of control, a RED landing signal light or direction arrow indicates that the car is in use that is the lift is travelling.

This type of control is recommended for the following applications.

- a) A single passenger lift serving up to 4 floors.
- b) Goods lifts serving any number of floors where it is usually the most suitable form of control.

For special purposes, the following two systems may be considered:

- a) Despatch from landings as an additional feature for a goods lift with manually operated doors. The call is registered by pressing the car push button and when the doors are closed the car will travel to the designed floor.
- b) Automatic with attendant control as an additional feature on goods lifts with a key operated switch in the car to transfer the control from normal automatic to attendant operation. There is also a visual call indicator with buzzer in the car to indicate to the attendant the landing floors at which push buttons have been pressed when the car is under attendant control.

5C.7.2.3 Collective Control

Collective control is a generic term for those methods of automatic operation by which calls made by pressing push buttons in the car and at lift landings are registered and answered by the car stopping in floor sequence at each lift landing for which calls have been registered irrespective of the order in which the calls have been made, and until all calls have had attention.

Collective control of any form is usually not suitable for goods lifts except where loading is not expected to fill the car and additional loads can be taken at other stops.

5C.7.2.4 Single Push Button Collective Control

Single push button collective control has a single push button at each landing. It is not recommended, as the direction in which it is desired to travel cannot be registered by the intending passenger.

5C.7.2.5 Down Collective Control

Down collective is a control system where landing calls are registered from a single push button, irrespective of the car being in motion or the landing door being open and calls are stored until answered. Any number of car calls can be registered and the car will stop in sequence in the down direction at each of the designated floors. The car will travel in the up direction to the highest call registered stopping only in response to car calls. It will then travel downwards answering calls in floor sequence. If only one call has been registered the car travels to the floor of call.

This system is suitable where there is traffic between the ground and upper floors only and no interfloor traffic. Two or three car banks have interconnected control.

With this type of control the following signals are included:

- a) A landing signal light indicates that the call has been registered and will be answered.
- b) Illuminated car position indicator above the entrance in the car.
- c) Arrow shaped signal lights in the back of the car or on the landing to indicate to the entering person in which direction the car is going to depart.

5C.7.2.6 Directional Collective Control for One Car

Directional collective control for one car is a control system having UP and DOWN push buttons at intermediate landings whereby the call is registered for the intended direction of travel. Calls from the car or landing push buttons are registered and stored until answered. The car will answer

calls in floor sequence in one direction of travel. Calls for the opposite direction of travel are answered when the direction of travel is reversed.

This system is suitable for single lifts serving 4 or more floors with interfloor traffic, such as small office blocks, hotels and blocks of flats.

With this type of control the following signals are included:

- a) A landing signal light for each landing push button indicated that the call has been registered and will be answered.
- b) Illuminated car position indicator above the entrance in the car.
- c) Arrow shaped signal lights in the back of the car or on the landing to indicate to the entering person in which direction the car is going to depart.

5C.7.2.7 Directional Collective Control for Two or Three Cars

Directional collective control for two or three cars is a system covering a control in which the two or three cars in a bank are interconnected. One push button unit with UP and DOWN push buttons or floor buttons (in case of car control from floor) are required at each landing and the call system is common to all lifts. If for architectural balance, in the case of a three car bank, extra push button units are required, these should be specified. Each landing call is automatically allocated to the best placed car. The control is designed so that cars are effectively spaced and thus give even service. When a car reaches the highest floor to which there is a call its direction of travel is automatically reversed when it next starts. One or more cars will return to the parking floor.

Automatically bypassing of landing calls when a car is fully loaded is an essential feature for three-car banks. It is also necessary for two-car banks in offices. Other cars will continue to provide service to all floors.

When three-car banks serve 7 or 8 floors and over, some form of automatic supervisory control (see 5C.7.2.8) is generally necessary in the interest of efficiency.

With this type of control the following signals are included:

- a) A landing signal light for each landing push button to indicate that the call has been registered and will be answered.
- b) Illuminated car position indicator above the entrance in the car.
- c) Arrow shaped signal lights in conjunction with an audible single stroke gong or an indication on the landing call push button station above each landing entrance to indicate to the waiting person(s) which car is going to stop and in which direction it will continue its course.

5C.7.2.8 Group Supervisory Control

A bank or group of intensive traffic passengers lifts requires a supervisory system to co-ordinate the operation of individual lifts which are all on collective control and are interconnected.

The very nature of intensive service calls for a sophisticated automatic supervisory control system so as to match the speed capacity of these lifts.

The supervisory system regulates the despatching of individual cars and provides service to all floors as different traffic conditions arise minimizing such unproductive factors as idle cars, uneven service and excessive waiting time. The system will respond automatically to traffic conditions such as UP and DOWN peaks, balanced or light traffic and provides for other specialized features.

If desired, a master station can be provided in the lift lobby which gives by indicators, visual information regarding the pattern under which the system is operating. Where the system is based on a definite programme, control means are provided for altering the type of traffic programme. There are other facilities, such as the removal of any lift from service.

5C.7.3 Features of Operation Systems

5C.7.3.1 Car Preference

Sometimes it is necessary to give a special personal service or a house service. When this service is required and for whatever purpose, it should be specified as 'car preference' is by a key operated switch in the car. The operation is then from the car only and the doors remain open until a car call is registered for a floor destination. All landing calls are bypassed and car position indicators on the landing for this lift are not illuminated. The removal of the key when the special operation is completed restores the control to normal service.

5C.7.3.2 Landing Call Automatic Bypass

For collective operation, automatic bypassing of landing calls can be provided. This device will bypass landing calls when a car is fully loaded but the calls are not cancelled.

5C.7.3.3 Motor Generator Shut Down

Lifts controlled by variable voltage system automatically shutdown when subject to an over-riding control which puts them out of service under certain conditions, for example, no demand for lift service. They are automatically put back into service as required.

5C.7.3.4 Basement Service

For lifts with collective control when service is required below the main parking floor, which is usually the ground floor, to a basement and/or a sub-basement, the lift maker should be informed of the type of service required, as special technical considerations are then usually necessary.

5C.7.3.5 Hospital Service

Lifts for carrying beds and stretchers require a car preference switch so that an attendant can have complete control of the car when required. This requirement should be specified as 'car preference' and it will function as described in 5C.7.3.1. Otherwise such lifts can have the same control system as for normal passenger lift, the choice depending on the number of floors and served, the service required and the number of lifts.

5C.7.3.6 Manually Operated Doors (Without Closers)

A 'door open' alarm should be provided to draw attention to a car or landing door which has been left open.

5C.7.3.7 Automatically Power Closed Doors

For passenger operation when the cars arrive at a landing the door will automatically open and then close after lapse of a time interval. This time interval can be overruled by the pressure of a push button in the car to give instant door closing.

An 'open door' push button is provided in the car to reverse closing motion of the doors or hold them open.

5C.7.3.8 Controlled Power Closed Doors

When there are conditions that particularly affect the safety of passengers or damage to vehicles or trucks, the closing of the door should only be made by the continuous pressure of push buttons in the car or on landings.

A 'door open' alarm should be provided to draw attention to a car or landing door which has been left open. This means of operation is required for some forms of good lifts.

5C.7.3.9 Safe Operation of Doors

The safety of passengers passing through lift entrances is fully covered by the provision of Part 5 A&B Electrical and Allied Installation MNBC 2012 or Latest version Myanmar Electricity (lift) Rule & Regulation, CP 2 2009, EN 81-1-1998. No modification of these provisions should be specified.

5C.7.3.10 Director Service

There are many forms of giving special service for individuals, but they should always be avoided. They range from key operated switches at preferred landings to the complete segregation of one out of a bank of lifts. It is obvious that any preferential treatment of this nature can seriously jeopardize the efficiency of the service as a whole. When a bank of say three lifts is installed to meet the anticipated traffic requirements and then, when the building is occupied, one lift is detached permanently for directors' service, the traffic handling can be reduced by a half rather than a third.

When preferential service is imperative, then the car preference feature should be available (see 5C.7.3.1)

5C.7.3.11 Indication of Car Arrival

As all lift cars are illuminated when available (in service). It is recommended that this illumination be used to signal the arrival of a car at a landing.

The following is the practice adopted for vision panels in doors:

- a) For lifts with manually operated car and landing doors, vision panels are provided in all doors
- b) For lifts with power operated car doors and manually operated landing doors, vision panels are provided in the landing doors only
- c) For lift with automatically opened car and landing doors, no vision panels are required and

5C.7.3.12 Service Switches

When switches are provided to take cars out of service, that is because the remaining cars in the groups can cater for the required passenger traffic, it is essential that such switches should not stop the fireman's control from being operative in the event of the lift being designated as a fireman's lift. Service switches should not be confused with maintenance switches which are only used when it is dangerous to attempt to operate the lift because maintenance work is actually in progress. A control station fitted on top of the car is regarded as a maintenance switch.

5C.7.3.13 Fire Switch

When required by the fire authority a fire switch has to be provided, the function of which is to enable the fire authority to take over the complete control of one or more lifts in an installation.

5C.7.3.14 Push Buttons and Signals

It is most important that the purpose of every push button and signal should be clearly understood by all passengers.

5C.7.3.15 In public places where blind persons are expected to use the lifts it is recommended to provide Braille buttons.

5C.7.4 Electrical Installation Requirements

5C.7.4.1 General

The lift are requirements for main switches and wiring with reference to relevant regulations. The lift maker should specify, on a schedule, particulars of full load current, starting current, maximum permissible voltage drop, size of switches and other details to suit requirements. For multiple lifts a diversity factor may be used to determine the cable size and should be stated by the lift manufacturer.

- a) Power supply mains – The lift sub-circuit from the intake room should be separate from other building service.

Each lift should be capable of being isolated from the mains supply. This means of isolation should be lockable.

- b) For banks of interconnected lifts, a separate sub-circuit is required for the common supervisory system, in order that any car may be shut down without isolating the supervisory control of the remainder.
- c) Lighting – Machine rooms and all other rooms containing lift equipment should be provided with adequate illumination and with a switch fixed adjacent to the entrance. At least one socket outlet, suitable for lamps or tools, should be provided in each room.

The supply to the car light should be from a separate circuit, and controlled by a switch in the machine room. For multiple lifts with a common machine room a separate supply should be provided for each car. The car lighting supply should be independent of the power supply mains. Plug should be provided with a light, the switch for which should be in the lift well, and accessible from the lower terminal floor entrance.

When the alarm system is connected to a transformer or trickle charger, the supply should be taken from the machine room lighting.

5C.7.4.2 Electric Wiring and Apparatus

5C.7.4.2.1 All electrical supply lines and apparatus in connection with the lift installation shall be so constructed and shall be so installed, protected, worked and maintained that there may be no danger to persons therefrom.

5C.7.4.2.2 All metal casings or metallic coverings containing or protecting any electric supply lines of apparatus shall be efficiently earthed.

5C.7.4.2.3 No bare conductor shall be used in any lift car as may cause danger to persons.

5C.7.4.2.4 All cables and other wiring in connection with the lift installation shall be of suitable grade for the voltage at which these are intended to be worked and if metallic covering is used it shall be efficiently earthed.

5C.7.4.2.5 Suitable caution notice shall be affixed near every motor or other apparatus in which energy is used at a pressure exceeding 250 V.

5C.7.4.2.6 Circuits which supply current to the motor shall not be included in any twin or multicore trailing cable used in connection with the control and safety devices.

5C.7.4.2.7 A single trailing cable for lighting control and signal circuit shall be permitted, if all the conductors of this trailing cable are insulated for maximum voltage running through any one conductor of this cable.

5C.7.4.3 Emergency Signal or Telephone

It is recommendatory that lift car be provided either with an emergency signal that is operative from the lift car audible outside the lift well or with a telephone.

When an alarm bell is to be provided each car is fitted with an alarm push which is wired to a terminal box in the lift well at the ground floor by the lift maker. This alarm bell, to be supplied by the lift maker (with indicator for more than one lift) should be fixed in an agreed position and wired to the lift well. The supply may be from a battery (or transformer) fixed in the machine room or, when available, from the building fire alarm supply.

When a telephone is to be provided in the lift car the lift maker should fit the cabinet in the car and provided wiring from the car to a terminal box adjacent to the lift well.

The type of telephone should be stated in the enquiry.

5C.7.4.4 Earthing

5C.7.4.4.1 The terminal for the earthing of the frame of the motor, the winding machine, the frame of the control panel, the cases and covers of the tappet switch and similar electric appliances which normally carry the main current shall be at least equivalent to a 5 mm diameter bolt, stud or screw. The cross-sectional area of copper earthing conductor shall be not smaller than half that of the largest current – carrying conductor subject to an upper limit of 65 mm² (Part 5

A&B Electrical and Allied Installation MNBC 2012 or Latest version) CP 2- 2009 & Myanmar Electricity rule & Regulation.

5C.7.4.4.2 The terminal for the earthing of the metallic cases and covers of door interlocks, door contacts, call and control buttons, stop buttons, car switches, limit switches, junction boxes and similar electrical fittings which normally carry only the control current (such terminal being one specially provided for this purpose), and the earth conductor should be appropriately sized in accordance with Part 5 A&B Electrical and Allied Installation MNBC 2012 or Latest version Myanmar Electricity rule & Regulation 1985.

The size of earthing conductor shall be in accordance with Part 5 A&B Electrical and Allied Installation MNBC 2012 or Latest version .

5C.7.4.4.3 The earthing conductor shall be secured to earthing terminal in accordance with the recommendations made in Part 5 A&B Electrical and Allied Installation MNBC 2012 or Latest version, Myanmar Electricity rule & Regulation 1985 and also in conformity with the latest provisions of Myanmar Electricity rule & Regulation and Rules framed thereunder from time to time.

5C.7.4.4.4 The exposed metal parts of electrical apparatus installed on a lift car shall be sufficiently bonded and earthed.

5C.7.4.4.5 Where screwed conduit screws into electric fittings carrying control current making the case and cover electrically continuous with the conduit, the earthing of the conduit may be considered to earth the fitting. Where flexible conduit is used for leading into a fitting, the fitting and such length of flexible conduit shall be effectively earthed.

5C.7.4.4.6 One side of the secondary winding of bell transformers and their cases shall be earthed.

5C.7.4.4.7 Where there are more than one lift in a building, there should be a separate earth pit for the lifts.

5C.7.5 Building Management Systems – Interface for Lifts

5C.7.5.1 Where more than three lifts are provided in a building and especially when these are provided at different locations in the building a form of central monitoring may be provided. Such central monitoring may be through a Building Management Systems, if provided in the building or through a display panel.

5C.7.5.2 The following signals should be given to the building management interface from each lift.

- a) Alarm button in car,
- b) Door Zone or floor level information,
- c) Lift moving information,
- d) Power on information and
- e) Lift position information.

5C.7.5.3 Each of these signals shall be provided through a potential free contact located in the lift machine room. The contacts shall be rated for 230 V ac/1A or 24 V dc/1A. A pair of wires should be used for each potential contact.

5C.7.5.4 The wiring between lift machine room to Building Management Systems shall be planned and carried out by the builder along with other wiring in the building.

5C.7.5.5 The building management system should ensure that any position information is read only when the lift is moving (lift moving information) or is capable of reading several times to detect a stable state.

In addition to the signals above the following signals may be added if required for the benefit of monitoring the lift performance.

- a) A summary fault output to indicate a lift in fault condition, which prevents the lift from providing service. This summary fault condition shall include the most common faults such as safety circuit open.
- b) Service or inspection mode.
- c) Attendant mode.
- d) Fire mode.
- e) Doors opening.
- f) Doors closing.
- g) Lift moving up.

(In combination with lift moving and lift moving up information, lift moving down information can be sensed by the Building Management Systems).

- h) Door Reopen Request (Summary of Door Open, Light Curtain, Photocell, Safety Edge Signals).

5C.7.5.6 Where it is desired that it should be possible to control the lift from Building Management Systems, the following control signals can be provided.

- a) Normal to service/inspection mode change over.
- b) Fault Accept/Rest Input

(Using this input, the lift controller may be allowed to clear an existing fault if this is other wise safe. It will be decided by the Lift manufacturer as to what faults can be cleared)

- c) Car call to top most floor and bottom most floor of each lift.

Where such control inputs are provided, it should be with a pass word and login feature that allows one to determine who has used these inputs and at what time. Always such inputs should be through authorized person only. The Building Management Systems should make all changeovers effective only when lift is not moving.

5C.7.5.7 Control inputs from Building Management Systems should be through a potential free contact capable of carrying 24 V dc/1A or 230 V ac/1A. The wiring should be terminated in each lift machine room.

5C.8 CONDITIONS FOR OPTIMUM PRACTICE

5C.8.1 Lift Entrance Operation

5C.8.1.1 General

Every lift journey involves two horizontal movements, in and out of the car, to one vertical movement. The type of door, and the operation of the doors, play a main part in the service given, and should receive careful consideration.

5C.8.1.2 Goods Traffic

Most types of goods traffic require relatively longer loading and unloading times and manual doors are frequently used for economy and simplicity.

Power operation can be applied, especially for large entrances, to give automatic opening; the doors then always open fully, reducing the risk of damage. For many types of goods traffic, it is preferable for closing though powered, to be controlled by continuous pressure button, rather than being.

For heavy duty lifts, a power operated vertically sliding door preferred, this can be made extremely robust, and is capable of extension to very large entrances.

5C.8.2 Painting at Works and on Site

Lift equipment with normally receive a protective coat of paint at works before dispatch to site. Further painting of lift equipment may be necessary and is normally in the form of a finishing coat and can take place on site. Alternatively, the further painting of the equipment may be carried out at works as a finishing coat with normal touching up after site erection as may be necessary.

Any additional painting, due to site conditions during erection and/or final operating conditions in the premises, is subject to negotiation between the lift maker and the purchaser.

Decorative finishes are a subject for separate negotiation.

5C.8.3 Special Environments

Standard equipment is suitable for use inside normal residential, commercial and industrial buildings but when unusual environments are likely to be encountered, the advice of the lift maker should be sought at the earliest possible stage to enable the most economic satisfactory solution to be found. Special mechanical protection and or electrical enclosures may be necessary as well as compliance with statutory or other regulations and with the purchaser's particular requirements, which should be fully considered at the time of enquiry.

Examples of situations which necessitate special consideration are:

- a) Exposure to weather, for example, car parks.
- b) Low temperatures, for example, cold stores.
- c) High temperature, for example, boiler plant.
- d) Hosing – down for example, for hygiene or decontamination.
- e) Corrosive atmosphere, for example, chemical works.
- f) Dusty atmospheres, for example, gas plant.
- g) Explosive and inflammable atmosphere, for example gas plants and petroleum and polyester industries.

5C.8.4 Ventilation of Machine Rooms

Machine rooms shall be ventilated. They shall be such that the motors and equipment as well as electric cables etc, are protected as far as possible from dust, harmful dusts and humidity. The ambient temperature in the machine room shall be maintained between 5°C and 40°C.

5C.8.5 Lighting and Treatment of Walls, Floors, Etc

5C.8.5.1 All machine rooms should be considered as plant space, and conditions provided to permit reliable operation of electrical switchgear and rotating machinery, and be conducive to good maintenance.

Lighting should be provided to give at least 200 lux around the controller and machine. The machine room walls, ceiling and floor should be faced in dust-resisting materials, tiles, etc, or painted as minimum to stop dust circulation which otherwise could damage rotating machinery and cause failure of switchgear. Machine rooms should also be weatherproof and if ventilation louvers are provided they should be designed and sited to prevent snow being driven through or to the apparatus.

5C.8.5.2 Lift wells should be constructed to be weatherproof and of a dust free surface material or should be painted to minimize dust circulation on to moving apparatus and from being pumped by the car movement into machine rooms or on to landings.

Sufficient number of light points should be provided in the lift shaft for proper illumination.

5C.8.5.3 Should a lift entrance open out into an area exposed to the weather the entrance should be protected by a suitable canopy and the ground level slope up to the entrance to prevent during rain or surface drainage from entering the lift well through the clearances around the landing doors. Any push buttons so enclosed should be of weatherproof type.

5C.8.6 Stairwell Enclosure

The location of lifts in stairwells is not recommended.

The use of stair stringers for fixing of guides normally involves extensive site measurement in order to fabricate purpose-made brackets. The resulting attachments are often unreliable and lacking in robustness. For stairwells of normal width, the span required for the lift machine support beams is excessive and unless uneconomic sections are used the deflections under varying load adversely affect the motor of the lift.

The necessary provision of suitable continuous enclosures can be very expensive.

5C.8.7 Handwinding Release Procedure and Indication

The release procedure by handwinding should only be carried out in an emergency and by authorized persons who have received the necessary instruction because it is dangerous for any other persons to attempt to do so.

Before attempting to move the car, it is imperative that any person in the car be warned of the intention to move the car and that they do not attempt to leave the car until they are advised that it is safe to do so. Any failure to carry out this precaution may render the person concerned guilty of negligence should an accident occur.

Before attempting to handwind the lift machine, it is vital that the supply is switched off at the main switch.

It is usually necessary to have two persons in the machine room: one to operate the brake release and the other to carry out the handwinding. The exceptions are small lift machines where the handwinding can be easily controlled by one man and larger machines which need two men to operate the handwinding alone with an additional man to control the brake release.

If the car is stuck in the lift well and cannot be moved when an attempt is made to move it in a downward direction, then no attempt at handwinding should be made because the car safety gear may have set. Any further procedure should be carried out under the instruction of a qualified lift mechanic.

Provided the car is free to be moved in the downward direction, then it should be hand wound to the nearest floor. There is a preference to move the car in a downward direction. However, this may not always be practical owing to the distance involved and the time taken to complete the movement. In addition the amount of out of balance load on the counterweight side, due to the size of car and the small number of persons inside it, may make it necessary to wind the car upwards. In the case of higher speed lifts the direction of handwinding will usually be governed by effort required to move the car because of the absence of a large gear reduction ratio.

It is essential that all detail operations be carried out according to the manufacturer's instructions for the lift concerned and these should be clearly stated and permanently displayed in the form of a notice in the machine room.

5C.9 RUNNING AND MAINTENANCE

5C.9.1 The lift installation should receive regular cleaning, lubrication, adjustment and adequate servicing by authorized competent persons at such intervals as the type of equipment and frequency of service demand. In order that the lift installation is maintained at all times in a safe condition, a proper maintenance schedule shall be drawn up in consultation with the lift manufacturer and rigidly followed. The provision of a log book to record all items relating to general servicing and inspection is recommended for all lifts. It is essential that the electrical circuit diagram of the lift with the sequence of operation of different components and parts should be kept readily available for the persons responsible for the maintenance and replacement where necessary.

5C.9.2 Particular attention may be directed for through periodical examination of wire ropes when in service. Attention should also be directed to the thorough examination of the groove of drums, sheaves and pulleys when installing a new rope. A groove deepened by rope wear is liable to lead to early failure of a new rope unless the groove is returned.

5C.9.3 Any accident arising out of operation of maintenance of the lifts should be duly reported to the Authority in accordance with the rules laid down. A notice may be put in the machine room to this effect.

5C.10 PROCEDURE FOLLOWING TEST, INCLUDING INSPECTION AND MAINTENANCE

5C.10.1 Acceptance

The purchaser should make timely arrangement for accepting the lift on completion of test, and for insurance cover. Special arrangements (see 5C.10.4) are necessary if there is no break interval before the lift goes into normal service.

5C.10.2 Guarantee and Servicing

Any guarantee provided by the lift maker should be conditional upon the lift receiving regular and adequate servicing, and should cover the free replacement of parts which prove defective through reasons of fault, materials or workmanship in the guarantee period, which is generally twelve months.

To ensure the continuance of satisfactory and safe operation, the purchaser (or building occupier) should arrange for the completed lift to receive regular servicing by competent persons at such intervals as the type of equipment and intensity of operation demand. Such service can be secured under a service contract. It is desirable and normal for the lift maker to be entrusted with the servicing during the guarantee period of a new lift.

The scope of a service contract may be extended to cover not only regular servicing, but also intermediate service calls, repairs and replacement of worn parts.

The building owner should co-operate with the service engineer, and should ensure that the equipment is properly used, and that unauthorized persons are not permitted to enter the lift well or machine rooms.

Particular attention should be paid to methods of ensuring that lifts are not overloaded when they are used in connection with furniture and equipment removals, and internal redecoration and other similar activities, which may be undertaken within the building.

5C.10.3 Statutory Examinations

Lifts in certain premises are required by statutory regulations to be examined at intervals, as specified by the Lift Rule and Regulation, by a competent person, who is required to report on a prescribed form. Such reports should normally be kept in a register.

Statutory examinations are not a substitute for servicing, the provision of statutory reports may be specially included in a service contract or may be arranged separately.

5C.10.4 Lift not in Immediate Use (Shut Down Maintenance)

When conditions do not permit a lift to be taken to normal service immediately following completion and acceptance, it should be immobilized. The main contractor should take effective precautions against damage especially to finishes, or damage to equipment from dampness and builder's debris, until such time as the lift is required.

A separate service contract should be made with the lift maker to make regular visits during this period, to inspect, lubricate and report on the condition of the lift.

A date should also be agreed with the lift maker from which his guarantee period will commence.

5C.10.5 Temporary Use of Lifts

If the purchaser intends to permit temporary use of a lift by some other party, such as the building contractor, before taking it into normal service, so that it is not immobilized, then the responsibilities of those concerned should be clearly defined and agreed. In addition to the precautions noted in 5C.10.4, temporary insurance cover should be arranged.

If temporary use of lifts is envisaged, it should preferably be given consideration at an early stage, having regard to the conditions under which it is likely to take place.

5C.10.6 Cleaning Down

Acceptance following test should include checking the condition of decorative finishes, before the lift maker leaves the site.

After a shut down (or temporary service) period, the lift may require a further general cleaning down immediately before taking into normal service. The lift maker should be instructed accordingly to undertake this work and if any accidental damage has occurred to repair this at the same time. Both these items should be the subject of extra costs.

5C.11 ESCALATORS

5C.11.1 Escalators are deemed essential where the movement of people, in large numbers at a controlled rate in the maximum of space, is involved, for example, railway stations, air-ports, etc. In exhibitions big departmental stores and the like, escalators encourage people to circulate freely and conveniently.

5C.11.1.1 As the escalators operate at a constant speed, serve only two levels and have a known maximum capacity, the traffic study is rather easy. Provided the population to be handled in a given time is known, it is easy to predict the rate at which the population can be handled.

5C.11.1.2 For normal peak periods, the recommended handling capacities for design purposes should be taken as 3200 to 6400 persons per hour depending upon the width of the escalator.

The number of persons that may be theoretically carried by the escalator in 1 hr. can be calculated as follows:

For determination of theoretical capacity it is assumed that one step with an average depth of 0.4 m can carry 1 person for a step width of 0.6 m, 1.5 persons for a step width of 0.8 m and 2 persons for a step width of 1.0 m.

The theoretical capacity then is:

$$3600 \times (\text{rated speed in m/s} \times k) / 0.4$$

Where

$$K=1.15, \text{ or } 2 \text{ for } 0.6, 0.8 \text{ and } 1.0 \text{ m step widths.}$$

Some values calculated as per the above are:

Step width	Theoretical Capacity in Persons/hour		
	0.5 m/s speed	0.65 m/s speed	0.75 m/s speed
0.6 m	4 500	5 850	6 750
0.8 m	6 750	8 775	10 125
1.0 m	9 000	11 700	13 500

5C.11.2 Terms and definitions

For the purposes of this document, the terms and definitions given the following apply.

5C.11.2.1 Angle of inclination

Maximum angle to the horizontal in which the steps, the pallets or the belt move

5C.11.2.2 Balustrade

Part of the escalator/moving walk which ensures the user's safety by providing stability, protecting from moving parts and supporting the handrail

5C.11.2.3 Balustrade decking

Transverse member of the balustrade which meets the handrail guidance profile and which forms the top cover of the balustrade

5C.11.2.4 Brake load

Load on the step/pallet/belt which the brake system is designed to stop the escalator/moving walk

5C.11.2.5 Comb

Pronged section at each landing that meshes with the grooves

5C.11.2.6 Comb plate

Platform at each landing to which the combs are attached

5C.11.2.7 Electrical safety system

Safety related part of the electrical control system as an arrangement of safety circuits and monitoring devices

5C.11.2.8 Electrical safety devices

Part of a safety circuit consisting of safety switches and/or fail safe circuits

5C.11.2.9 Escalator

Power-driven, inclined, continuous moving stairway used for raising or lowering persons in which the user carrying surface (e.g. steps) remains horizontal

NOTE Escalators are machines - even when they are out of operation - and cannot be considered as fixed staircases.

5C.11.2.10 Exterior panel

Part of the exterior side of the enclosure of an escalator or moving walk

5C.11.2.11 Fail safe circuit

Safety related electrical and/or electronic system with defined failure mode behaviour

5C.11.2.12 Handrail

Power-driven moving rail for persons to grip while using the escalator or moving walk

5C.11.2.13 Interior panel

Panel located between the skirting or lower inner decking and the handrail guidance profile or balustrade decking

5C.11.2.14 Lower inner decking

Profile that connects the skirting with the interior panel when they do not meet at a common point

5C.11.2.15 Lower outer decking

Profile that connects the exterior panels with the interior panel

5C.11.2.16 Machinery

Escalator or moving walk machine(s) mechanisms and associated equipment

5C.11.2.17 Machinery spaces

Space(s) inside or outside of the truss where the machinery as a whole or in parts is placed

5C.11.2.18 Maximum capacity

Maximum flow of persons that can be achieved under operational conditions

5C.11.2.19 Moving walk

Power-driven installation for the conveyance of persons in which the user carrying surface remains parallel to its direction of motion and is uninterrupted (e.g. pallets, belt)

NOTE Moving walks are machines - even when they are out of operation – and should not be used as a fixed access.

5C.11.2.20 Newel

End of the balustrade

5C.11.2.21 Nominal speed

Speed in the direction of the moving steps, pallets or the belt, when operating the equipment under no load condition (i.e. without persons), stated by the manufacturer as that for which the escalator or moving walk has been designed

NOTE Rated speed is the speed the escalator/moving walk moves under rated load conditions.

5C.11.2.22 Rated load

Load which the equipment is designed to move

5C.11.2.23 Rise

Vertical distance between the upper and lower finished floor levels

5C.11.2.24 Safety circuit

Part of the electric safety system consisting of electrical safety devices

5C.11.2.25 Skirting

Vertical part of the balustrade interfacing with the steps, pallets or belt

5C.11.2.26 Skirt deflector

Device to minimize the risk of trapping between the step and the skirting

5C.11.2.27 Stand-by operation

Mode in which an escalator/moving walk can be stopped or operated under no load condition with any speed below the nominal speed

5C.11.3 Symbols and abbreviations

The following symbols and corresponding units of measurement of the following Table 1 are used in this standard.

Table 1 — Symbols and corresponding units of measurement used in this standard

Symbol	Designation	Unit	Figure
b1	Distance between the handrail centre lines	m	3
b2	Width of the handrail	mm	3
b3	Horizontal distance between skirting and interior panel	mm	3
b4	Width of the horizontal part of the lower inner decking that directly joins the interior panel	mm	3
b5	Horizontal distance between the inner edge of the handrail and the top edge of the interior panel	mm	3
b6', b6"	Horizontal distance between the handrail profile and guide or cover profiles	mm	3
b7	Width of the grooves	mm	2
b8	Web width	mm	2
b9	Horizontal distance between the outer edge of the handrail and a non- continuous obstruction, e.g. roof intersection, column	mm	A.1
b10	Horizontal distance between the outer edge of the handrail and a continuous obstruction, e.g. wall	mm	A.1
b11	Horizontal distance between the handrails of adjacent escalators/moving walks	mm	A.1
b12	Vertical distance between the lower edge of the handrail and the balustrade decking	mm	3
b13	Width of the lower outer decking	mm	4
b14	Horizontal distance between the outer edges of interior panels on adjacent escalators or moving walks	mm	4
b15	Horizontal distance between the building structure (wall) and the centre line of the handrail	mm	4
b16	Horizontal distance between the centre lines of the handrails of adjacent escalators/moving walks	mm	4
b17	Horizontal distance of the anti-slide device to the outer edge of the handrail	mm	4
h1	Vertical distance between the top of the handrail and step nose or pallet surface or belt surface	m	2, 3
h2	Vertical distance between top edge of skirting or bottom edge of cover joints and the line of the step nose or the tread surface of the pallets or belt	mm	3
h3	Distance between the entry of handrail into the newel and the	m	2,3

Table -1 Continued

Symbol	Designation	Unit	Figure
h4	Free height above any point of step surfaces, pallets or belt over the area between both outer edges of the handrails	m	2, A.1
h5	Height of the deflector	m	2,4
h6	Clearance between the upper edge of the tread surface and the root of the comb teeth	mm	2
h7	Depth of the grooves	mm	2
h8	Mesh depth of the comb into the grooves of the tread	mm	2
h9	Vertical distance between floor and lower end of the anti-climbing	mm	4
h10	Vertical distance between lower edge of the handrail and upper end of the access restriction device	mm	4
h11	Height of the anti-slide device	mm	4
h12	Height of the upper edge of the free space outside the handrail	mm	A.1
h13	Vertical distance between the upper and lower finished floor levels	m	2
L1	Root of the comb teeth	-	2
l1	Horizontal distance between supports	m	2
L2	Comb intersection line	-	2
l2	Distance between the furthest point reached by the handrail and the comb intersection line measured parallel to the tread surface	m	2
l3	Length of the straight portion of the handrail in the direction of landing measured from the comb intersection line	m	2
l4	Distance between the furthest point reached by the handrail and the point of entry into the newel measured parallel to the tread surface	m	2
l5	Length of anti-climbing device on the lower outer decking	mm	4
v	Nominal speed	m/s	-
x1	Step height	m	5
y1	Step depth	m	5
z1	Nominal width for the load carrying area (step, pallet or belt)	m	3, 5
z2	Horizontal distance between skirting	m	3
z3	Transverse distance between the supporting rollers	mm	8
α	Angle of inclination of the escalator or moving walk	°(degree)	2
β	Design angle of the teeth of the comb	°(degree)	2
γ	Cross-sectional angle of inclination of the lower inner decking	°(degree)	3
μ	Friction coefficient	-	-

5C.11.4 List of significant hazards**5C.11.4.1 General**

This clause contains all the significant hazards, hazardous situations and events, as far as they are dealt with in this standard, identified by risk assessment as significant for escalators and moving walks and which require action to eliminate or reduce the risk.

5C.11.4.2 Mechanical hazards

Mechanical hazards on escalators and moving walks and in their immediate vicinity can occur because of the design of the machine or access to it.

These include:

- Contact with moving machinery parts (e.g. driving unit, handrail drive) normally not accessible to the public (see 5C.11.5.2(b), 5C.11.5.2(d), 5C.11.5.2(e), 5C.11.5.2(f), 5C.11.5.6.1, A.3.2, A.3.3);
- Impact on bodies caused by collision with building structures (wall, roof, criss-cross arrangement or with persons on adjacent escalators/moving walks (see A.2.1, A.2.2, A.2.3, A.2.4);
- Trapping between step and step or pallet and pallet (see 5C.11.5.4).

5C.11.4.3 Electric hazards

Electric hazardous situations can occur due to:

- Contact of persons with live parts
- Indirect contact
- Inadequate emergency stops [see 5C.11.5.12.2(c)]
- Wrong assembly of electric components
- Electrostatic phenomena
- External influences on electric equipment [see 5C.11.5.12.1(d), 5C.11.5.12.1(e), 5C.11.5.12.2(d)]

5C.11.4.4 Fire hazard

Fire hazards can be generated by accumulation of combustible material inside the truss, by the isolation material for cables and overloading of drives [see 5C.11.5.2.1(d), 5C.11.5.10].

5C.11.4.5 Hazards generated by neglecting ergonomic principles in machinery design

Hazardous situation can occur because of:

- Inadequate lighting in the working places and access to them (see 5C.11.5.9.3(a), 5C.11.5.9.3(b), A.3.4, A.3.5).
- Insufficient space in working places (see 5C.11.5.11.2(b), 5C.11.5.11.2(c), 5C.11.5.11.2(d), A.3.6, A.3.7, A.3.8).
- Missing lifting equipment for heavy loads (see 5C.11.5.9.2.2).

5C.11.4.6 Hazards generated by break-up during operation

Even if the design of an escalator or moving walks follows the requirements of EN 115-1, there are specific hazards which can occur due to

- Greater than specified user and structural loads on the truss (see 5C.11.5.2.3).
- Loads greater than specified on the steps/pallets by unforeseeable misuse (see 5C.11.5.5).

5C.11.4.7 Slipping, tripping and falling hazards

Most of the dangerous situations on escalators and moving walks are caused by the slipping and falling of persons.

This is:

- Falling caused by inadequate lighting at the landings (see A.2.8,A.2.9).

5C.11.5 Safety requirements and/or protective measures

5C.11.5.1 General

Escalators and moving walks shall comply with the safety requirements and/or protective measures of this clause.

5C.11.5.2 Supporting structure (truss) and enclosure

5C.11.5.2.1 General

- (a) All mechanically moving parts of the escalator or moving walk shall be completely enclosed within imperforate panels or walls. Except from this are the accessible steps, the accessible pallets, the accessible belt and that part of the handrail available for the user. Apertures for ventilation are permitted [see also 5C.11.5.2.1(e)].
- (b) The exterior panels shall withstand a force of 250 N at any point at right angles on an area of 25 cm² without breakage or deflection resulting in any gap. The fixing shall be designed in that way to carry at least twice the dead load of the enclosure.
- (c) It is permissible to omit an enclosure of the mechanically moved parts if other measures (such as rooms with locked doors accessible to authorized personnel only) make a hazard to the public impossible.
- (d) Accumulation of materials (e.g. grease, oil, dust, paper) represents a fire risk. Therefore it shall be possible to clean the inner part of the escalator/moving walk.
- (e) Ventilation apertures shall be built or arranged. However it shall not be possible to pass a straight rigid rod 10 mm in diameter through the enclosure and to touch any moving part through a ventilation aperture.
- (f) Any exterior panels which are designed to be opened (e.g. for cleaning purposes) shall be provided with an electric safety device).

5C.11.5.2.2 Angle of inclination

The angle of inclination α of the escalator shall not exceed 30° , but for rises h_{13} not exceeding 6 m and a nominal speed not exceeding 0,50 m/s the angle of inclination is permitted to be increased up to 35° (see α in Figure 2).

The angle of inclination of moving walks shall not exceed 12° .

5C.11.5.2.3 Structural design

The supporting structure shall be designed in a way that it can support the dead weight of the escalator or moving walk plus a rated load of 5 000 N/m².

Based on the rated load, the maximum calculated or measured deflection shall not exceed 1/750 of the distance l_1 between the supports.

5C.11.5.3 Steps, pallets, belt

5C.11.5.3.1 General

In the user carrying area of the escalator, the step treads shall be horizontal with a tolerance of $\pm 1^\circ$ in the direction of travel.

Tread surfaces for escalators and moving walks shall provide a secure foothold.

5C.11.5.4 Dimensions

5C.11.5.4.1 General

For escalators and moving walks the nominal width z_1 shall be not less than 0,58 m and not exceed 1,10 m. For moving walks with an angle of inclination up to 6° widths up to 1,65 m are permitted.

- Step treads and pallets (see Figure 2, detail X and Figure 5).
- The step height x_1 shall not exceed 0,24 m.
- The step depth y_1 shall be not less than 0,38 m.
- The surface of the step treads and pallets shall have grooves in the direction of movement with which the teeth of the combs mesh.
- The step risers shall be cleated and the surface of the cleat shall be smooth. The ends of the step tread shall mesh with the cleating of the next step riser.
- The width b_7 of the grooves shall be at least 5 mm and not exceed 7 mm.
- The depth h_7 of the grooves shall be not less than 10 mm.
- The web width b_8 shall be at least 2,5 mm and not exceed 5 mm.
- The step treads and step risers or pallets shall not finish with a groove at their side edges.

- The edge between the surface of the step tread and the riser shall have any sharpness relieved.
- Belts (see Figure 2, detail X).
- The belts shall have grooves in the direction of travel with which the teeth of the comb mesh.
- The width b_7 of the grooves shall be at least 4,5 mm and not exceed 7 mm, and shall be measured at the tread surface of the belt.
- The depth h_7 of the grooves shall be not less than 5 mm.
- The web width b_8 shall be at least 4,5 mm and not exceed 8 mm and shall be measured at the tread surface of the belt.
- The belt shall not finish with a groove at the side edge of the belt.

Splicing of the treadway belt shall be such as to provide a continuous unbroken treadway surface.

5C.11.5.5 Structural design

5C.11.5.5.1 General

The materials shall retain their strength characteristics during their specified life cycle taking into account the environmental conditions, e.g. temperature, ultra violet radiation, humidity, corrosion.

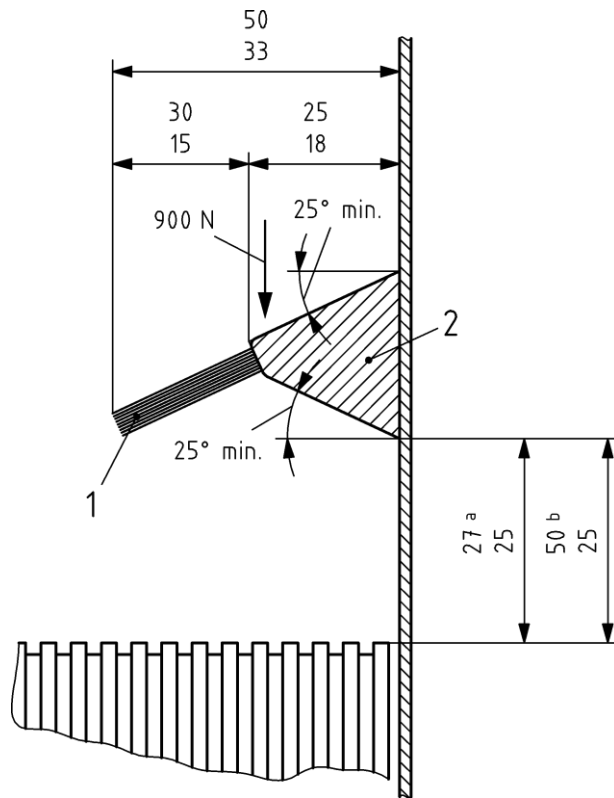
The steps, pallets and the belt shall be designed to withstand all possible loading and distortion effects, which may be imposed by the tracking, guiding and driving system during normal operation and shall be designed to support an equally distributed load corresponding to 6 000 N/m².

NOTE 6000 N/m² is derived from a static load of 5000 N/m² plus an impact factor of 1.2.

Assembled steps and pallets shall be designed such that all component parts e.g. inserts or fixings are securely attached and do not become loose during their life cycle. The inserts and fixings shall withstand the reaction force of operating the comb/comb plate electric safety device.

Key

- 1** flexible part
- 2** rigid part
- a** in the inclined area
- b** in the transition and horizontal areas



Dimensions in millimetres

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure 1 — Requirements on skirt deflectors

5C.11.5.6 Newel

5C.11.5.6.1 The newel including the handrails shall project horizontally beyond the comb intersection line by at least 0,60 m in longitudinal direction (see L_2 and l_2 in Figure 2 and detail X).

5C.11.5.6.2 The horizontal portion of the handrail shall continue longitudinally at the landings for a distance l_3 (see Figure 2) of at least 0,30 m past the comb intersection line (see L_2 in Figure 2 and detail X).

In the case of inclined moving walks without a horizontal section at the landings, the continuation of the handrail parallel to the angle of inclination is permitted.

5C.11.5.7 Landings

5C.11.5.7.1 Surface properties

The landing area of escalators and moving walks (i.e. comb plate and floor plate) shall have a surface that provides a secure foothold for a minimum distance of 0,85 m measured from the root of the comb teeth (see L_1 in Figure 2 and detail X).

5C.11.5.7.2 Configuration of steps, pallets and belts

- (a) At the landings, the steps of the escalator shall be guided in such a way that the front edges of the steps leaving the comb and the rear edges of the steps entering the comb are moving horizontally for a length of at least 0,80 m measured from point L₁ (see Figure 2 and detail X).

At nominal speeds above 0,50 m/s and not more than 0,65 m/s or rises h_{13} above 6 m this length shall be at least 1,20 m, measured from point L₁ (see Figure 2 and detail X).

At nominal speeds above 0,65 m/s this length shall be at least 1,60 m measured from point L₁ (see Figure 2 and detail X).

A vertical difference in level between two consecutive steps of 4 mm is permitted.

- (b) For escalators, the radius of curvature in the upper transition from incline to horizontal shall be:

- At least 1,00 m for nominal speeds $v \leq 0,5$ m/s (inclination of max 35°).
- At least 1,50 m for nominal speeds $0,5 \text{ m/s} < v \leq 0,65$ m/s (inclination of max 30°).
- At least 2,60 m for nominal speeds $v > 0,65$ m/s (inclination of max 30°).

The radius of curvature in the lower transition from incline to horizontal of the escalator shall be at least 1,00 m up to 0,65 m/s the nominal speed and at least 2,00 m above 0,65 m/s.

- (c) For belt moving walks, the radius of curvature in the transition from incline to horizontal shall be at least 0,40 m.

For pallet moving walks, it is not necessary to determine the radius of curvature because, on account of the maximum permissible distance between two consecutive pallets, it will always be sufficiently large.

- (d) At the upper landings of moving walks with an inclination of more than 6°, the pallets or belt shall move for a length of at least 0,40 m at a maximum angle of 6° before entering or after leaving the comb.

Analogous to 5C.11.5.7.2 (a), for pallet moving walks the movement is specified as follows:

The front edge of the pallet leaving the comb and the rear edge of the pallet entering the comb shall move without changing the degree of angle over at least 0,40 m.

- (e) Provisions shall be made in the area of the combs to ensure the correct meshing [see 5C.11.5.7.2(e)] of the comb teeth with the grooves of the tread surface.

Belts shall be supported in this area in a suitable manner, e.g. by drums, rollers, sliding plates.

5C.11.5.8 Combs

5C.11.5.8.1 General

Combs shall be fitted at both landings to facilitate the transition of users. The combs shall be easily replaceable.

5C.11.5.8.2 Design

(a) The teeth of the combs shall mesh with the grooves of the steps, pallets or belt [see 5C.11.5.8.2.(g)] The width of the comb teeth shall be not less than 2,5 mm, measured at the tread surface (see Figure 2, detail X).

(b) The ends of the combs shall be rounded off and so shaped as to minimise the risk of trapping between combs and steps, pallets or belt.

(c) The radius of the teeth end shall be not greater than 2 mm.

(d) The teeth of the comb shall have a form and inclination so that the feet of users, leaving the escalator or moving walk, should not stub against them. The design angle β shown in Figure 2, detail X shall not exceed 35°.

(e) The combs or their supporting structure shall be adjustable, to ensure correct meshing (see Figure 2, detail X).

(f) The combs shall have such a design that upon trapping of foreign bodies either their teeth deflect and remain in mesh with the grooves of the steps, pallets or belt, or they break.

(g) In the case of objects being trapped which are not dealt with by the means described in [5C.11.5.8.2(e)] and in the case of comb/step/pallet impact the escalator or moving walk shall be stopped automatically.

(h) Mesh depth of the combs into the grooves

(i) The mesh depth h_8 of the combs into the grooves of the tread (see Figure 2, detail X) shall be at least 4 mm.

(j) The clearance h_6 (see Figure 2, detail X) shall not exceed 4 mm.

5C.11.5.9 Machinery spaces, driving station and return stations

5C.11.5.9.1 General

These rooms/spaces shall be used only for accommodating the equipment necessary for the operation and maintenance and inspection of the escalator or moving walk. Fire alarm systems, equipment for direct fire abatement and sprinkler heads, provided they are sufficiently protected against incidental damage, are permitted in these rooms provided they do not generate additional risks for maintenance operation.

5C.11.5.9.2 Dimensions and equipment

(a) In machinery spaces, especially in driving and return stations inside the truss, space with a sufficiently large standing area shall be kept free from permanently installed parts of any kind.

The size of the standing area shall be at least $0,30 \text{ m}^2$ and the smaller side shall be at least 0,50 m long.

(b) If the controller cabinet has to be moved or lifted for maintenance purposes, then suitable attachments for lifting shall be provided, e.g. eyebolts, handle.

(c) Where the main drive or brake is arranged between the user side of the step, pallet or belt and the return line, a level standing area in the working zone of not less than $0,12 \text{ m}^2$ shall be provided. The minimum dimension shall be not less than 0,30 m. This standing area is permitted to be fixed or removable.

NOTE For machinery spaces, see also A.3.

5C.11.5.9.3 Lighting and socket outlets

(a) The electric lighting and the socket outlets shall be independent of the power supply to the machine being fed either by a separate cable or a branch cable which is connected before the main switch of the escalator or moving walk. It shall be possible to break the supply of all phases by means of a separate.

(b) Electric lighting installations in driving and return stations and machinery spaces inside the truss shall be by means of a portable lamp permanently available in one of these places. One or more socket outlets shall be provided in each of these places.

The light intensity shall be at least 200 lx in working areas.

5C.11.5.9.4 Socket outlets shall be

Either of type 2 P+PE (2 poles + earth conductor), 250 V, directly supplied by the mains, or of a type that is supplied at a safety extra low voltage in accordance with Local Rule. 5C.11.5.11.3 Maintenance and repair stop switch. There shall be a stop switch in the driving and return station. Escalators and moving walks with the driving unit arranged between the user side of the step, pallet or belt and the return line, or outside the return stations, shall have additional stop switches in the area of the driving unit. The operation of these stop switches shall cause the disconnection of the power supply from the driving machine and allow the operational brake to become effective to stop the escalator or moving walk.

The stop switches shall be achieve a category 0 stop. When activated it shall prevent the escalator or moving walk from starting. The switching positions shall be marked clearly and permanently.

SPECIFIC CASE A stop switch need not be provided in a machinery space if a main switch according to 5C.11.5.10 is located therein.

5C.11.5.10 Fire protection

Fire protection and building requirements differ from country to country and so far neither have been harmonized. Therefore, this standard cannot include specific requirements for fire protection and building requirements. However, it is recommended that as far as possible, escalators and moving walks are made of materials that do not create an additional hazard in case of fire.

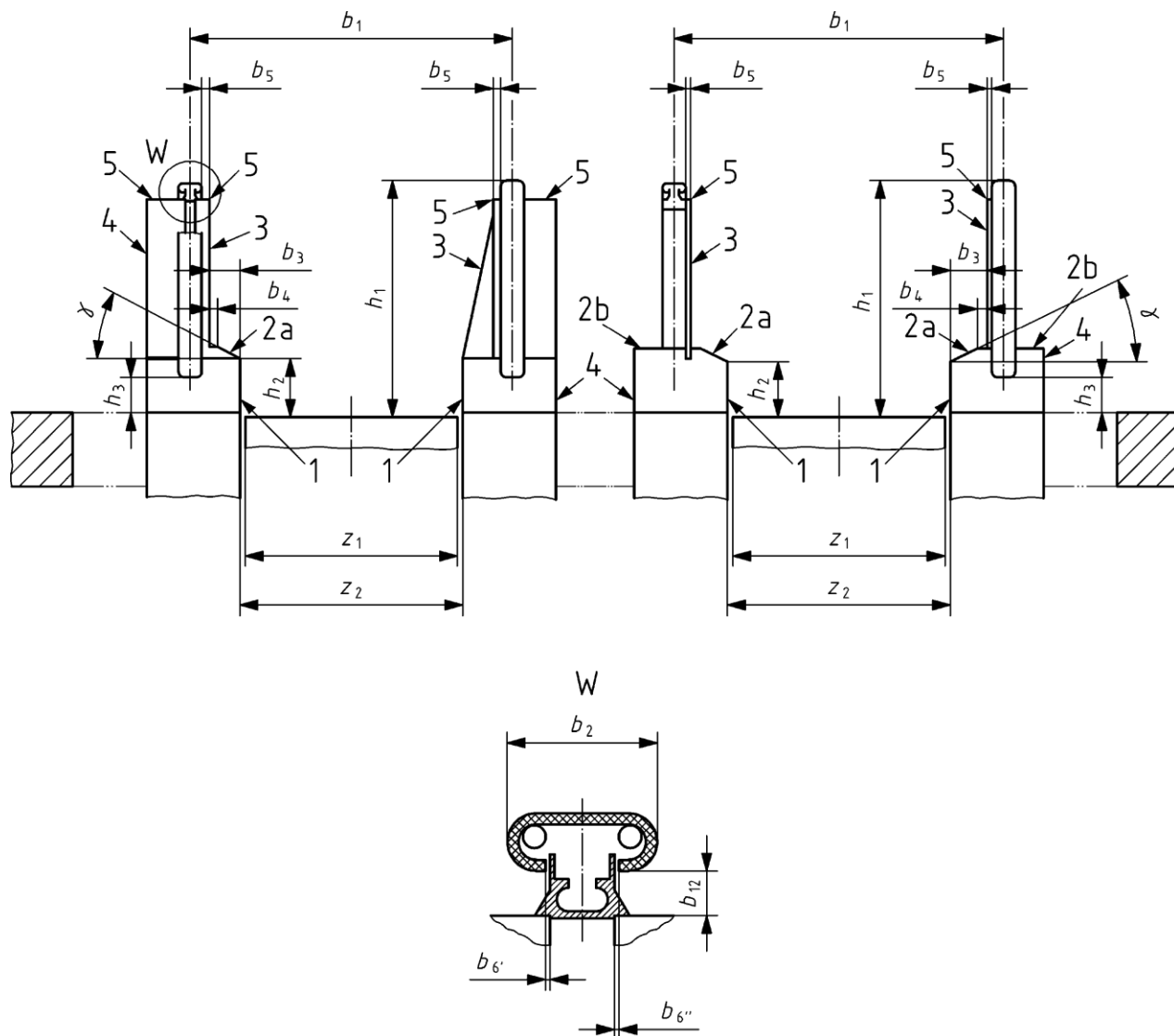


Figure 2 — Escalator (elevation), principal dimensions

Principal dimensions	Clause	Principal dimensions	Clause
b7 5 mm to 7 mm (step treads and pallets)	11.5.4.1(f)	h8 $\geq$ 4 mm	11.5.8.2(h)
b7 4,5 mm to 7 mm (belts)	11.5.4.1(m)	h13 Rise	
b8 2,5 mm to 5 mm (step treads and pallets)	11.5.4.1(b)	L1 Root of the comb teeth	
b8 4,5 mm to 8 mm (belts)	11.5.4.1(o)	L2 Comb intersection line	
h1 0,90 m to 1,10 m	11.5.8.2(a)	l1 Distance between supports	
h3 0,10 m to 0,25 m		l2 $\geq$ 0,60 m	
h4 $\geq$ 2,30 m		l3 $\geq$ 0,30 m	
h5 $\geq$ 0,30 m		l4 $\geq$ 0,30 m	
h6 $\leq$ 4 mm	11.5.8.2(i)	α Angle of inclination	
h7 $\geq$ 10 mm (step treads and pallets)	11.5.8.2(g)	$\beta \leq 35^\circ$	11.5.8.2(c)
h7 $\geq$ 5 mm (belts)	11.5.8.2(b)		

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure 2 — Escalator (elevation), principal dimensions



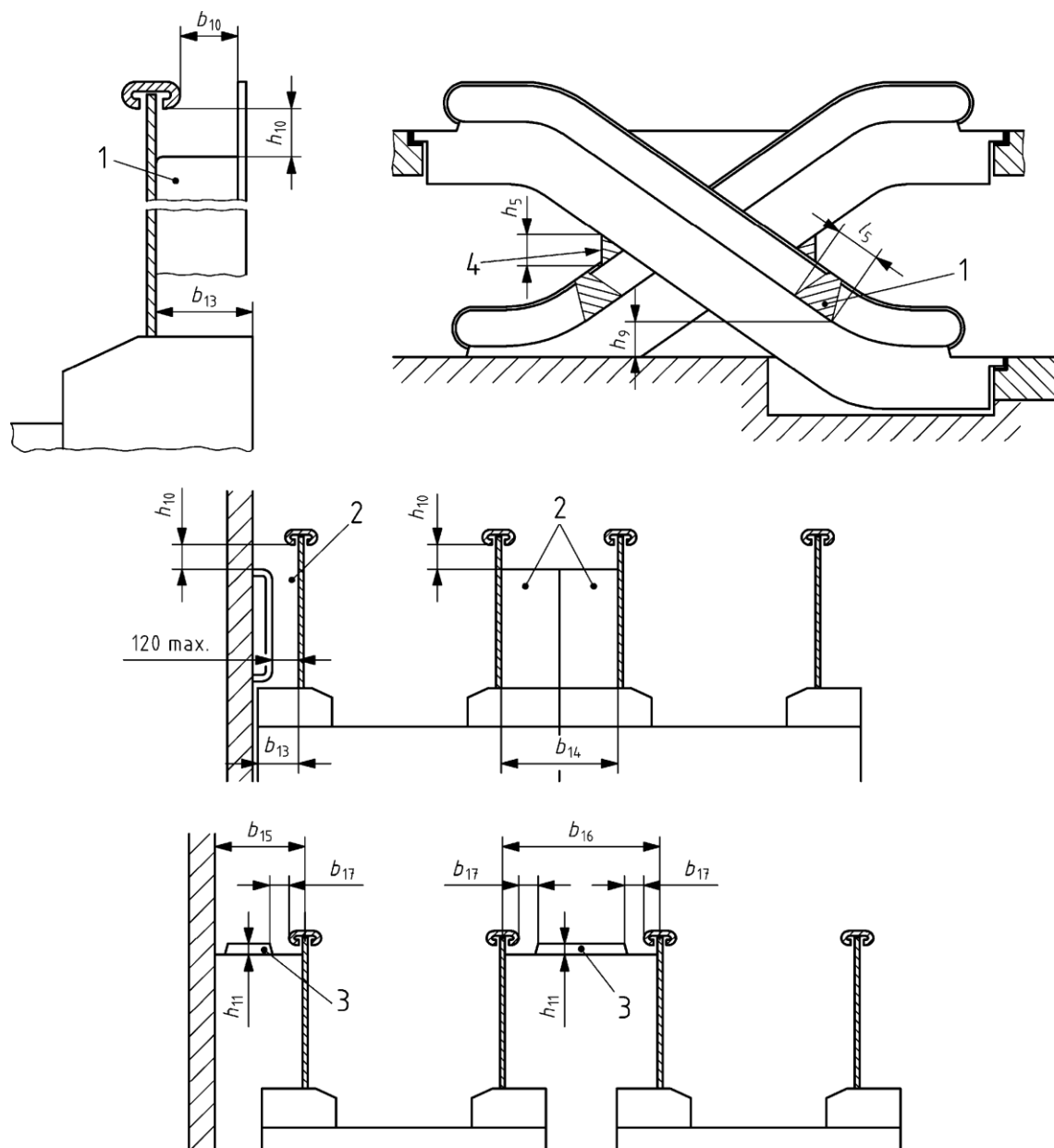
Key

1	skirting	3	interior panel
2a	lower inner decking	4	exterior panel
2b	lower outer decking	5	balustrade decking

Principal dimensions	Clause	Principal	Clause	Principal	Clause
$b_1 \leq z_2 + 0,45 \text{ m}$		$b_6' + b_6'' \leq 8 \text{ mm}$		$z_2 = z_1 + 7 \text{ mm};$	
$b_2 \quad 70 \text{ mm to } 100$		$b_{12} \geq 25 \text{ mm}$	A. 2.2	distance	
$b_3 < 0,12 \text{ m}$ (if γ less		$h_1 \quad 0,90 \text{ m to}$		between skirting	
$b_4 < 30 \text{ mm}$		$h_2 \geq 25 \text{ mm}$		$\gamma \geq 25^\circ$	
$b_5 \leq 50 \text{ mm}$		$h_3 \quad 0,10 \text{ m to } 0,25$			

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure 3 — Escalator/moving walk (sectional view), principal dimensions



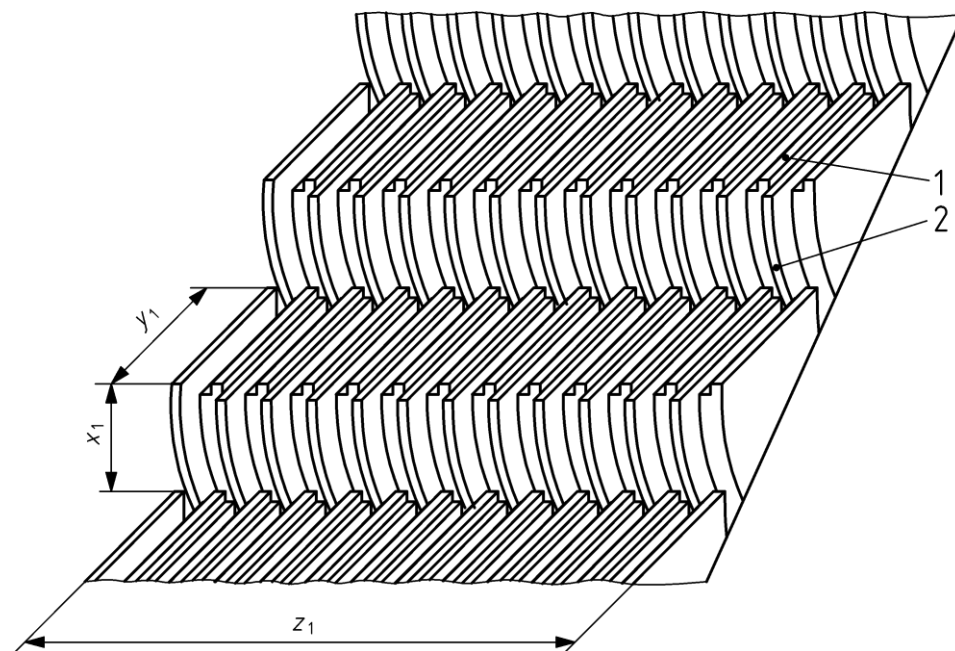
Key

1 anti-climbing device	3 anti-slide device
2 access restriction device	4 vertical deflector

Principal dimensions	Clause	Principal dimensions	Clause
$b_{13}, b_{14}, b_{15}, b_{16}$		$h_{10} = 25 \text{ mm to } 150 \text{ mm}$	
$b_{17} \geq 100 \text{ mm}$		$h_{11} \geq 20 \text{ mm}$	
$h_5 > 0.30 \text{ m}$	A.2.4	$L_5 \geq 1000 \text{ mm}$	
$h_9 = (1000 \pm 50) \text{ mm}$			

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure 4 — Anti-misuse devices



Key

- 1 step treads
- 2 step risers

Principal dimensions	Clause
$x_1 \leq 0,24 \text{ m}$	11.5.4.1(b)
$y_1 \geq 0,38 \text{ m}$	11.5.4.1(c)
$z_1 \quad 0,58 \text{ m to } 1,10 \text{ m}$	11.5.4

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.
 Figure 5 — Steps, principal dimensions

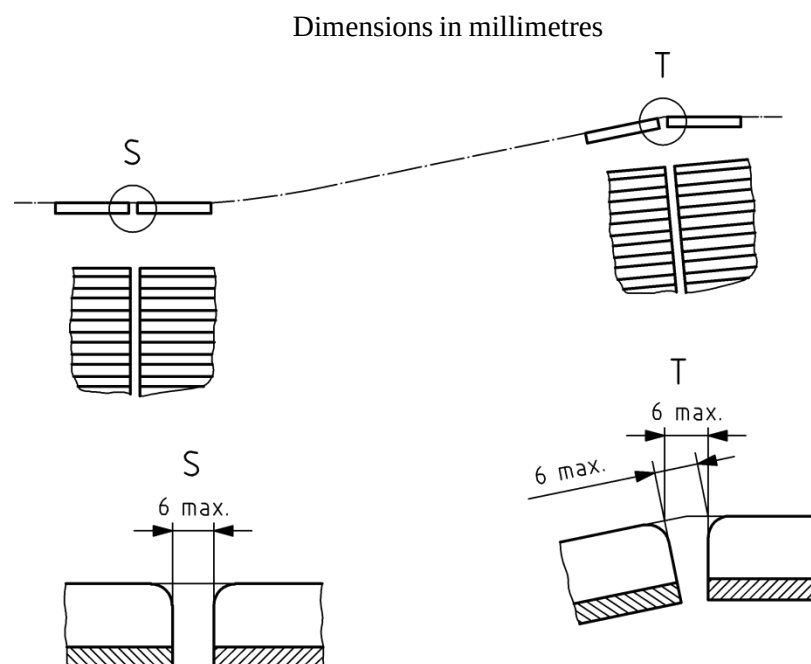


Figure 6 — Pallets, clearance and mesh depth (pallet type moving walk without meshed front and rear edges) in lower and upper landing and transition curves

Dimensions in millimetres

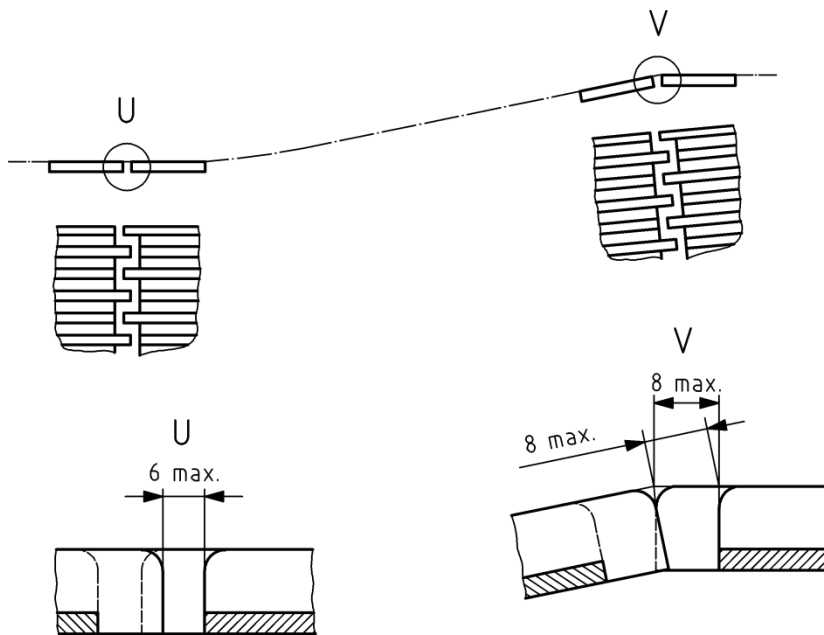
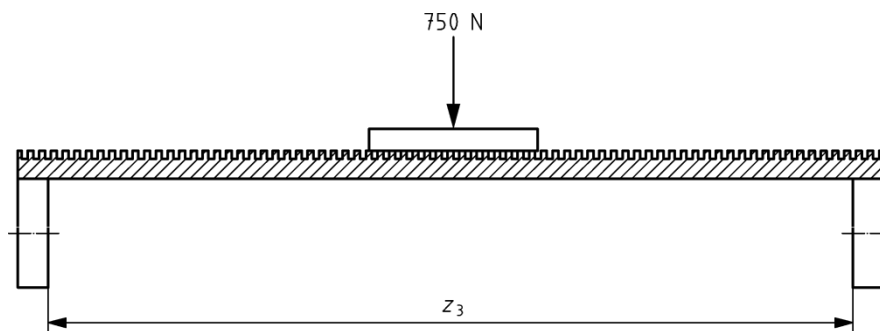


Figure 7 — Pallets, clearance and mesh depth (pallet type moving walk with meshed front and rear edges) in lower and upper landing and transition curves



Symbol for quantity/Designation	Clause
z3 Transverse distance between the supporting rollers	

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure 8 — Belt (sectional view), single force

5C.11.5.11 Electric installations and appliances

5C.11.5.11.1 General

Introduction

The electric installation of escalators or moving walks shall be so designed and manufactured as to ensure protection against hazards arising from the electric equipment or which may be caused by external influences on it, provided the equipment is used in applications for which it was made and is adequately maintained.

Therefore, the electric equipment shall:

- (i) Comply with the requirements stated in Myanmar Electrical Regulations;
- (ii) Where no harmonised standards as referred to in a) exist, comply with the requirements of the International Electrotechnical Commission (IEC)

Limits of application

The requirements of this standard relating to the installation and to the constituent components of the electric equipment apply:

- (i) To the main switch of each independent power circuit (e.g. machine, heating system) of the escalator or moving walk and dependent circuits;
- (ii) To the switch for the lighting circuit of the escalator or moving walk and dependent circuits.

The escalator or moving walk shall be considered as a whole, in the same way as a machine with its incorporated apparatus.

The electricity supply to the input terminals of the switches refers to in (b) and the electricity supply to the lighting of the machinery spaces, driving and return stations are not laid down by this standard.

5C.11.5.11.2 Voltage limit for control and safety circuits

For control and safety circuits, the value in direct current or the r.m.s. value in alternating current between conductors or between conductors and earth shall not exceed 250 V.

- (a) Conductor for neutral and earth-continuity
- (b) Contactors, relay contactors, components of fail safe circuits
- (c) Contactors and relay contactors
- (d) To stop the driving machine the main contactors shall belong to the following categories .
 - (i) AC-3 for contactors of alternating current motors;
 - (ii) DC-3 for contactors of direct current machines.

- (e) Relay contactors shall belong to the following categories ,
 - (i) AC-15 for contactors in alternating current control circuits;
 - (ii) DC-13 for contactors in direct current control circuits.
- (f) Components of fail safe circuits
- (g) When devices according to 5C.11.5.11.2 (e) are used as relays in a fail safe circuit, the assumptions of also apply.
- (h) If the relays used are such that the break and make contacts are never closed simultaneously for any position of the armature, the possibility of partial attraction of the armature is permitted to be disregarded
- (i) Devices connected after electric safety devices shall meet the requirements of 5C.11.5.12.2
- (j) With regard to the creep distances and air gaps (not with regard to the separation distances).

This requirement does not apply to the devices mentioned in 5C.11.5.11.2(c).

5C.11.5.11.3 Main switches

- (a) In the vicinity of the machine or in the return stations, or in the vicinity of the control devices, there shall be a main switch capable of breaking the supply to the motor, to the brake releasing device and to the control circuit in the live conductors.

This switch shall not cut the supply to the socket outlets or to the lighting circuits necessary for inspection and maintenance (see 5C. 11.5.9).

When separate supplies are provided for auxiliary equipment such as heating, balustrade lighting and comb lighting, it shall be possible to switch them off independently. The corresponding switches shall be located close to the main switch and be marked unambiguously.

- (b) The main switches as defined in 5C. 11.5.11.3 (a) shall be capable of being locked or otherwise secured in the "isolated" position, with the use of a padlock or equivalent, to ensure no inadvertent operation by others . The control mechanism of the main switch shall be easily and rapidly accessible after opening of the doors or trap doors.
- (c) Main switches shall be capable of interrupting the highest current involved in normal operating conditions of the escalator or moving walk.
- (d) Where the main switches of several escalators or moving walks are positioned together it shall be possible to easily identify to which escalator or moving walk they refer.

5C.11.5.12 Electric safety devices

5C.11.5.12.1 General requirements

- (a) The electric safety devices for the (events escalator or moving walk listed in Table 6) shall prevent the driving machine from starting or cause the immediate stopping of the driving machine and consist of:

- (i) Either one or more safety switches satisfying 5C. 11.5.12.2 directly disconnecting the supply to the contactors or their relay contactors, or
- (ii) Fail safe circuits satisfying consisting of:
 - 1) Either one or more safety switches satisfying 5C. 11.5.12.2 not directly disconnecting the supply to the contactors or their relay contactors, or
 - 2) Contacts not satisfying the requirements of 5C. 11.5.12.2 or
 - 3) Other components in accordance with the requirements of Annex B.
- (b) No electric equipment shall be connected in parallel with an electric safety device with the exception of:
 - (i) Electric safety devices in case of inspection mode;
 - (ii) Connections to different points of the safety circuit for information about the status of electric safety devices; the devices used for that purpose shall fulfil the requirements of Annex B.
- (c) The effects of internal or external inductance or capacitance shall not cause failures of fail safe circuits.
- (d) An output signal emanating from a fail safe circuit shall not be altered by an extraneous signal emanating from another electric device placed further down the same circuit, which would cause a dangerous condition to result.
- (e) The construction and arrangement of the internal power supply units shall be such as to prevent the appearance of false signals at the outputs of electric safety devices due to the effects of switching. In particular, voltage peaks arising from the operation of the escalator or moving walk or other equipment on the network shall not create inadmissible disturbances in electronic components .

5C.11.5.12.2 Safety switches

- (a) The operation of a safety switch shall be by positive mechanical separation of the contacts. This positive mechanical separation shall even occur if the contacts are welded together.

Positive mechanical separation is achieved when all contacts are brought to their open position in such a way that for a significant part of the travel there are no resilient elements (e.g. springs) between the moving contacts and the part of the actuator to which the actuating force is applied.

The design shall be such as to minimise the risk of a short-circuit resulting from a faulty component.

- (b) The safety switch shall be provided for a rated insulation voltage of 250 V if the enclosure provides a degree of protection of at least IP, or 500 V if the degree of protection of the enclosure is less than IP 4X.

- (i) AC-15 for safety switches in alternating current circuits;
- (ii) DC-13 for safety switches in direct current circuits.

(c) If the protective enclosure is not at least of type IP 4X the air gaps shall be at least 3 mm and creep distances at least 4 mm.

After separation the distance for contacts shall be at least 4 mm.

(d) In the case of multiple breaks, the individual distances for breaking contacts shall be at least 2 mm after separation.

(e) Debris from the conductive material shall not lead to short-circuiting of contacts.

The starting switch(es) shall be located within reach of a stop switch according to 5C.11.5.12.2(b). For remote starting devices the requirements above shall apply.

NOTE For the obligation of the maintainer to observe a complete revolution of the step/pallet band before making the escalator/moving walk available to the public after maintenance.

NOTE An average speed against for a walking person of 1 m/s should be taken into account.

The requirements protection of electric faults shall be met. Constructional measures may be necessary to prevent circumvention of the control elements.

(f) Stop switch for emergency situations, manually operated

(g) Stop switch for emergency situations shall be provided to stop the escalator or moving walks in the event of an emergency. They shall be placed in conspicuous and easily reachable positions at least at or near each landing of the escalator or moving.

The distances between stop switches for emergency situations shall not exceed:

- 30 m on escalators;
- 40 m on moving walks.

If necessary, additional stop switches shall be provided to maintain the distance.

For moving walks intended to transport shopping trolleys and baggage carts (C-2).

(h) Stop switch for emergency situations shall be electric safety devices according to electric safety devices.

(i) Stopping initiated by monitoring or electric safety devices [see 5C.11.5.12.1(a)]

Annex A(normative)

Building interfaces

A.1 General

The requirements in A.2 and A.3 are important for the safety of users and maintenance personal.

If it is not possible for the manufacturers of the escalator or moving walk to fulfill these requirements (or some of them) due to the fact that e.g. they are not installing the escalator or moving walk, those requirements that are not fulfilled have to be part of the instruction handbook as an obligation for the owner. Recommendations do not use escalators as regular staircases or emergency exits. Provide the staircases from user in case of emergency each floor.

A.2 Free space for users

A.2.1 The clear height above the steps of the escalator or pallets or belt of the moving walk at all points shall be not less than 2,30 m (see h₄ in Figures 2 and A.1).

The clear height shall extend to the end of the newel.

NOTE - The clear height of 2,30 m should also be applied to the unrestricted area.

A.2.2 To prevent collision, a minimum free area around the escalator or moving walk is defined as per Figure A.1. The height h₁₂, measured from the steps of the escalator or the pallets or the belt of the moving walk shall be at least 2,10 m. The distance between the outer edge of the handrail and walls or other obstacles (see b₁₀ in Figure A.1) shall under no circumstances be less than 80 mm horizontally and 25 mm vertically below the lower edge of the handrail (see b₁₂ in Figure 3). The area is permitted to be smaller, if by appropriate measures, the risk of injury is minimized.

A.2.3 For escalators arranged adjacent to one another either parallel or criss-cross, the distance between the handrails shall be not less than 160 mm (see b₁₁ in Figure A.1).

A.2.4 Where building obstacles can cause injuries, appropriate preventive measures shall be taken.

In particular, at floor intersections and on criss-cross escalators or moving walks, a vertical deflector of not less than 0,30 m in height, not presenting any sharp cutting edges, shall be placed above the handrail level and extend at least 25 mm below the lower edge of the handrail, e.g. as an imperforate triangle (see h₅ in Figures 2 and 4).

It is not necessary to comply with these requirements when the distance b₉ between the outer edge of the handrail and any obstacle is equal to or greater than 400 mm (see Figure A.1).

14.A.2.5 At the exit(s) of each individual escalator or moving walk a sufficient unrestricted area shall be available to accommodate persons. The width of the unrestricted area shall at least correspond to the distance between the outer edges of the handrails plus 80 mm on each side. The depth shall be at least 2,50 m measured from the end of the balustrade. It shall be permissible to reduce it to 2,00 m if the width of the unrestricted area is increased to at least double the distance between the outer edges of the handrails plus 80 mm on each side.

For succeeding escalators and moving walks the depth of an unrestricted area shall be determined in each individual case depending on e.g. type of use (persons only or persons

with transport devices, number of intermediate exits, relative orientation and theoretical capacity).

A.2.6 In the case of successive escalators and moving walks without intermediate exits, they shall have the same capacity.

A.2.7 Where it is possible for people to come into contact with the outer edge of a handrail at a landing and can be drawn into a hazardous situation, such as toppling over a balustrade, appropriate preventative measures shall be taken (for an example, see Figure A.2).

Some examples are:

- ☐ Prevention of entry into the space by the placement of permanent barriers;
- ☐ Increasing the height of the building structure of the fixed balustrade in the hazard area by at least 100 mm above the handrail level and positioned between 80 mm and 120 mm from the outer edge of the handrail.

A.2.8 The surrounds of the escalator or moving walk shall be illuminated, especially in the vicinity of the combs.

NOTE - Information should be exchanged between the manufacturer and the customer.

A.2.9 It is permissible to arrange the lighting in the surrounding space and/or at the installation itself. The intensity of illumination at the landings including the combs shall be related to the intensity of illumination of the general lighting in the area. The intensity of illumination shall be not less than 50 lx at the comb intersection line measured at floor level.

A.3 Machinery spaces outside the truss

A.3.1 A safe access for persons to machinery spaces shall be provided.

A.3.2 Machinery spaces shall be lockable and only accessible to authorised

A.3.3 Machinery spaces shall be provided with permanently installed electric lighting on the following basis:

- a)** A minimum of 200 lx at floor level in working areas;
- b)** A minimum of 50 lx at floor level in access routes leading to these working areas.

A.3.4 Emergency lighting shall be installed to allow the safe evacuation of all personnel working in any machinery space.

NOTE - Emergency lighting is not intended for continuation of maintenance or other activities.

A.3.5 The dimensions of machinery spaces shall be sufficient to permit easy and safe working on equipment, especially the electrical equipment.

In particular there shall be provided at least a clear height of 2,00 m at working areas, and:

- a)** A clear horizontal area in front of the control panels and the cabinets. This area is defined as follows:
 - 1)** Depth, measured from the external surface of the enclosures: at least 0,70 m.
 - 2)** Width, the greater of the following values: 0,50 m or the full width of the cabinet or panel.

b) A clear horizontal area of at least 0,50 m x 0,60 m for maintenance and inspection of moving parts at points where this is necessary.

A.3.6 The clear height for movement shall not be less than 1,80 m.

The access ways to the clear spaces mentioned in A.3.6 shall have a width of at least 0,50 m. This value may be reduced to 0,40 m where there are no moving parts.

This full height for movement is taken to the underside of the structural roof beams and measured from both:

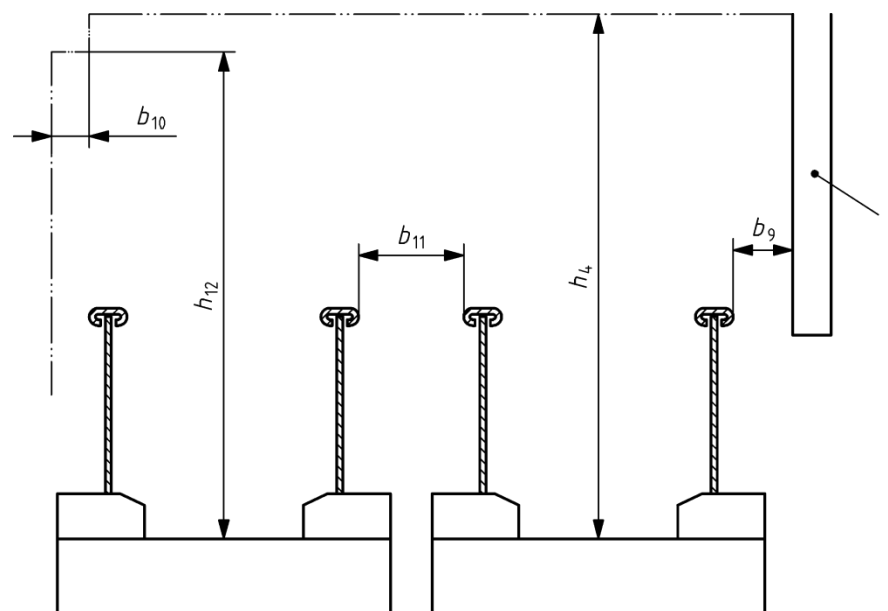
- a) The floor of the access area.
- b) The floor of the working area.

A.3.7 In machinery spaces the clear height shall under no circumstances be less than 2,0 m.

A.4 Electric power supply

Agreements shall be made between the owner and the manufacturer about electric supply and electric protection requirements (e.g. electric shock, short circuit; overload).

The installation shall with the requirements of the national rules of the country where it is installed.



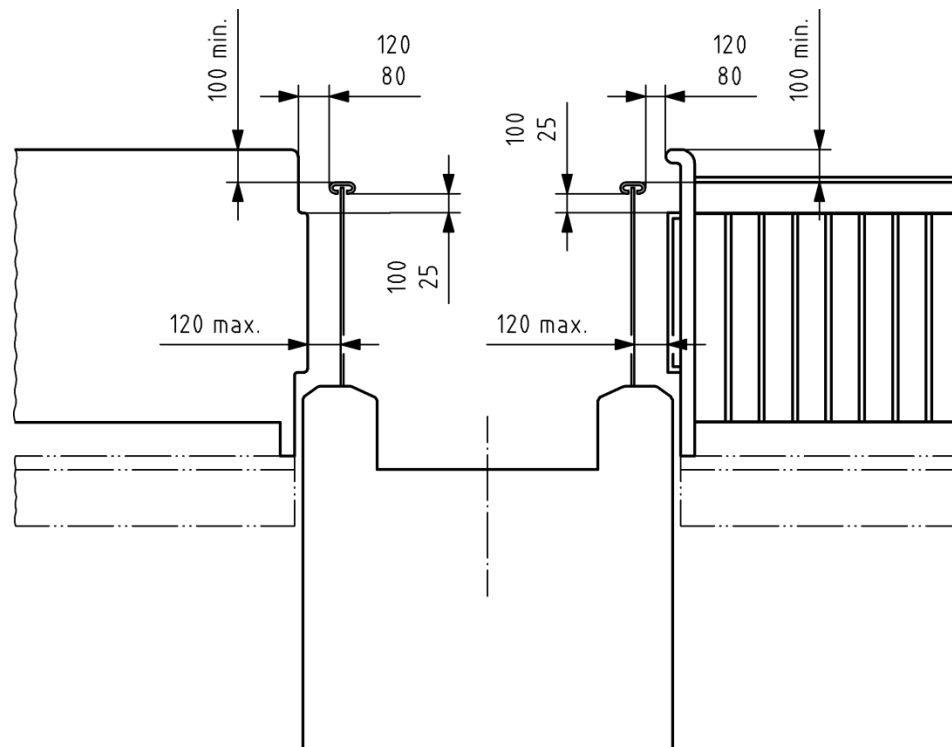
Key

1 obstacle (e.g. column)

Principal dimensions	Clause	Principal dimensions	Clause
$b_9 \geq 400 \text{ mm}$	A.2.4	$h_4 \geq 2300 \text{ mm}$	A.2.1
$b_{10} \geq 80 \text{ mm}$	A.2.2	$h_{12} \geq 2100 \text{ mm}$	A.2.2
$b_{11} \geq 160 \text{ mm}$	A.2.3		

NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure A.1 — Clearances between building structure and escalator/moving walk units



NOTE This figure has not been drawn to scale. It only serves to illustrate the requirements.

Figure A.2 — Example of barriers at landings

Annex B (informative)

Design guide-line for safety circuits

This design guide-line gives recommendations to avoid dangerous situations in the case when information is collected from the safety circuit for control purposes, for remote control, alarm control, etc.

Some dangerous situations are recognised coming from the possibility of bridging one or several electric safety devices by short circuiting or by local interruption of common lead (earth) combined with one or several other failures. It is good practice to follow the recommendations given below:

- Design the board and circuits with distances in accordance with specifications Connectors Terminals Plugs and Printed Circuit Board.
- Organise common lead so that the common lead for the control of the escalator/moving walk comes behind the electronic components. Any rupture will cause a non-operation of the control (danger exists that changes in wiring occur during the life of the escalator/moving walk).

- ☐ Make always calculations about the "worst case" condition.
- ☐ Always use outside (out of element) resistors as protective devices of input elements; internal resistor of the device should not be considered as safe.
- ☐ Use only components according to listed specifications.
- ☐ Consider backwards voltage coming from electronics. Using galvanically separated circuits can solve the problems in some cases.
- ☐ The "worst case" calculation cannot be avoided, whatever the design. If modifications or add-ons are made after the installation of the escalator/moving walk, the "worst case" calculation, involving new and existing equipment, must be carried out again
- ☐ Some failure exclusions can be accepted, according to electronics & electrical components.
- ☐ Failures outside the environment of the escalator/moving walk need not be taken into consideration.
- ☐ "An interruption of the earth from the main supply of the building to the controller collection earth bar (rail).

can be excluded, providing the installation is made in accordance with local electrical rules and regulations.

Annex C (normative)

Requirements on escalators and moving walks intended to transport shopping trolleys and baggage carts

C.1 Escalators

The use of both shopping trolleys and baggage carts on escalators is unsafe and shall not be permitted.

The principle reasons why the use of these products is considered to be unsafe are foreseeable misuse, overloading and width restriction.

Where shopping trolleys and/or baggage carts are available in the area around escalator installations, suitable barriers shall be provided to prevent access.

Outline guidance is given as follows:

Shopping trolleys or baggage carts which are chosen for use on an escalator must be specified between the shopping trolley or baggage cart manufacturer and the escalator manufacturer. If non-specified shopping trolleys or baggage carts are available in the escalator area, there is a serious risk of misuse. It is necessary to prevent access to the escalator entrance.

The width of the shopping trolley or baggage cart and its contents should be at least 400 mm less than the nominal step width. Passengers should be able to leave the escalator, even if shopping trolleys or baggage carts are on the escalator.

The escalators should be supplied with a horizontal step run of 1,6 m at both landing areas, minimum transition radii of 2,6 m at the upper landing and 2,0 m at the lower landing, and limiting the rated speed to 0,5 m/s and the inclination to 30°.

Combs should be designed with an angle β of max. 19° combined with a diameter of the shopping trolley or baggage cart roller of at least 120 mm diameter.

Additional stops for emergency situations at handrail level (taking into account A.2.2) with a distance between 2,0 m and 3,0 m before the step reaches the comb intersection line should be provided. The stop for emergency situations near the transition curve should be reachable from inside the escalator and the stops for emergency situations at exit(s) shall be reachable from outside of the escalator.

Shopping trolleys or baggage carts should conform to the escalator design:

- ☐ The shopping trolley or baggage cart design should ensure a safe and correct loading.
- ☐ The maximum weight for a shopping trolley or baggage cart should be 160 kg when loaded.
- ☐ Shopping trolley or baggage cart should automatically lock themselves on the inclined part of escalators.
- ☐ Shopping trolley or baggage cart should be fitted with a braking or blocking system.
- ☐ Shopping trolley or baggage cart should have deflectors (bumpers) to reduce the risk of clamping.
- ☐ For safe exit from the escalator, it is necessary that the rear rollers of the shopping trolley or baggage cart are able to push the front rollers over the comb. The front rollers and/or blocking system should easily release from the steps

- ☐ Deflectors and guiding devices should be added to the surrounding area to ensure correct alignment of shopping trolley or baggage cart when entering the escalator.
- ☐ Safety signs about safe and correct use of the shopping trolley or baggage cart should be added.

C.2 Moving walks

The use of suitably designed shopping trolleys and baggage carts on moving walks is permitted.

Shopping trolleys or baggage carts which are chosen for use on a moving walk shall be specified between the baggage cart manufacturer and the moving walk manufacturer. If non-specified shopping trolleys or baggage carts are available in the moving walk area, there is a serious risk of misuse. It is necessary to prevent access to the moving walk entrance.

The width of the shopping trolley or baggage cart and its contents shall be at least 400 mm less than the nominal pallet/belt width. Passengers shall be able to leave the moving walk, even if shopping trolleys or baggage carts are on the moving walk.

For moving walks with an inclination greater than 6°, the rated speed shall be limited to 0,5 m/s.

Combs shall be designed with an angle β of max. 19° combined with a diameter of the shopping trolley or baggage cart roller of at least 120 mm diameter.

Additional stops for emergency situations at handrail level (taking into account A.2.2) with a distance between 2,0 m and 3,0 m before the pallet reaches the comb intersection line shall be provided. The stop for emergency situations near the transition curve shall be reachable from inside the moving walk and the stops for emergency situations at exit(s) shall be reachable from outside of the moving walk.

Shopping trolleys or baggage carts shall conform to the moving walk design:

- ☐ The shopping trolley or baggage cart design shall ensure a safe and correct loading.
- ☐ The maximum weight for a shopping trolley or baggage cart shall be 160 kg when loaded.
- ☐ Shopping trolley or baggage cart shall automatically lock themselves on the inclined part of moving walks.
- ☐ Shopping trolley or baggage cart shall be fitted with a braking or blocking system.
- ☐ Shopping trolley or baggage cart shall have deflectors (bumpers) to reduce the risk of clamping.
- ☐ For safe exit from the moving walk, it is necessary that the rear rollers of the shopping trolley or baggage cart are able to push the front rollers over the comb. The front rollers and/or blocking system shall easily release from the pallet.
- ☐ Deflectors and guiding devices shall be added to the surrounding area to ensure correct alignment of shopping trolley or baggage cart when entering the moving walk.
- ☐ Safety signs about safe and correct use of the shopping trolley or baggage cart should be added.

D.2 Testing and assessing anti-slip properties

The procedure for testing anti-slip properties is governed by local rules.

Your attention is drawn to the fact that the intermediary medium of oil in the test procedure is not used to give the test a particularly adverse operating condition. The use of a specific, defined oil is used as a constant test parameter with which, as has been proved, better differentiation of the test results is achieved.

NOTE – This procedure is based on the people carrying out the test treading on the covering to be tested on an inclined plane. It is used as an aid to deciding whether the respective covering is suitable for use on escalators and moving walks.

The average inclination angle determined from a range of measurements is critical for classifying the covering in one of five assessment groups. The assessment group is used as a benchmark for the level of anti-slip properties where coverings in assessment group R 9 meet the lowest anti-slip requirements and those in assessment group R 13 the highest. The allocation of assessment groups to the angle ranges is shown in TableD.1.

Table D.1 — Allocating the overall average values of the inclination angles to the anti-slip assessment groups

Overall average value	Assessment group
from 6° to 10°	R 9
over 10° to 19°	R 10
over 19° to 27°	R 11
over 27° to 35°	R 12
greater than 35°	R 13

The assessment of the anti-slip properties of coverings with surface profiles arranged in a specific direction, e.g. a step covering with lengthwise grooves or cover plates with transverse grooves, shall be based on average values that take into consideration the place the coverings are laid and the direction the users walk on them.

Coverings that meet at least assessment group R 9 are considered anti-slip for indoor installations and at least assessment group R 10 for outdoor installations.

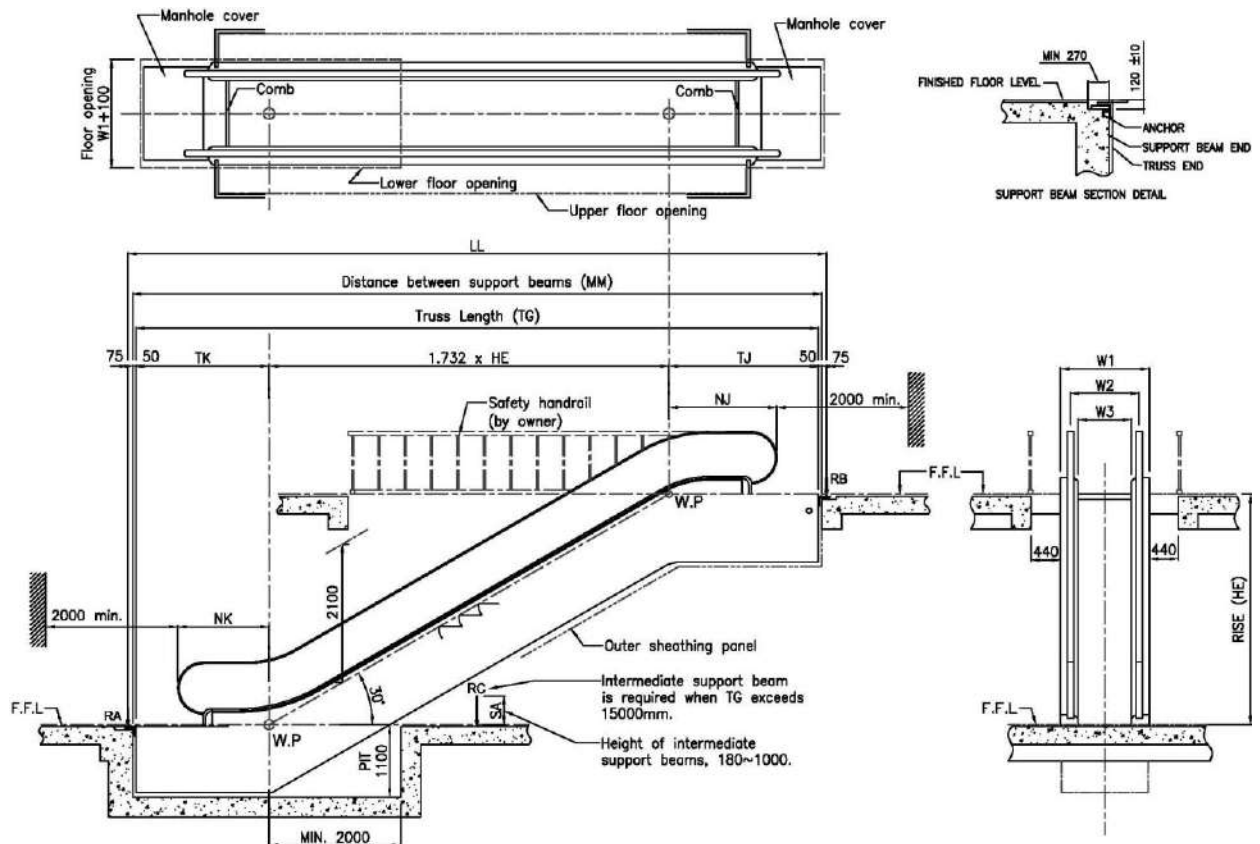
NOTE – If, at the landings of escalators and moving walks and their allocated floors, there are different assessment groups, it should be taken care that neighbouring floors shall only differ by one in their assessment groups.

The part of the test related to the area below the surface of cleated profiles is not used to assess the anti-slip properties of coverings on escalators and moving walks.

Attach Figure-1

Standard Installation of Escalator for 30 ° Inclination Angle

All dimension in millimeters



Dimensions (mm)

Dimensions (mm)

Type	Step width (mm)		
	600	800	1000
W1 (Escalator width)	1150	1350	1550
W2 (Between Moving Handrails)	840	1040	1240
W3 (Between Skirt Panels)	610	810	1010

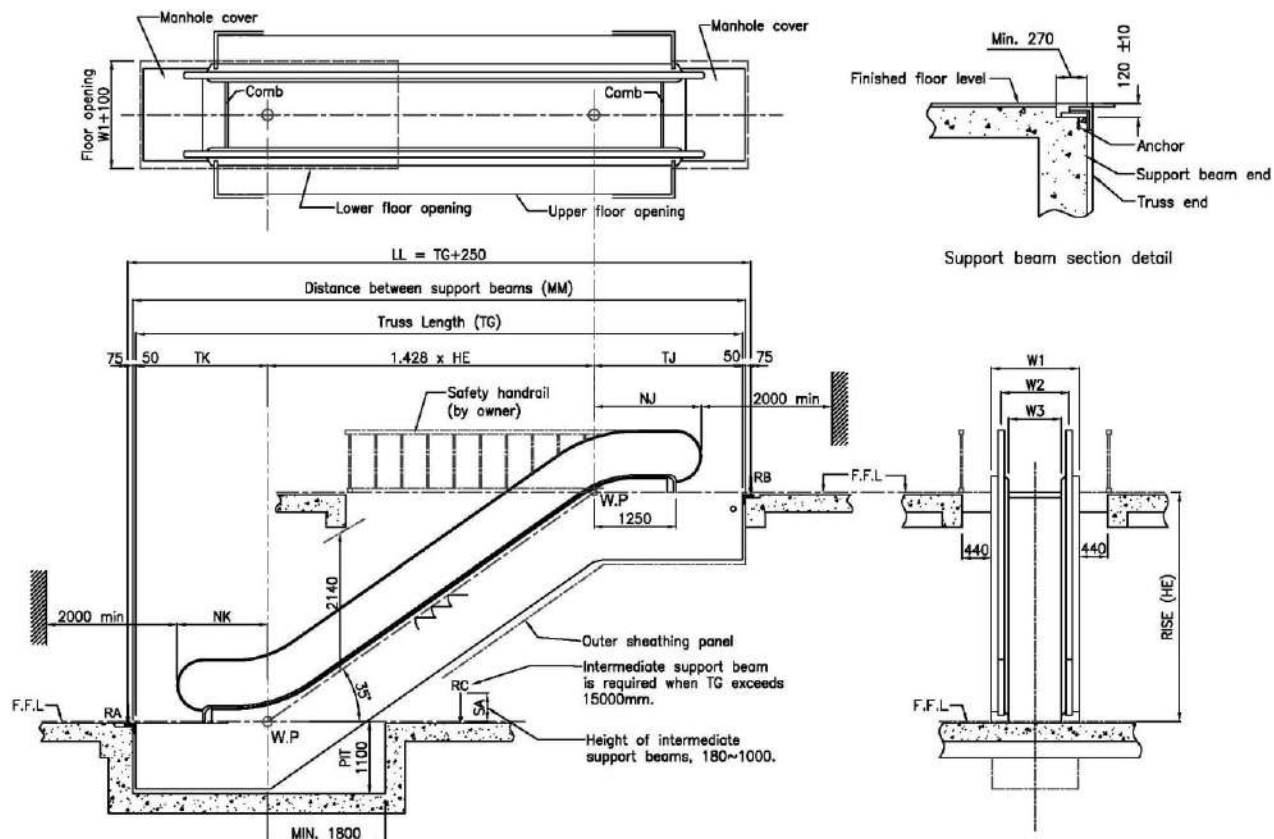
Horizontal Steps	NK	NJ	TJ	TK
1.5 Steps (Nominal)	1385	1635	2265	2015

3 Setps	1975	2260	2890	2605

Attach Figure-2

Standard Installation of Escalator for 35 ° Inclination Angle

All dimension in millimeters



Dimensions (mm)

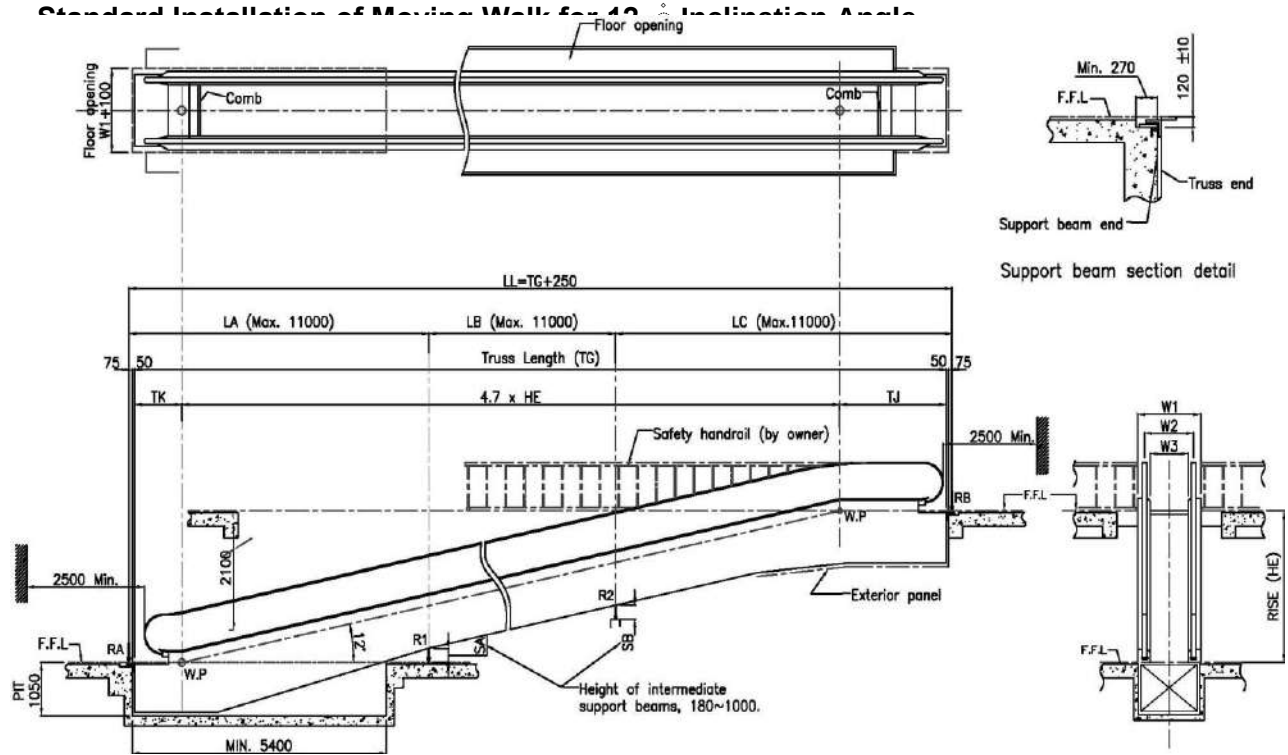
Type	Step width (mm)		
	600	800	1000
W1 (Escalator width)	1150	1350	1550
W2 (Between Moving Handrails)	840	1040	1240
W3 (Between Skirt Panels)	610	810	1010

Horizontal Steps	NK	NJ	TJ	TK

2 Steps	1630	1900	2530	2260

Attach Figure-3

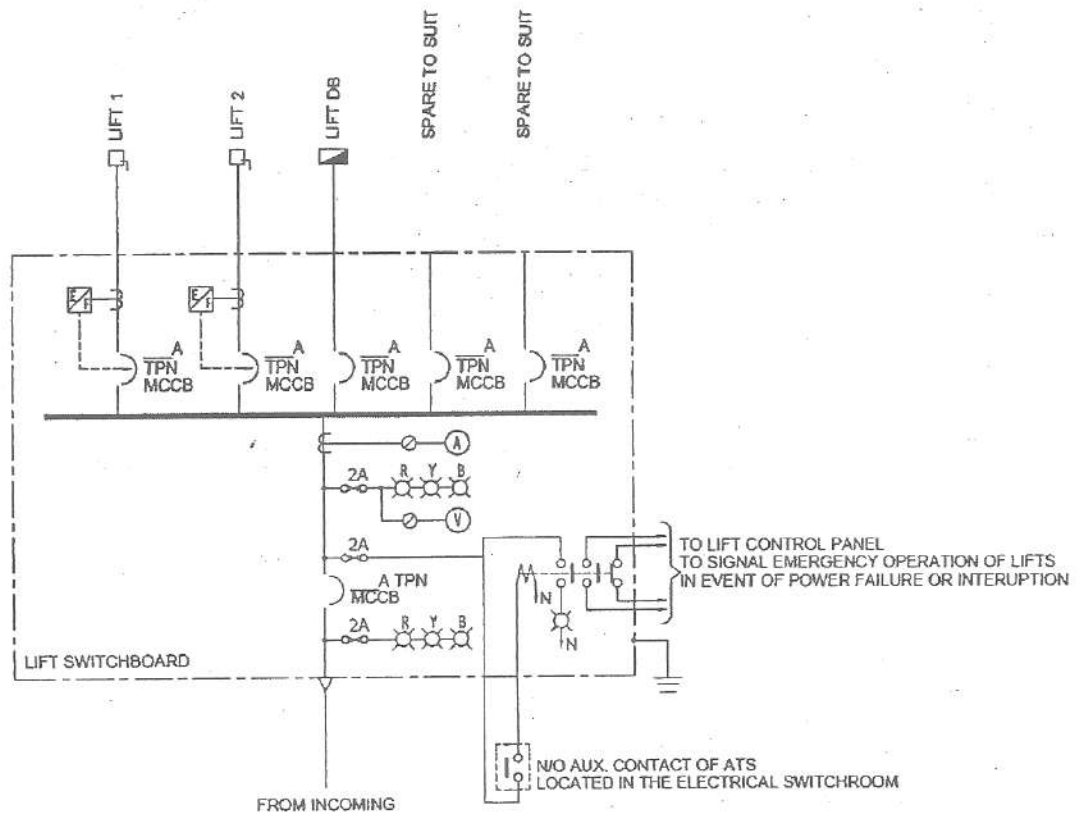
Standard Installation of Moving Walk for 4.3° Inclination Angle



Dimensions (mm)

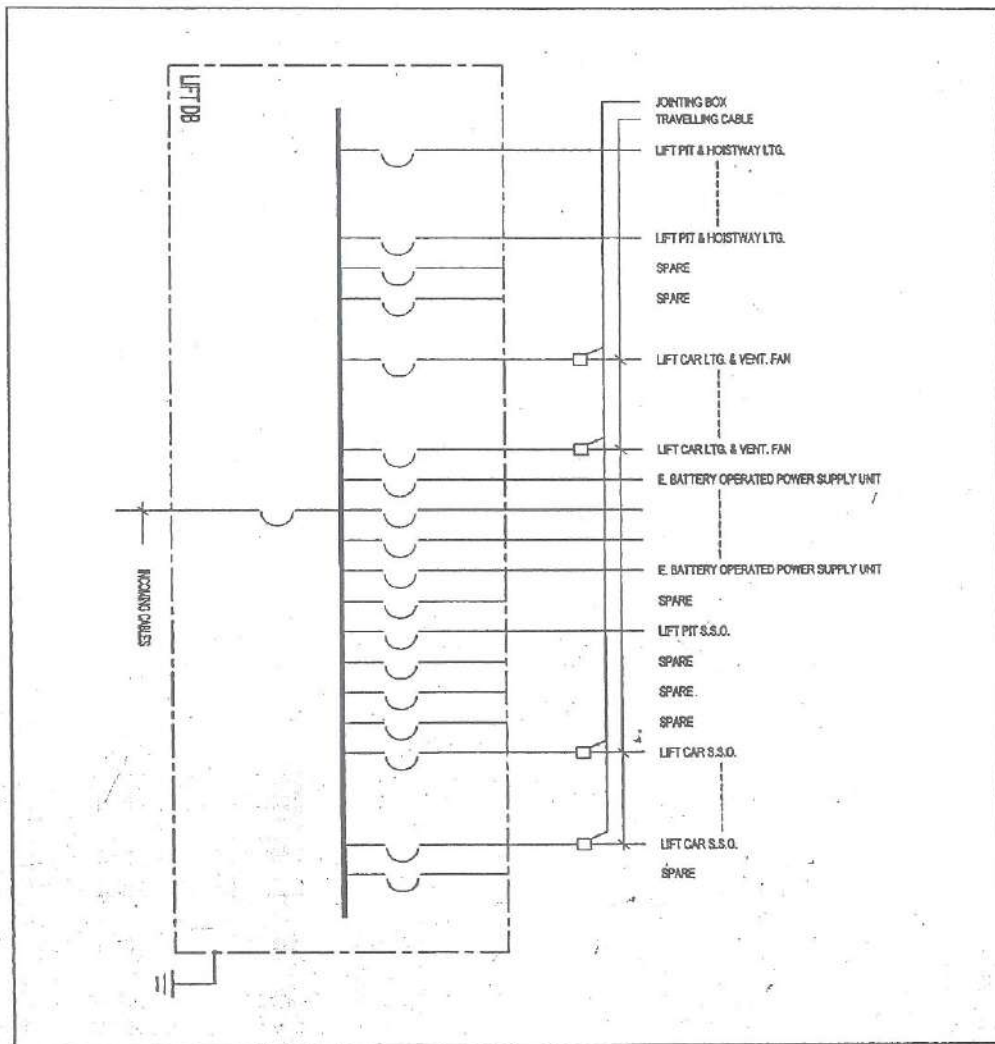
Type	1200
W1 (Escalator width)	1550
W2 (Between Moving Handrails)	1280
W3 (Between Skirt Panels)	1010
TK	990
TJ	2321 (HE ≤ 5400) 2675 (5400 ≤ HE ≤ 6500)

Attach Figure - 4



Typical example of lift switchboard in lift machine room

Attach Figure - 5



Typical example of lift distribution board in lift machine room

IS No.	Title
(1) 14665 (Part 1) : 2000 (Part 3/Sec 1 & 2) 2000 (Part 4/Sec 1 to 9): 2001	Electric traction lifts: Guidelines for outline dimensions of passenger, goods, service and hospital lifts Safety rules, Section 1 Passenger and goods lifts, Section 2 Service lifts Components, Section 1 Lift Buffers, Section 2 Lift guide rails and guide shoes, Section 3 Lift carframe, car, counterweight and suspension, Section 4 Lift safety gears and governors, Section 5 Lift retiring cam, Section 6 Lift doors and locking devices and contacts, Section 7 Lift machines and brakes. Section 8 Lift wire ropes, Section 9 Controller and operating devices
(2) 14665 (Part 4/Sec 1 to 9) 2001	Electric traction lifts: Components, Section 1 Lift buffers, Section 2 Lift guide rails and guide shoes, Section 3 Lift carframe, car, counterweight and suspension, Section 4 Lift safety gears and governors, Section 5 Lift retiring cam, Section 6 Lift doors and locking devices and contacts, Section 7 Lift machines and brakes, Section 8 Lift wire ropes, Section 9 Controller and operating devices
(3) 14665 (Part 3/Sec 1&2): 2000	Electric traction lifts: Part 3 Safety rules, Section 1 Passenger and goods lifts, Section 2 service lifts
(4) 14665 (Part 2/Sec 1&2): 2000	Electric traction lifts : Part 2 Code of practice for installation, [operation and maintenance], Section 1 Passenger and goods lifts, Section 2 Service lifts
(5) 962 : 1989	Code of practice for architectural and building drawings (second revision)
(6) 2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning (second revision)
(7) 1950 : 1962	Code of practice for sound insulation of non-industrial buildings
(8) 14665 (Part 3/Sec 1&2) : 2000	Electric traction lifts: Part 3 Safety rules – Section 1 Passenger and goods lifts, Section 2 Service lifts
(9) 3043 : 1987	Code of practice for earthing
(10) 4591 : 1968	Code of practice for installation and maintenance of escalators
(11) SS550: 2009	Code of practice for Installation , operation and maintenance of electric passenger and goods lift
(12) EN 81 – 1 1998	European Standard
(13) 1985	Myanmar Electricity Regulation
(14) EN 115 : 1995	European Standard
(15) CP – 15 – 2004	Code of practice for installation operation and maintenance of escalator and passenger conveyors

**MYANMAR
NATIONAL
BUILDING
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2016**

PART 5D

WATER SUPPLY, DRAINAGE AND SANITATION

PLUMBING SERVICES

PART-5D WATER SUPPLY, DRAINAGE AND SANITATION (INCLUDING SOLID WASTE MANAGEMENT)

The following codes are made with reference to the activities covered under central product classification.(here in after referred to as ‘CPC’) Code 8672 – Subclass 86724, of the provisional CPC of the United Nation.

5D.1 SCOPE

5D.1.1

This Section covers the basic requirements of water supply for residential, business and other types of buildings, including traffic terminal stations. This Section also deals with general requirements of plumbing connected to public water supply and design of water supply systems.

5D.1.1.1

This Section does not take into consideration the requirements of water supply for industrial plants and processes, which have to be provided for separately. It also does not provide the requirements of water supply for other purposes, such as fire fighting, and street cleaning.

5D.1.2

This Section also covers the design, layout, construction and maintenance of drains for foul water, surface water and subsoil water and sewage; together with all ancillary works, such as connections, manholes and inspection chambers used within the building and from building to the connection to a public sewer, private sewer, individual sewage-disposal system, cesspool, soak away or to other approved point of disposal/ treatment work.

NOTE — A sanitary drainage system consists of a building sewer, a building drain, a soil and/or waste stack, horizontal branches or fixture drain, and vents. The sanitary drainage of a large building may have a number of primary and secondary branches, and several soil and/or waste stacks, each of them in turn may have a number of horizontal branches.

5D.2 TERMINOLOGY

5D.2.1.1 Access Panel

Removable panel mounted in a frame, normally secured with screws and mounted in a wall or ceiling, to provide access to concealed appurtenances or items which may require maintenance.

5D.2.1.2 Air Gap

The distance between the lowest point of a water inlet or feed pipe to an appliance and the spill-over level (or the overflowing level) of the appliance.

5D.2.1.3 Air Valve

A valve that releases air from a pipeline automatically without loss of water, or introduce air into a line automatically if the internal pressure becomes less than that of the atmosphere.

5D.2.1.4 Authority Having Jurisdiction

The Authority which has been created by a statute and which for the purpose of administering the Code/Part may authorize a committee or an official to act on its behalf; hereinafter called the 'Authority'.

5D.2.1.5 Available Head

The head of water available at the point of consideration due to mains' pressure or overhead tank or any other source of pressure.

5D.2.1.6 Back Siphonage

The flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel into a water supply due to a reduced pressure in such pipe (**see** Backflow).

5D.2.1.7 Back Up

A condition where the wastewater may flow back into another fixture or compartment but not back into the potable water system.

5D.2.1.8 Backflow

a) The flow of water or other liquids, mixtures or substances into the distributing pipes of a system of supply of potable water from any source or sources other than its intended source.

b) The flow of a liquid in a direction reverse of that intended.

5D.2.1.9 Backflow Prevention Device

Any approved measure or fitting or combination of fittings specifically designed to prevent backflow or back-siphonage in a water service.

5D.2.1.10 Barrel

This portion of a pipe in which the diameter and wall thickness remain uniform throughout.

5D.2.1.11 Base

The lowest portion or lowest point of a stack of vertical pipe.

5D.2.1.12 Battery of Fixtures

Any group of two or more similar adjacent fixtures which discharge into a common horizontal waste or soil pipe.

5D.2.1.13 Bedding

The material on which the pipe is laid and which provides support for the pipe. Bedding can be concrete, granular material or the prepared trench bottom.

5D.2.1.14 Benching

Slopping surfaces constructed on either side of channels at the base of a manhole or inspection chamber for the purpose of confining the flow of sewage, avoiding the accumulation of deposits and providing a safe working platform.

5D.2.1.15 Branch

a) Special form of sewer pipe used for making connections to a sewer or water main. The various types are called 'T', 'Y', 'T-Y' double Y and V branches, according to their respective shapes.

b) Any part of a piping system other than a main or stack.

5D.2.1.16 Branch Soil Pipe (BSP)

A pipe connecting one or more soil appliances to the main soil pipe.

5D.2.1.17 Branch Soil Waste Pipe (BSWP)

A pipe connecting one or more soil and/or waste appliances to the main soil waste pipe (one pipe system).

5D.2.1.18 Branch Ventilating Pipe (BVP)

A pipe, one end of which is connected to the system adjacent to the trap of an appliance and the other to a main ventilating pipe or a drain-ventilating pipe. It is fitted to prevent loss of water seal from a trap owing to partial vacuum, back-pressure, or surging caused by air movement within the pipe system. It also provides ventilation for the branch waste pipe.

5D.2.1.19 Branch Waste Pipe (BWP)

A pipe connecting one or more waste appliances to the main waste pipe.

5D.2.1.20 Building Drain, Combined

A building drain which conveys both sewage and storm water or other drainage.

5D.2.1.21 Building Drain, Sanitary

A building drain which conveys sewage and sullage only.

5D.2.1.22 Building Drain, Storm

A building drain which conveys storm water or other drainage but no sewage.

5D.2.1.23 Building Sewer

That part of the horizontal piping of a drainage system which extends from the end of the building drain and which receives the discharge of the building drain and conveys it to a public sewer, private sewer, individual sewage- disposal system or approved point of disposal.

5D.2.1.24 Building Sub-Drain

That portion of a drainage system which cannot drain by gravity in the building sewer.

5D.2.1.25 Building Trap

A device, fitting or assembly of fittings installed in the building drain to prevent circulation of air between the drainage of the building and the building sewer. It is usually installed as running trap.

5D.2.1.26 Cesspool

- a) An underground chamber for the reception and storage of foul water, the contents of which are periodically removed for disposal.
- b) A box-shaped receiver constructed in a roof or gutter for collecting rainwater which then passes into a rainwater pipe connected thereto.

5D.2.1.27 Chair

A bed of concrete or other suitable material on the trench floor to provide a support for the pipes at intervals.

5D.2.1.28 Channel

The open waterway through which sewage, storm water or other liquid wastes flow at the invert of a manhole or an inspection chamber.

5D.2.1.29 Chute

A vertical pipe system passing from floor to floor provided with ventilation and inlet openings for receiving refuse from successive floors and ending at the ground floor on the top of the collecting chambers.

5D.2.1.30 Cistern

A fixed container for water in which water is at atmospheric pressure. The water is usually supplied through a float operated valve.

5D.2.1.31 Cleaning Eye

An access opening in a pipe or pipe fitting arranged to facilitate the cleaning of obstructions and fitted with removable cover.

5D.2.1.32 Clear Waste Water

Cooling water and condensate drainage from refrigeration and air conditioning equipment, cooled condensate from steam heating systems, cooled boiler blow-down water, waste water drainage from equipment rooms and other areas where water is used without an appreciable addition of oil, gasoline, solvent, acid, etc, and treated effluent in which impurities have been reduced below a minimum concentration considered harmful.

5D.2.1.33 Collection Chamber

A compartment situated at the lower end of the chute for collecting and housing the refuse during the period between two successive cleanings.

5D.2.1.34 Communication Pipe

That part of a service pipe which vests in the water undertakes. It starts at the water main and terminate at a point which differs according to the circumstances of the case.

5D.2.1.35 Connection

The junction of a foul water drain, surface water drain or sewer from building or building with public sewer treatment works, public sewer, private sewer, individual sewage-disposal system, cess pool, soakaway or to other approved point of disposal/treatment work.

5D.2.1.36 Consumer

Any person who uses or is supplied water or on whose application such water is supplied by the Authority.

5D.2.1.37 Consumer's Pipe

The portion of service pipe used for supply of water and which is not the property of the Authority (*see Fig. 1*).

5D.2.1.38 Cover

- a) A removable plate for permitting access to a pipe, fitting, vessel or appliance.
- b) The vertical distance between the top of the barrel of a buried pipe or other construction and the surface of the ground.

5D.2.1.39 Cross-Connection

A connection between two normally independent pipelines which permits flow from either pipeline into the other.

5D.2.1.40 Crown of Trap

The topmost point of the inside of a trap outlet.

5D.2.1.41 Deep Manhole

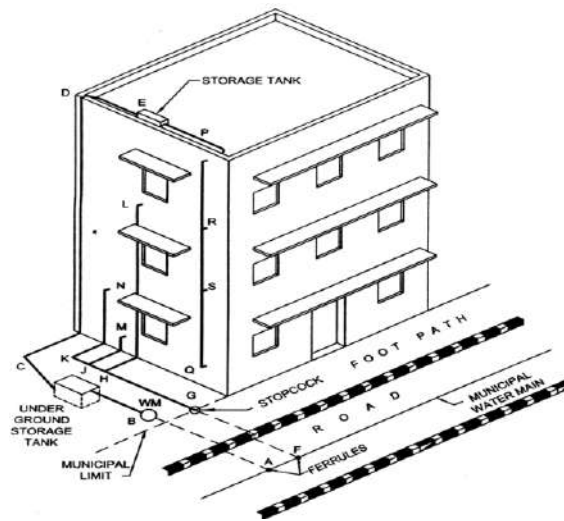
A manhole of such depth that an access shaft is required in addition to the working chamber.

5D.2.1.42 Depth of Manhole

The vertical distance from the top of the manhole cover to the outgoing invert of the main drain channel.

5D.2.1.43 Diameter

The nominal internal diameter of pipes and fittings.



NOTE – The illustration is not intended to indicate recommended positions of underground storage tank (where provided), pipes, etc and this will depend on local situations.

FIG. 1 TYPICAL SKETCH FOR IDENTIFICATION OF DIFFERENT TYPES OF WATER SUPPLY PIPES

5D.2.1.44 Direct Tap

A tap which is connected to a supply pipe and is subject to pressure from the water main.

5D.2.1.45 Down take Tap

A tap connected to a system of piping not subject to water pressure from the water main.

5D.2.1.46 Drain

A conduit, channel or pipe for the carriage of storm water, sewage, waste water or other water-borne wastes in a building drainage system.

5D.2.1.47 Drain Ventilating Pipe (DVP)

A pipe installed to provide flow of air to or from a drain to prevent undue concentration of foul air in the drain. The main soil pipe or main waste pipe may serve as drain ventilating pipe wherever their upper portions, which do not receive discharges, are extended to the roof level and let open to air.

5D.2.1.48 Drainage

The removal of any liquid by a system constructed for the purpose.

5D.2.1.49 Drainage Work

The design and construction of a system of drainage.

5D.2.1.50 Drop Connection

A length of conduit installed vertically immediately before its connection to a sewer or to another drain.

5D.2.1.51 Drop Manhole

A manhole installed in a sewer where the elevation of the incoming sewer considerably exceeds that of the outgoing sewer; a vertical waterway outside the manhole is provided to divert the waste from the upper to the lower level so that it does not fall freely into the manhole except at peak rate of flow.

5D.2.1.52 Effective Opening

The minimum cross- sectional area at the point of water supply, measured or expressed in terms of:

- a) the diameter of a circle; and
- b) the diameter of a circle of equivalent cross- sectional area, if the opening is not circular.

5D.2.1.53 Feed Cistern

A storage vessel used for supplying cold water to a hot water apparatus, cylinder or tanks.

5D.2.1.54 Fittings

Fittings shall mean coupling, flange, branch, bend, tees, elbows, unions, waste with plug, P or S trap with vent, stop ferrule, stop tap, bib tap, pillar tap, globe tap, ball valve, cistern storage tank, baths, water-closets, boiler, geyser, pumping set with motor and accessories, meter, hydrant, valve and any other article used in connection with water supply, drainage and sanitation.

5D.2.1.55 Fixture Unit

A quantity in terms of which the load producing effects on the plumbing system of different kinds of plumbing fixtures is expressed on some arbitrarily chosen scale.

5D.2.1.56 Fixture Unit Drainage

A measure of probable discharge into the drainage system by various types of plumbing fixtures. The drainage fixture unit value for a particular fixture depends on its volume rate of drainage discharge, on the time duration of a single drainage operation and on the average time between successive operations.

5D.2.1.57 Float Operated Valve

Ball valves or ball taps and equilibrium valves operated by means of a float.

5D.2.1.58 Flushing Cistern

A cistern provided with a device for rapidly discharging the contained water and used in connection with a sanitary appliance for the purpose of cleaning the appliance and carrying away its contents into a drain.

NOTE — The nominal size of a cistern is the quantity of water discharged per flush.

5D.2.1.59 Formation

The finished level of the excavation at the bottom of a trench or heading prepared to receive the permanent work.

5D.2.1.60 French Drain or Rubble Drain

A shallow trench filled with coarse rubble, clinker, or similar material with or without field drain pipes.

5D.2.1.61 Frost Line

The line joining the points of greatest depths below ground level up to which the moisture in the soil freezes.

5D.2.1.62 General Washing Place

A washing place provided with necessary sanitary arrangement and common to more than one tenement.

5D.2.1.63 Geyser

An apparatus for heating water with supply control on the inlet side and delivering it from an outlet.

5D.2.1.64 Gully Chamber

The chamber built of masonry round a gully trap for housing the same.

5D.2.1.65 Gully Trap

A trap provided in a drainage system with a water seal fixed in a suitable position to collect waste-water from the scullery, kitchen sink, wash basins, baths and rain water pipes.

5D.2.1.66 Haunching

Outward sloping concrete support to the sides of a pipe or channel above the concrete bedding.

5D.2.1.67 Heel Rest Bend or Duck-Foot Bend

A bend, having a foot formed integrally in its base, used to receive a vertical pipe.

5D.2.1.68 High Altitudes

Elevations higher than 1 500 m above mean sea level (MSL).

5D.2.1.69 Highway Authority

The public body in which is vested, or which is the owner of, a highway repairable by the inhabitants collectively; otherwise the body or persons responsible for the upkeep of the highway.

5D.2.1.70 Horizontal Pipe

Any pipe of fitting which makes an angle of more than 45° with the vertical.

5D.2.1.71 Hot Water Tank

A vessel for storing hot water under pressure greater than atmospheric pressure.

5D.2.1.72 Inlet Hopper

A receptacle fitting for receiving refuse from each floor and dropping it into the chute.

5D.2.1.73 Inspection Chamber

A water-tight chamber constructed in any house-drainage system which takes wastes from gully traps and disposes of to manhole with access for inspection and maintenance.

5D.2.1.74 Interceptor

A device designed and installed so as to separate and retain deleterious, hazardous or undesirable matter from normal wastes and permit normal sewage or liquid wastes to discharge into the disposal terminal by gravity.

5D.2.1.75 Interceptor Manhole or Interceptor Chamber

A manhole incorporating an intercepting trap and providing means of access thereto.

5D.2.1.76 Invert

The lowest point of the internal surface of a pipe or channel at any cross-section.

5D.2.1.77 Junction Pipe

A pipe incorporating one or more branches.

5D.2.1.78 Lagging

Thermal insulation or pipes.

5D.2.1.79 Licensed Plumber

A person licensed under the provisions of this Code.

5D.2.1.80 Main Soil Pipe (MSP)

A pipe connecting one or more branch soil pipes to the drain.

5D.2.1.81 Main Soil and Waste Pipe (MSWP)

A pipe connecting one or more branch soil and waste pipes to the drain.

5D.2.1.82 Main Ventilating Pipe (MVP)

A pipe which receives a number of branch ventilating pipes.

5D.2.1.83 Main Waste Pipe (MWP)

A pipe connecting one or more branch waste pipes to the drain.

5D.2.1.84 Manhole

An opening by which a man may enter or leave a drain, a sewer or other closed structure for inspection, cleaning and other maintenance operations, fitted with suitable cover.

5D.2.1.85 Manhole Chamber

A chamber constructed on a drain or sewer so as to provide access thereto for inspection, testing or clearance of obstruction.

5D.2.1.86 Non-Service Latrine

Other than 'service latrine'.

5D.2.1.87 Offset

A pipe fitting used to connect two pipes whose axes are parallel but not in line.

5D.2.1.88 Period of Supply

The period of the day or night during which water supply is made available to the consumer.

5D.2.1.89 Pipe System

The system to be adopted will depend on the type and planning of the building in which it is to be installed and will be one of the following:

- Single stack system (see Fig. 2)** — The one- pipe system in which there is no trap ventilation.
- Single stack — Partially Vented** — A via media between the one-pipe system and the single stack system (see one-pipe system, partially ventilated).
- One-pipe system (see Fig. 3)** — The system of plumbing in which the wastes from the sinks, baths and wish basins, and the soil pipe branches are all collected into one main pipe, which is connected, directly to the drainage system. Gully traps and waste pipes are completely dispersed with, but all the traps of the water closets, basins, etc, are completely ventilated to preserve the water seal.
- One-pipe system — Partially vented (also called single stack, partially ventilated)** — A system in which there is one soil pipe into which all water closets, baths, sinks, and basins discharge. In addition, there is a relief vent, which ventilates only the traps of water closets.

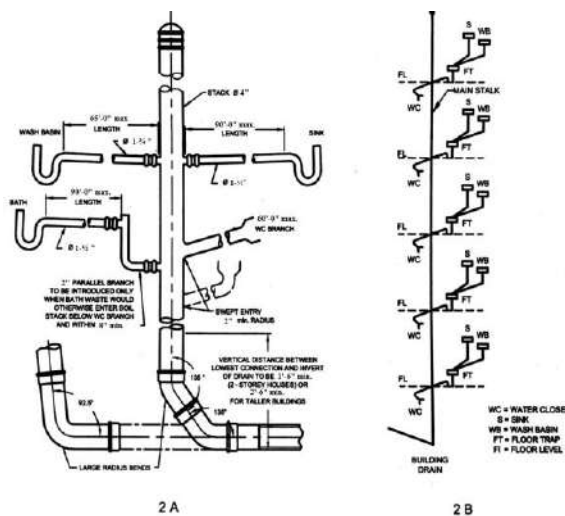
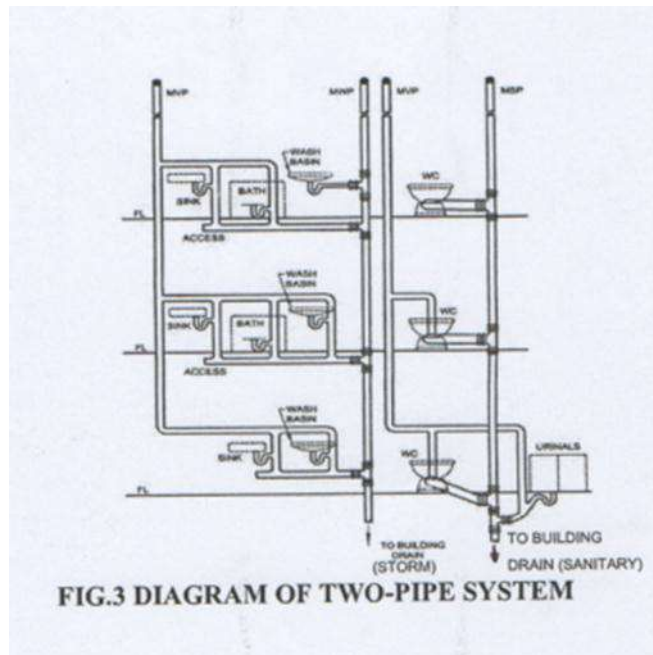


FIG. 2 SINGLE STACK SYSTEM – MAIN FEATURE OF DESIGN

- Two-pipe system (see Fig. 4)** — The system of plumbing in which soil and waste pipes are distinct and separate. The soil pipes being connected to the

drain direct and waste pipes through a trapped gully. All traps of all appliances are completely ventilated in this system.



5D.2.1.90 Pipe Work

Any installation of piping with its fittings.

5D.2.1.91 Plumbing

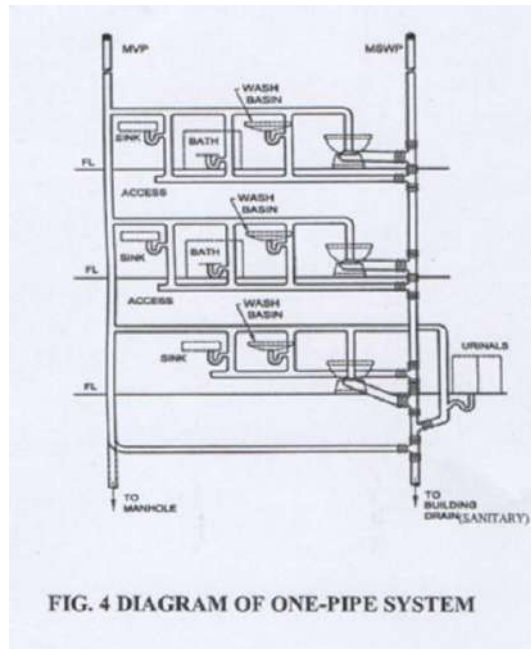
- a) The pipes, fixtures and other apparatus inside a building for bringing in the water supply and removing the liquid and water borne wastes.
- b) The installation of the foregoing pipes, fixtures and other apparatus.

5D.2.1.92 Plumbing System

The plumbing system shall include the water supply and distribution pipes; plumbing fittings and traps; soil, waste, vent pipes and anti-siphonage pipes; building drains and building sewers including their respective connections, devices and appurtenances within the property lines of the premises; and water-treating or water-using equipment.

5D.2.1.93 Potable Water

Water which is satisfactory for drinking, culinary and domestic purposes and meets the requirements of the Authority.



5D.2.1.94 Premises

Premises shall include passages, buildings and lands of any tenure, whether open or enclosed, whether built on or not, and whether public or private in respect of which a water rate or charge is payable to the Authority or for which an application is made for supply of water.

5D.2.1.95 Puff Ventilation

The ventilation provided for waste traps in two-pipe system, in order to preserve the water seal.

5D.2.1.96 Residual Head

The head available at any particular point in the distribution system.

5D.2.1.97 Saddle

A purpose made fitting, so shaped as to fit over a hole cut in a sewer or drain used to form connections.

5D.2.1.98 Sanitary Appliances

The appliances for the collection and discharge of soil or waste matter.

5D.2.1.99 Service Latrine

A latrine from which the excreta are removed by manual agency and not by water carriage.

5D.2.1.100 Service Pipe

Pipe that runs between the distribution main in the street and the riser in case of a multi-storeyed building or the water meter in the case of an individual house and is subject to water pressure from such main.

5D.2.1.101 Sewer

A pipe or conduit, generally closed, but normally not flowing full for carrying sewage and/ or other waste liquids.

5D.2.1.102 Slop Hopper (Slop Sink)

A hopper shaped sink, with a flushing run and outlet similar to those of a WC pan, for the reception and discharge of human excreta.

5D.2.1.103 Soakaway

A pit, dug into permeable ground lined to form a covered perforated chamber or filled with hard-core, to which liquid is led, and from which it may soak away into the ground.

5D.2.1.104 Soffit (Crown)

The highest point of the internal surface of a sewer or culvert at any cross-section.

5D.2.1.105 Soil Appliances

A sanitary appliance for the collection and discharge of excretory matter.

5D.2.1.106 Soil Pipe

A pipe that conveys the discharge of water closets or fixtures having similar functions, with or without the discharges from other fixtures.

5D.2.1.107 Soil Waste

The discharge from water closets, urinals, slop hopper, stable yard or cowshed gullies and similar appliances.

5D.2.1.108 Stop-Cock

A cock fitted in a pipe line for controlling the flow of water.

5D.2.1.109 Stop Tap

Stop tap includes stop-cock, stop valve or any other device for stopping the flow of water in a line or system of pipes at will.

5D.2.1.110 Storage Tank

A container used for storage of water which is connected to the water main or tube- well by means of supply pipe.

5D.2.1.111 Sub-Soil Water

Water occurring naturally in the sub-soil.

5D.2.1.112 Sub-Soil Water Drain

- a) A drain intended to collect and carry away sub-soil water.
- b) A drain intended to disperse into the sub-soil from a septic tank.

5D.2.1.113 Sub-Zero Temperature Regions

Regions where temperatures fall below 0°C and freezing conditions occur.

5D.2.1.114 Sullage

See 5D.2.1.129.

5D.2.1.115 Supply Pipe

So much of any service pipe as is not a communication pipe.

5D.2.1.116 Supports

Hangers and anchors or devices for supporting and securing pipe and fittings to walls, ceilings, floors or structural members.

5D.2.1.117 Surface Water

Natural water from the ground surface, paved areas and roofs.

5D.2.1.118 Surface Water Drain

A drain conveying surface water including storm water.

5D.2.1.119 Systems of Drainage

- a) Combined system** — A system in which foul water (sewage) and surface water are conveyed by the same sewers and drains.
- b) Separate system** — A system in which foul water (sewage) and surface water are conveyed by the separate sewers and drains.
- c) Partially separate system** — A modification of the separate system in which part of the surface water is conveyed by the foul (sanitary) sewers and drains.

5D.2.1.120 Trade Effluent

Any liquid either with or without particles of matter in suspension which is wholly or in part produced in the course of any trade or industry, at trade premise. It includes farm wastes but does not include domestic sewage.

5D.2.1.121 Trap

A fittings or device so designed and constructed as to provide, when properly vented, a liquid seal which will prevent the back passage of air without materially affecting the flow of sewage or waste water through it.

5D.2.1.122 Vertical Pipe

Any pipe or fitting which is installed in a vertical position or which makes an angle or not more than 45° with the vertical.

5D.2.1.123 Vent Slack/Vent Pipe

A vertical vent pipe installed primarily for the purpose of proving circulation of air to and from any part of the drainage system. It also protects trap seals from excessive pressure fluctuation.

5D.2.1.124 Vent System

A pipe or pipes installed to provide a flow of air to or from a drainage system or to provide a circulation of air with in such system to protect traps seals from siphonage and back-pressure.

5D.2.1.125 Warning Pipe

An overflow pipe so fixed that its outlet, whether inside or outside a building, is in a conspicuous position where the discharge of any water therefrom can be readily seen.

5D.2.1.126 Wash-Out Valve

A device located at the bottom of the tank for the purpose of draining a tank for cleaning, maintenance, etc.

5D.2.1.127 Waste Appliance

A sanitary appliance for the collection and discharge of water after use for ablutionary, culinary and other domestic purpose.

5D.2.1.128 Waste Pipe

In plumbing, any pipe that receives the discharge of any fixtures, except water-closets or similar fixtures and conveys the same to the house drain or soil or waste stack. When such pipe does not connect directly with a house drain or soil stack, it is called an indirect waste pipe.

5D.2.1.129 Waste-Water (Sullage)

The discharge from wash basins, sinks and similar appliances, which does not contain human or animal excreta.

5D.2.1.130 Water Main (Street Main)

A pipe laid by the water undertakers for the purpose of giving a general supply of water as distinct from a supply to individual consumers and includes any apparatus used in connection with such a pipe.

5D.2.1.131 Water Outlet

A water outlet, as used in connection with the water distributing system, is the discharge opening for the water (a) to a fitting; (b) to atmospheric pressure (except into an open tank which is part of the water supply system); and (c) to any water- operated device or equipment requiring water to operate.

5D.2.1.132 Water Seal

The water in a trap, which acts as a barrier to the passage of air through the trap.

5D.2.1.133 Water Supply System

Water supply system of a building or premises consists of the water service pipe, the water distribution pipes, and the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises.

5D.2.1.134 Waterworks

Waterworks for public water supply include a lake, river, spring, well, pump with or without motor and accessories, reservoir, cistern, tank, duct whether covered or open, sluice, water main, pipe, culvert, engine and any machinery, land, building or a thing used for storage, treatment and supply of water.

5D.2.1.135 Grey Water Reuse Systems

A system where grey water (wastewater but not soil or black water), is collected, not treated and reused for acceptable purposes.

5D.2.1.136 Recycled Water

Water that has been treated and provided for reuse by a water distributor through a reticulated water system.

5D.2.1.137 Aquifer Recharge

The infiltration or injection of natural waters or recycled waters into an aquifer, providing replenishment of the ground water resource.

5D.2.1.138 Aquifer Storage And Recovery

Injection of recycled water into aquifers for storage ,which may be recovered later to meet water demands.

5D.2.1.139 Black Water

Toilet wastewater that contains organic matter from urine , faecal matter and toilet paper.

5D.2.1.140 Direct Potable Recycling

The immediate addition of recycled water to the drinking water distribution system (without an intermediate stage of storage or mixing with surface or ground water).

5D.2.1.141 Dual Reticulation

The simultaneous supply of water from two separate sources, requiring two sets of pipes: one to provide potable water (for drinking, cooking and bathing purposes) ; the other to provide recycled water for non potable purposes.

5D.2.1.142 Effluent

Treated or untreated liquid waste flowing from agricultural and industrial processes , or treated wastewater discharged from sewage treatment plants.

5D.2.1.143 Greywater

A combination of wastewater from the laundry , bathroom and kitchen . Kitchen wastewater is usually not suitable for reuse.

5D.2.1.144 Grond Water

Subsurface water from which wells , springs or bores are fed.

5D.2.1.145 Indirect Potable Recycling

The withdrawal , treatment and distribution of potable (drinking) water from surface or ground water that contains some proportion of recycled water. Compare with “direct potable recycling” , above.

5D.2.1.146 Industrial Purposes

Use of cycled water by industry for purposes including cooling processes , operation of boilers , manufacturing and processing activities , washdown and cleaning , window washing , toilet and urinal flushing and other uses (e.g. dust suppression and irrigation of grounds)

5D.2.1.147 Internal Recycling

The use of recycled water by the entity that produced the wastewater irrigation . The watering of crops ,pasture , golf courses ,parks , gardens and open spaces ,which may involve using different applications (e.g. drip ,trickle, spray and flood).

5D.2.1.148 Municipal Effluent

Used water from community and industry that enters the sewerage system.

5D.2.1.149 Non – Potable Purposes

The use of water for purposes other than drinking ,cooking , bathing and laundry : for example ,irrigation of gardens ,lawns and toilet flushing.

5D.2.1.150 Potable

(Water) of a quality suitable for drinking ,cooking and personal bathing.

5D.2.1.151 Rainwater tanks

Tanks used to collect and store rainfall from household roofs for beneficial use

5D.2.1.152 Raw Water

Water that forms the source supply for potable water ,before it has been treated .

5D.2.1.153 Recycled Water

Appropriately treated effluent and urban storm water suitable for further use .

5D.2.1.154 Sewage

The used water of community or industry , conveyed through sewers to be treated at a sewage treatment plant.

5D.2.1.155 Storm Water

All surface water runoff from rainfall , predominantly in urban catchments ; such areas may include rural residential zones.

5D.2.1.156 Wastewater

The used water of community , industry or agriculture.

5D.2.1.157 Water Quality

The chemical , physical and biological condition of water.

5D.2.1.158 Water Recycling

Use of appropriately treated wastewater and urban stormwater for beneficial purposes.

5D.2.1.159 Water Resource

The sources of supply of ground and surface water in a given area.

5D.3 GENERAL

5D.3.1 Basic Principles

5D.3.1.1 Potable Water

All premises intended for human habitation, occupancy, or use shall be provided with supply of potable water. This water supply shall not be connected with unsafe water resources, nor shall it be subject to the hazards of backflow.

5D.3.1.2 Water Provision

Plumbing fixtures, devices and appurtenances shall be provided with water in sufficient volume and at pressures adequate to enable them to function properly and without undue noise under normal conditions of use.

There should be at least a residual head of **6 ft** at the consumer's tap.

NOTE — The residual head shall be taken at the highest/farthest outlets in the building.

5D.3.1.3 Water Conservation

Plumbing system shall be designed, installed and adjusted to use the optimum quantity of water consistent with proper performance and cleaning.

5D.3.1.4 Safety Devices

Plumbing system shall be designed and installed with safety devices to safeguard against dangers from contamination, explosion, overheating, etc.

5D.3.1.5 Plumbing Fixtures

It is recommended that each family dwelling unit should have at least one water closet, one lavatory, one kitchen wash place or a sink, and one bathing wash place or shower to meet the basic requirements of sanitation and personal hygiene.

5D.3.1.6 Drainage System

The drainage system shall be designed, installed and maintained to guard against fouling, deposit of solids and clogging and with adequate cleanouts so arranged that the pipes may be readily cleaned.

5D.3.1.7 Materials and Workmanship

The plumbing system shall have durable material, free from defective workmanship and so designed and installed as to give satisfactory service for its reasonable expected life.

5D.3.1.8 Fixture Traps and Vent Pipes

Each fixture directly connected to the drainage system shall be equipped with a liquid seal trap. Trap seals shall be maintained to prevent sewer gas, other potentially dangerous or noxious fumes, or vermin from entering the building. Further, the drainage system shall be designed to provide an adequate circulation of air in all pipes with no danger of siphonage, aspiration, or forcing of trap seals under conditions of ordinary use by providing vent pipes throughout the system.

5D.3.1.9 Foul Air Exhaust

Each vent terminal shall extend to the outer air and be so installed as to minimize the possibilities of clogging and the return of foul air to the building, as it conveys potentially noxious or explosive gases to the outside atmosphere. All vent pipes shall be provided with a cowl.

5D.3.1.10 Testing

The plumbing system shall be subjected to required tests to effectively disclose all leaks and defects in the work or the material.

5D.3.1.11 Exclusion from Plumbing System

No substance that will clog or accentuate clogging of pipes, produce explosive mixtures, destroy the pipes or their joints, or interfere unduly with the sewage-disposal process shall be allowed to enter the drainage system.

5D.3.1.12 Light and Ventilation

Wherever water closet or similar fixture shall be located in a room or compartment, it should be properly lighted and ventilated.

5D.3.1.13 Individual Sewage Disposal Systems

If water closets or other plumbing fixtures are installed in buildings where connection to public sewer is not possible, suitable provision shall be made for acceptable treatment and disposal.

5D.3.1.14 Maintenance

Plumbing systems shall be maintained in a safe and serviceable condition.

5D.3.1.15 Accessibility

All plumbing fixtures shall be so installed with regard to spacing as to be accessible for their intended use and for cleaning. All doors, windows and any other device needing access within the toilet shall be so located that they have proper access.

5D.3.1.16 Fixture for Disabled

Special toilet fixtures shall be provided for the disabled with required fixtures and devices.

5D.3.1.17 Structural Safety

Plumbing system shall be installed with due regard to preservation of the structural members and prevention of damage to walls and other surfaces.

5D.3.1.18 Protection of Ground and Surface Water

Sewage or other waste shall not be discharged into surface or sub-surface water without acceptable form of treatment.

5D.3.2 Water Supply Connection

5D.3.2.1 Application for Obtaining Supply Connection

Every consumer, requiring a new supply of water or any extension or alteration to the existing supply shall apply in writing in the prescribed form (*see Annex A*) to the Authority.

5D.3.2.2 Bulk Supply

In the case of large housing colonies or where new services are so situated that it will be necessary for the Authority to lay new mains or extend an existing main,

full information about the proposed housing scheme shall be furnished to the Authority; information shall also be given regarding their phased requirements of water supply with full justification. Such information shall include site plans, showing the layout of roads, footpaths, building and boundaries and indicating thereon the finished line and level of the roads or footpaths and water supply lines and appurtenances.

5D.3.2.3 Completion Certificate

On completion of the plumbing work for the water supply system, the licensed plumber shall give a completion certificate in the prescribed form to the Authority for getting the water connection from the mains.

5D.3.3 Drainage and Sanitation

5D.3.3.1 Preparation and Submission of Plan

No person shall install or carry out any water-borne sanitary installation or drainage installation or any works in connection with anything existing or new buildings or any other premises without obtaining the previous sanction of the Authority.

The owner shall make an application in the prescribed form to the Authority to carry out such a work.

5D.3.3.2 Site Plan

A site plan of the premises on which the building is to be situated or any such work is to be carried out shall be prepared drawn to a scale not smaller than 1":40' (see Part 2 'Administration'). The site plan of the building premises shall show:

- a) the adjoining plots and streets with their names;
- b) the position of the municipal sewer and the direction of flow in it;
- c) the invert level of the municipal sewer, the road level, and the connection level of the proposed drain connecting the building in relation to the sewer,
- d) the angle at which the drain from the building joints the sewer; and
- e) the alignment, sizes and gradients of all drains and also of surface drains, if any.

A separate site plan is not necessary if the necessary particulars to be shown in such a site plan are already shown in the drainage plan.

5D.3.3.3 Drainage Plan

The application (3.3.1) shall be accompanied by a drainage plan drawn to a scale of not smaller than 1":8' and furnished along with the building plan (see Part 2 'Administration'). The plans shall show the following:

- a) Every floor of the building in which the pipes or drains are to be used;
- b) The position, forms, level and arrangement of the various parts of such building, including the roof thereof;
- c) All new drains as proposed with their sizes and gradients;

- d) Invert levels of the proposed drains with corresponding ground levels;
- e) The position of every manhole, gully, soil and waste pipe, ventilating pipe, rain water pipe, water-closet, urinal, latrine, bath, lavatory, sink, trap or other appliances in the premises proposed to be connected to any drain and the following colours are recommended for indicating sewers, waste water pipes, rainwater pipes an existing work.

Description of Work	Colour
Sewers	Red
Waste water pipes and rain-water pipes	Blue
Existing work	Black

- f) The position of refuse chute, inlet hopper and collection chamber.

5D.3.3.3.1

In the case of an alteration or addition to an existing building, this clause shall be deemed to be satisfied if the plans as furnished convey sufficient information for the proposals to be readily identified with previous sanctioned plans and provided the locations of tanks and other fittings are consistent with the structural safety of the building.

5D.3.3.3.2

The plans for the building drainage shall in every case be accompanied by specifications for the various items of work involved. This information shall be supplied in the prescribed form.

5D.3.3.4

In respect of open drains, cross-sectional details shall be prepared to a scale not smaller than 1":4' showing the ground and invert levels and any arrangement already existing or proposed for the inclusion of any or exclusion of all storm water from the sewers.

5D.3.3.5 Completion Certificate

At the completion of the plumbing installation work, the licensed plumber shall give a completion certificate in the prescribed form.

5D.3.4 Licensing/Registration of Plumbers

5D.3.4.1 Execution of Work

The work which is required to be carried out under the provisions of this Section, shall be executed only by a licensed plumber under the control of the Authority and shall be responsible to carry out all lawful directions given by the Authority. No individual shall engage in the business of plumbing unless so licensed under the provisions of this Section.

5D.3.4.1.1

No individual, firm, partnership or corporation shall engage in the business of installing, repairing or altering plumbing unless the plumbing work performed in the course of such business is under the direct supervision of a licensed plumber and who has been assigned duties by authority.

5D.3.4.2 Examination and Certification

The Authority shall establish standards and procedure for the qualification, examination and licensing of plumbers and shall issue licenses to such persons who meet the qualifications thereof and successfully pass the examination.

5D.3.4.3

For guidelines for registration of plumbers including the minimum standards for qualifications for the grant of licenses, reference may be made to Authority concerned .

5D.4 WATER SUPPLY

5D.4.1 Water Supply Requirements for Buildings

5D.4.1.1 Water Supply for Residences

A minimum of 15gal to 22gallons per capita per day (gpcd) may be considered adequate for domestic needs of urban communities, apart from non-domestic needs as flushing requirements. As a general rule the following rates per capita per day may be considered minimum for domestic and non-domestic needs:

a) For communities with population up to 20 000 and without flushing system:

1) water supply through stand post	9 gpcd ,
Min 2) water supply through house service connection	
15 to 20 gpcd	

b) For communities with population 20 000 to 100 000 20 to 30 gpcd

together with full flushing system

c) For communities with population above 100 000 30 to 40 gpcd

together with full flushing system

NOTE — The value of water supply given as 30 to 40 gallons per capita per day may be reduced to 30 gallons per capita per day for houses for Lower Income Groups (LIG) and Economically Weaker Section of Society (EWS), depending upon prevailing conditions.

5D.4.1.1.1 Out of the 30 to 40 gallons per capita per day, 10 gallons per capita per day may be taken for flushing requirements and the remaining quantity for other domestic purposes. For estimating purpose regardless of community population, water requirement may be assumed 40 gallons per capita per day.

5D.4.1.2 Water Supply for Buildings Other than Residences

Minimum requirements for water supply for buildings other than residences shall be in accordance with Table 1(a) and Table 1(b).

Table 1(a): Water Requirements for Buildings Other than Residences*(Clause 4.1.2)*

SI No. (1)	Type of Building (2)	Consumption per Day, gallons (3)
i)	Factories where bath rooms are required to be provided	20 gpcd
ii)	Factories where no bath rooms are required to be provided	10 gpcd
iii)	Hospital (including laundry):	
	a) Number of beds not exceeding 100	75 gpcd
	b) Number of beds exceeding 100	80 gpcd
iv)	Nurses' homes and medical quarters	40 gpcd
v)	Hostels	30 per head
vi)	Hotel (up to 4 Star)	40 per head
vii)	Hotel (5 Star and above)	70 per head
viii)	Offices	10 gpcd
ix)	Restaurants	16 gpd per seat
x)	Cinemas, concert halls and theatres	3 per head
xi)	Schools:	
	a) Day schools	10 gpcd
	b) Boarding schools	30 per head

NOTE — For calculating water demand for visitors a consumption of 3gallons per head, per day may be taken.

TABLE 1.(b) POPULATION EQUIVALENT

No.	Type of Premises / Establishment	Population Equivalent (recommended) PE
1.	Residential	5 – 6 per apartment
2.	Commercial (includes entertainment/ recreational centres, theatres)	3 – 5 per 1000 square feet gross area
3.	Shopping centre.	3 – 5 per 1000 square feet gross area
4.	Schools/ Educational Institutions:	
	- Day schools/ institutions	0.25 per student
	- Fully residential	0.75 per student
	- Partial residential	0.5 per student
5.	Hospitals	80 gpcd
	- Number of beds not exceeding 100	

	- Number of beds exceeding 100	2.0 per bed 2.5 per bed
6.	Clinic	0.5 per patient
7.	Hotels (with dining and laundry facilities) Hotels (without dining and laundry)	4 per room 2.0 per room
8.	Market (wet type)	5 – 7 per 1000 square feet gross area
9.	Market (dry type)	3 – 5 per 1000 square feet gross area
10.	Beauty saloon	0.5 per client
11.	Restaurants, cafeteria	0.4 per seat
12.	Office	0.25
13.	(i)Factories where bath rooms are required to be provided (ii) Factories where no bath rooms are required to be provided	0.5 0.25
14.	Nurses' homes and medical quarters	1

Note:

- 1 PE is equivalent to 40 gallons per capita per day (gpcd)
- 30 % of water supply is generally taken as soil water.

5D.4.1.3 Water Supply Requirements of Traffic Terminal Stations

The water supply requirements of traffic terminal stations (railway stations, bus stations, harbours, airports, etc) include provisions for waiting rooms and waiting halls. They do not, however, include requirements for retiring rooms. Requirements of water supply for traffic terminal stations shall be according to Table 2.

**Table 2: Water Supply Requirements for Traffic Terminal Stations
(Clause 4.1.3)**

SI No. (1)	Nature of Station/Terminal (2)	Where Bathing Facilities are Provided gallons/capita (3)	Where Bathing Facilities are not Provided gallons/capita (4)
i)	Intermediate stations (excluding mail and express stops)	10	5
ii)	Junction stations and intermediate stations where mail or express stoppage is provided	15	10
iii)	Terminal stations	10	10
iv)	International and domestic airports	15	15

NOTES

- 1 The number of persons shall be determined by average number of passengers handled by the station daily; due consideration may be given to the staff and vendors likely to use facilities.
- 2 Consideration should be given for seasonal average peak requirements.

5D.4.1.4 Water Supply for Fire Fighting Purposes

5D.4.1.4.1 The Authority shall make provision to meet the water supply requirements for fire fighting in the city/area, depending on the population density and types of occupancy.

5D.4.1.4.2 Provision shall be made by the owner of the building for water supply requirements for fire fighting purposes within the building, depending upon the height and occupancy of the building, in conformity with the requirements laid down in Part 4 'Fire and Life Safety'.

5D.4.1.4.3 The requirements regarding water supply in storage tanks, capacity of fire pumps, arrangements of wet riser-cum-down comer and wet riser installations for buildings above 50ft in height, depending upon the occupancy use, shall be in accordance with Part 4 'Fire and Life Safety'.

5D.4.1.5 Water Supply for Other Purposes

5D.4.1.5.1 Water supply in many buildings is also required for many other applications other than domestic use, which must be identified in the initial stages of planning so as to provide the requisite water quantity, storage capacity and pressure as required for each application. In such instances information about the water use and the quality required may be obtained from the users. Some typical uses other than domestic use and fire fighting purposes are air conditioning and air washing, swimming pools and water bodies and gardening.

5D.4.2 Water Sources and Quality

5D.4.2.1 Sources of Water

The origin of all sources of water is rainfall. Water can be collected as it falls as rain before it reaches the ground; or as surface water when it flows over the ground or is pooled in lakes or ponds; or as ground water when it percolates into the ground and flows or collects as ground water; or from the sea into which it finally flows.

5D.4.2.2 The quality of water to be used for drinking shall follow WHO GUIDELINES .

5D.4.2.3 For purposes other than drinking, water if supplied separately, shall be absolutely safe from bacteriological contamination so as to ensure that there is no danger to the health of the users due to such contaminants.

5D.4.2.4 Waste Water Reclamation

Treated sewage or other waste water of the community may be utilized for non-domestic purposes such as water for cooling, flushing, lawns, parks, fire fighting and for certain industrial purposes after giving the necessary treatment to suit the nature of the use. This supply system shall be allowed in residences only if proper provision is made to avoid any cross connection of this treated waste water with domestic water supply system.

5D.4.2.5 Whenever a building is used after long intervals, the water quality of the stored water must be checked so as to ensure that the water is safe for use as per water quality requirements specified in this Code.

5D.4.3 Estimate of Demand Load

5D.4.3.1 Estimates of total water supply requirements for buildings shall be based on the occupant load consistent with the provisions of **4.1**.

5D.4.3.1.1 For residential buildings, the requirements of water shall be based on the actual number of occupants; where this information is not available, the number of occupants for each residential unit may be based on a family of five to six. For assessing the population in other occupants, reference may be made to Part 4 'Fire and Life Safety'.

5D.4.3.1.2 In making assessment of water supply requirements of large complexes, the future occupant load shall be kept in view. Use may be made of the following methods for estimating future requirements:

- a) demographic method of population projection,
- b) arithmetic progression method,
- c) geometrical progression method,
- d) method of varying increment or incremental increase,
- e) logistic method,
- f) graphical projection method, and
- g) graphical comparison method.

5D.4.4 Storage of Water

5D.4.4.1 In a building, provision is required to be made for storage of water for the following reasons:

- a) to provide against interruptions of the supply caused by repairs to mains, etc;
- b) to reduce the maximum rate of demand on the mains;
- c) to tide over periods of intermittent supply; and
- d) to maintain a storage for the fire fighting requirement of the building (*see* Part 4 'Fire and Life Safety').

5D.4.4.2 The water may be stored either in overhead tanks (OHT) and/or underground tanks (UGT).

5D.4.4.3 Materials Used

Reservoirs and tanks for the reception and storage of water shall be constructed of reinforced concrete brick masonry, ferro cement precast, mild steel, stainless steel, galvanized iron or plastic.

5D.4.4.3.1 Tanks made of steel may be of welded, riveted or pressed construction. The metal shall be galvanized coated externally with a good quality anti-corrosive weather-resisting paint. Lead-based paint shall not be used in the tank. Lead-lined tanks shall not be used. Rectangular pressed steel tanks shall conform to good practice [9-1(3)].

5D.4.4.4 Each tank shall be provided with the following:

- a) *Manholes* — Adequate number of manholes for access and repair. The manholes shall be made of corrosion resistant material (for example, cast iron, reinforced cement concrete, steel fibre reinforced concrete, galvanized steel, high density polyethylene, fibre glass reinforced plastic or such other materials acceptable to the Authority). Manholes shall be provided with locking arrangement to avoid misuse and tampering.
- b) *Catch Rings and Ladders* — Tanks higher than 3 feet deep shall be provided with corrosion resistant catch rings, steps or ladders according to the depth to enable a person to reach the bottom of the tank.
- c) *Overflow Pipe* — Each tank shall be provided with an overflow pipe terminating above the ground/terrace level to act as a 'Warning Pipe' to indicate overflow conditions. The size of the overflow pipe shall be adequate to accept the flow. Normally the overflow pipe size shall be one size higher than the inlet pipe. When the inlet pipe diameter is large, two or more overflow pipes of equivalent cross- section may be provided.
- d) *Vent Pipes* — Tanks larger than 1200 gallons capacity shall be provided with vent pipes to prevent development pressure in the tank which might result in NO FLOW condition or inward collapse of the tank.

Scour Pipe — Each tank shall be provided with a scour pipe with an accessible valve for emptying the tank.
- e) *Connection of Overflow and Scour Pipe* — Under no circumstances tank overflow and scour pipe shall be connected to any drain, gully trap or manhole

to prevent back flow and contamination of the water. All such connections shall be discharged over a grating with an air gap of 2 inches. All overflow and vent pipes shall be provided with a mosquito proof brass grating to prevent ingress of mosquito, vermin and other insects.

f) The top slab of the tank must be suitably sloped away from its centre for proper drainage of the rainwater.

g) Tanks on terraces and above ground shall be supported by appropriate structural members so as to transfer the load of the tank and the water directly on the structural members of the building.

5D.4.4.5 Every storage tank shall be easily accessible and placed in such a position as to enable thorough inspection and cleaning to be carried out. If the storage capacity required is more than 1200 gallons, it is advantageous to arrange it in a series of tanks so interconnected that each tank can be isolated for cleaning and inspection without interfering with the supply of water. In large storage tanks, the outlet shall be at the end opposite the inlet to avoid stagnation of the water.

5D.4.4.6 The outlet pipe shall be fixed 2 inches to 3 inches above the bottom of the tank and fitted with a strainer, preferably of brass.

5D.4.4.7 In the case of underground storage tanks, the design of the tank shall be such as to provide for the draining of the tank when necessary and water shall not be allowed to collect around the tank. The tank shall be perfectly water-proof and shall be provided with a cement concrete cover, having a manhole opening, with a properly fitting hinged cast iron cover on a leak-proof cast iron frame.

The underground tanks should not be located in low lying areas or near any public or private sewer, septic tank, leaching pool or soakage pit to prevent any contamination. The overflow of the tank should be well above (preferably 2 feet) the external surface level and terminate as a warning pipe with a mosquito proof grating. Care must be taken to prevent backflow of local surface water into the tank in case of local flooding. Otherwise the overflow must be terminated in a more safer manner as per the site conditions. For tanks with at least one side exposed to a basement, it is safer to discharge the overflow into the basement level.

The tank top slab shall also be designed to carry the load due to fire tender movement where anticipated as in the case of an extended basement.

There should be no common wall between the tanks storing safe water and tanks storing water from unsafe sources.

In the case of storage tanks built under the floor slab, it must have at least 2 feet space around the perimeter of the tank to enable regular inspection and maintenance. It must have at least 3 feet vertical space between the floor slab and cover slab of the tank to enable regular inspection and maintenance.

5D.4.4.8 In case of overhead tanks, bottom of the tanks shall be placed clear off the terrace slab such that the elevation difference between the outlet pipe of the tank and the highest fixture at the top floor of the building is minimum 6 feet, which shall also prevent leakage into the structural slab. In tall buildings, the top of the tank shall be provided with the safe ladder or staircase. The top slab shall be provided with railing or a parapet wall.

5D.4.4.9 For jointing steel pipe to a storage tank, the end of the pipe shall be screwed, passed through a hole in the tank and secured by backnuts, both inside and outside. The pipe end shall be flush with the face of the inside backnut. For jointing copper pipe to steel or copper tank, a connector of non-ferrous material shall be used. The connector shall have a shoulder to bear on the outside of the tank and shall be secured by a backnut inside.

5D.4.4.10 The quantity of water to be stored shall be calculated taking into account the following factors:

- a) hours of supply at sufficiently high pressure to fill up the overhead storage tanks;
- b) frequency of replenishment of overhead tanks, during the 24 h;
- c) rate and regularity of supply; and
- d) consequences of exhausting storage particularly in case of public buildings like hospitals.

If the water supply is intermittent and the hours of supply are irregular, it is desirable to have a minimum storage of half a day's supply for overhead tanks. For additional requirement of water storage for firefighting purposes, reference may be made to Part 4 'Fire and Life Safety'.

NOTE — General guidelines for calculation of capacity of these storage tanks are as follows:

- a) In case only OHT is provided, it may be taken as minimum one day's requirement;
- b) In case only UGT is provided, it may be taken as minimum 150 percent of one day's requirement; and
- c) In case combined storage is provided, it may be taken as minimum 100 percent UGT and minimum 50 percent OHT of one day's requirement.

5D.4.4.11 When only one communication pipe is provided for water supply to a building, it is not necessary to have separate storage for flushing and sanitary purposes for health reasons. In such cases when only one storage tank has been provided, tapping of water may be done at two different levels (the lower tapping for flushing) so that a part of the water will be exclusively available for flushing purposes.

5D.4.5 Materials, Fittings and Appliances

5D.4.5.1 Standards for Materials, Fittings and Appliances

All materials, water fittings and appliances shall conform to Part 5 'Building Materials'.

5D.4.5.2 Materials for Pipes

Pipes may be of any of the following materials:

- a) cast iron, vertically cast or centrifugally (spun) cast,
- b) steel (internally lined or coated with bitumen or a bituminous composition, and out-coated with cement concrete or mortar, where necessary),

- c) reinforced concrete,
- d) prestressed concrete,
- e) galvanized mild steel tubes,
- f) copper,
- g) brass,
- h) wrought iron,
- i) asbestos cement,
- j) polyethylene,
- k) unplasticized PVC,
- l) chlorinated PVC, or
- m) stainless steel.

5D.4.5.2.1 The material chosen shall be resistant to corrosion, both inside and outside or shall be suitably protected against corrosion.

5D.4.5.2.2 Polyethylene and unplasticized PVC pipes shall not be installed near hot water pipes or near any other heat sources. For temperature limitations in the use of polyethylene and unplasticized **PVC** pipes to convey water, reference may be made to good practice [9-1(4)].

5D.4.6 Design of Distribution Systems

5D.4.6.1 General

All buildings shall conform to the general requirements given in **3.1**.

5D.4.6.2 Rate of Flow

One of the important items that needs to be determined before the sizes of pipes and fittings for any part of the water piping system may be decided upon, is the rate of flow in the service pipe which, in turn depends upon the number of hours for which the supply is available at sufficiently high pressure. If the number of hours for which the supply is available is less, there will be large number of fittings in use simultaneously and the rate of flow will be correspondingly large.

The data required for determining the size of the communication and service pipes are:

- a) the maximum rate of discharge required;
- b) the length of the pipe; and
- c) the head loss by friction in pipes, fittings and meters.

5D.4.6.3 Discharge Computation

5D.4.6.3.1 Design of consumer's pipes based on fixture units

The design of the consumers' pipes or the supply pipe to the fixtures is based on:

- a) the number and kind of fixtures installed;
- b) the fixture unit flow rate; and

c) the probable simultaneous use of these fixtures.

The rates at which water is desirably drawn into different types of fixtures are known. These rates become whole numbers of small size when they are expressed in fixture unit.

The fixture units for different sanitary appliances or groups of appliances are given in Table 3 and Table 4.

Table 3: Fixture Unit for Different Types of Fixtures with Inlet Pipe Diameter
(CLAUSE 4.6.3.1)

SI No. (1)	Type of Fixture (2)	Fixture Unit FU as Load Factor (3)	Minimum Normal Size of Fixture Branch, in (4)
i)	Ablution tap	1	$\frac{1}{2}$
ii)	Bath tub supply by spout <i>Shower over tub does not add to the load</i>	3	$\frac{1}{2}$
iii)	Shower stall domestic	2	$\frac{1}{2}$
iv)	Shower in groups per head	3	$\frac{1}{2}$
v)	Wash basin domestic use	1	$\frac{1}{2}$
vi)	Wash basin public use	2	$\frac{1}{2}$
vii)	Wash basin surgical	2	$\frac{1}{2}$
viii)	Scrub station in hospitals per outlet	3	$\frac{1}{2}$
ix)	Drinking water fountain/water cooler	0.5	$\frac{1}{2}$
x)	Water-closet with cistern (single/double flush)	1	$\frac{1}{2}$
xi)	Water-closet with flush or magic eye operated valve	8	1 / $1\frac{1}{4}$
xii)	Urinals with auto flushing cisterns	4	$\frac{1}{2}$ / $\frac{3}{4}$
xiii)	Urinals with flush or magic eye operated valve	2	$\frac{1}{2}$ / $\frac{3}{4}$
xiv)	Kitchen sink (domestic use)	2	$\frac{1}{2}$ / $\frac{3}{4}$
xv)	Washing machine	3	$\frac{1}{2}$ / $\frac{3}{4}$

Table 4: Fixture Unit for Different Types of Fixtures Based on Pipe or Trap Diameter
(CLAUSE 4.6.3.1)

SI No. (1)	Drain or Trap Outlet Diameter(inches) (2)	Fixture Unit (FU) (3)
i)	1¼ or smaller	1
ii)	1½	2
iii)	2	3
iv)	2½	4
v)	3	5
vi)	4	6

NOTE — Before using the above figures check the actual flow from the outlets of special equipment, for example, small period high discharges, for example, from washing machines, boiler blow downs, filter backwash and water tank emptying operations.

Table 5: Probable Simultaneous Demand
(Clause 4.6.3.2)

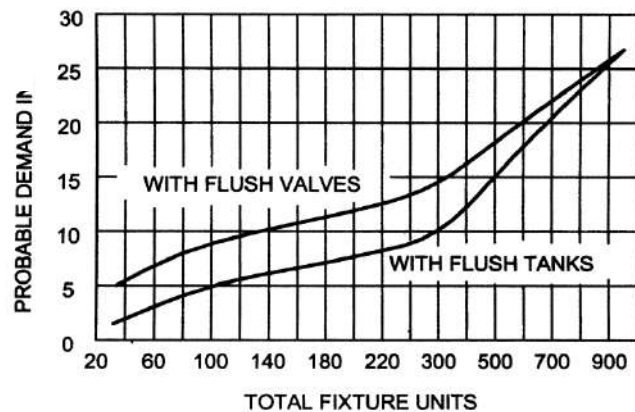
No. of Fixture Units (1)	System with Flush Tanks Demand (Based on Fixture Units)		System with Valves Demand (After Hunter)	
	Unit Rate Flow ¹⁾ (2)	Flow in gallon per minute (3)	Unit Rate Flow ¹⁾ (4)	Flow in gallon per minute (5)
20	2.0	12.45	4.7	29.28
40	3.3	20.55	6.3	39.25
60	4.3	26.80	7.4	46.09
80	5.1	31.77	8.3	51.70
100	5.7	35.51	9.1	56.69
120	6.4	39.86	9.8	61.05
140	7.1	44.22	10.4	64.79
160	7.6	47.34	11.0	68.53
180	8.2	51.08	11.6	72.27
200	8.6	53.57	12.3	76.63
220	9.2	57.31	12.7	79.11
240	9.6	59.80	13.1	84.60
300	11.4	71.02	14.7	91.56
400	14.0	87.21	17.0	105.91
500	16.7	104.04	19.0	118.36
600	19.4	120.85	21.1	131.45
700	21.4	133.32	23.0	143.29
800	24.1	150.13	24.5	152.61
900	26.1	162.58	26.1	162.58
1000	28.1	175.05	28.1	175.05
1500	36.1	224.88	36.1	224.88
2000	43.9	273.48	43.9	273.48
2500	51.1	318.32	51.1	318.32
3000	57.8	360.07	57.8	360.07

¹⁾Unit rate of flow = Effective fixture units

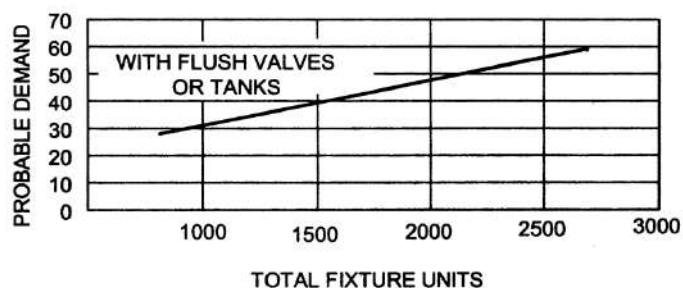
5D.4.6.3.2 Probable simultaneous demand

The possibility that all water supply taps in any system in domestic and commercial use will draw water at the same time is extremely remote. Designing the water mains for the gross flow will result in bigger and uneconomical pipe mains and is not necessary. A probability study made by Hunter suggests the relationship shown in Fig. 5 and Table 5. In the absence of similar studies in MYANMAR, the curves based on Hunter's study may be followed. In making use of these curves, special allowances are made as follows:

- Demands for service sinks are ignored in calculating the total fixture demand.
- Demands of supply outlets such as hose connections and air conditioners through which water flows more or less continuously over a considerable length of time must be added to the probable flow rather than the fixture demand.
- Fixtures supplied with both hot and cold water exert reduced demands upon main hot water and cold water branches (not fixture branches).



5A GRAPH FOR PROBABLE DEMAND ON PIPE LINES UPTO DEMAND OF 900 FU



5B GRAPH FOR PROBABLE DEMAND OVER 900 FU

FIG.5 GRAPH FOR PORTABLE DEMAND

5D.4.6.4 Pipe Size Computation

Commercially available standard sizes of pipes are only to be used against the sizes arrived at by actual design. Therefore, several empirical formulae are used, even though they give less accurate results. The Hazen and William's formula and the charts based on the same may be used without any risk of inaccuracy in view of the fact that the pipes normally to be used for water supply are of smaller sizes. Nomogram of Hazen and William's equation has been provided in Annex F.

5D.4.7 Distribution Systems in Multi-Storeyed Buildings

5D.4.7.1

There are four basic methods of distribution of water to multi-storeyed buildings.

- a) Direct supply from mains to ablutionary taps and kitchen with WCs and urinals supplied by overhead tanks.
- b) Direct Pumping Systems
- c) Hydro-Pneumatic Systems
- d) Overhead Tanks Distribution

5D.4.7.2 Direct Supply System

This system is adopted when adequate pressure is available round the clock at the topmost floor. With limited pressure available in most city mains, water from direct supply is normally not available above two or three floors. For details of this system, reference may be made to good practice [9-1(5)] may be referred.

5D.4.7.3 Direct Pumping

5D.4.7.3.1 Water is pumped directly into the distribution system without the aid of any overhead tank, except for flushing purposes. The pumps are controlled by a pressure switch installed on the line. Normally a jockey pump of smaller capacity installed which meets the demand of water during low consumption and the main pump starts when the demand is greater. The start and stop operations are accomplished by a set of pressure switches are installed directly on the line. In some installation, a timer switch is installed to restrict the operating cycle of the pump.

5D.4.7.3.2 Direct pumping systems are suitable for buildings where a certain amount of constant use of water is always occurring. These buildings are all centrally air conditioned buildings for which a constant make up supply for air conditioning cooling towers is required.

5D.4.7.3.3 The system depends on a constant and reliable supply of power. Any failure in the power system would result in a breakdown in the water supply system.

5D.4.7.3.4 The system eliminates the requirements of overhead tanks for domestic purposes (except for flushing) and requires minimum space (see Fig. 6).

5D.4.7.4 Hydro-Pneumatic Systems

5D.4.7.4.1 Hydro-pneumatic system is a variation of direct pumping system. An air-tight pressure vessel is installed on the line to regulate the operation of the pumps. The vessel capacity shall be based on the cut-in and cut-out pressure of the pumping system depending upon allowable start/stops of the pumping system. As pumps operate, the incoming water in the vessel, compresses the air on top. When a predetermined pressure is reached in the vessel, a pressure switch installed on the vessel switches off the pumps. As water is drawn into the system, pressure falls into the vessel starting the pump at preset pressure. The air in the pressure tank slowly reduces the volume due to dissolution in water and leakages from pipe lines. An air compressor is also necessary to feed air into the vessel so as to maintain the required air-water ratio. The system shall have reliable power supply to avoid breakdown in the water supply.

5D.4.7.4.2 There is an alternate option of providing variable speed drive pumping system where a pump with a large variation in its pressure-discharge and speed of the pump is efficiently used to deliver water at rates of flow as required by the system by changing its speed by a varying its with the assistance of an electronic device which will reduce the rate of flow from speed of the motor from 960 rpm to 3 000 rpm. With this arrangement the same pump is able to deliver water as required at different times of the day. The system consumes energy in proportion to the work done and save considerable amount of power as compared to the fixed speed pumps used conventionally.

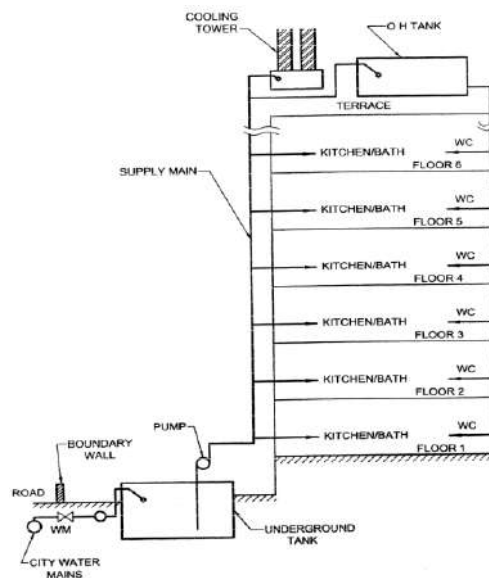


FIG. 6 DIRECT PUMPING SYSTEM APPLICABLE WHERE THERE IS CONTINUOUS DEMAND ON SYSTEM

5D.4.7.4.3 Hydro-pneumatic system generally eliminates the need for an over head tank and may supply water at a much higher pressure than available from overhead tanks particularly on the upper floors, resulting in even distribution of water at all floors (see Fig. 7).

5D.4.7.5 Overhead Tank Distribution

5D.4.7.5.1 This is the most common of the distribution systems adopted by various type of buildings.

5D.4.7.5.2 The system comprises pumping water to one or more overhead tanks placed at the top most location of the hydraulic zone.

5D.4.7.5.3 Water collected in the overhead tank is distributed to the various parts of the building by a set of pipes located generally on the terrace.

5D.4.7.5.4 Distribution is accomplished by providing down takes to various fixtures (see Fig. 8).

5D.4.8 General Requirements for Pipe Work

5D.4.8.1 Mains

The following principles shall apply for the mains:

Service mains shall be of adequate size to give the required rate of flow.

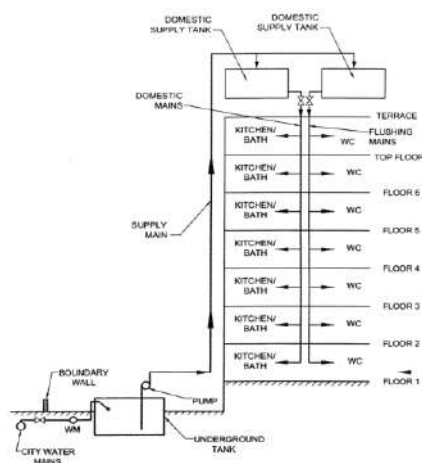


FIG. 7 HYDRO – PNEUMATIC SYSTEM DISTRIBUTION

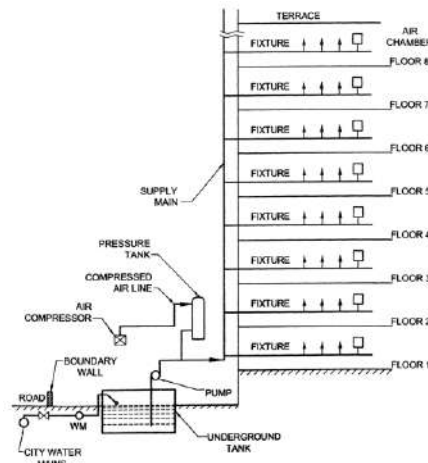


FIG. 8 OVERHEAD TANK

- The mains shall be divided into sections by the provisions of sluice valves and other valves so that water may be shut off for repairs.
- To avoid dead ends, the mains shall be arranged in a grid formation or in a network.
- Where dead ends are unavoidable, a hydrant shall be provided to act as a wash-out.
- The wash-out valve shall not discharge directly into a drain or sewer, or into a manhole or chamber directly connected to it; an effectively trapped chamber shall be interposed, into which the wash-out shall discharge.
- Air valves shall be provided at all summits, and wash-out at low points between summits.

- f) Mains need not be laid at unvarying gradients, but may follow the general contour of the ground. They shall, however, fall continuously towards the wash-out and rise towards the air valves. The gradient shall be such that there shall always be a positive pressure at every point under working conditions.
- g) The cover for the mains shall be at least 3 feet under roadways and 2 feet 6 inches in the case of footpaths. This cover shall be measured from the top of the pipe to the surface of the ground.
- h) The mains shall be located sufficiently away from other service lines like electric and telegraph cables to ensure safety and where the mains cannot be located away from such lines, suitable protective measures shall be accorded to the mains.

5D.4.8.2 Communication Pipes

- a) Every premises that is supplied with water by the Authority shall have its own separate communication pipe. In the case of a group or block of premises belonging to the same owner the same communication pipe may supply water to more than one premises with the prior permission of the Authority.
- b) The communication pipe between the water main and the stop-cock at the boundary of the premises shall be laid by the Authority.
- c) Connections up to 2 inches diameter may be made on the water main by means of screwed ferrules, provided the size of the connections does not exceed one-third the size of the water main. In all other cases, the connection shall be made by a T-branch off the water main.
- d) As far as practicable, the communication pipe and the underground service pipe shall be laid at right angles to the main and in approximately straight lines to facilitate location for repairs. It is also recommended that the communication pipe be laid in a pipe sleeve of larger dia. Made of non-corrosive material to protect the communication pipe.
- e) Every communication pipe shall have a stopcock and meter inserted in it. The waterway of each such fitting shall not be less than the internal sectional area of the communication pipe and the fittings shall be located within the premises at a conspicuous place accessible to the Authority which shall have exclusive control over it.

5D.4.8.3 Consumer Pipes

- a) No consumer pipe shall be laid in the premises to connect the communication pipe without the approval of the Authority.
- b) The consumer pipe within the premises shall be laid underground with a suitable cover to safeguard against damage from traffic and extremes of weather.
- c) To control the branch pipe to each separately occupied part of a building supplied by a common service pipe, a stop tap shall be fixed to minimize the interruption of the supply during repairs. All such stop valves shall be fixed in accessible positions and properly protected. To supply water for drinking or for culinary purposes, direct taps shall be provided on the branch pipes

connected directly to the consumer pipe. In the case of multi-storeyed buildings, downtake taps shall be supplied from overhead tanks.

- d) Pumps shall not be allowed on the service pipe, as they cause a drop in pressure on the suction side, thereby affecting the supply to the adjoining properties. In cases where pumping is required, a properly protected storage tank of adequate capacity shall be provided to feed the pump.
- e) No direct boosting (by booster pumps) shall be allowed from the service pipes (communication and consumer pipes).
- f) Consumer pipes shall be so designed and constructed as to avoid air-locks. Draining taps shall be provided at the lowest points from which the piping shall rise continuously to draw-off taps.
- g) Consumer pipes shall be so designed as to reduce the production and transmission of noise as much as possible.
- h) Consumer pipes in roof spaces and unventilated air spaces under floors or in basements shall be protected against corrosion.
- i) Consumer pipes shall be so located that they are not unduly exposed to accidental damage and shall be fixed in such positions as to facilitate cleaning and avoid accumulations of dirt.
- j) All consumer pipes shall be so laid as to permit expansion and contraction or other movements.

5D.4.8.4 Prohibited Connections

- a) A service pipe shall not be connected into any distribution pipe; such connection may permit the backflow of water from a cistern into the service pipe, in certain circumstances, with consequent danger of contamination and depletion of storage capacity. It might also result in pipes and fittings being subjected to a pressure higher than that for which they are designed, and in flooding from overflowing cisterns.
- b) No pipe for conveyance or in connection with water supplied by the Authority shall communicate with any other receptacle used or capable of being used for conveyance other than water supplied by the Authority.
- c) Where storage tanks are provided, no person shall connect or be permitted to connect any service pipe with any distributing pipe.
- d) No service or supply pipe shall be connected directly to any water-closet or a urinal. All such supplies shall be from flushing cisterns which shall be supplied from storage tank.
- e) No service or supply pipe shall be connected directly to any hot water system or to any other apparatus used for heating other than through a feed cistern thereof.

5D.4.9 Jointing of Pipes

5D.4.9.1 Cast Iron Pipes

Jointing may be done by any of the following methods:

- a) spigot and socket joints, or

- b) flanged joints in accordance with good practice [9-1(6)]. The lead shall conform to the accepted standards [9-1(7)].

5D.4.9.2 Steel Pipes

Plain-ended steel pipes may be jointed by welding. Electrically welded steel pipes shall be jointed in accordance with good practice [9-1(8)].

5D.4.9.3 Wrought Iron and Steel Screwed Pipes

Screwed wrought iron or steel piping may be jointed with screwed and socketed joints. Care shall be taken to remove any burr from the end of the pipes after screwing. A jointing compound approved by the Authority and containing no red lead composition shall be used. Screwed wrought iron or steel piping may also be jointed with screwed flanges.

5D.4.9.4 Asbestos Cement Pipes

Asbestos cement pipes may be jointed in accordance with good practice [9-1(9)].

5D.4.9.5 Copper Pipes

Copper pipes shall be jointed by internal solder ring joint, end-brazing joint or by use of compression fitting. The flux used shall be non-toxic and the solder used shall be lead free. The use of dezincification fittings shall be made in case of jointing of copper pipe and steel pipe.

5D.4.9.6 Concrete Pipes

Concrete pipes shall be jointed in accordance with good practice [9-1(10)].

5D.4.9.7 Polyethylene and Unplasticized PVC Pipes

Polyethylene and unplasticized PVC pipes shall be jointed in accordance with good practice [9-1(11)].

5D.4.10 Backflow Prevention

5D.4.10.1 The installation shall be such that water delivered is not liable to become contaminated or that contamination of the public water supply does not occur.

5D.4.10.2 The various types of piping and mechanical devices acceptable for backflow protection are:

- a) Barometric loop,
- b) Air gap,
- c) Atmosphere vacuum breaker,
- d) Pressure vacuum breaker,
- e) Double check valve, and
- f) Reduced pressure backflow device.

5D.4.10.3 The installation shall not adversely affect drinking water:

- a) by materials in contact with the water being unsuitable for the purpose;
- b) as a result of backflow of water from water fittings, or water using appliances into pipework connected to mains or to other fittings and appliances;

- c) by cross-connection between pipes conveying water supplied by the water undertaker with pipes conveying water from some other source; and
- d) by stagnation, particularly at high temperatures.

5D.4.10.4 No pump or similar apparatus, the purpose of which is to increase the pressure in or rate of flow from a supply pipe or any fitting or appliance connected to a supply pipe, shall be connected unless the prior written permission of the water supplier has been obtained in each instance.

The use of such a pump or similar apparatus is likely to lead to pressure reduction in the upstream pipe work which, if significant, increase the risk of backflow from other fittings.

5D.4.10.5 The water shall not come in contact with unsuitable materials of construction.

5D.4.10.6 No pipe or fitting shall be laid in, on or through land fill, refuse, an ash pit, sewer, drain, cesspool or refuse chute, or any manhole connected with them.

5D.4.10.7 No pipe susceptible to deterioration by contact with any substance shall be laid or installed in a place where such deterioration is likely to occur. No pipe that is permeable to any contaminant shall be laid or installed in any position where permeation is likely to occur.

5D.4.10.8 If a liquid (other than water) is used in any type of heating primary circuit, which transfers heat to water for domestic use, the liquid shall be non-toxic and non-corrosive.

5D.4.10.9 A backflow prevention device shall be arranged or connected at or as near as practicable to each point of delivery and use of water. Appliances with built-in backflow prevention shall be capable of passing the test. All backflow prevention devices shall be installed so that they are accessible for examination, repair or replacement. Such devices shall be capable of being tested periodically by the Authority to ensure that the device is functioning efficiently and no backflow is occurring at any time.

5D.4.11 Conveyance and Distribution of Water Within the Premises

5D.4.11.1 Basic Principles

Wholesome water supply provided for drinking and culinary purposes shall not be liable to contamination from any less satisfactory water. There shall, therefore, be no cross-connection whatsoever between the distribution system for wholesome water and any pipe or fitting containing unwholesome water, or water liable to contamination, or of uncertain quality, or water which has been used for any other purpose. The provision of reflux or non-return valves or closed and sealed stop valves shall not be construed as a permissible substitute for complete absence of cross-connection.

5D.4.11.2 The design of the pipe work shall be such that there is no possibility of backflow towards the source of supply from any cistern or appliance, whether by siphonage or otherwise. Reflux non-return valves shall not be relied upon to prevent such backflow.

5D.4.11.3 Where a supply of less satisfactory water than wholesome water becomes inevitable as an alternative or is required to be mixed with the latter, it shall be delivered only into a cistern and by a pipe or fitting discharging into the air gap

at a height above the top edge of the cistern equal to twice its nominal bore and in no case less than 6 inches. It is necessary to maintain a definite air gap in all appliances or taps used in water- closets.

5D.4.11.4

All pipe work shall be so designed, laid or fixed and maintained as to remain completely water-tight, thereby avoiding wastage, damage to property and the risk of contamination.

5D.4.11.5

No water supply line shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith nor through any ash pit or manure pit or any material of such nature that is likely to cause undue deterioration of the pipe, except where it is unavoidable.

5D.4.11.5.1

Where the laying of any pipe through corrosive soil or previous material is unavoidable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means as approved by the Authority. Any existing piping or fitting laid or fixed, which does not comply with the above requirements, shall be removed immediately by the consumer and relaid by him in conformity with the above requirements and to the satisfaction of the Authority.

5D.4.11.5.2

Where lines have to be laid in close proximity to electric cables or in corrosive soils, adequate precautions/protection should be taken to avoid corrosion.

5D.4.11.6

Underground piping shall be laid at such a depth that it is unlikely to be damaged by frost or traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided, special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

5D.4.11.7

In designing and planning the layout of the pipe work, due attention shall be given to the maximum rate of discharge required, economy in labour and materials, protection against damage and corrosion, water hammer, protection from frost, if required, and to avoidance of airlocks, noise transmission and unsightly arrangement.

5D.4.11.8

To reduce frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection at the joints, whether of the jointing materials or otherwise.

5D.4.11.9

Change in diameter and in direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made which is likely to materially diminish or alter the cross- section.

5D.4.11.10

No boiler for generating steam or closed boilers of any description or any machinery shall be supplied direct from a service or supply pipe. Every such boiler or machinery shall be supplied from a feed cistern.

5D.4.12 Laying of Mains and Pipes on Site

5D.4.12.1

The mains and pipes on site shall be laid in accordance with good practice [9-1(12)].

5D.4.12.2 Excavation and Refilling

The bottoms of the trench excavations shall be so prepared that the barrels of the pipes, when laid, are well bedded for their whole length on a firm surface and are true to line and gradient. In the refilling of trenches, the pipes shall be surrounded with fine selected material, well rammed so as to resist subsequent movement of the pipes. No stones shall be in contact with the pipes; when resting on rock, the pipes shall be bedded on fine-selected material or (especially where there is a steep gradient) on a layer of concrete.

5D.4.12.2.1

The pipes shall be carefully cleared of all foreign matter before being laid.

5D.4.12.3 Laying Underground Mains

Where there is a gradient, pipe laying shall proceed in 'uphill' direction to facilitate joint making.

5D.4.12.3.1

Anchor blocks shall be provided to withstand the hydraulic thrust.

5D.4.12.4

Iron surface boxes shall be provided to give access to valves and hydrants and shall be supported on concrete or brickwork which shall not be allowed to rest on pipes.

5D.4.12.5 Laying Service Pipes

5D.4.12.5.1

Service pipes shall be connected to the mains by means of right-hand screw down ferrule or T-branches. The ferrules shall conform to accepted standards [9-1(13)].

5D.4.12.5.2

Precaution against contamination of the mains shall be taken when making a connection and, where risk exists, the main shall be subsequently disinfected. The underground water service pipe and the building sewer

or drain shall be kept at a sufficient distance apart so as to prevent contamination of water. Water service pipes or any underground water pipes shall not be run or laid in the same trench as the drainage pipe. Where this is unavoidable, the following conditions shall be fulfilled:

- a) The bottom of the water service pipe, at all points, shall be at least 1 ft above the top of the sewer line at its highest point.
- b) The water service pipe shall be placed on a solid shelf excavated on one side of the common trench.
- c) The number of joints in the service pipe shall be kept to a minimum.
- d) The materials and joints of sewer and water service pipe shall be installed in such a manner and shall possess such necessary strength and durability as to prevent the escape of solids, liquids and gases there from under all known adverse conditions, such as corrosion strains due to temperature changes, settlement, vibrations and superimposed loads.

5D.4.12.5.3

The service pipe shall pass into or beneath the buildings at a depth of not less than 2 ft 6 in below the outside ground level and, at its point of entry through the structure, it shall be accommodated in a sleeve which shall have previously been solidly built into the wall of the structure. The space between the pipe and the sleeve shall be filled with bituminous or other suitable material for a minimum length of 6 inches at both ends.

5D.4.12.6 Pipes Laid Through Ducts, Chases, Notches or Holes

Ducts or chases in walls for piping shall be provided during the building of the walls. If they are cut into existing walls, they shall be finished sufficiently smooth and large enough for fixing the piping.

5D.4.12.6.1

Piping laid in notches or holes shall not be subjected to external pressure.

5D.4.12.7 Lagging of Pipes

Where lagged piping outside buildings is attached to walls, it shall be entirely covered all round with waterproof and fire insulating material and shall not be in direct contact with the wall. Where it passes through a wall, the lagging shall be continued throughout the thickness of the wall.

5D.4.13 Hot Water Supply Installations

5D.4.13.1 Design Consideration

5D.4.13.1.1 General

In electric water heating practice for domestic purposes, the accepted method is to use storage heaters in which water is steadily heated up to a predetermined temperature and stored until required for use. The heating by electricity of a large quantity of water, such as water required for a hot bath, within the time normally taken to run the water into the bath, requires a heater of too high a rating to be practicable in normal domestic premises.

5D.4.13.1.2

In modern hotels and apartment blocks and service apartments, centralized storage and distribution systems are adopted, where other energy sources such as oil, gas, solar panels, etc, may be used for the generation of hot water as these options prove more economical and convenient in heating large volumes of water for storage.

5D.4.13.1.3

When water supplied to the buildings contain dissolved salts resulting in hardness of water, measures such as installation of water softening plants etc shall be taken to avoid formation of scales in the hot water installations.

5D.4.13.2 Storage Temperature

5D.4.13.2.1

The design of hot water supply system and its appliances shall be based on the

temperatures at which water is normally required for the various uses, namely:

Scalding	150°F (65°C)
Sink	140°F (60°C)
Hot bath	110°F (43°C) as run, for use at 105°F (41°C)
Warm bath	98°F (37°C)
Tepid bath	85°F (29.5°C)

5D.4.13.2.2

In order to minimize the danger of scalding, precipitation of scale from hard water, standing heat losses, risk of steam formation and the possibility of damage to porcelain or other fittings and to surface finishes, a storage temperature of 140°F is recommended. If storage capacity is limited, a higher temperature up to 150°F may be adopted when soft water is used.

5D.4.13.3 Storage Capacity

The size of the storage vessel is governed by the maximum short time demand of the domestic premises. Depending on local conditions this shall be 10 gal to 15 gal at 140°F in a dwelling with a bath tub and 5 gal at 140°F for a shower or a tap (for bucket supply). The capacity of the storage vessel shall not be less than 20 percent in excess of the required maximum short time demand. In larger houses where a single hot water heater is intended to supply hot water to more than one bathroom or kitchen or both, the maximum short time demand shall be estimated and the capacity decided accordingly. Small electric or gas storage heaters of 3 gal to 5 gal capacity may be used to supply one or two points of draw off depending on the use of hot water. Values of volume of hot water required for a bath, when cold water is mixed with it are given in Table 6.

Table 6: Volume of Hot Water Required for a Bath when cold water is Mixed with It
(Clause 4.13.3)

Storage Temperature, °F	167	158	150	140	130	122
Percentage of hot water required	51	55	60	66	73	82.5
Quantity of hot water in gallons required for a 25 gallons bath	13	14	15	17	18.5	21

NOTE – Hot bath temperature at 106°F and cold water at about 41 to 42°F.

5D.4.13.4 Rate of Flow

With storage type installation, the recommended minimum rates of flow for different types of fixtures are given in Table 7.

Table 7: Rate of Hot Water Flow

(Clause 4.13.4)

SI NO. (1)	Fixtures (2)	Rate of Flow gallons/ min (3)
i)	Bath tub	5
ii)	Kitchen	3
iii)	Wash basin	1.5
iv)	Shower (spray type)	1.5

5D.4.13.5 Design of Storage Vessel

Storage tanks shall be oblong or cylindrical in shape and shall be installed, preferably with the long side vertical in order to assist the effective stratification or 'layering' of hot or cold water. The ratio of height to width or diameter shall not be less than 2:1. An inlet baffle should preferably be fitted near the cold inflow pipe in order to spread the incoming cold water.

5D.4.13.6 Materials for Storage Vessel and Pipes

5D.4.13.6.1

Under no circumstances shall ungalvanized (black) mild steel pipes and fittings, such as sockets, bushes, etc, be used in any part of a hot water installation, including the cold feed pipe and the vent pipe. Materials resistant to the chemical action of water supplied shall be used in construction of vessels and pipes. Each installation shall be restricted to one type of metal only, such as all copper or all galvanized mild steel. When water supplied is known to have appreciable salt content, galvanized iron vessels and pipes shall not be used. However, it is advisable to avoid use of lead pipes in making connection to wash basins. Where required it is also advisable to use vessels lined internally with glass, stainless steel, etc.

5D.4.13.6.2

In general tinned copper and other metals such as other metals etc are suitable for most types of water. The suitability of galvanized mild steel for storage tanks depends upon the pH value of the water and the extent of its temporary hardness. For values of *pH* 7.2 or less, galvanized mild steel should not be used. For values of *pH* 7.3 and above, galvanized mild steel may be used provided the corresponding temporary hardness is not lower than those given below:

pH Value	Minimum Temporary Hardness Required (ppm)
7.3	210
7.4	150
7.5	140
7.6	110
7.7	90
7.8	80
7.9-8.5	70

5D.4.13.7 Location of Storage Vessel

The loss of heat increases in proportion to the length of pipe between the storage vessel and the hot water outlet since each time the water is drawn, the pipe fills with hot water which then cools. The storage vessel shall therefore be so placed that the pipe runs to the most frequently used outlets are as short as possible.

5D.4.13.8 Immersion Heater Installation**5D.4.13.8.1**

If a domestic storage vessel is to be adopted to electric heating by the provision of an immersion heater and thermostat, the following precautions shall be observed:

- a) **Location of immersion heaters** — The immersion heater shall be mounted with its axis horizontal, except in the case of the circulation type which is normally mounted with its axis approximately vertical.
- b) In a tank with a flat bottom, a space of not less than 3in below the immersion heater and 5in below the cold feed connection shall be provided to allow for accumulation of sludge and scale, where it will not affect the working of the immersion heater.
- c) In a cylindrical storage vessel with inwardly dished bottom, the inlet pipe shall be so arranged that the incoming cold water is not deflected directly into the hot water zone. The lowest point of the immersion heater shall be 1inch above the centre line of the cold feed inlet, which, in turn, is usually 4inches above the cylinder rim.

- d) **Location of thermostat** — Where the thermostat does not form an integral part of the immersion heater, it shall be mounted with its axis horizontal, at least 2in away from and not lower than the immersion heater.
- e) **Dual heater installations** — If desired, the principle of the dual heater may be adopted. In this case, one heater and its thermostat shall be installed at a low level as indicated in (b) and (c). The second heater and its thermostat shall be similarly disposed in the upper half of the cylinder at a level depending on the reserve of hot water desired for ordinary domestic use. The bottom heater shall be under separate switch control.
- f) **Clearance around storage vessel** — Adequate clearance shall be provided between the tank and the cupboard, door or walls to allow convenient insertion and adjustment of the immersion heater and thermostat and to give space for thermal insulation.

5D.4.13.8.2 Rating of Immersion Heaters

The rating of an immersion heater shall be determined according to the following factors:

- a) proposed hot water storage capacity (the maximum with cold water as indicated in 4.13.3 shall be taken into account),
- b) rate of utilization (draw off frequency),
- c) permissible recovery period, and
- d) inlet water temperature.

For details regarding rated input of water, refer to good practice [9-1(14)].

5D.4.13.9 Thermal Insulation

The hot water storage vessel and pipes shall be adequately insulated wherever necessary to minimize heat loss. The whole external surface of the storage vessel including the cover to the hand hole, shall be provided with a covering equivalent to not less than 3 inches thickness of thermal insulating material having a conductivity of not more than $0.05 \text{ W/(m}^2\text{.}^\circ\text{C)/mm}$ at mean temperature of 122°F .

5D.4.13.10 Cold Water Supply to Heaters

5D.4.13.10.1

A storage water heater (pressure type) shall be fed from a cold water storage tank and under no circumstances connected directly to the water main, except the type which incorporates a feed tank with ball valves and overflow pipe arrangement (cistern type heaters) or non-pressure type heaters.

5D.4.13.10.2 Storage cisterns

5D.4.13.10.2.1

The storage capacity of a cold water tank shall be at least twice the capacity of the hot water heater. The capacity of the storage tank

may, however, be 1.5 times when the number of heaters connected to one common tank exceeds 10.

5D.4.13.10.2.2

The storage tank for supply of cold water to hot water heaters shall be separate, if practicable. In the case of a common tank which also supplies cold water to the fixtures, this cold water supply connection shall be so arranged that 50 percent of the net capacity, worked out as in **4.13.10.2.1**, shall be available for supply to the hot water heaters.

5D.4.13.10.2.3

In the case of multi-storeyed buildings where a common overhead tank over the stair/lift well is generally installed, it is advisable to have one or more local tanks for supply to the hot water heaters. This arrangement shall help in reducing the length of the vent pipes (*see Fig. 9*).

5D.4.13.10.2.4

In tall multi-storeyed buildings where the static pressure increases with the height, the total static pressure on the hot water heaters on the lowest floor shall not exceed the rated working pressure of the hot water heater installed. Should the height of the building so require, additional tanks shall be provided on the intermediate floors to restrict the static head to permissible limits (*see Fig. 10*).

5D.4.13.10.2.5

As an alternative to the arrangements stated in **4.13.10.2.3** and **4.13.10.2.4** an individual storage tank in each flat may be provided for supply to hot water heaters (*see Fig. 11*).

5D.4.13.11 Cold Water Feed

5D.4.13.11.1

The feed pipe connecting cold water tank with the hot water heater shall not be of less than $\frac{3}{4}$ inches bore and it shall leave the cold water tank at a point not less than 2 inches above the bottom of the tank and shall connect into the hot water heater near its bottom. The feed pipe shall not deliver cold water to any other connection, but into the hot water cylinders only.

5D.4.13.11.2

In the case of multi-storeyed buildings, a common cold water feed pipe may be installed, but each hot water heater shall be provided with a check valve (horizontal type check valve shall be preferred to vertical type for easy maintenance).

5D.4.13.11.3

Care shall be taken in installing the piping to prevent air locks in the piping and negative pressure in the hot water heater. Cold water feedpipe shall

not be cross connected with any other source of supply under pressure (see Fig. 9).

5D.4.13.12 Hot Water Piping

5D.4.13.12.1 Expansion pipe or vent pipe

5D.4.13.12.1.1

Each pressure type hot water heater or cylinder shall be provided with a vent pipe of not less than $\frac{3}{4}$ in bore. The vent pipe shall rise above the water line of the cold water tank by at least 6 in plus $\frac{1}{4}$ in for every 1 ft height of the water line above the bottom of the heater. The vent shall discharge at a level higher than the cold water tank and preferably in the cold water tank supplying the hot water heaters. Care shall be taken to ensure that any accidental discharge from the vent does not hurt or scald any passerby or persons in the vicinity.

5D.4.13.12.1.2

The vent pipe shall be connected to the highest point of the heater vessel and it shall not project downwards inside it, as otherwise air may be trapped inside, resulting in surging and consequent noises.

5D.4.13.12.1.3

At no point, after leaving the vessel, shall the vent pipe dip below the level of its connection with the vessel.

5D.4.13.12.1.4

A vent pipe may, however, be used for supply of hot water to any point between the cold water tank and the hot water heaters.

5D.4.13.12.1.5

The vent pipe shall not be provided with any valve or check valves.

5D.4.13.12.2 Hot water heaters

5D.4.13.12.2.1

The common hot water delivery pipe shall leave the hot water heater near its top and shall be of not less than $\frac{3}{4}$ inch bore generally, not less than 1 inch bore if hot water taps are installed on the same floor as that on which the hot water heater is situated.

5D.4.13.12.2.2

Hot water taps shall be of such design as would cause the minimum friction. Alternatively, oversized tap may be provided, such as a $\frac{3}{4}$ inch tap on a $\frac{1}{2}$ inch pipe.

5D.4.13.12.2.3

The hot water distributing system shall be so designed as to ensure that the time lag between opening of the draw-off taps and discharge of hot water is reduced to the minimum to avoid wastage of an undue amount of water which may have cooled while standing in the pipes when the

taps are closed. With this end in view, a secondary circulation system with flow and return pipes from the hot water tank shall be used where justified. Whether such a system is used or not, the length of pipe to a hot water draw-off tap, measured along the pipe from the tap to the hot water tank or the secondary circulation pipe, shall not exceed the lengths given in Table 8.

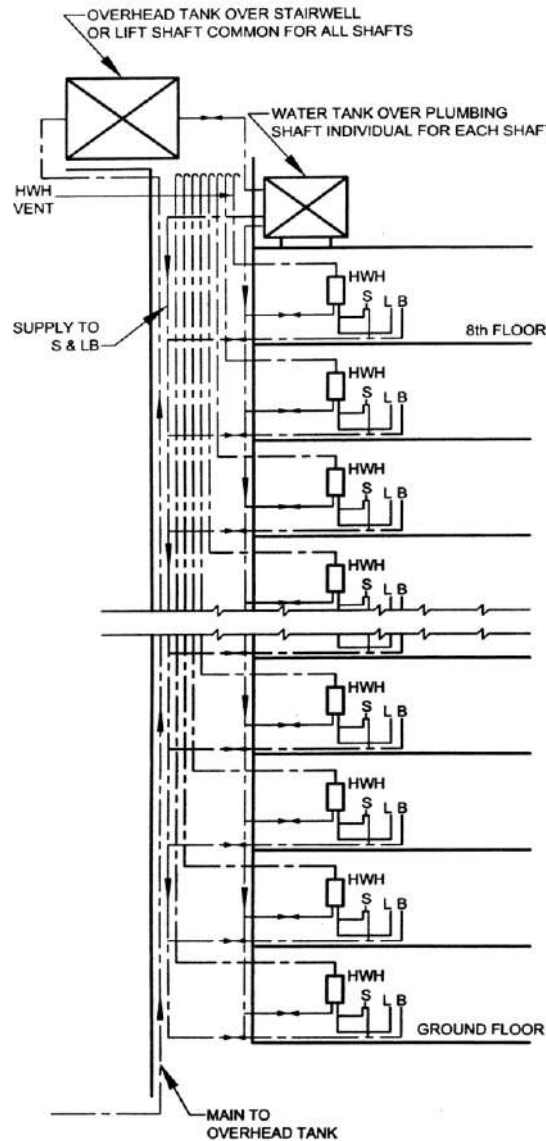


FIG. 9 INSTALLATION FOR 8 – STOREYED BUILDING

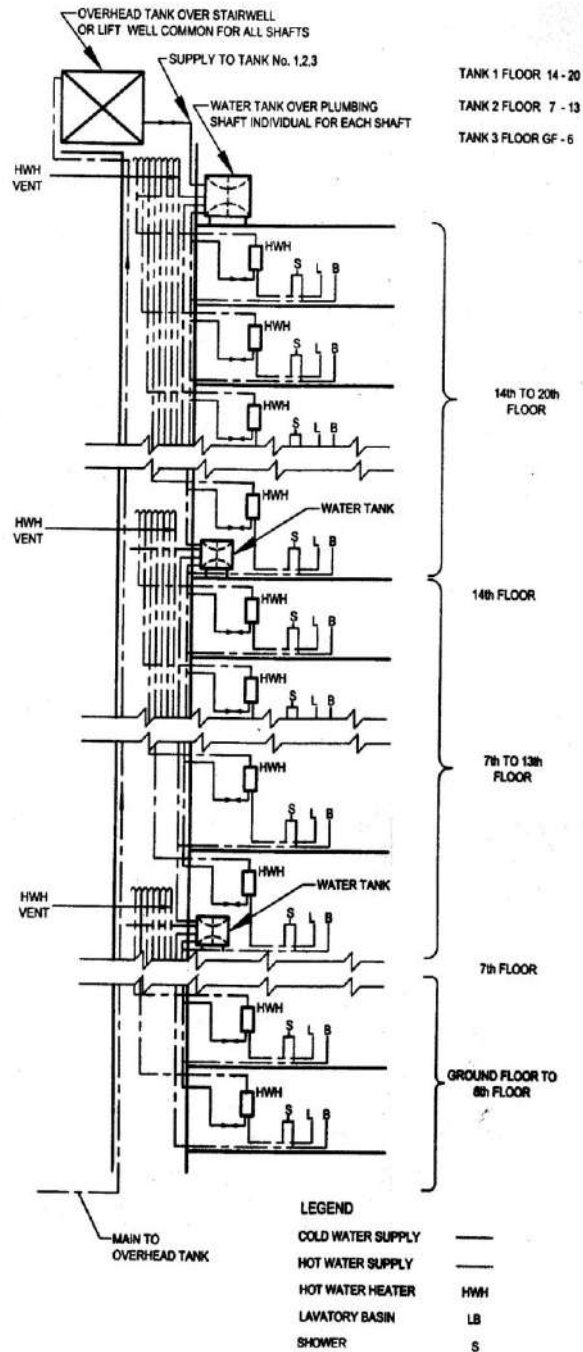


FIG. 10 INSTALLATION FOR 20 – STOREYED BUILDING

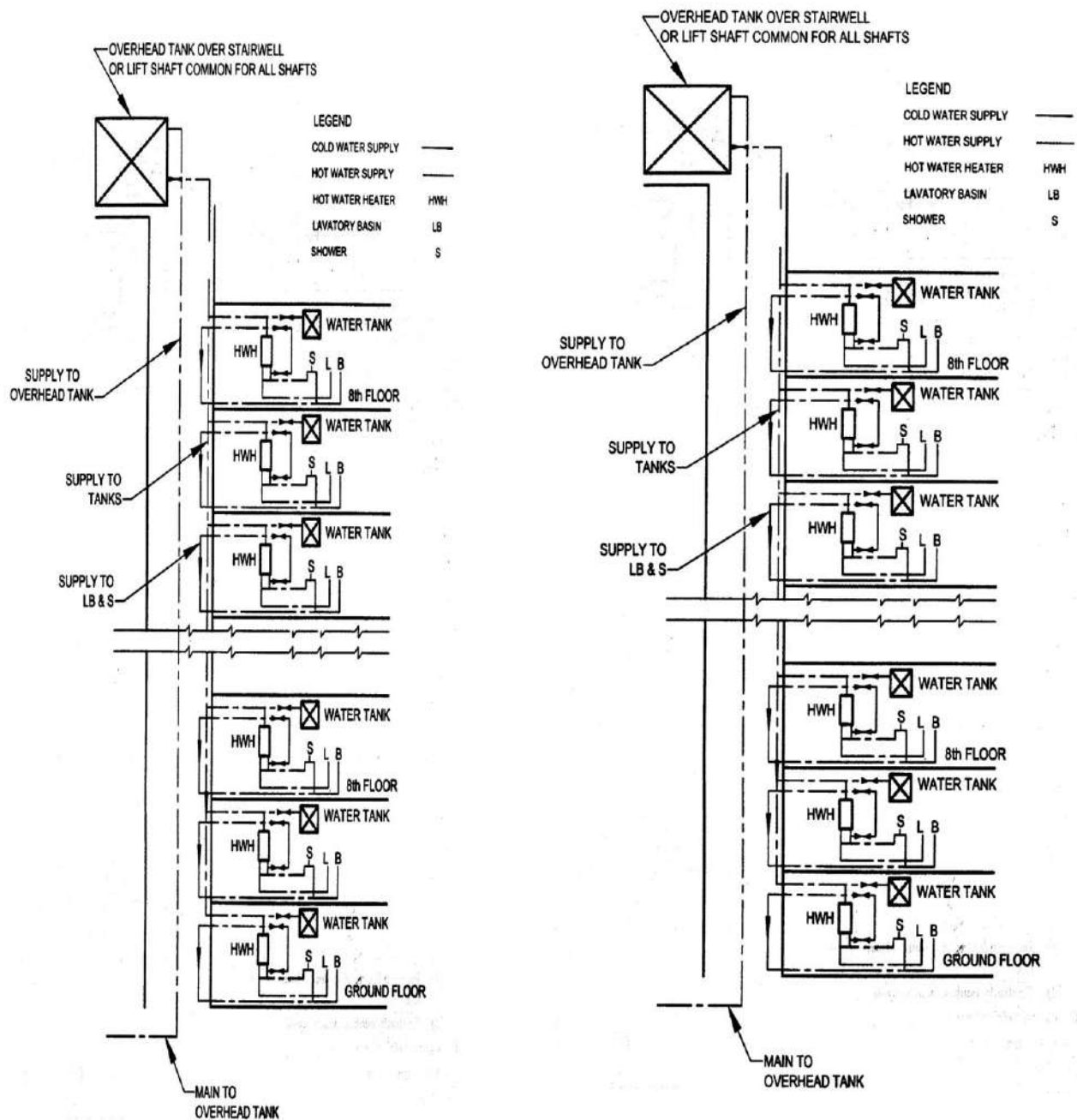


**FIG. 11 INSTALLATION FOR 8 – STOREYED BUILDING
WITH INDIVIDUAL WATER TANKS**

Table 8: Maximum Permissible Lengths of Hot Water Draw-off Pipes*(Clause 4.13.12.2.3)*

SI NO. (1)	Largest Internal Diameter of Pipe (2)	Length, feet (3)
i)	Not exceeding $\frac{3}{4}$ inch	40'
ii)	Exceeding $\frac{3}{4}$ inch but not exceeding 1 inch	15'
iii)	Exceeding 1 inch	10'
NOTE – In the case of a composite pipe of different diameters, the largest diameter is to be taken into consideration for the purpose of this table.		

5D.4.13.12.2.4

Wherever mixing of hot and cold water is done by a mixing fitting, that is, hot and cold stop-cocks deliver to a common outlet of mixed water (that is, showers, basin or bath supply fittings), the pressure in the cold and hot water systems shall be equal. This can be achieved by connecting the cold water supply from an overhead tank at the same static height as the overhead tank supplying cold water to the hot water heaters. In case this is not possible, hot and cold water should be supplied to the fixtures by separate supply taps.

5D.4.13.13 Types of Hot Water Heaters

The various types of water heaters used for preparation of hot water are as follows:

a) Electric Storage Heaters:

- (1) Non-pressure or open outlet type,
- (2) Pressure type,
- (3) Cistern type, and
- (4) Dual heater type.

b) Gas Water Heaters:

- (1) Instantaneous type, and
- (2) Storage type.

c) Solar Heating Systems:

- (1) Independent roof mounted heating units, and
- (2) Centrally banked heated system.

d) Central Hot Water System

- (1) Oil fired, and
- (2) Gas fired.

5D.4.13.13.1

The quality and construction of the different types of hot water heaters shall be in accordance with good practice [9-1(15)].

5D.4.13.13.2 Typical arrangement of water heater is shown in Fig. 12.

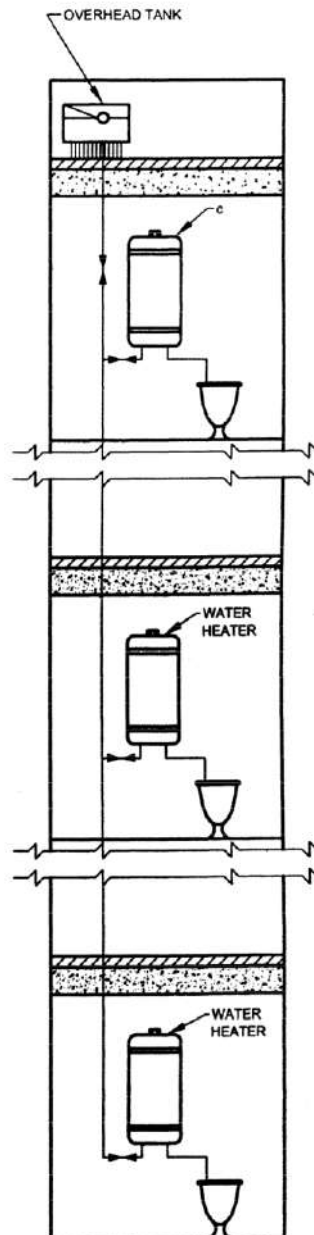


FIG. 12 NON – PRESSURE TYPE INSTALLATION

5D.4.13.13.3

Requirements in regard to inspection and maintenance of hot water supply installations shall be in accordance with 4.14.1 to 4.14.4.

5D.4.14 Inspection and Testing

5D.4.14.1 Testing of Mains Before Commencing Work

All pipes, fittings and appliances shall be inspected, before delivery at the site to see whether they conform to accepted standards. All pipes and fittings shall be inspected and tested by the manufacturers at their factory and shall comply with the requirements of this Section. They shall be tested hydraulically under a pressure equal to 1.5 times this maximum permissible working pressure or under such greater pressure as may be specified. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.

5D.4.14.2 Testing of Mains After Laying

After laying and jointing, the main shall be slowly and carefully charged with water by providing a 1 inch inlet with a stop-cock, so that all air is expelled from the main. The main is then allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 168 ft or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or, in the case of long mains or mains of a large diameter, by a power-driven test pump, provided the pump is not left unattended. In either case, due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauges shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable loss for at least 5 min. The mains shall be tested in sections as the work of laying proceeds; it is an advantage to have the joints exposed for inspection during the testing. The open end of the main may be temporarily closed for testing under moderate pressure by fitting a water-tight expanding plug of which several types are available. The end of the main and the plug shall be secured by struts or otherwise, to resist the end thrust of the water pressure in the mains.

5D.4.14.2.1

If the section of the main tested terminates into a sluice valve, the wedge of the valve shall not be used to retain the water; instead the valve shall be temporarily fitted with a blank flange, or, in the case of a socketed valve, with a plug, and the wedge placed in the open position while testing. End support shall be given as in 4.14.2.

5D.4.14.3 Testing of Service Pipes and Fittings

When the service pipe is complete, it shall be slowly and carefully charged with water, allowing all air to escape, care being taken to avoid all shock or water hammer. The service pipe shall then be inspected under working conditions of pressure and flow. When all draw-offs taps are closed, the service pipe shall be absolutely water-tight. All piping, fittings and appliances shall be checked for

satisfactory support, and protection from damage, corrosion and frost. Because of the possibility of damage in transit, cisterns shall be re-tested for water-tightness on arrival at the site, before fixing.

5D.4.14.4

In addition to the provisions given in **4.14.1**, provisions given in **4.14.4.1** to **4.14.4.3** shall also apply to hot water supply installations in regard to inspection and testing.

5D.4.14.4.1 Testing of the system after installation

After the hot water system, including the hot water heaters, has been installed, it shall be carefully charged with water, so that all air is expelled from the system. The entire system shall then be hydraulically tested to a pressure of 168 ft or twice the working pressure, whichever is greater, for a period of at least half an hour after a steady state is reached. The entire installation shall then be inspected visually for leakages, and sweating. All defects found shall be rectified by removing and remaking the particular section. Caulking of threads, hammering and welding of leaking joints shall not be allowed.

5D.4.14.4.2 Hot water testing

After the system has been proved water-tight, the hot water heaters shall be commissioned by connecting the same to the electrical supply. The system shall then be observed for leakage in pipes due to expansion or overheating. The temperature of water at outlets shall be recorded. The thermostats of the appliances shall be checked and adjusted to temperatures specified in **5D.4.13.2.1**.

5D.4.14.4.3 Electrical connection

For relevant provisions regarding general and safety requirements for household and similar electrical appliances, reference may be made to good practice [9-1(14)]. The metal work of the water heating appliances and installation other than current carrying parts shall be bonded and earthed in conformity with the good practice [9-1(14)]. It should be noted that screwing of an immersion heater into a tank or cylinder cannot be relied upon to effect a low resistance earth connection, a satisfactory separate earthing of heater should be effected.

5D.4.15 Cleaning and Disinfection of the Supply System

5D.4.15.1

All water mains communications pipes, service pipes and pipes used for distribution of water for domestic purposes shall be thoroughly and efficiently disinfected before being taken into use and also after every major repair. The method of disinfection shall be subject to the approval of the Authority. The pipes shall also be periodically cleaned at intervals, depending upon the quality of water, communication pipes and the storage cisterns shall be thoroughly cleaned at least once every year in order to remove any suspended impurities that may have settled in the pipes or the tanks.

5D.4.15.2 Disinfection of Storage Tanks and Downtake Distribution Pipes

The storage tanks and pipes shall first be filled with water and thoroughly flushed out. The storage tank shall then be filled with water again and a disinfecting chemical containing chlorine added gradually while the tanks are being filled, to ensure thorough mixing. Sufficient quantities of chemicals shall be used to give the water a dose of 50 parts of chlorine to one million parts of water. If ordinary bleaching powder is used, the proportions will be 0.33 lb of powder to 220 gallons of water. The powder shall be mixed with water to a creamy consistency before being added to the water in the storage tank. When the storage tank is full, the supply shall be stopped and all the taps on the distributing pipes opened successively working progressively away from the storage tank. Each tap shall be closed when the water discharged begins to smell of chlorine. The storage tank shall then be topped up with water from the supply pipe and with more disinfecting chemical in the recommended proportions. The storage tank and pipes shall then remain charged for at least 3 hours. Finally, the tank and pipes shall be thoroughly flushed out before any water is used for domestic purposes.

5D.4.16 Water Supply Systems in High Altitudes and/ or Sub-zero Temperature Regions

5D.4.16.1 Selection and Source

In general, the site selected for a water source shall be such as to minimize the length of transmission line so as to reduce the inspection and upkeep. Attempt shall be made, where feasible, to locate the source near the discharge of waste heat, such as of power plants provided it does not affect the potability of water.

5D.4.16.2 Pumping Installation

Pump and pumping machinery shall be housed inside well-insulated chambers. Where necessary, arrangements shall be made for heating the inside of pump houses. Pump houses, as far as possible, should be built directly above the water intake structures.

5D.4.16.3 Protection of Storage Water and Treatment

Where ambient temperatures are so low as to cause danger of freezing, proper housing, insulation and protection shall be provided for all processes and equipment. If necessary, means shall be provided for proper heating of the enclosure.

5D.4.16.4 Transmission and Distribution

Freezing of the buried pipe may be avoided primarily by laying the pipe below the level of the frost line; well consolidated bedding of clean earth or sand, under, around or over the pipe should be provided. For the efficient operation and design of transmission and distribution work, the available heat in the water shall be economically utilized and controlled. If the heat which is naturally present in water is made equate to satisfy heat losses from the system, the water shall be warmed. Where economically feasible, certain faucets on the distribution system may be kept in a slightly dripping condition so as to keep the fluid in motion and thus prevent is freezing. If found unsuitable for drinking purposes, such water may be used for heating purposes. Heat losses shall be reduced by insulation, if necessary. Any material that will catch, absorb or hold moisture shall not be used for

insulation purposes. Adequate number of break pressure water tanks and air release valves shall be provided in the distribution system.

NOTE — The level of frost line is generally found to be between 3 ft and 4 ft below ground level in the northern regions of MYANMAR, wherever freezing occurs.

5D.4.16.4.1 Materials for pipes

Distribution pipes shall be made of any of the following materials conforming to Part 5 'Building Materials':

- (a) high density polyethylene pipes,
- (b) asbestos cement pipes,
- (c) galvanized iron pipes,
- (d) cast iron pipes, and
- (e) unplasticized PVC pipes (where it is laid before frost line).

5D.4.16.4.2 Materials for insulation of pipes

The normal practice in MYANMAR is to surround the pipe with straw, grass or jute wrapped over with gunny and painted with bitumen; alternatively, other materials, like 85 percent magnesia, glass wool, etc, or with the approval of the Authority may also be used.

5D.4.16.4.3 Distribution methods

Distribution by barrels or tank trucks shall be employed, where the water requirements are temporary and small. Utmost care shall be exercised for preventing the water from being contaminated by maintaining a residual of disinfecting agent at all times. Hoses, pails and the tank shall be kept free from dust and filth during all period of operation. Where winter temperatures are low, making frost penetration depths greater during the winter, and where adequate facilities for heating the water in the distribution system do not exist, the use of tank trucks or barrels for delivery of water shall be considered only for cold weather; during the warm weather, piping system for seasonal use may be supplemented.

5D.4.16.4.4

In the conventional distribution system involving the use of a network of pipelines requiring no auxiliary heat, it is essential that the pipelines are buried well below the frost line. Adequate facilities for draining the pipelines shall be provided where there is a danger of frost.

5D.4.16.4.5 House service connections

House service connections shall be kept operative by the use of adequate insulation at exposed places extending below the frost line. Figure 10 shows a typical arrangement for providing insulation for house service connections.

5D.4.16.5

For detailed information on planning and designing water supply system peculiar to high altitudes and/or sub-zero temperature regions of the country, reference may be made to good practice [9-1(16)].

5D.4.17 Guidelines to Maintenance

5D.4.17.1

Storage tanks shall be regularly inspected and shall be cleaned out periodically, if necessary. Tanks showing signs of corrosion shall be emptied, thoroughly wire brushed to remove loose material (but not scraped), cleaned and coated with suitable bituminous compositions or other suitable anti-corrosive material not liable to impart taste or odor or otherwise contaminate the water. Before cleaning the cistern, the outlets shall be plugged to prevent debris from entering the pipes. Tanks shall be examined for metal wastage and water tightness after cleaning.

5D.4.17.2

Record drawings showing pipe layout and valve positions shall be kept up to date and inspection undertaken to ensure that any maintenance work has not introduced cross-connections or any other undesirable feature. Any addition or alterations to the systems shall be duly recorded from time-to-time.

5D.4.17.3

Any temporary attachment fixed to a tap or outlet shall never be left in such a position that back-siphonage of polluted water may occur into the supply system.

5D.4.17.4

All valves shall periodically be operated to maintain free movement of the working parts.

5D.4.17.5

All taps and ball valves shall be watertight, glands shall be made good, washers shall be replaced and the mechanism of spring operated taps and ball valves shall be repaired where required.

5D.4.17.6

All overflow pipes shall be examined and kept free from obstructions.

5D.4.17.7

The electrical installation shall be checked for earth continuity and any defects or deficiencies corrected in the case of hot water supply installations.

5D.5 DRAINAGE AND SANITATION

5D.5.1 Types of Sanitary Appliances

5D.5.1.1 Soil Appliances

5D.5.1.1.1 Water-closet

It shall essentially consist of a closet consisting of a bowl to receive excretory matter, trap and a flushing apparatus. It is recommended to provide ablution tap adjacent to the water-closet, preferably on right hand side wall. The various types/style of water-closets may be:

- a) Squatting Indian type water closet,
- b) Washdown type water closet,
- c) Siphonic washdown type water closet, and
- d) Universal or Anglo-Indian water closet.

5D.5.1.1.2 Bidet

It is provided with hot and cold water connection. The bidet outlet should essentially connect to soil pipe in a two-pipe system.

5D.5.1.1.3 Urinal

It is a soil appliance and is connected to soil pipe after a suitable trap. Urinal should have adequate provision of flushing apparatus. The various types/style of urinal may be:

- a) Bowl type urinal: Flat back or Angle back,
- b) Slab (single) type urinal,
- c) Stall (single) type urinal,
- d) Squatting plate type urinal, and
- e) Syphon jet urinal with integral trap.

5D.5.1.1.4 Slop sink and bed pan sink

Slop sink is a large sink of square shape. The appliance is used in hospitals installed in the nurse's station, operation theatres and similar locations for disposal of excreta and other foul waste for washing bed pans and urine bottles/pans. It is provided with a flushing mechanism.

5D.5.1.2 Waste Appliances

5D.5.1.2.1 Washbasin

It is of one piece construction having a combined overflow and preferably should have soap holding recess or recesses that should properly drain into the bowl. Each basin shall have circular waste hole through which the liquid content of the basin shall drain.

5D.5.1.2.2 Wash-trough

It is a linear trough for simultaneous use by number of persons.

5D.5.1.2.3 Sink

It is used in kitchen and laboratory for the purpose of cleaning utensils/apparatus and also serve the purpose of providing water for general usage. The sink may be made with or without overflow arrangement. The sink shall be of one piece construction including combined over flow, where provided. The sink shall have a circular waste hole into which the interiors of the sink shall drain.

5D.5.1.2.4 Bath tub

Bath tub may be of enameled steel, cast iron, gel- coated, glass fibre reinforced plastic or may be cast *in-situ*. It shall be stable, comfortable, easy to get in and out, water tight, with anti-skid base, and easy to install and maintain. The bath tub shall be fitted with overflow and waste pipe of nominal diameter of not less than 1.25 inches and 1.5 inches respectively.

5D.5.1.2.5 Drinking fountain

It is a bowl fitted with a push button tap and a water bubbler or a tap with a swan neck outlet fitting. It has a waste fitting, a trap and is connected to the waste pipe.

5D.5.1.3

The requirements of various soil appliances and waste appliances shall be in accordance with accepted standards [9-1(17)].

5D.5.2 Drainage and Sanitation Requirements

5D.5.2.1 General

There should be at least one water tap and arrangement for drainage in the vicinity of each water-closet or group of water-closet in all the buildings.

5D.5.2.2

Each family dwelling unit on premises (abutting on a sewer or with a private sewage disposal system) shall have, at least, one water-closet and one kitchen type sink. A bath or shower shall also be installed to meet the basic requirements of sanitation and personal hygiene.

5D.5.2.3

All other structures for human occupancy or use on premises, abutting on a sewer or with a private sewage-disposal system, shall have adequate sanitary facilities, but in no case less than one water-closet and one other fixture for cleaning purposes.

5D.5.2.4 For Residences

5D.5.2.4.1

Dwelling with individual convenience shall have at least the following fitments:

- a) One bathroom provided with a tap and a floor trap;

- b) One water-closet with flushing apparatus with an ablution tap; and
- c) One tap with a floor trap or a sink in kitchen or wash place.

5D.5.2.4.1.1

Where only one water-closet is provided in a dwelling, the bath and water-closet *desirably* shall be separately accommodated.

NOTE — Water-closets, unless indicated otherwise, shall be of Indian style (squatting type).

5D.5.2.4.2

Dwellings without individual conveniences shall have the following fitments:

- a) One water tap with floor trap in each tenement,
- b) One water-closet with flushing apparatus and one ablution tap bath
for every two tenements, and
- c) One bath with water tap and floor trap for every two tenements.

5D.5.2.5 For Buildings Other than Residences

5D.5.2.5.1

The requirements for fitments for drainage and sanitation in the case of buildings other than residences shall be in accordance with Table 9 to Table 22. The following shall be, in addition, taken into consideration:

- a) The figures shown are based upon one (1) fixture being the minimum
required for the number of persons indicated or part thereof.
- b) Building categories not included in the tables shall be considered separately by the Authority.
- c) Drinking fountains shall not be installed in the toilets.
- d) Where there is the danger of exposure to skin contamination with poisonous, infectious or irritating material, washbasin with eye wash jet and an emergency shower located in an area accessible at all times with the passage/ right of way suitable for access to a wheel chair, shall be provided.
- e) When applying the provision of these tables for providing the number of fixtures, consideration shall be given to the accessibility of the fixtures. Using purely numerical basis may not result in an installation suited to the need of a specific building. For example, schools should be provided with toilet facilities on each floor. Similarly toilet facilities shall be provided for temporary workmen employed in any establishment according to the needs; and in any case one WC and one washbasin shall be provided.

- f) All buildings used for human habitation for dwelling, work, occupation, medical care or any purpose detailed in the various tables, abutting a public sewer or a private sewage disposal system, shall be provided with minimum sanitary facilities as per the schedule in the tables. In case the disposal facilities are not available, they shall be provided as a part of the building design for ensuring high standards of sanitary conditions in accordance with this section. The location of the facility or facilities shall be selected with due regard given to health, sanitary and environment requirements, within the building's jurisdiction.
- g) Workplaces where crèches are provided, they shall be provided with one WC for 10 persons or part thereof, one washbasin for 15 persons or part thereof, one kitchen sink with floor trap for preparing food/milk preparations. The sink provided shall with a drinking water tap.
- h) In all types of buildings, individual toilets and pantry should be provided for executives, and for meeting/seminar/conference rooms, etc as per the user requirement.
- j) Where food is consumed indoors, water stations may be provided in place of drinking water fountains.

Table 9 Office Buildings
(Clause 5.2.5.1)

Sl No	Fixtures	Public Toilets		Staff Toilets	
		Male	Females	Male	Females
(1)	(2)	(3)	(4)	(5)	(6)
i)	Executive Rooms and Conference Halls in Office Buildings Toilet suite comprising one WC, one washbasin (with optional shower stall if building is used round the clock at user's option) Pantry optional as per user requirement	Unit could be common for Male/Female or separate depending on the number of user of each facility		For individual officer rooms	
ii)	Main Office Toilets for Staff and Visitors				
a)	Water-closets	1 per 25	1 per 15	1 per 25	1 per 15
b)	Ablution tap with each water-closet	1 in each water-closet			
c)	Urinals	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100 101-200 Over 200	—	Nil up to 6	—
	Add @ 3% for Add @ 2.5 %				
d)	Washbasins	1 per 25	1 per 25	1 per 25	1 per 25
e)	Drinking water fountain	1 per 100	1 per 100	1 per 100	1 per 100
f)	Cleaner's sink	1 per floor			
g)	WC for the Disabled persons	At least one male WC / one female WC (or) unisex WC per floor			

Table 10 Factories
(Clause 5.2.5.1)

Sl No	Fixtures	Offices/Visitors		Workers	
		Male	Female	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water-closets (Workers & Staff)	1 for up to 25 2 for 16-35 3 for 36-65 4 for 66-100	1 for up to 15 2 for 16-25 3 for 26-40 4 for 41-57 5 for 58-77 6 for 78-100	1 for up to 15 2 for 16-35 3 for 36-65 4 for 66-100	1 for up to 12 2 for 13-25 3 for 26-40 4 for 41-57 5 for 58-77 6 for 78-100
	For persons 101-200 add	3%	5%	3%	5%
	For persons over 200 add	2.5%	4%	2.50%	4%
ii)	Ablution tap	1 in each water-closet	1 in each water-closet	1 in each water-closet	1 in each water-closet
iii)	Urinals	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100	—	Nil up to 6 1 for 7-20 2 for 21-45 3 for 46-70 4 for 71-100	—
	For persons 101-200 add	3%		3%	
	For persons over 200 add	2.50%		2.50%	
iv)	Washbasins	1 per 25 or part thereof	1 per 25 or part thereof	1 per 25 or part thereof	1 per 25 or part thereof
	Washbasins in rows or troughs and taps spaced 750 mm c/c				
v)	Drinking water fountain	1 per every 100 or part thereof with minimum one on each floor		1 per every 100 or part thereof with minimum one on each floor	
vi)	Cleaner's sink	1 on each floor	1 on each floor	1 on each floor	1 on each floor
vii)	Showers/Bathing rooms	As per trade requirements			
viii)	Emergency shower and eye wash fountain	—	—	1 per every shop floor per 500 persons	
ix)	WC for the Disabled persons	At least one male WC / one female WC (or) unisex WC per floor			

NOTE — For factories requiring workers to be engaged in dirty and dangerous operations or requiring them to be extremely clean and sanitized conditions additional and separate (if required so) toilet facilities and if required by applicable Industrial and Safety Laws and the *Factories Act* must be provided in consultation with the user.

Table 11 Cinema, Multiplex Cinema, Concerts and Convention Halls, Theatres
(Clause 5.2.5.1)

Sl No.	Fixtures	Public		Staff	
		Male	Female	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water-closets	1 per 100 up to 400 Over 400 add at 1 per 250 or part thereof	3 per 100 up to 200 Over 200 add at 2 per 100 or part thereof	1 for up to 15	1 for up to 12
ii)	Ablution tap	1 in each water-closet	1 in each water-closet	1 in each water-closet	1 in each water-closet
		1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals			
iii)	Urinals	1 per 25 or part thereof	—	Nil up to 6 1 for 7-20 2 for 21-45	—
iv)	Washbasins	1 per 200 or part thereof		1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
v)	Drinking water fountain	← 1 per 100 persons or part thereof →			
vi)	Cleaner's sink	← 1 per floor →			
vii)	Showers/Bathing rooms	← As per trade requirements →			
viii)	WC for the Disabled persons	At least one male WC / one female WC (or) unisex WC per floor			

NOTES

1 Some WCs may be European style if desired.

2 Male population may be assumed as two-third and female population as one-third.

Table 12 Art Galleries, Libraries and Museums
(Clause 5.2.5.1)

Sl No.	Fixtures	Public		Staff	
		Male	Female	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water-closets	1 per 200 up to 400 Over 400 add at 1 per 250 or part thereof	1 per 100 up to 200 Over 200 add at 1 per 150 or part thereof	1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
ii)	Ablution tap	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet
		1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals			
iii)	Urinals	1 per 50	—	Nil up to 6 1 per 7 to 20 2 per 21-45	—
iv)	Washbasins	1 for every 200 or part thereof. For over 400, add at 1 per 250 persons or part thereof	1 for every 200 or part thereof. For over 200, add at 1 per 150 persons or part thereof	1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
v)	Drinking water fountain	← 1 per 100 persons or part thereof →			
vi)	Cleaner's sink	← 1 per floor, Min →			
vii)	Showers/Bathing rooms	← As per requirements →			
viii)	WC for the Disabled persons	At least one male WC / one female WC (or) unisex WC per floor			

NOTES

1 Some WC's may be European style if desired.

2 Male population may be assumed as two-third and female population as one-third.

Table 13 Hospitals with Indoor Patient Wards
(Clause 5.2.5.1)

Sl No.	Fixtures	Patient Toilets		Staff Toilets	
		Male (3)	Female (4)	Male (5)	Female (6)
(1)	(2)				
i)	Toilet suite comprising one WC and one washbasin and shower stall	Private room with up to 4 patients		For individual doctor/staff officer's rooms	
For General Wards, Hospital Staff and Visitors					
ii)	Water-closets	1 per 8 beds or part thereof	1 per 8 beds or part thereof	1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
iii)	Abution tap	One in each water-closet 1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals	One in each water-closet	One in each water-closet	One in each water-closet
iv)	Urinals	1 per 30 beds	—	Nil up to 6 1 for 7 to 20 2 for 21-45	—
v)	Washbasins	2 for every 30 beds or part thereof. Add 1 per additional 30 beds or part thereof	—	1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
vi)	Drinking water fountain	1 per ward		1 per 100 persons or part thereof	
vii)	Cleaner's sink	1 per ward		—	
viii)	Bed pan sink	1 per ward		—	
ix)	Kitchen sink	1 per ward		—	
x)	WC for Disabled persons	At least one male WC/one female WC or unisex WC per floor			
NOTES					
1. Some WC's may be European style if desired.					
2. Male population may be assumed as two-third and female population as one-third.					
3. Provision for additional and special hospital fittings where required shall be made.					

Table 14 Hospitals Outdoor Patient Department
(Clause 5.2.5.1)

Sl No.	Fixtures	Patient Toilets		Staff Toilets	
		Male	Female	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Toilet suite comprising one WC and one washbasin (with optional shower stall if building used for 24 h)	For up to 4 patients		For individual doctor/staff officer's rooms	
ii)	Water-closets	1 per 100 persons or part thereof	2 per 100 persons or part thereof	1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
iii)	Abution tap	One in each water-closet 1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals	One in each water-closet	One in each water-closet	One in each water-closet
iv)	Urinals	1 per 30 persons or part thereof	—	Nil up to 6 1 for 7 to 20 2 for 21-45	—
v)	Washbasins	1 per 100 persons or part thereof	2 per 100 persons or part thereof	1 for up to 15 2 for 16-35	1 for up to 12 2 for 13-25
vi)	Drinking water fountain	1 per 500 persons or part thereof		1 per 100 persons or part thereof	
vii)	WC for Disabled Persons	At Least one male WC/one female WC or unisex WC per floor			
NOTES					
1. Some WC's may be European style if desired.					
2. Male population may be assumed as two-third and female population as one-third.					
3. Provision for additional and special hospital fittings where required shall be made.					

Table 15 Hospitals, Administrative Buildings
(Clause 5.2.5.1)

Sl No.	Fixtures	Staff Toilets	
		Male	Female
(1)	(2)	(3)	(4)
i)	Toilet suite comprising one WC and one washbasin (with optional shower stall if building used for 24 h)	For individual doctor's/officer's rooms	
ii)	Water-closets	1 per 25 persons or part thereof	1 per 15 persons or part thereof
iii)	Ablution tap	One in each water-closet 1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals	One in each water-closet
iv)	Urinals	Nil up to 6 1 for 7 to 20 2 for 21-45	—
v)	Washbasins	1 per 25 persons or part thereof	1 per 25 persons or part thereof
vi)	Drinking water fountain	1 per 100 persons or part thereof	
vii)	Cleaner's sink	1 per floor, <i>Atls</i>	
viii)	Kitchen sink	1 per floor, <i>Mis</i>	
ix)	WC for the Disabled person	At least one male WC/one female WC (or) unisex WC per floor	
NOTE — Some WC's may be European style if desired.			

Table 16 Hospitals Staff Quarters and Nurses Homes
(Clause 5.2.5.1)

Sl No.	Fixtures	Staff Quarters		Nurses Homes	
		Male	Female	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water-closets	1 per 4 persons or part thereof	1 per 4 persons or part thereof	1 per 4 persons or part thereof 2 for 16-35	1 per 4 persons or part thereof 2 for 13-25
ii)	Ablution tap	One in each water-closet 1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals	One in each water-closet	One in each water-closet	One in each water-closet
iii)	Washbasins	1 per 8 persons or part thereof		1 per 8 persons or part thereof	
iv)	Bath (Showers)	1 per 4 persons or part thereof		1 per 4 to 6 persons or part thereof	
v)	Drinking water fountain	1 per 100 persons or part thereof, minimum 1 per floor		1 per 100 persons or part thereof, minimum 1 per floor	
vi)	Cleaner's sink	1 per Floor		1 per Floor	

NOTES

1 Some WC's may be European style if desired.

2 For independent housing units fixtures shall be provided as for residences.

Table 17 Hotels
(Clause 5.2.5.1)

Sl No.	Fixtures	Public Rooms		Non-Residential Staff	
		Male (3)	Female (4)	Male (5)	Female (6)
(1)	(2)				
i)	Toilet suite comprising one WC, Washbasin with Shower or a Bath tub	Individual guest rooms with attached toilets			—
Guest Rooms with Common Facilities					
ii)	Water-closets	1 per 100 persons up to 400 Over 400 add at 1 per 250 or part thereof	2 per 100 persons up to 200 Over 200 add at 1 per 100 or part thereof	1 for up to 15 2 for 16-35 3 for 36-65 4 for 66-100	1 for up to 12 2 for 13-25 3 for 26-40 4 for 41-57 5 for 58-77 6 for 78-100
iii)	Ablution tap	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet
1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals.					
iv)	Urinals	1 per 50 persons or part thereof	—	Nil up to 6 1 for 7 to 20 2 for 21-45 3 for 46-70 4 for 71-100	—
v)	Washbasins	1 per WC/Urinal	1 per WC	1 for up to 15 2 for 16-35 3 for 36-65 4 for 66-100	1 for up to 12 2 for 13-25 3 for 26-40 4 for 41-57
vi)	Bath (Showers)	1 per 10 persons or part thereof		—	—
vii)	Cleaner's sink	1 per 30 rooms, minimum 1 per floor			
viii)	Kitchen sink	1 per kitchen			
ix)	WC for the Disabled persons	At least one male WC / one female WC (or) unisex WC per floor			
NOTES					
1 Some WC's may be European style if desired					
2 Male population may be assumed as two-third and female population as one-third.					
3 Provision for additional and special fittings where required shall be made.					

Table 18 Restaurants
(Clause 5.2.5.1)

Sl No.	Fixtures	Public Rooms		Non-Residential Staff	
		Male (3)	Female (4)	Male (5)	Female (6)
i)	Water-closets	1 per 50 seats up to 200 Over 200 add at 1 per 100 or part thereof	2 per 50 seats up to 200 Over 200 add at 1 per 100 or part thereof	1 for up to 15 2 for 16-35 3 for 36-65 4 for 66-100	1 for up to 12 2 for 13-25 3 for 26-40 4 for 41-57 5 for 58-77 6 for 78-100
ii)	Ablution tap	One in each water-closet 1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals	One in each water-closet	One in each water-closet	One in each water-closet
iii)	Urinals	1 per 50 persons or part thereof	—	Nil up to 6 1 for 7 to 20 2 for 21-45 3 for 46-70 4 for 71-100	—
iv)	Washbasins	1 per WC	1 per WC	1 per WC	1 per WC
v)	Cleaner's sink	1 per each restaurant			
vi)	Kitchen sink/Dish washer	1 per kitchen			
vii)	WC for the Disabled persons	At least one male WC / one female WC (or) unisex WC per floor			
NOTES					
1 Some WC's may be European style if desired					
2 Male population may be assumed as two-third and female population as one-third.					
3 Provision for additional and special fittings where required shall be made.					

Table 19 Schools and Educational Institutions

(Clause 5.2.5.1)

Sl No.	Fixtures	Nursery School	Non-Residential		Residential	
			Boys	Girls	Boys	Girls
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Water-closets	1 per 15 pupils or part thereof	1 per 40 pupils or part thereof	1 per 25 pupils or part thereof	1 per 8 pupils or part thereof	1 per 6 pupils or part thereof
ii)	Ablution tap	One in each water-closet 1 water tap with draining arrangements shall be provided for every 50 persons or part thereof in the vicinity of water-closets and urinals	One in each water-closet	One in each water-closet	One in each water-closet	One in each water-closet
iii)	Urinals	—	1 per 20 pupils or part thereof	—	1 per 25 pupils or part thereof	—
iv)	Washbasins	1 per 15 pupils or part thereof	1 per 60 pupils or part thereof	1 per 40 pupils or part thereof	1 per 8 pupils or part thereof	1 per 6 pupils or part thereof
v)	Bath/Showers	1 per 40 pupils or part thereof	—	—	1 per 8 pupils or part thereof	1 per 6 pupils or part thereof
vi)	Drinking water fountain or taps	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof	1 per 50 pupils or part thereof
vii)	Cleaner's sink				1 per each floor	
viii)	WC for Disabled persons	At least one male WC / one female WC (or) unisex WC per floor				
NOTES						
1 Some WC's may be European style if desired.						
2 For teaching staff, the schedule of fixtures to be provided shall be the same as in case of office building.						

Table 20 Hostels

(Clause 5.2.5.1)

[illegible]

5D.5.3 Materials, Fittings and Appliances

5D.5.3.1 Standards for Materials, Fittings and Sanitary Appliances

All materials, fittings and sanitary appliances shall conform to Part 5 'Building Materials'.

5D.5.3.2 Choice of Material for Pipes

5D.5.3.2.1 Salt glazed stoneware pipe

For all sewers and drains in all soils, except where supports are required as in made-up ground, glazed stoneware pipe shall be used as far as possible in preference to other types of pipes. These pipes are particularly suitable where acid effluents or acid subsoil conditions are likely to be encountered. Salt glazed stoneware pipes shall conform to accepted standards [9-1(18)].

5D.5.3.2.2 Cement concrete pipes

When properly ventilated, cement concrete pipes with spigot and socket or collar joints present an alternative to glazed stoneware sewers of over 6 inches diameter. These shall not be used to carry acid effluents or sewage under conditions favourable for the production of hydrogen sulphide and shall not be laid in those sub soils that are likely to affect adversely the quality or strength of concrete. Owing to the longer lengths of pipes available, the joints would be lesser in the case of cements concrete pipes. These pipes may be used for surface water drains in all diameters. Cement concrete pipes shall conform to accepted standards [9-1(19)].

5D.5.3.2.3 Cast iron pipes

5D.5.3.2.3.1

These pipes shall be used in the following situation:

- a) in bed or unstable ground where soil movement is expected;
- b) in-made-up or tipped ground;
- c) to provide for increased strength where a sewer is laid at insufficient depth, where it is exposed or where it has to be carried on piers or above ground;
- d) under buildings and where pipes are suspended in basements
and like situations;
- e) in reaches where the velocity is more than 9 ft/s; and
- f) for crossings of watercourses.

NOTE — In difficult foundation condition such as in the case of black cotton soil, the cast iron pipes shall be used only when suitable supporting arrangements are made.

5D.5.3.2.3.2

It shall be noted that cast iron pipes even when given a protective paint are liable to severe external corrosion in certain soils; among such soils are:

- a) soils permeated by peaty waters; and
- b) soils in which the sub-soil contains appreciable concentrations of sulphates. Local experiences shall be ascertained before cast iron pipes are used where corrosive soil conditions are suspected. Where so used, suitable measures for the protection of the pipes may be resorted to as an adequate safeguard.

5D.5.3.2.3.3

Cast iron pipes shall conform to accepted standards [9-1(20)].

5D.5.3.2.4 Asbestos cement pipes

Asbestos cement pipes are commonly used for house drainage systems and they shall conform to accepted standards [9-1(21)]. They are not recommended for underground situations. However, asbestos cement pressure pipes conforming to accepted standards [9-1(21)] may be used in underground situations also, provided they are not subject to heavy superimposed loads. These shall not be used to carry acid effluents or sewage under conditions favourable for the production of hydrogen sulphide and shall not be laid in those sub-soils which are likely to affect adversely the quality or strength of asbestos cement pipes. Where so desired, the life of asbestos cement pipes may be increased by lining inside of the pipe with suitable coatings like epoxy/polyester resins etc.

5D.5.3.2.5 PVC pipes

Unplasticized PVC pipes may be used for drainage purposes; however, where hot water discharge is anticipated, the wall thickness shall be minimum 0.1inches irrespective of the size and flow load.

PVC and HDPE pipes shall conform to accepted standards [9-1(23)].

NOTE — Where possible, high density polyethylene pipes (HDPE) and PVC pipes may be used for drainage and sanitation purposes, depending upon the suitability.

5D.5.4 Preliminary Data for Design

5D.5.4.1 General

Before the drainage system for a building or group of buildings is designed and constructed, accurate information regarding the site conditions is essential. This information may vary with the individual scheme but shall, in general, be covered by the following:

- (a) Site Plan (see 5D.3.3.2).
- (b) Drainage Plan (see 5D.3.3.3).

- (c) Use — A description of the use for which the building is intended and periods of occupation in order that peak discharges may be estimated;
- (d) Nature of Waste — While dealing with sewage from domestic premises, special problems under this head may not arise; however, note shall be taken of any possibility of trade effluents being discharged into the pipes at a future date;
- (e) Outlet Connection — The availability of sewers or other outlets;
- (f) Cover — The depth (below ground) of the proposed sewers and drains and the nature and weight of the traffic on the ground above them;
- (g) Sub-soil Condition:
 - (1) The approximate level of the subsoil water, and any available records of flood levels shall be ascertained, as also the depth of the water table relative to all sewer connections, unless it is known to be considerably below the level of the latter;
 - (2) In the case of deep manholes, this information will influence largely the type of construction to be adopted. The probable safe bearing capacity of the subsoil at invert level may be ascertained in the case of a deep manhole.
 - (3) Where work of any magnitude is to be undertaken, trial pits or boreholes shall be put at intervals along the line of the proposed sewer or drain and the data therefrom tabulated, together with any information available from previous works carried out in the vicinity. In general the information derived from trial pits is more reliable than that derived from boreholes. For a long length of sewer or drain, information derived from a few trial pits at carefully chosen points may be supplemented by that obtained from number of intermediate boreholes. Much useful information is often obtained economically and quickly by the use of a soil auger;
 - (4) The positions of trial pits or boreholes shall be shown on the plans, together with sections showing the strata found and the dates on which water levels are recorded.
- (a) Location of Other Services** — The position, depth and size of all other pipes, mains, cables, or other services, in the vicinity of the proposed work, may be ascertained from the Authority, if necessary;
- (b) Reinstatement of Surfaces** — Information about the requirements of the highway authority is necessary where any part of the sewer or drain is to be taken under a highway. Those responsible for the sewer or drain shall be also responsible for the maintenance of the surface until permanently reinstated. The written consent of the highway authority to break up the surface and arrangement as to the charges thereof and the method and type of surface reinstatement shall always be obtained before any work is commenced;
- (c) Diversion and Control of Traffic**

In cases where sewers cross roads or footpaths, cooperation shall be maintained with the police and Authorities regarding the control and diversion of vehicular and/or pedestrian traffic as may be necessary. Access to properties along the road shall always be maintained and adequate notice shall be given to the

occupiers of any shops or business premises, particularly if obstruction is likely;

During the period of diversion, necessary danger lights, red flags, diversion boards, caution boards, watchmen, etc, shall be provided as required by the Authority;

(d)Way-leaves (Easements) — The individual or authority carrying out the work is responsible for negotiating way-leaves where the sewer crosses land in other ownership. The full extent and conditions of such way-leaves shall be made known to the contractor and his employees, and prior notice of commencement of excavation shall always be given to the owners concerned, and cooperation with them shall be maintained at all stages, where sewers run across fields or open ground, the exact location of manholes shall be shown on way-leaves or easement plans. The right of access to manhole covers and the right to maintain the sewer shall be specifically included in any way-leave or easement arrangements which may be made with the owner of the land; and

(e)Damage to Buildings and Structures — When sewer trenches have to be excavated near buildings or walls a joint inspection with the owners of the property shall be made to establish whether any damage or cracks exist before starting the work, and a properly authenticated survey and record of the condition of buildings likely to be affected shall be made. Tell tales may be placed across outside cracks and dated, and kept under observation. Un-retouched photographs taken by an independent photographer may provide useful evidence.

5D.5.4.2 Drainage into a Public Sewer

Where public sewerage is available, the following information is particularly necessary and may be obtained from the Authority:

- (a) the position of the public sewer or sewers in relation to the proposed buildings;
- (b) the invert level of the public sewer;
- (c) the system on which the public sewers are designed (combined, separate or partially separate), the lowest level at which connection may be made to it, and the Authority in which it is vested;
- (d) the material of construction and condition of the sewer if connection is not to be made by the Authority;
- (e) the extent to which surcharge in the sewer may influence the drainage scheme;
- (f) whether the connection to the public sewer is made, or any part of the drain laid, by the Authority, or whether the owner is responsible for this work; if the latter, whether the Authority imposes any special conditions;
- (g) whether an intercepting trap is required by the Authority on the drain near the boundary of the curtilage; and
- (h) where manholes are constructed under roads, the approval of the Highway Authority for the type of cover to be fitted shall be obtained.

5D.5.4.3 Other Methods of Disposal of Sewage

5D.5.4.3.1

Where discharge into a public sewer is not possible, the drainage of the building shall be on a separate system. Foul water shall be disposed of by adequate treatment approved by the Authority on the site. The effluent from the plant shall be discharged into a natural watercourse or public drain or disposed into sub-soil, preferably a porous sub-soil. The treated soil water shall have effluent quality of BOD₅ =20 mg/L, SS= 30 mg/L, COD= 60 mg/L and the effluent must be chlorinated before being discharged.

5D.5.4.3.2

In the case of dilution into a natural stream course, the quality of the effluent shall conform to the requirements of the Authority controlling the prevention of pollution of streams.

5D.5.4.3.3

In the case of sub-soil dispersion, the requirements of the Authority for water supply shall be observed to avoid any possible pollution of local water supplies or wells.

5D.5.4.3.4

The general sub-soil water level and the subsoil conditions shall be ascertained, including the absorptive capacity of the soil.

5D.5.4.3.5

A sub-soil dispersion is not desirable near a building or in such positions that the ground below the foundations is likely to be affected.

5D.5.4.3.6

Under the separate system, drainage of standard the building shall be done through septic tanks of different sizes or by stabilization ponds or by any other methods approved by the Authority.

For detailed information on the design and construction of septic tanks and waste stabilization ponds, reference may be made to good practice [9-2(24)].

5D.5.4.4 Disposal of Surface and Sub-soil Waters

All information which may influence the choice of methods of disposal of surface and/or sub-soil waters shall be obtained. In the absence of surface water drainage system, and if practicable and permissible, disposal into a natural water-course or soakaway may be adopted. The location and flood levels of the water course as also the requirements of the Authority controlling the river or the waterway shall be ascertained.

5D.5.5 Planning and Design Considerations

5D.5.5.1 Aim

The efficient disposal of foul and surface water from a building is of great importance to public health and is an essential part of the construction of the building. In designing a drainage system for an individual building or a housing colony, the aim shall be to provide a system of self-cleaning conduits for the conveyance of foul, waste, surface or subsurface waters and for the removal of such wastes speedily and efficiently to a sewer or other outlet without risk of nuisance and hazard to health.

5D.5.5.1.1

To achieve this aim a drainage system shall satisfy the following requirements:

- a) rapid and efficient removal of liquid wastes without leakage;
- b) prevention of access of foul gases to the building and provision for their escape from the system.
- c) adequate and easy access for clearing obstructions;
- d) prevention of undue external or internal corrosion, or erosion of joints and protection of materials of construction; and
- e) avoidance of air locks, siphonage, proneness to obstruction, deposit and damage.

5D.5.5.1.2

The realization of an economical drainage system is added by compact grouping of fitments in both horizontal and vertical directions. This implies that if care is taken and ingenuity brought into play when designing the original building or buildings to be drained, it is possible to group the sanitary fittings and other equipment requiring drainage; both in vertical and horizontal planes, as to simplify the drainage system and make it most economical.

5D.5.5.1.3

Efficient and an economical plumbing system can be achieved by planning the toilets in compact grouping with the layout of the bathrooms and observing the following guidelines:

- a) Placing of plumbing fixtures around an easily accessible pipe shaft; in high rise buildings the pipe shafts may have to be within the building envelope and easy provision for access panels and doors should be planned in advance, in such cases.
- b) Adopting repetitive layout of toilets in the horizontal and vertical directions.
- c) Avoiding any conflict with the reinforced cement concrete structure by avoiding embedding pipes in it, avoiding pipe crossings in beams, columns and major structural elements.

- d) Identifying open terraces and areas subject to ingress of rainwater directly or indirectly and providing for location of inlets at each level for down takes for disposal at ground levels.
- e) Avoiding crossing of services of individual property through property of other owners.
- f) Planning to avoid accumulation of rain water or any backflow from sewers particularly in planned low elevation areas in a building.

5D.5.5.2 Layout

5D.5.5.2.1 General

Rain-water should preferably be dealt separately from sewage and sullage. Sewage and sullage shall be connected to sewers. However, storm water from the courtyard may be connected to the sewer where it is not possible to drain otherwise; after obtaining permission of the Authority.

5D.5.5.2.2 Additional Requirement

The following requirements are suggested to be considered in the design of drainage system:

- a) The layout shall be as simple and direct as practicable.
- b) The pipes should be laid in straight lines, as far as possible, in both vertical and horizontal planes.
- c) Anything that is likely to cause irregularity of flow, as abrupt changes of direction, shall be avoided.
- d) The pipes should be non-absorbent, durable, smooth in bore and of adequate strength.
- e) The pipes should be adequately supported without restricting movement.
- f) Drains should be well ventilated, to prevent the accumulation of foul gases and fluctuation of air pressure within the pipe, which could lead to unsealing of gully or water-closet traps.
- g) All the parts of the drainage system should be accessible for feasibility of inspection and practical maintenance.
- h) No bends and junctions whatsoever shall be permitted in sewers except at manholes and inspection chambers.
- i) Sewer drain shall be laid for self-cleaning velocity of 2.5 ft/s and generally should not flow more than half-full.
- j) Pipes crossing in walls and floors shall be through mild steel sleeves of diameter leaving an annular space of 0.2 inches around the outer diameter of the pipe crossing the wall.
- k) Pipes should not be laid close to building foundation.

- l) Pipes should not pass near large trees because of possibility of damage by the roots.
 - m) Branch connections should be swept in the direction of flow.
 - n) Sewer pipes should be at least 3 ft below road and at least 2 ft below fields and gardens.
 - o) Pipes should not pass under a building unless absolutely necessary.
 - p) Where it is necessary to lay pipes under a building, the following conditions shall be observed:
 - 1) Pipes shall be cast iron pressure pipe as per good practice [9-2(20)];
 - 2) The pipe shall be laid in straight line and at uniform gradient;
 - 3) Means of access in form of manholes/ inspection chamber shall be provided at *each* end, immediately outside the building; and
 - 4) In case the pipe or any part of it is laid above the natural surface of the ground, it shall be laid on concrete supports, the bottom of which goes at least 6 inches below the ground surface.
- NOTE** — It is desirable that pipe/drains should not be taken through a living room or kitchen and shall preferably be taken under a staircase room or passage.
- q) Consideration shall be given to alternative layouts so as to ensure that the most economical and practical solution is adopted. The possibility of alterations shall be avoided exercising due care and forethought.

5D.5.5.2.3 Protection against vermin and dirt

The installation of sanitary fittings shall not introduce crevices which are not possible to inspect and clean readily.

Pipes, if not embedded, shall be run well clear of the wall. Holes through walls to taken pipes shall be made good on both sides to prevent entry of insects. Materials used for embedding pipes shall be rodent-proof. Passage of rodents from room-to-room or from floor- to-floor shall be prevented by suitable sealing. The intermediate lengths of ducts and chases shall be capable of easy inspection. Any unused drains, sewers, etc, shall be demolished or filled in to keep them free from rodents.

All pipe shafts shall be plastered before any pipes are installed in the shaft. This will provide a smooth surface and prevent location for survival of insects and vermins.

5D.5.5.2.4 Choice of plumbing system

In selecting one or more of the type of piping systems, the building and the layout of toilets; relationship with other services; acceptability to the Authority; and any special requirements of users, shall be studied.

(a) Two-pipe system

- (1) This system is ideal when the location of toilets and stacks for the WCs and waste fittings is not uniform or repetitive.

- (2) In large buildings and houses with open ground and gardens the sullage water from the waste system can be usefully utilized for gardening and agriculture.
- (3) In larger and multi-storied buildings, the sullage is treated within the building for re-use as makeup water for cooling towers for air conditioning system and is also used for flushing water-closets provided it has absolutely no connection with any water supply line, tank or system used for domestic and drinking supply.

(b) One-pipe system

- (1) This system is suitable for buildings where the toilet layouts and the shafts are repetitive. It requires less space, and is economical.
- (2) Continuous flow of water in the pipe from waste appliances makes it less prone to blockage and makes the system more efficient.
- (3) The system eliminates the need for a gully trap which requires constant cleaning.
- (4) The system is ideal when the main pipes run at the ceiling of the lowest floor or in a service floor. Two-pipe system may present space and crossing problems which this system eliminates.

(c) Single stack system

- (1) The single stack system (without any vent pipe) is ideal when the toilet layouts are repetitive and there is less space for pipes on the wall.
- (2) In any system so selected there should be not more than two toilet connections per floor.
- (3) The system requires minimum 4 inches diameter stack for a maximum of five floors in a building.
- (4) All the safeguards for the use of this system given in 5.5.2.4.1 shall be complied with.

(d) Single stack system (partially ventilated)

- (1) The system and the applicable safeguards under this system are the same as for single stack system. The prime modification is to connect the waste appliances, such as wash basin, bath tub or sink to a floor trap.
- (2) For detailed information regarding design and installation of soil, waste and ventilating pipes, reference may be made to good practice [9-2(25)].

5D.5.5.2.4.1 Safeguards for single stack system

- a) as far as practicable, the fixtures on a floor shall be connected to stack in order of increasing discharge rate in the downward direction;
- b) the vertical distance between the waste branch (from floor trap or from the individual appliance) and the soil branch connection, when soil pipe is connected to stack above the waste pipe, shall be not less than 8 inches;

- c) depth of water seal traps from different fixtures shall be as follows:

Water closets 2 inches

Floor traps 2 inches

Other fixtures directly connected to the stack.

- 1) Where attached to branch waste pipes of 3 inches dia or more
1.5 inches
- 2) Where attached to branch waste pipes of less than 3 inches dia
3 inches

NOTE — When connection is made through floor trap, no separate seals are required for individual fixtures.

- d) branches and stacks which receive discharges from WC pans should not be less than 4 inches, except where the outlet from the siphonic water closet is $3\frac{1}{4}$ inches, in which case a branch pipe of $3\frac{1}{4}$ inches may be used. For outlet of floor traps 3 inches dia pipes may be used;
- e) the horizontal branch distance for fixtures from stack, bend(s) at the foot of stack to avoid back pressure as well as vertical distance between the lowest connection and the invert of drain shall be as shown in Fig. 2A; and
- f) for tall buildings, ground floor appliances are recommended to be connected directly to manhole/inspection chamber.

5D.5.5.3 Drainage (Soil, Waste and Ventilating) Pipes

5D.5.5.3.1 General considerations

5D.5.5.3.1.1

Drainage pipes shall be kept clear of all other services. Provisions shall be made during the construction of the building for the entry of the drainage pipes. In most cases this may be done conveniently by building sleeves or conduit pipes into or under the structure in appropriate positions. This will facilitate the installation and maintenance of the services.

5D.5.5.3.1.2

Horizontal drainage piping should be so routed as not to pass over any equipment or fixture where leakage from the line could possibly cause damage or contamination. Drainage piping shall never pass over switch-gear or other electrical equipment. If it is impossible to avoid these areas and piping must run in these locations, then a pan or drain tray should be installed below the pipe to collect any leakage or condensation. A drain line should run from this pan to a convenient floor drain or service sink.

5D.5.5.3.1.3

All vertical soil, waste, ventilating and anti-siphonage pipes shall be covered on top with a copper or heavily galvanized iron wire dome or cast iron terminal guards. All cast iron pipes, which are to be painted periodically, shall be fixed to give a minimum clearance of 2 inches clear from the finished surface of the wall by means of a suitable clamps.

NOTE — Asbestos cement cowls may be used in case asbestos cement pipes are used as soil pipes.

5D.5.5.3.1.4

Drainage pipes shall be carried to a height above the buildings as specified for ventilating pipe (*see* 5D. 5.5.3.4).

5D.5.5.3.2 Soil pipes

A soil pipe, conveying to a drain, any solid or liquid filth, shall be circular and shall have a minimum diameter of 4 inches.

5D.5.5.3.2.1

Except where it is impracticable, the soil pipe shall be situated outside the building or in suitably designed pipe shafts and shall be continued upwards without diminution of its diameter, and (except where it is unavoidable) without any bend or angle, to such a height and position as to afford by means of its open end a safe outlet for foul air. The position of the open end with its covering shall be such as to comply with the conditions set out in 5D.5.5.3.4 relating to ventilating pipe. Even if the pipes are laid externally, the soil pipes shall not be permitted on a wall abutting a street unless the Authority is satisfied that it is unavoidable. Where shafts for pipes are provided, the cross-sectional area of the shaft shall be suitable to allow free and unhampered access to the pipes and fittings proposed to be installed in the shaft. However in no case cross-section area of the shaft shall be less than a square of one meter side. All pipe shafts shall be provided with an access door at ground level and facilities for ventilation.

5D.5.5.3.2.2

Soil pipes, whether insider or outside the building, shall not be connected with any rainwater pipe and there shall not be any trap in such soil pipe or between it and any drain with which it is connected.

5D.5.5.3.2.3

Soil pipes shall preferably be of cast iron. Asbestos cement building pipes may also be used as soil pipes only above ground level.

5D.5.5.3.2.4

The soil pipe shall be provided with heel rest bend which shall rest on sound footing, if terminating at firm ground level. When the stack is terminating at the ceiling of a floor, the bend shall be provided with sufficient structural support to cater for the stack dead weight and the thrust developed from the falling soil/waste. Vertical stack shall be fixed at least 2 inches clear of the finished surface of the wall by means of a suitable clamps of approved type.

5D.5.5.3.3 Waste pipes

Every pipe in a building for carrying off the waste or overflow water from every bath, washbasin or sink to a drain shall be of 1¼ inches to 2 inches diameter, and shall be trapped immediately beneath such washbasins or sink by an efficient siphon trap with adequate means for inspection and cleaning. Such traps shall be ventilated into the external air whenever such ventilation is necessary to preserve the seal of the trap. Waste pipes, traps, etc, shall be constructed of iron, lead, brass, stoneware, asbestos cement or other approved material. The overflow pipe from washbasin, sinks, etc, shall be connected with the waste pipe immediately above the trap. Vertical pipes carrying off waste water shall have a minimum diameter of 3 inches.

NOTE — Whenever washbasins and sinks have in-built overflow arrangements, there is no need to provide overflow pipes in such cases.

5D.5.5.3.3.1

Every pipe in a building for carrying off waste water to a drain shall be taken through an external wall of the building by the shortest practicable line, and shall discharge below the grating or surface box of the chamber but above the *inlet* of a properly trapped gully. The waste pipe shall be continued upwards without any diminution in its diameter and (except when unavoidable) without any bend or angle to such a height and position as to afford by means of the open end of the waste pipe, a safe outlet for foul air, the position of the open end and its covering being such as to comply with the conditions.

5D.5.5.3.3.2

Except where it is impracticable, the common waste pipe shall be situated outside the building and shall be continued upwards without diminution of its diameter (except where it is unavoidable) without any bend or angle being formed to such a height and position as to avoid by means of the open end a safe outlet for foul air, the position of the open end and the covering threat being such as to comply with the conditions set out in 5.5.3.4 relating to ventilating pipe.

5D.5.5.3.3.3

If the waste pipe is of cast iron, it shall be firmly attached 2 inches clear of the finished surface of the wall by means of a suitable clamps or with properly fixed holder bats or equally suitable and efficient means.

5D.5.5.3.4 Ventilating pipes

Ventilating pipes should be so installed that water cannot be retained in them. They should be fixed vertically. Whenever possible, horizontal runs should be avoided. Ventilating pipe shall be carried to such a height and in such a position as to afford by means of the open end of such pipe or vent shaft, a safe outlet for foul air with the least possible nuisance.

5D.5.5.3.4.1

The upper end of the main ventilating pipe may be continued to the open air above roof level as a separate pipe, or it may join the MSP and/or MWP above the floor level of the highest appliance. Its lower end may be carried down to join the drain, at a point where air relief may always be maintained.

5D.5.5.3.4.2

Branch ventilating pipes should be connected to the top of the BSP and BWP between 3 inches and 1 ft 6 in from the crown of the trap.

5D.5.5.3.4.3

The ventilating pipe shall always be taken to a point 2 ft above the level of the eaves or flat roof or terrace parapet whichever is higher or the top of any window within a horizontal distance of 5 ft. The least dimension shall be taken as a minimum and local conditions shall be taken into account. The upper end of every ventilating pipe shall be protected by means of a cowl.

5D.5.5.3.4.4

In case the adjoining building is taller, the ventilating pipe shall be carried higher than the roof of the adjacent building, wherever it is possible.

5D.5.5.3.4.5

The building drain intended for carrying waste water and sewage from a building shall be provided with at least one ventilating pipe situated as near as practicable to the building and as far away as possible from the point at which the drain empties into the sewer or other carrier.

5D.5.5.3.4.6 Size of ventilating pipe

- (a) The building drain ventilating pipe shall be of not less than 3 inches diameter when, however, it is used as MSP or MWP. The upper portion, which does not carry discharges, shall not be of lesser diameter than the remaining portion;
- (b) The diameter of the main ventilating pipe in any case should not be less than 2 inches;
- (c) A branch ventilating pipe on a waste pipe in both one-and two-pipe systems shall be of not less than two-thirds the diameter of the branch waste ventilated pipe; subject to a minimum of 1 inch; and
- (d) A branch ventilating pipe on a soil pipe in both one-and two-pipe systems shall be not less than 1¼ inches in diameter.

5D.5.5.3.5 Design of drainage pipes

5D.5.5.3.5.1 Estimation of maximum flow of sewer

a) Simultaneously discharge flow

- (1) The maximum flow in a building drain or a stack depends on the probable maximum number of simultaneously discharging appliances. For the calculation of this peak flow certain loading factors have been assigned to appliances in terms of fixture units, considering their probability and frequency of use. These fixture unit values are given in Table 23.
- (2) For any fixtures not covered under Table 23, Table 24 may be referred to for deciding their fixture unit rating depending on their drain or trap size,
- (3) From Tables 23 and 24, the total load on any pipe in terms of fixtures units may be calculated knowing the number and type of appliances connected to this pipe.
- (4) For converting the total load in fixture units to the peak flow in gallons per minute, Fig. 13 is to be used.
- (5) The maximum number of fixture units that are permissible various recommended pipe size in the drainage system are given in Tables 25 and 26.
- (6) Results should be checked to see that the soil, waste and building sewer pipes are not reduced in diameter in the direction of flow. Where appliances are to be added in fixture, these should be taken into account in assessing the pipe sizes by using the fixture units given in Tables 21 and 22,

b) **Maximum discharge flow** — The maximum rate of discharge flow shall be taken as thrice the average rate, allowance being made in addition for any exceptional peak discharges. A good average rule is to allow⁷ for a flow of liquid wastes from buildings at the rate of 3 litres per minute per 10 persons.

5D.5.5.3.5.2 Gradients**5D.5.5.3.5.2.1**

The discharge of water through a domestic drain is intermittent and limited in quantity and, therefore, small accumulations of solid matter are liable to form in the drains between the building and the public sewer. There is usually a gradual shifting of these deposits as discharges take place. Gradients should be sufficient to prevent these temporary accumulations building up and blocking the drains.

Table 21 Fixture Units for Different Sanitary Appliances or Groups**(Clause 5.5.3.5.1)**

SI No. (1)	Type of Fixture (2)	Fixture Unit Value as Load Factors (3)
i)	One bathroom group consisting of water-closet, washbasin and bath tub or shower stall:	
	a) Tank water-closet	6
	b) Flush-valve water-closed	8
ii)	Bath tub ¹⁾	3
iii)	Bidet	3
iv)	Combination sink-and-tray (drain board)	3
v)	Drinking fountain	½
vi)	Floor traps ²⁾	1
vii)	Kitchen sink, domestic	2
viii)	Wash basin, ordinary ³⁾	1
ix)	Washbasin, surgeon's	2
x)	Shower stall, domestic	2
xi)	Showers (group) per head	3
xii)	Urinal, wall lip	4
xiii)	Urinal, stall	4
xiv)	Water-closet, tank-operated	4
xv)	Water-closet, valve-operated	8
¹⁾ A shower head over a bath tub does not increase the fixture unit value. ²⁾ Size of floor trap shall be determined by the area of surface water to be drained. ³⁾ Washbasins with 32 mm and 40 mm trap have the same load value.		

Table 22 Fixture Unit Values for Fixtures Based on Fixture Drain on Trap Size
(Clause 5.5.3.5.1)

SI No.	Fixture Drain on Trap Size	Fixture Unit Value
(1)	(2)	(3)
i)	1¼ in and smaller	1
ii)	1½ in	2
iii)	2 in	3
iv)	2½ in	4
v)	3 in	5
vi)	4 in	6

**Table 23 Maximum Number of Fixture Units that can be Connected to
Branches and Stocks**
(Clause 5.5.3.5.1)

Sl No.	Diameter of Pipe mm	Maximum Number of Fixture Units ¹⁾ that can be Connected			
		Any Horizontal Fixture Branch ²⁾	One Stack of 3 Storeys in Height or 3 Intervals	More Than 3 Storeys in Height	
				Total for Stack	Total at One Storey or Branch Interval
(1)	(2)	(3)	(4)	(5)	(6)
i)	30	1	2	2	1
ii)	40	3	4	8	2
iii)	50	6	10	24	6
iv)	65	12	20	42	9
v)	75	20	30	60	16
vi)	100	160	240	500	90
vii)	125	360	540	1 100	200
viii)	150	620	960	1 900	350
ix)	200	1 400	2 200	3 600	600
x)	250	2 500	3 800	5 600	1 000
xi)	300	3 900	6 000	8 400	1 500
xii)	375	7 000	—	—	—

¹⁾ Depending upon the probability of simultaneous use of appliances considering the frequency of use and peak discharge rate.

²⁾ Does not include branches of the building sewer.

**Table 24 Maximum Number of Fixture Units that can be Connected to
Building Drains and Sewers**
(Clause 5.5.3.5.1)

Sl No.	Diameter of Pipe mm	Maximum Number of Fixture Units that can be Connected to Any Portion ¹⁾ of the Building Drain or the Building Sewer for Gradient			
		1/200	1/100	1/50	1/25
	(2)	(3)	(4)	(5)	(6)
i)	100	—	180	216	250
ii)	150	—	700	840	1 000
iii)	200	1 400	1 600	1 920	2 300
iv)	250	2 500	2 900	3 300	4 200
v)	300	3 900	4 600	5 600	6 700
vi)	375	7 000	8 300	10 000	12 000

¹⁾ Includes branches of the building sewer.

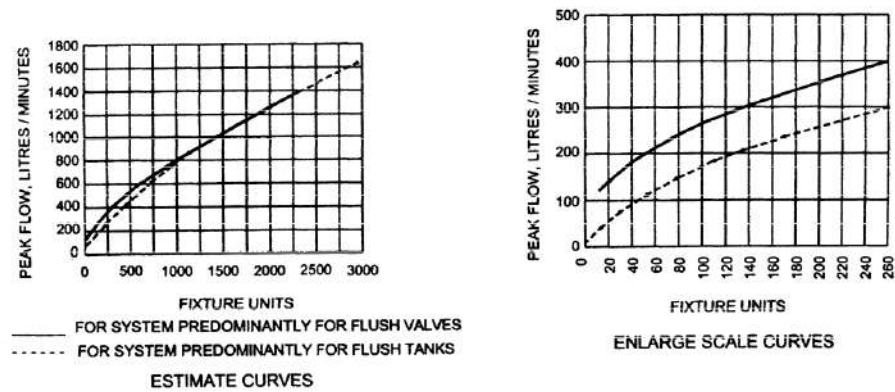


FIG. 13 PEAK FLOW LOAD CURVES

5D.5.5.3.5.2.2

When flow occurs in drain piping, it should not entirely fill the cross-section of the pipe under flow condition. If the pipe were to flow full, pressure fluctuations would occur which could possibly destroy the seal of the traps within the building. Normally, the sewer shall be designed for discharging the peak flow as given in 5.5.3.5.1, flowing half-full with a minimum self-cleansing velocity of 2.5 ft/s. The approximate gradients which give this velocity for the sizes of pipes likely to be used in building drainage and the corresponding discharges when flowing half-full are given in Table 27.

5D.5.5.3.5.2.3

In cases where it is practically not possible to conform to the ruling gradients, a flatter gradient may be used, but the minimum velocity in such cases shall on no account be less than 2 ft/s and adequate flushing should be done.

NOTE — Where gradients are restricted, the practice of using a pipe of larger diameter than that required by the normal flow, in order to justify laying at a flatter gradient does not result in increasing the velocity of flow, further this reduces the depth of flow and thus for this reasons the above mentioned practice should be discouraged.

5D.5.5.3.5.2.4

On the other hand, it is undesirable to employ gradients giving a velocity of flow greater than 8 ft/s. Where it is unavoidable, cast iron pipes shall be used. The approximate gradients, which give a velocity of 8 ft/s for pipes of various sizes and the corresponding discharge when flowing half-full are given in Table 27.

5D.5.5.3.5.2.5

The discharge values corresponding to nominal diameter and gradient given in Table 27 are based on Manning's formula ($n = 0.015$).

NOTE — Subject to the minimum size of 4 inches, the sizes of pipes shall be decided in relation to the estimated quantity of flow and the available gradient.

Table 25 Different Dia Pipes Giving Velocity and Corresponding Discharge at Minimum and Maximum Gradient

(Clauses 5.5.3.5.2.2, 5.5.3.5.2.4, 5.5.3.5.2.5)

SI No.	Diameter in	Minimum Gradient (Velocity:2.5 ft/s)	Discharge at the Minimum Gradient (ft ³ /s)	Maximum Gradient (Velocity:8 ft/s)	Discharge at the Maximum Gradient (ft ³ /s)
(1)	(2)	(3)	(4)	(5)	(6)
i)	4	1 in 57	0.11	1 in 5.6	0.35
ii)	6	1 in 100	0.25	1 in 9.7	0.78
iii)	8	1 in 145	0.43	1 in 14	1.41
iv)	9	1 in 175	0.55	1 in 17	1.75
v)	10	1 in 195	0.65	1 in 19	2.12
vi)	12	1 in 250	1.00	1 in 24.5	3.12

5D.5.5.3.6 Drain appurtenances**5D.5.5.3.6.1 Trap**

All traps shall be protected against siphonage and back pressure ensuring access to atmospheric air for air circulation and preserving the trap seal in all conditions.

5D.5.5.3.6.1.1

A trap may be formed as an integral trap with the appliance during manufacture or may be a separate fitting called an attached trap which may be connected to the waste outlet of the appliance.

5D.5.5.3.6.1.2

Traps should always be of a self-cleansing pattern. A trap, which is not an integral part of an appliance, should be directly attached to its outlet and the pipe should be uniform throughout and have a smooth surface.

5D.5.5.3.6.1.3

The trap should have minimum size of outlet/exit, same as that of largest waste inlet pipe.

5D.5.5.3.6.1.4

Traps for use in domestic waste installations and all other traps should be conveniently accessible and provided with cleansing eyes or other means of cleaning.

5D.5.5.3.6.1.5

The minimum internal diameter for sanitary appliances shall be as follows:

Sanitary Appliance	Minimum Diameter Outlet (inches)	Internal of Waste
<i>Soil appliances</i>		
a) Indian and European type water closets		4
b) Bed pan washers and slop sinks		4
c) Urinal with integral traps		3
d) Stall urinals (with not more than 5 inches of channel drainage)		2
e) Lipped urinal small/large40		1½
<i>Waste appliances</i>		
f) Drinking fountain		1
g) Wash basin		1¼
h) Bidets		1¼
i) Domestic sinks and baths		1½
j) Shower bath trays		1½
k) Domestic bath tubs		2
l) Hotel and canteen sinks		2
m) Floor traps (outlet diameter)		2½

5D.5.5.3.6.2 Floor drains

All toilets/bathrooms in a building desirably should be provided with floor drains to facilitate cleaning.

5D.5.5.3.6.2.1

Floor drains shall connect into a trap so constructed that it can be readily cleaned and of a size to serve efficiently the purpose for which it is intended. The trap shall be either accessible from the floor drain or by a separate cleanout within the drain.

5D.5.5.3.6.2.2

Floor drain also receives, waste piping which does not connect to the sanitary system, known as indirect waste. This discharge

from an indirect waste should be conveyed into a water supplied, trapped and vented floor drain.

5D.5.5.3.6.2.3

Floor drain should be provided in mechanical equipment rooms, where pumps, boilers, water chillers, heat exchangers and other air conditioning equipments are periodically drained for maintenance and repair. Boiler requires drain at safety relief valve discharge.

5D.5.5.3.6.2.4

Strategically floor drains are required to be located in buildings with wet fire protection sprinkler systems to drain water in case of activation of sprinkler heads.

5D.5.5.3.6.3 Cleanouts

The cleanout provides access to horizontal and vertical lines and stacks to facilitate inspection and means to remove obstructions common to all piping systems, such as solid objects, greasy wastes, hair and the like.

5D.5.5.3.6.3.1

Cleanouts in general should be gas and water-tight, provide quick and easy plug removal, allow ample space for rodding tools, have means of adjustments to finished floor level, be attractive and be designed to support whatever load is directed over them.

5D.5.5.3.6.3.2

Waste lines are normally laid beneath the floor slab at a sufficient distance to provide adequate back-fill over the joints. Cleanouts are then brought up to floor level grade by pipe extension pieces.

5D.5.5.3.6.3.3

The size of the cleanout within a building should be the same size as the piping up to 4 inches. For larger size piping 4 inches cleanouts are adequate for their intended purpose.

5D.5.5.3.6.3.4

Cleanouts are suggested to be provided at the following locations:

- a) Inside the building at a point of exit, Y junction branch or a trap.
- b) At every change of direction greater than 45°.
- c) At the base of all stacks.

- d) At the horizontal header, receiving vertical stacks and serving the purpose of offset header.

5D.5.5.4 Indirect Wastes

5D.5.5.4.1 General

Waste, overflow and drain pipes from the following types of equipment shall not be connected into any drainage system directly to prevent backflow from the drainage system into the equipment/installation:

a) Plumbing and kitchen appliances.

- 1) Underground or overhead water tanks.
- 2) Drinking water fountains.
- 3) Dishwashing sinks and culinary sinks used for soaking and preparation of food.
- 4) Cooling counters for food and beverages.
- 5) Kitchen equipment for keeping food warm.
- 6) Pressure drainage connections from equipment.

b) Air conditioning, heating and other mechanical equipments

- 1) Air handling equipment.
- 2) Cooling tower and other equipments.
- 3) Condensate lines from equipments
- 4) Storage tanks.
- 5) Condensate lines.
- 6) Boiler blow down lines.
- 7) Steam trap drain lines.

c) Laboratories and other areas

- 1) Water stills.
- 2) Waste from laboratory in specified sinks.
- 3) Sterlizers and similar equipments.
- 4) Water purification equipments.

5D.5.5.4.2 Indirect waste receptors

All plumbing fixtures or other receptors receiving the discharge of indirect waste pipes shall be of such shape and capacity as to prevent splashing or flooding and shall be located where they are readily accessible for inspection and cleaning.

5D.5.5.4.3 Pressure drainage connections

Indirect waste connections shall be provided for drains, overflows or relief vents from the water supply system, and no piping or equipment carrying wastes or producing wastes or other discharges under pressure shall be directly connected to any part of the drainage system.

The above shall not apply to any approved sump pump or to any approved plumbing fixture discharging pressurized waste or device when the Authority has been satisfied that the drainage system has the capacity to carry the waste from the pressurized discharge.

5D.5.5.5 Special Wastes

5D.5.5.5.1 General

Wastes having characteristics which may be detrimental to the pipes in which it is disposed as well as to the persons handling it. Such wastes used in a building need to be specially identified and a suitable and safe method of its disposal installed to ensure that the piping system is not corroded nor the health and safety of the occupants is affected in any way.

Whenever the occupant or the user of any wastes is unaware of the dangers of the consequences of disposing the waste, he shall be made aware of the dangers of his action along with providing suitable warning and instruction for correct disposal be provided to him.

Piping system for all special wastes should be separate and independent for each type of waste and should not be connected to the building drainage system. Other applicable provisions for installation of soil and waste pipe system shall be however be followed.

5D.5.5.5.2 Laboratory waste

A study of the possible chemical and corrosive and toxic properties of wastes handled and disposed off in a laboratory need to be ascertained in advance. The relevant statutory rules and regulation regarding the method of disposal of strong and objectionable wastes shall be followed.

All sinks, receptacles, traps, pipes, fittings and joints shall of materials resistant to the liquids disposed off in the system.

In laboratories for educational, research and medical institutions, handling mildly corrosive and toxic wastes, they may be neutralized in chambers using appropriate neutralizing agents. The chamber shall be provided with chambers at inlet and outlet for collecting samples of the incoming and outgoing waste for monitoring its characteristics.

5D.5.5.5.3 Infected wastes

Infected liquid wastes are generated in hospitals from patient excreta; operation theatres; laboratories testing samples of stools, urine, blood, flesh; etc which shall not be disposed off into the drainage system. Such waste shall be collected separately and pre-treated before disposal into the building drainage system.

Soiled and linen from infectious patients needs to be collected from the respective areas of the hospital in separate linen bins and pre-washed and sterilized in the laundry before final wash in the hospital laundry. Liquid wastes from the washing operations shall be neutralized to prevent any cross contamination before disposal in the building's drainage system.

5D.5.5.4 Research laboratory wastes

Research laboratories conducting research in all areas of science and technology, for example chemical industry, pharmacy, metallurgy, bio-sciences, agriculture, atomic energy, medicine, etc, shall follow the established procedures laid down by statutory bodies to handle, treat and dispose wastes which are highly toxic, corrosive, infectious, inflammable, explosive and having bacterial cultures, complex organic and inorganic chemicals. Such wastes shall not be disposed off in a building drainage system or the city sewerage system unless they are pre-treated and meet the disposal criteria in accordance with the relevant rules/regulations.

5D.5.5.6 Grease Traps

Oil and grease is found in wastes generated from kitchens in hotels, industrial canteens, restaurant, butcheries, some laboratories and manufacturing units having a high content of oil and greases in their final waste.

Waste exceeding temperature of 60° C should not be allowed in the grease trap. When so encountered it may be allowed to cool in a holding chamber before entering the grease trap.

Oil and greases tend to solidify as they cool within the drainage system. The solidified matter clogs the drains and the other matter in the waste stick to it due to the adhesion properties of the grease. Oil and greases are lighter than water and tend to float on the top of the waste water.

Grease traps shall be installed in building having the above types of wastes. In principle the grease laden water is allowed to retain in a grease trap which enables any solids to be settled or separated for manual disposal. The retention time allows the incoming waste to cool and allow the grease to solidify. The clear waste is then allowed to discharge into the building's drainage system.

5D.5.5.7 Oil Interceptors

Oils and lubricants are found in wastes from vehicle service stations, workshops manufacturing units whose waste may contain high content of oils. Oils, for example, petroleum, kerosene and diesel used as fuel, cooking, lubricant oils and similar liquids are lighter than water and thus float on water in a pipe line or in a chamber when stored. Such oils have a low ignition point and are prone to catch fire if exposed to any flame or a spark and may cause explosion inside or outside the drainage system. The flames from such a fire spread rapidly if not confined or prevented at the possible source. Lighter oils and lubricants are removed from the system by passing them through an oil interceptor/petrol gully. They are chambers in various compartments which allow the solids to settle and allow the oils to float to the top. The oil is then decanted in separate containers for disposal in an approved manner. The oil free waste collected from the bottom of the chamber is disposed in the building drainage system.

5D.5.5.8 Radioactive Waste

Scientific research institutions, hospital and many types of manufacturing processes use radioactive material in form of radio isotopes and other

radioactive sources for their activities. Manufacture, sale, use and disposal of radioactive material is regulated by the statutory rules and regulation. Proposal for usage and disposal of radioactive materials shall be done in consultation with and prior permission of the Authority by the users of the materials. No radioactive material shall be disposed off in any building drainage system without the authorization of the Authority.

5D.5.5.9 Special Situations of Waste Water Disposal

Buildings may generate uncontaminated waste water from various sources continuously, intermittently or in large volumes for a short time, for example, emptying any water tanks or pools, testing fire and water lines for flow conditions, etc. Connections from all such sources shall be made to the building drainage system indirectly through a trap. It should be ensured in advance that the building drain or a sump with a pump has the capacity to receive to rate of flow. In case the capacity is less the rate of discharge from the appliances should be regulated to meet the capacity of the disposal. Under no circumstances shall any waste water described above shall be disposed off in any storm water drains.

5D.5.5.10 Manholes

5D.5.5.10.1 General

A manhole or inspection chamber shall be capable of sustaining the loads which may be imposed on it, exclude sub-soil water and be water-tight. The size of the chamber should be sufficient to permit ready access to the drain or sewer for inspection, cleaning and rodding and should have a removable cover of adequate strength, constructed of suitable and durable material. Where the depth of the chamber so requires, access rungs, step irons, ladders or other means should be provided to ensure safe access to the level of the drain or sewer. If the chamber contains an open channel, benching should be provided having a smooth finish and formed so as to allow the foul matter to flow towards the pipe and also ensure a safe foothold.

No manhole or inspection chamber shall be permitted inside a building or in any passage therein. Further, ventilating covers shall not be used for domestic drains. At every change of alignment, gradient or diameter of a drain, there shall be a manhole or inspection chamber. Bends and junctions in the drains shall be grouped together in manholes as far as possible.

5D.5.5.10.2 Maximum Spacing of manhole

The maximum spacing of manholes for a given pipe size should be as follows:

Pipe Diameter Manhole	Maximum Spacing of
inches	feet
Up to 6	50
> 6 to 12	100

>12 to 18	150
>18 to 36	250
Beyond 36	300 or spacing shall depend upon local condition and shall be gotten approved by the Authority

Where the diameter of a drain is increased, the crown of the pipes shall be fixed at the same level and the necessary slope given in the invert of the manhole chamber. In exceptional cases and where unavoidable, the crown of the branch sewer may be fixed at a lower level, but in such cases the peak flow level of the two sewers shall be kept the same.

5D.5.5.10.3 Size of manhole

The manhole or chamber shall be of such size as will allow necessary examination or clearance of drains. The size of manhole shall be adjusted to take into account any increase in the number of entries into the chamber.

5D.5.5.10.3.1

Manholes may be rectangular, arch or circular type. The minimum internal size of manholes, chambers (between faces of masonry) shall be as follows:

a) Rectangular Manholes

- (1) For depths less than 3 feet 3 feet x 2 feet 8 inches
- (2) For depths from 3 feet and up to 8 feet 4 feet x 3 feet

b) Arch Type Manholes

- a) For depths of 8 feet and above 4 feet 6 inches x 3 feet

NOTE—The width of manhole chamber shall be suitably increased more than 3 feet on bends, junctions or pipes with diameter greater than 1 foot 6 inches so that benching width in either side of channel is minimum 8 inches.

c) Circular Manholes

- 1) For depths above 3 feet and up to 5 feet 6 inches
3 feet - diameter
- 2) For depths above 5 feet 6 inches and up to 7 feet 6 inches
4 feet - diameter
- 3) For depths above 7 feet 6 inches and up to 29 feet 6 inches
5 feet - diameter
- 4) For depths above 29 feet 6 inches and up to 46 feet
6 feet – diameter

NOTES

- 1 In adopting the above sizes of chambers, it should be ensured that these sizes accord with full or half bricks with

standard thickness of mortar joints so as to avoid wasteful cutting of bricks.

2 The sizes of the chambers may be adjusted to suit the availability of local building materials and economics of construction.

3 The access shaft shall be corbelled inwards on three sides at the top to reduce its size to that of the cover frame to be fitted or alternatively the access shaft shall be covered over by a reinforced concrete slab of suitable dimensions with an opening for manhole cover and frame.

5D.5.5.10.4 Construction

5D.5.5.10.4.1 Excavation

The manhole shall be excavated true to dimensions and levels as shown on the plan. The excavation of deep manholes shall be accompanied with safety measures like timbering, staging, etc. In areas where necessary, appropriate measures for dewatering should be made.

5D.5.5.10.4.2 Bed Concrete

The manhole shall be built on a bed of concrete 1:4:8 (1 cement: 4 coarse sand: 8 graded stone aggregate 1½ in nominal size). The thickness of bed concrete shall be at least 6 in for manholes up to 3 feet in depth, at least 8 inches for manholes from 3 feet upto 8 feet in depth and at least 1 ft for manholes of greater depth, unless the structural design demands higher thickness.

This thickness may be verified considering the weight of wall, cover, the wheel loads, impact of traffic which are transmitted through cover and the shaft walls and for water pressure, if any. In case of weak soil, special foundation as suitable shall be provided.

5D.5.5.10.4.3 Brickwork

The thickness of walls shall be designed depending upon its shape and taking into account all loads coming over it, including earth pressure and water pressure.

Generally the brickwork shall be with first class bricks in cement mortar 1:5 (1 cement: 5 coarse sand). All brickwork in manhole chambers and shafts shall be carefully built in English Bond, the jointing faces of each brick being well "buttered" with cement mortar before laying, so as to ensure a full joint. The construction of walls in brickwork shall be done in accordance with good practice [9-1(26)].

For various depths the recommended thickness of wall may be as follows:

Depth of the Chamber

Thickness of Wall

a) Up to 7 feet 6 inches length)	8 inches (one brick length)
b) From 7 feet 6 inches up to 10 feet length)	1 foot (one and half brick length)
c) From 10 feet up to 16 feet 6 inches brick length)	1 foot 4 inches (two brick length)
d) From 16 feet 6 inches up to 29 feet 6 inches (two and half brick length)	1 foot 8 inches
e) Above 29 feet 6 inches length)	2 feet (three brick length)

The actual thickness in any case shall be calculated on the basis of engineering design. Typical sections of the manholes are illustrated in Fig. 14, 15 and 16.

NOTES

- 1 Rich mix of cement mortar, not weaker than 1:3, should be used in brick masonry, where sub-soil water conditions are encountered.
- 2 For arched type of manholes, the brick masonry in arches and arching over pipes shall be in cement mortar 1:3.

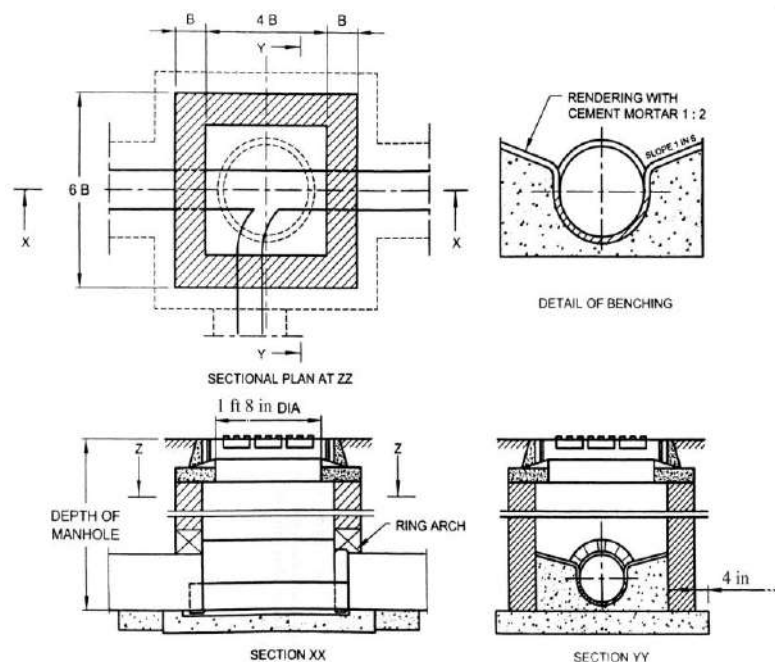


FIG. 14 DETAIL OF MANHOLE (DEPTH LESS THAN 3 FEET)

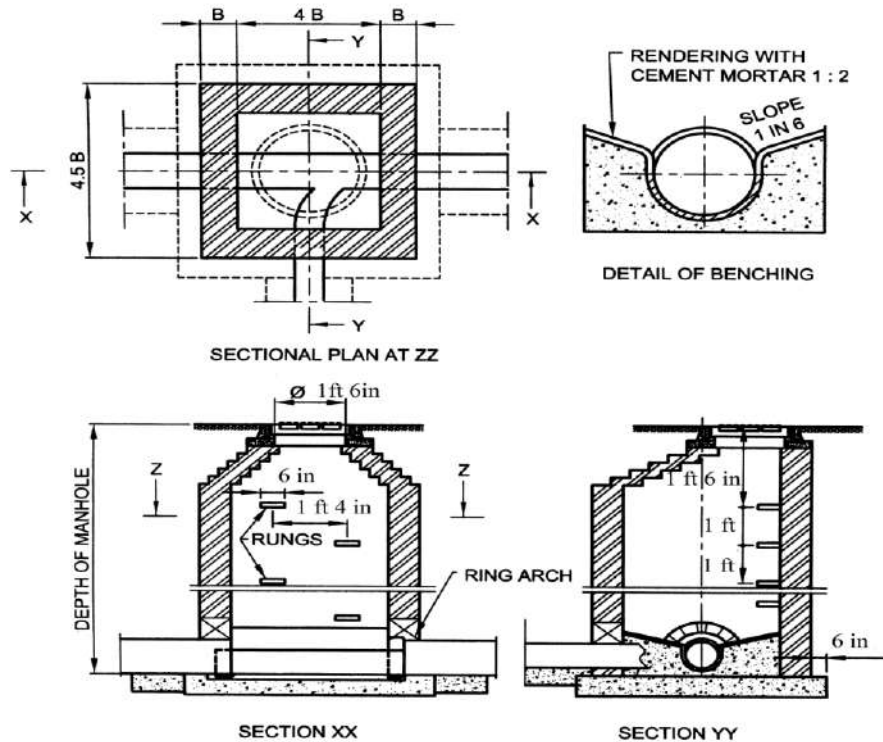


FIG. 15 DETAIL OF MANHOLE (DEPTH 3 FEET AND UP TO 8 FEET)

5D.5.5.10.4.4 Plastering

The wall shall be plastered ($\frac{1}{2}$ inches, Min) both inside and outside within cement mortar 1:3 and finished smooth with a coat of neat cement. Where sub-soil water conditions exist, a richer mix may be used and it shall further waterproofed with addition of approved waterproofing compound in a quantity as per manufacturer specifications.

All manholes shall be so constructed as to be watertight under test.

All angles shall be rounded to 3 inches radius and all rendered internal surface shall have hard impervious finish obtained using a steel trowel.

5D.5.5.10.4.5 Channels and benching

These shall be semi-circular in the bottom half and of diameter equal to that of the sewer. Above the horizontal diameter, the sides shall be extended vertically 2 inches above the crown of sewer pipe and the top edge shall be suitably rounded off. The branch channels shall also be similarly constructed with respect to the benching, but at their junction with the main channel an appropriate fall, if required suitably rounded off in the direction of flow in the main channel shall be given.

The channel/drain and benching at the bottom of the chamber shall be done in cement concrete 1:2:4 and subsequently plastered

with cement mortar of 1:2 proportion or weaker cement mortar with a suitable waterproofing compound and finished smooth, to the grade (where required). The benching at the sides shall be carried up in such a manner as to provide no lodgment for any splashing in case of accidental flooding of the chamber.

Channels shall be rendered smooth and benchings shall have slopes towards the channel.

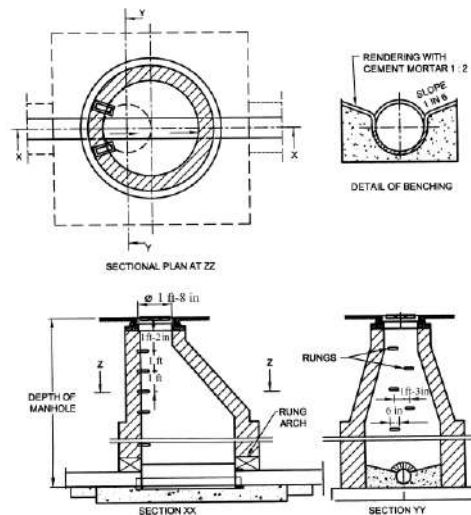


FIG. 16 DETAIL OF MANHOLE (DEPTH 8 FT AND ABOVE)

5D.5.5.10.4.6 Rungs

Rungs shall be provided in all manholes over 2 feet 6 inches in depth and shall be of preferably of cast iron and of suitable dimensions, conforming to accepted standards [9-1(27)]. These rungs may be set staggered in two vertical rungs which may be 1 foot apart horizontally as well as vertically and shall project a minimum of 4 inches beyond the finished surface if the manhole wall. The top rung shall be 1 foot 6 inches below the manhole cover and the lowest not more than 1 foot above the benching.

5D.5.5.10.4.7 Manhole covers and frames

The size of manhole covers shall be such that there shall be a clear opening of at least 1 foot 8 inches in diameter for manholes exceeding 3 feet in depth. The manhole covers and frames are used they shall conform to accepted standards [9-1(28)].

The frame of manhole shall be firmly embedded to concrete alignment and level in plain concrete on the top of masonry.

5D.5.5.10.5 Drop manhole

Where it is uneconomic or impracticable to arrange the connection within 2 feet height above the invert of the manholes, the connection

shall be made by constructing a vertical shaft outside the manhole chamber, as shown in Fig. 17. If the difference in level between the incoming drain and the sewer does not exceed 2 feet, and there is sufficient room in the manhole, the connecting pipe may be directly brought through the manhole wall and the fall accommodated by constructing a ramp in the benching of the manhole.

For detailed information regarding manholes in sewerage system, reference may be made to good practice [9-1(29)].

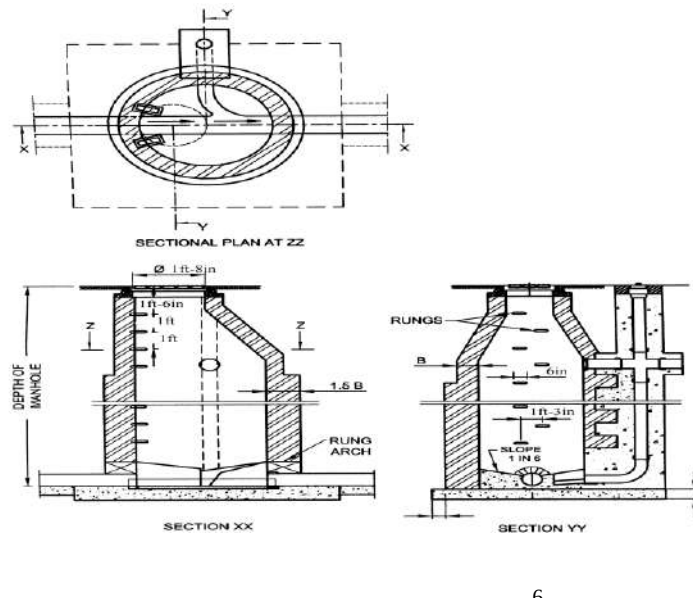


FIG. 17 DROP MANHOLE

NOTE – Wall thickness have been indicated in brick length to provide for use of modular bricks or traditional bricks. In the Fig. B = one brick length, 1.5B = one and a half brick length etc.

5D.5.5.11 Storm Water Drainage

5D.5.5.11.1 General

The object of storm water drainage is to collect and carry, the rain-water collected within the premises of the building, for suitable disposal.

5D.5.5.11.2 Design factors

Estimate of the quantity that reaches the storm water drain depends on the following factors:

- Type of soil and its absorption capacity determined by its soil group.
- Ground slope and the time in which the area is drained.
- Intensity of the rainfall for a design period.
- Duration of the rain/storm.

5D.5.5.11.2.1 Imperviousness

The soil conditions and the ground slope determine the impermeability factor. Impermeability factor is the proportion of the total rainfall received on the surface which will be discharging into the a storm water drain after allowing for initial abstraction (in local pond and lakes), ground absorption by evaporation, vegetation and other losses. The net flow reaching the storm water drain is called runoff.

The percentage of imperviousness of the drainage area may be obtained from available data for a particular area. In the absence of such data, the following values may serve as a guide:

factor(percent)	Type of area	Imperviousness
	Commercial and industrial areas	70-90
	Residential areas (high density)	60-75
	Residential areas (low density)	35-60
	Parks and underdeveloped areas	10-20

5D.5.5.11.2.2 Terrain modeling

Areas planned for urbanization from agricultural land, forest or low grade land for example, low lying areas prone to flooding, marshy or abandoned quarries, etc need detailed and careful consideration with respect to its drainage. A detailed contour survey shall be carried out not only with respect to the site but also the surrounding areas to verify the quantity/area contributing runoff, presence of any low lying and natural water body acting as holding pond or any natural drain passing through the area and beyond whose filling up or diversion may cause water logging problem on the site or to the surrounding areas.

The planning of the area should ensure that:

- a) All areas become self draining by gravity with respect to the high flood level of the area or the drainage channels passing whichever is higher.
- b) As far as possible, natural drainage pattern with respect to the whole area be maintained except when low lying areas need to be filled up for grading purposes.
- c) The drainage in the area shall be planned in accordance with the natural slopes.
- d) Levels of the main highway or road connecting to the property shall be determined to ensure proper drainage and protection of the site.

- e) The formation levels of the entire area shall be prepared to determine proposed formation levels by preparing a terrain model which will show the proposed the site contours, ground and road levels and connections to all services including storm water disposal system.

5D.5.5.11.2.3 Design frequency

Storm water drainage system for an urbanized area is planned on the basis of the design frequency of the storm which shall be determined by the designer. Frequency is the period in which the selected design intensity recurs in a given period of time in years.

5D.5.5.11.2.4 Time of concentration

Time of concentration is the time required for the rainwater to flow to reach the farthest point of the drainage system or the outfall under consideration. Time of concentration is equal to the inlet time plus the time required for the flow to reach the main or branch drain. The inlet time is the time dependent on the distance of the farthest point in the drainage area to the inlet of the manhole and the surface slopes, etc and will vary between 5 min to 30 min.

In highly developed sections for example with impervious surfaces it may be as low as 3 min or lower (with good slopes) as in building terraces and paved areas. Correspondingly the design intensity for the drainage for such areas will be much higher. Rainwater pipes have to be designed for an intensity for a very low time of concentration.

5D.5.5.11.2.5 Natural infiltration

In planning any area with buildings, layout with paved and non-permeable surfaces, care should be taken to allow maximum discharge of the rain-water to flow directly or indirectly to permeate into the ground for enabling the ground water to be recharged. Some of the techniques which allow infiltration that may be considered are:

- a) Use of brick paved open jointed storm water drains.
- b) Providing bore holes in the storm water drains.
- c) Using paving tiles with open joints which enable water to percolates as it flows on it.

5D.5.5.11.3 Combined system

A combined system of drainage is one which carries the sewerage as well as the runoff from the storm water drainage. Relevant applicable statutory rules/ regulations may not allow such system in new areas and the sewerage and the storm water drainage have to be separate and independent of each other. Such systems are however existing in many old cities and the storm water may have to be discharged into the combined drainage system.

Where levels do not permit for connection to a public storm water drain, storm water from courtyards of buildings may be connected to the public sewer, provided it is designed to or has the capacity to convey combined discharge. In such cases, the surface water shall be admitted to the soil sewer through trapped gullies in order to prevent the escape of foul air.

5D.5.5.11.4 Discharging into a watercourse

It may often be convenient to discharge surface water to a nearby stream or a watercourse. The invert level of the outfall shall be about the same as the normal water level in the watercourse or ideally should be above the highest flood level of the watercourse. The out-fall shall be protected against floating debris by a screen.

5D.5.5.11.5 Discharge to a public storm water drain

Where it is necessary to connect the discharge rainwater into a public storm water drain, such drains shall be designed for the intensity of rain based on local conditions, but in no case shall they be designed for intensity of rainfall of less than 2 inches / hour. Rainwater from each building plot shall be connected to the storm water drainage through a separate pipe or an open public drain directly. No trap shall be installed before the connection.

5D.5.5.11.6 Rain-water pipes for roof drainage

5D.5.5.11.6.1

The roofs of a building shall be so constructed or framed as to permit effectual drainage of the rain-water there from by means of a sufficient number of rain-water pipes of adequate size so arranged, jointed and fixed as to ensure that the rainwater is carried away from the building without causing dampness in any part of the walls or foundations of the building or those of an adjacent building.

5D.5.5.11.6.2

The rain-water pipes shall be fixed to the outside of the external walls of the building or in recesses or chases cut or formed in such external wall or in such other manner as may be approved by the Authority.

5D.5.5.11.6.3

Rain-water pipes conveying rain- water shall discharge directly or by means of a channel into or over an inlet to a surface drain or shall discharge freely in a compound, drained to surface drain but in no case shall it discharge directly into any closed drain.

5D.5.5.11.6.4

Whenever it is not possible to discharge a rain-water pipe into or over an inlet to a surface drain or in a compound or in a street drain within 100 ft from the boundary of the premises, such rain-water pipe shall discharge into a gully trap which shall be connected with the street drain for storm water and such a gully- trap shall have a screen and a silt catcher incorporated in its design.

5D.5.5.11.6.5

If such streets drain is not available within 100ft of the boundary of the premises, a rain-water pipe may discharge directly into the kerb drain and shall be taken through a pipe outlet across the foot path, if any, without obstructing the path.

5D.5.5.11.6.6

A rain water pipe shall not discharge into or connect with any soil pipe or its ventilating pipe or any waste pipe or its ventilating pipe nor shall it discharge into a sewer unless specifically permitted to do so by the Authority, in which case such discharge into a sewer shall be intercepted by means of a gully trap.

5D.5.5.11.6.7

Rain-water pipes shall be constructed of cast iron, PVC, asbestos cement, galvanized sheet or other equally suitable material and shall be securely fixed.

5D.5.5.11.6.8

The factors that decide the quantity of rain water entering are:

- a) Intensity of rainfall, and
- b) Time of concentration selected for rain-water pipe.

A bell mouth inlet at the roof surface is found to give better drainage effect, provided proper slopes are given to the roof surface. The spacing of rain-water pipes depends on the locations available for the down takes and the area which each pipe serves. The spacing will also be determined by the amount of slopes that can be given to the roof. The recommended slopes for the flat roofs with smooth finish would be 1:150 to 1:133, with rough stone/tiles 1:100 and for gravel set in cement or loosely packed concrete finish 1:75 to 1:66. The effective strainer area should preferably be 1.5 to 2 times the area of pipe to which it connects to considerably enhance the capacity of rain water pipes.

The rain water pipes of cast iron (coefficient of roughness 0.013) shall normally be sized on the basis of roof areas according to Table 28. The vertical down take rain-water pipes, having a bell mouth inlet on the roof surface with effective cross-sectional area of grating 1.5 to 2 times the rain-water pipe area, may be designed by considering the outlet pipe as weir.

For full circumference of pipe acting as weir, the roof area (RA) for drainage may be worked out by using $RA = 0.084 \times d^{5/2} / I$

Where d = Pipe diameter; inches

I = Intensity of rainfall (inches / hour)

Table 26 Sizing of Rain-Water Pipes for Roof Drainage
(Clause 5.5.11.6.8)

Dia of Pipe (in)	Average Rate of Rainfall (inches / hour)					
	2	3	4	5	6	7
	Roof Area (ft ²)					
2	144.24	95.80	71.04	57.05	47.36	35.52
2½	259.41	172.23	129.17	103.33	86.11	64.58
3	439.17	290.63	219.59	175.45	146.39	109.79
4	919.25	613.55	459.62	368.13	306.77	229.27
5	1719.12	1148.84	866.50	692.13	575.87	430.56
6	2686.69	1795.65	1348.41	107.64	899.87	674.90

NOTE – For rain-water pipes of other materials, the roof areas shall be multiplied by (0.013/coefficient of roughness of surface of that material).

5D.5.5.11.6.9

The storm water may be led off in a suitable open drain to a watercourse. The open drain, if not a *pucca* masonry throughout, shall be so at least where there is either a change in direction or gradient.

5D.5.5.12 Rain-water Harvesting

5D.5.5.12.1 General

To supplement the ever growing shortage of protected, pure and safe water supply for human consumption rainwater is an ideal source which can be conserved and used in a useful manner by the people. The amount of rainfall available varies from region to region. Each area has to develop its own method and system to conserve, store and use it to suit its requirements and local conditions. There are several methods by which rain-water can be stored, used and conserved. Each system depends on the amount of precipitation, the period in which the rainfall occurs in a year and the physical infrastructure for example, space available to store the water, etc.

There are several techniques available for catching and storing the rain-water. Most of the techniques are applicable for large open areas, farms, sloping grounds etc, with a low population base. Two major systems that are ideal for urban and semi-urban developed areas are:

- Artificial ground water recharge, and
- Roof top rain-water harvesting.

5D.5.5.12.2 Artificial ground water recharge

With increase in the impermeable surfaces in modern built up areas, a large quantity of water normally percolating into the ground runs off to the natural drains and into the rivers causing increased runoff and flooding of downstream areas as it also deprives the original catchment area of the natural percolation that would have recharged the area in the normal course if the ground was in its natural condition for example a farm, open ground, forest, etc. It is therefore essential to catch the runoff and use it for augmentation of ground water reservoir by modifying the natural movement of surface water by recharging it by artificial means for example, construction of recharge structures (*see* Fig. 18). The main objectives achieved may be:

- a) Enhancement of sustainable yield in areas where there is over development and depletion of the aquifers.
- b) Conservation and storage of excess surface water in the aquifers.
- c) Improve the quality of the existing ground water through dilution.
- d) Remove bacteriological and suspended impurities during the surface water transition within the sub-soil.
- e) Maintain the natural balance of the ground water and its usage as the rain-water is a renewable supply source. A well managed and controlled tapping of the aquifers will provide constant, dependable and safe water supply.

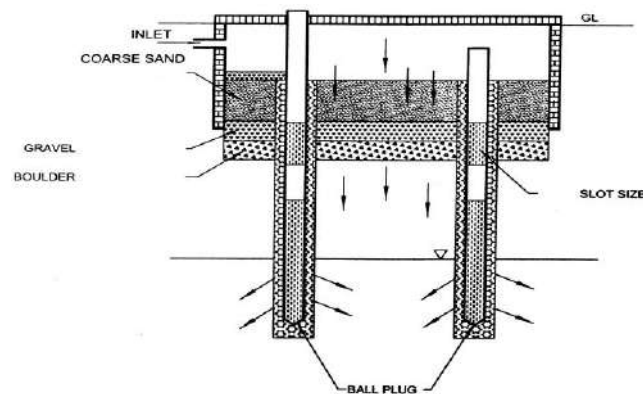


FIG. 18 ARTIFICIAL GROUND WATER RECHARGE STRUCTURE

In planning and designing the ground water recharge structures following should be taken into consideration:

- a) Annual rainfall (for estimating approx rainwater recharge per year).
- b) Peak intensity and duration of each storm.
- c) Type of soil and sub-soil conditions and their permeability factor.
- d) Ground slopes and runoff which cannot be caught.
- e) Location of recharge structures and its overflow outfall.
- f) Rainwater measuring devices for finding the flow of water in the system.

For artificial recharge to ground water, Guidelines for Artificial Recharge to Ground Water (*under preparation*) may be referred.

5D.5.5.12.3 Roof top rain-water harvesting

5D.5.5.12.3.1 Harvesting in regular rainfall areas

In areas having rainfall over a large period in a year for example, in hilly areas and coastal regions, constant and regular rainfall can be usefully harvested and stored in suitable water tanks. Water is collected through roof gutters and down take pipes. Provision should be made to divert the first rainfall after a dry spell so that any dust, soot, leaves etc, are drained away before the water is collected into the water tank. The capacity of the water tank should be enough for storing water required for consumption between two dry spells. The water tank shall be located in a well protected area and should not be exposed to any hazards of water contamination from any other sources. The water shall be chlorinated using chlorine tablets or solution to maintain a residual chlorine of approximately 1 ppm. The tank must have an overflow leading to a natural water courses or to any additional tanks (*see* Table 29).

Table 27 Rainwater Available from Roof Top Harvesting

(Clause 5.5.12.13.1)

Rain Fall (inch)	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
Roof Top Area (ft ²)	Harvested Water from Roof Tops (x 10 ³ ft ³) (80 percent of gross precipitation)																			
100	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
200	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48	0.52	0.56	0.6	0.64	0.68	0.72	0.76	0.8
300	0.06	0.12	0.18	0.24	0.3	0.36	0.42	0.48	0.54	0.6	0.66	0.72	0.78	0.84	0.9	0.96	1.02	1.08	1.14	1.2
400	0.08	0.16	0.24	0.32	0.4	0.48	0.56	0.64	0.72	0.8	0.88	0.96	1.04	1.12	1.2	1.28	1.36	1.44	1.52	1.6
500	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
600	0.12	0.24	0.36	0.48	0.6	0.72	0.84	0.96	1.08	1.2	1.32	1.44	1.56	1.68	1.8	1.92	2.04	2.16	2.28	2.4
700	0.14	0.28	0.42	0.56	0.7	0.84	0.98	1.12	1.26	1.4	1.54	1.68	1.82	1.96	2.1	2.24	2.38	2.52	2.66	2.8
800	0.16	0.32	0.48	0.64	0.8	0.96	1.12	1.28	1.44	1.6	1.76	1.92	2.08	2.24	2.4	2.56	2.72	2.88	3.04	3.2
900	0.18	0.36	0.54	0.72	0.9	1.08	1.26	1.44	1.62	1.8	1.98	2.16	2.34	2.52	2.7	2.88	3.06	3.24	3.42	3.6
1000	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8	4
1100	0.22	0.44	0.66	0.88	1.1	1.32	1.54	1.76	1.98	2.2	2.42	2.64	2.86	3.08	3.3	3.52	3.74	3.96	4.18	4.4
1200	0.24	0.48	0.72	0.96	1.2	1.44	1.68	1.92	2.16	2.4	2.64	2.88	3.12	3.36	3.6	3.84	4.08	4.32	4.56	4.8
1300	0.26	0.52	0.78	1.04	1.3	1.56	1.82	2.08	2.34	2.6	2.86	3.12	3.38	3.64	3.9	4.16	4.42	4.68	4.94	5.2
1400	0.28	0.56	0.84	1.12	1.4	1.68	1.96	2.24	2.52	2.8	3.08	3.36	3.64	3.92	4.2	4.48	4.76	5.04	5.32	5.6
1500	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6
2000	0.4	0.8	1.2	1.6	2	2.4	2.8	3.2	3.6	4	4.4	4.8	5.2	5.6	6	6.4	6.8	7.2	7.6	8
2500	0.5	1	1.5	2.0	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
3000	0.6	1.2	1.8	2.4	3	3.6	4.2	4.8	5.4	6	6.6	7.2	7.8	8.4	9	9.6	10.2	10.8	11.4	12
4000	0.8	1.6	2.4	3.2	4	4.8	5.6	6.4	7.2	8	8.8	9.6	10.4	11.2	12	12.8	13.6	14.4	15.2	16
5000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10000	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
20000	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
30000	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120

5D.5.5.12.3.2 Harvesting in urban areas

In urban areas with the rainfall limited during the monsoon period (usually from 15-90 days) roof top rain-water cannot be stored and used as mentioned above and is best used for recharging the ground water. For individual properties and plots the roof top rain-water should be diverted to existing open or abandoned tube wells. In a well building complex the system should be laid out so that the runoff is discharged in bore-wells as per designs specified by the Authority.

For roof top rain water harvesting in hilly areas reference may be made to good practice [9-1(30)].

5D.5.5.12.4 Care to taken in rain-water harvesting

Water conservation technique discussed above shall be constructed with due care taking following precautions:

- a) No sewage or waste water should be admitted into the system.
- b) No waste water from areas likely to have oil, grease or other pollutants should be connected to the system.
- c) Each structure/well shall have an inlet chamber with a silt trap to prevent any silt from finding its way into the sub-soil water.
- d) The wells should be terminated at least 16 feet 6 inches above the natural static sub-soil water at its highest level so that the incoming flow passes through the natural ground condition and prevents contamination hazards.
- e) No recharge structure or a well shall be used for drawing water for any purpose.

5D.5.5.13 Sub-soil Water Drainage

5D.5.5.13.1 General

Sub-soil water is that portion of the rainfall which is absorbed into the ground.

The drainage of sub-soil water may be necessary for the following reasons:

- a) to avoid surface flooding;
- b) to alleviate or to avoid causing dampness in the building, especially in the cellars;
- c) to reduce the humidity in the immediate vicinity of the building; and
- d) to increase the workability of the soil.

5D.5.5.13.2 Depth of water table

The standing level of the sub-soil water will vary with the season, the amount of rainfall and the proximity and level of drainage channels. Information regarding this level may be obtained by means of boreholes or trial pits, preferably the latter. It is desirable though not always practicable to ascertain the level of the standing water over a

considerable period so as to enable the seasonal variations to be recorded and in particular the high water level. The direction of flow of the sub-soil water may usually be judged by the general inclination of the land surface and the main lines of the subsoil drains shall follow the natural falls, wherever possible.

5D.5.5.13.3 Precautions

Sub-soil drains shall be so sited as not to endanger the stability of the buildings or earthwork. In some portions of the drain, it may be necessary to use non-porous jointed pipes.

5D.5.5.13.3.1

No field pipe shall be laid in such a manner or in such a position as to communicate directly with any drain constructed or adopted to be used for conveying sewage, except where absolutely unavoidable and in such case a suitable efficient trap shall be provided between sub-soil drain and such sewer.

5D.5.5.13.4 Systems of sub-soil drainage

Clay or concrete porous field drain pipes may be used and shall be laid in one of the following ways (*see also* Fig, 19):

- a) **Natural** — The pipes are laid to follow the natural depressions or valleys of the site; branches discharge into the main as tributaries do into a river.
- b) **Herringbone** — The system consists of a number of drains into which discharges from both sides smaller subsidiary branch drains parallel to each other, but at an angle to the mains forming a series of herringbone pattern. Normally these branch drains should not exceed 30 m in length.
- c) **Grid** — A main or mains drain is laid to the boundaries of the site into which subsidiary branches discharge from one side only.
- d) **Fan-Shaper** — The drains are laid converging to a single outlet at one point on the boundary of a site, without the use of main or collecting drains.
- e) **Moat or cut-off system** — This system consists of drains laid on one or more sides of a building to intercept the flow of subsoil water and carry it away, thereby protecting the foundations of a building.

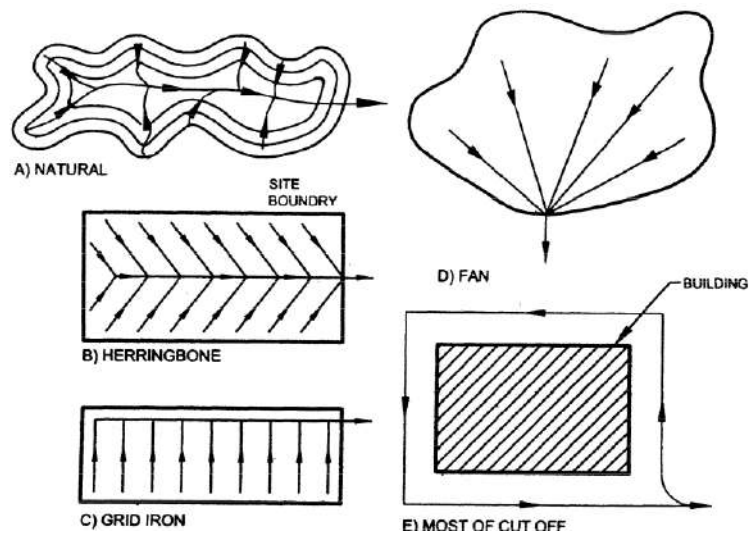


FIG. 19 DETAILS OF DRAINAGE SYSTEM

The choice of one or more of these systems will naturally depend on the local conditions of the site. For building sites, the mains shall be not less than 3 inches in diameter and the branches not less than $2\frac{1}{2}$ inches in diameter and the branches not less than $2\frac{1}{2}$ inches in diameter but normal practice tends towards the use of 4 inches and 3 inches respectively. The pipes shall generally be laid at 2 feet to 3 feet depth, or to such a depth to which it is desirable to lower the water-table and the gradients are determined rather by the fall of the land than by considerations of self-cleansing velocity. The connection of the subsidiary drain to the main drain is best made by means of a clay ware or concrete junction pipe. The outlet of a sub-soil system may discharge into a soak away or through a catch pit into the nearest ditch or watercourse. Where these are not available, the sub-soil drains may be connected, with the approval of the Authority, through an intercepting trap to the surface water drainage system,

NOTE — Care shall be taken that there is no backflow from sub-surface drains during heavy rains.

5D.5.5.14 Waste Disposal Systems in High Altitudes and or Sub-zero Temperature Regions

5D.5.5.14.1

In general, all the cases to be exercised regarding water supply systems shall also be applicable in the case of waste disposal systems shall also be applicable in the case of waste disposal systems. The biological and chemical reduction of organic material proceeds slowly under low temperature conditions, consequently affecting the waste disposal systems. The waste disposal methods given in 5.5.14.2, 5.5.14.3 and 5.5.14.4 shall be used only where it is not practical to install water carriage system.

5D.5.5.14.2 Box and can system

Where box and can systems are employed, adequate arrangements shall be made for the cleaning and disinfection of the can after it is emptied of its contents. The excrement from the can shall be disposed of by burial in isolated spots far from habitation or by incineration, where feasible. The can shall be fitted with a tight fitting lid for use when it is carried for emptying.

5D.5.5.14.3 Trench or pit latrines

Trench or pit latrines shall be used only where soil and sub-soil conditions favour their use. Whenever they are used, they shall not be closer than 60 ft from any source of drinking water, such as well, to eliminate the possibility of bacterial pollution of water.

5D.5.5.14.4 Chemical toilets

For the successful functioning of chemical toilets, they shall preferably be installed in heated rooms or enclosures.

NOTE — Chemical toilet essentially consists of small cylindrical tanks with a water-closet seat for the use of 8 to 10 persons. A ventilation pipe is fitted to the seat. A strong solution of caustic soda is used as a disinfectant. It kills bacteria, liquefies the solids and thus checks the decomposition of organic matter. The tank is provided with a drain plug for which liquid runs to a soak pit at the time of disposal.

5D.5.5.14.5 Water-borne sanitation systems

Water-borne sanitation systems shall be used, where practicable. Sanitation systems for the collection of sewage should be constructed in such a manner that maximum heat is retained by insulation, if necessary.

5D.5.5.14.5.1 Sewerage laying

Under normal circumstances, sewers shall be laid below the frost line. Manholes shall be made of airtight construction so as to prevent the cold air from gaining access inside and freezing the contents. The trenches for sewers shall be loosely filled with earth after laying sewers, since loose soil is a better insulator than compacted soil. Consequently, sewers laid under traffic ways and other places where soil compaction may be expected are required to be given adequate insulation. Where feasible, sewers shall be so located that the trench line is not in shadow, when the sun is shining. Concrete, cast iron and stoneware pipes conduct heat relatively rapidly and as such should be adequately insulated.

5D.5.5.14.5.2 Septic tanks

Septic tanks can function only when it can be ensured that the contents inside these do not freeze at low temperature. For this purpose, the septic tanks shall be located well below the frost line. The location of manhole openings shall be marked by staves. Fencing around the septic tanks shall be provided for discouraging traffic over them. As the rate of biological activity is reduced by

50 percent for every 10°C fall in temperature, the capacity of septic tanks shall be increased by 100 percent for operation at 10°C over that for operation at 20°C.

5D.5.5.14.5.3 Seepage pits

Seepage pits can function only when the soil and subsoil conditions are favourable. Frozen soil extending to a great depth would preclude the use of such disposal devices in view of the lower water absorption capacity. The discharge of effluent should be made below the frost line.

5D.5.5.14.5.4 Sewage treatment plants

Suitable design modifications for sedimentation, chemical and biological processes shall be applied to sewage treatment plants for satisfactory functioning.

NOTE — Lavatories and bathrooms shall be kept heated to avoid freezing of water inside traps and flushing cisterns.

5D.5.6 Construction Relating to Conveyance of Sanitary Wastes

5D.5.6.1 Excavation

5D.5.6.1.1 General

The safety precautions as given in Part 7 'Constructional Practices and Safety' shall be ensured.

5D.5.6.1.2

Turf, topsoil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement. All suitable broken surface material and hard-core shall be set on one side for use in subsequent reinstatement.

5D.5.6.1.3

Excavated material shall be stacked sufficiently away from the edge of the trench and the size of the spoil bank shall not be allowed to become such as to endanger the stability of the excavation. Spoil may be carried away and used for filling the trench behind the work.

5D.5.6.1.4

Excavation shall proceed to within about 3 inches of the finished formation level. This final 3 inches is to be trimmed and removed as a separate operation immediately prior to the laying of the pipes or their foundations.

5D.5.6.1.5

Unless specified otherwise by the Authority, the width at bottom of trenches for pipes of different diameters laid at different depths shall be as given below:

a) For all diameters, up to an average depth of 4 ft, width of trench in ft = diameter of pipe + 1 ft;

b) For all diameters for depths above 4 ft; width of trench in ft = diameter of pipe + 1½ ft; and

c) Notwithstanding (a) and (b), the total width of trench at the top should not be less than 2 ft 6 in for depths exceeding 3 ft.

5D.5.6.1.6

Excavation in roads shall be so arranged, in agreement with the proper authority, as to cause the minimum obstruction to traffic. The methods to be adopted shall depend on local circumstances.

5D.5.6.1.7

All pipes, ducts, cables, mains or other services exposed in the trench shall be effectively supported by timber and/or chain or rope-slings.

5D.5.6.1.8

All drainage sumps shall be sunk clear of the work outside the trench or at the sides of manholes. After the completion of the work, any pipes or drains leading to such sumps or temporary sub-soil drains under permanent work shall be filled in properly with sand and consolidated.

5D.5.6.2 Laying of Pipes

Laying of pipes shall be done in accordance with good practice [9-1(31)].

5D.5.6.3 Jointing

All soil pipes, waste pipes, ventilating pipes and other such pipes above ground shall be gas-tight. All sewers and drains laid below the ground shall be water-tight. Jointing shall be done in accordance with good practice [9-1(31)].

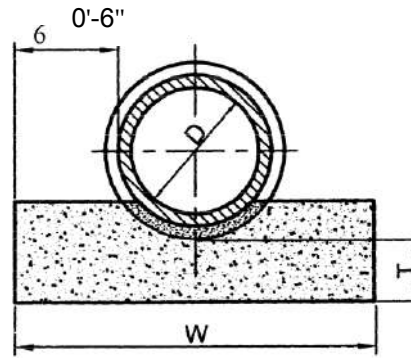
5D.5.6.4 Support or protection for pipes

5D.5.6.4.1 General

It may be necessary to support or surround pipe sewers or drains by means of concrete in certain circumstances. Some of the suggested methods are given in 5.6.4.2 to 5.6.4.4.

5D.5.6.4.2 Bedding

Bedding (*see* Fig. 20) shall be rectangular in section and shall extend laterally at least 6 inches beyond and on both sides of the projection of the barrel of the pipe. The thickness of the concrete below the barrel of the pipe shall be not less than 4 inches for pipes under 6 inches diameter and 6 inches for pipes 6 inches and over in diameter. Where bedding is used alone, the concrete shall be brought up at least to the invert level of the pipe to form a cradle and to avoid line contact between the pipe and the bed.



$$W = D + 1'-0"$$

where D is external diameter of the pipe

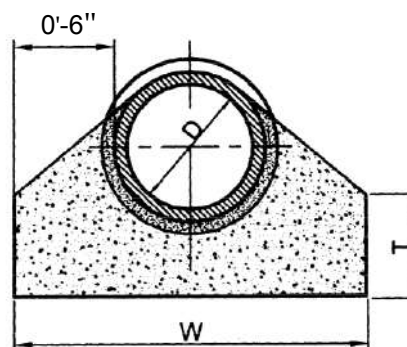
T = 4" for pipes under 6" nominal dia (or) 6" for pipes of 6" nominal dia and over

FIG. 20 BEDDING

5D.5.6.4.3 Hunching

Concrete hunching (see Fig. 21) shall consist of:

- A concrete bed as described for bedding (see Fig- 5.6.4.2);
- The full width of the bed carried up to the level of the horizontal diameter of the pipe; and
- Splays from this level carried up on both sides of the pipe, from the full width of the bed to meet the pipe barrel tangentially.



$$W = D + 1'-0"$$

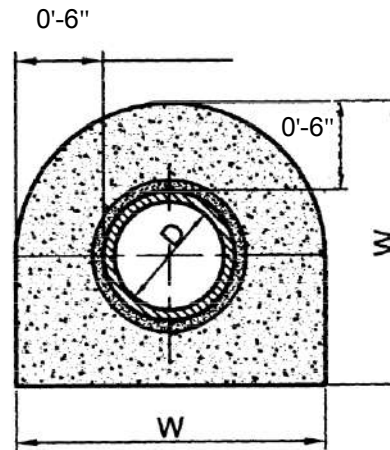
where D is external diameter of the pipe

T = 4" for pipes under 6" nominal dia (or) 6" for pipes of 6" nominal dia and over

FIG. 21 HAUNCHING

5D.5.6.4.4 Surround or Encasing

The surround or encasing (*see Fig. 22*) shall be similar to hunching up to the horizontal diameter of the pipe and the top portion over this shall be finished in a semicircular form to give a uniform encasing for the top half of the pipe.



$$W = D + 1'-0"$$

where D is external diameter of the pipe

FIG. 22 SURROUND OR ENCASING

5D.5.6.5 Connection to Existing Sewers

The connection to an existing sewer shall, as far as possible, be done at the *manholes*. Where it is unavoidable to make connection in between two manholes, the work of breaking into the existing sewer and forming the connection shall be carried out by the Authority or under its supervision.

5D.5.6.5.1

Breaking into the sewer shall be effected by the cautious enlargement of a small hole and every precaution shall be taken to prevent any material from entering the sewer. No connection shall be formed in such a way as to constitute a projection into the sewer or to cause any diminution in its effective size.

5D.5.6.6 Back-Filling

5D.5.6.6.1

Filling of the trench shall not be commenced until the length of pipes therein has been tested and passed (*see 5.10.2*).

5D.5.6.6.2

All timber which may be withdrawn with safety shall be removed as filling proceeds.

5D.5.6.6.3

Where the pipes are unprotected by concrete haunching, the first operation in filling shall be carefully done to hand-pack and tamp selected fine material around the lower half of the pipes so as to buttress them to the sides of the trench.

5D.5.6.6.4

The filling shall then be continued to 6 inches over the top of the pipe using selected fine hand-packed material, watered and rammed on both sides of the pipe with a wooden rammer. On no account shall material be tipped into the trench until the first 6 inches of filling has been completed. The process of filling and tamping shall proceed evenly so as to maintain an equal pressure on both sides of the pipeline.

5D.5.6.6.5

Filling shall be continued in layers not exceeding 6 inches in thickness, each layer being watered and well rammed.

5D.5.6.6.6

In roads, surface materials previously excavated shall be replaced as the top layer of the filling, consolidated and maintained satisfactorily till the permanent reinstatement of the surface is made by the Authority.

5D.5.6.6.7

In gardens, the top soil and turf, if any, shall be carefully replaced.

5D.5.7 Construction Relating to Conveyance of Rain or Storm Water

5D.5.7.1 Roof Gutters

Roof gutters shall be of any material of suitable thickness. All junctions and joints shall be water-tight.

5D.5.7.2 Rain-Water Pipes

Rain water pipes shall conform to the accepted standards [9-1(32)].

5D.5.7.3 Sub-soil Drain Pipes

5D.5.7.3.1 Field drain pipes

Suitable pipes for this purpose are plain cylindrical glazed water pipes, or concrete porous pipes though the latter may prove unsuitable where sub-soil water carries sulphates or is acidic. Trenches for these pipes need be just wide enough at the bottom to permit laying the pipes, which shall be laid with open joints to proper lines and gradients.

It is advisable to cover the pipes with clinker free from fine ash, brick ballast or other suitable rubble, or a layer of inverted turf, brush-wood or straw before refilling the trench, in order to prevent the infiltration of silt through the open joints. Where the sub-soil drain is also to serve the purpose of collecting surface water, the rubble shall be carried upto a suitable level and when required for a lawn or playing field, the

remainder of the trench shall be filled with pervious top soil. When refilling the trenches, care shall be taken to prevent displacement of pipes in line of levels. When they pass near trees or through hedges, socket pipes with cement or bitumen joints shall be used to prevent penetration by roots.

5D.5.7.3.2 French Drain

A shallow trench is excavated, the bottom neatly trimmed to the gradient and the trench filled with broken stone, gravel or clinker, coarse at the bottom and finer towards the top.

5D.5.8 Selection and Installation of Sanitary Appliances

5D.5.8.1

Selection, installation and maintenance of sanitary appliances shall be done in accordance with good practice [9-1(33)].

5D.5.9 Refuse Chute System

5D.5.9.1

Refuse chute system is provided in multi- storeyed buildings for transporting and collecting in a sanitary way the refuse from floors at different heights. The refuse is received from the successive floor through the inlets located on the vertical system of pipes that convey refuse through it and discharge it into the collecting chamber from where the refuse is cleared at suitable intervals.

5D.5.9.2

This system has got three functionally important components, namely, the chutes, the inlet hopper and the collection chamber.

5D.5.9.2.1

The chute may be carried through service shafts meant for carrying drainage pipes. However, the location shall be mostly determined by the position of the inlet hopper and the collecting chamber that is most convenient for the user. It should also be considered to locate the chute away from living rooms in order to avoid noise and smell nuisance.

5D.5.9.2.2

In individual chute system, the inlet hopper shall be located in the passage near the kitchen and in the common chute system towards the end of the common passage. Natural ventilation should be adequate to prevent any possible odour nuisance. There should be adequate lighting at this location. For ground floor (floor 1), the inlet hopper may be placed at a higher level and a flight of steps may be provided for using the same.

5D.5.9.2.3

The collection chamber shall be situated at ground level.

5D.5.9.2.4

Requirements in regard to the design and construction of refuse chute system shall be in accordance with good practice [9-1(34)].

5D.5.10 Inspection and Testing

5D.5.10.1 Inspection

5D.5.10.1.1

All sanitary appliances and fitments shall be carefully examined for defects before they are installed and also on the completion of the work.

5D.5.10.1.2

Pipes are liable to get damaged in transit and, notwithstanding tests that may have been made before dispatch, each pipe shall be carefully examined on arrival on the site. Preferably, each pipe shall be rung with a hammer or mallet and those that do not ring true and clear shall be rejected. Sound pipes shall be carefully stored to prevent damage. Any defective pipes shall be segregated, marked in a conspicuous manner and their use in the works prevented.

5D.5.10.1.3

Cast iron pipes shall be carefully examined for damage to the protective coating. Minor damage shall be made good by painting over with hot tar or preferably bitumen. But if major defects in coating exist, the pipes shall not be used unless recoated. Each pipe shall be carefully re-examined for soundness before laying.

5D.5.10.1.4

Close inspection shall be maintained at every stage in the work, particularly as to the adequacy of timber supports used in excavation and the care and thoroughness exercised in filling.

5D.5.10.1.4.1

Careful note shall be kept of the condition of any sewer, manhole or other existing work which may be uncovered and any defects evident shall be pointed out immediately to the Authority.

5D.5.10.1.4.2

No work shall be covered over or surrounded with concrete until it has been inspected and approved by the Authority.

5D.5.10.2 Testing

5D.5.10.2.1

Comprehensive tests of all appliances shall be made by simulating conditions of use. Overflow shall be examined for obstructions.

5D.5.10.2.2 Smoke test

All soil pipes, waste pipes, and vent pipes and all other pipes when above ground shall be approved gas-tight by a smoke test conducted under a pressure of 1 inch of water and maintained for 15 min after all trap seals have been filled with water. The smoke is produced by burning only waste or tar paper or similar material in the combustion chamber of a smoke machine. Chemical smokes are not satisfactory.

5D.5.10.2.3 Water test

5D.5.10.2.3.1 For pipes other than cast iron

Glazed and concrete pipes shall be subjected to a test pressure of at least 5 ft head of water at the highest point of the section under test. The tolerance figure of 8 gallons / inches of diameter/mile may be allowed during a period of 10 min. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provide the required test head, or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of the test water may be due to one or more of the following causes:

absorption by pipes and joints;

sweating of pipes or joints;

leakage at joints or from defective pipes; and

trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased after which the test proper should commence. Any leakage will be visible and the defective part of the work should be cut out and made good. A slight amount of sweating which is uniform may be overlooked, but excessive sweating from a particular pipe or joint shall be watched for and taken as indicating a defect to be made good. A slight amount of sweating which is uniform may be overlooked, but excessive sweating from a particular pipe or joint shall be watched for and taken as indicating a defect to be made good.

NOTE — This test will not be applicable to sanitary pipe work above ground level.

5D.5.10.2.3.2 For cast iron pipes

Cast iron sewers and drains shall be tested as for glazed and concrete pipes. The drain plug shall be suitably strutted to prevent their being forced out of the pipe during the test.

5D.5.10.2.4 Tests for straightness and obstruction

The following tests shall be carried out:

- a) by inserting at the high end of the sewer or drain a smooth ball of a diameter $\frac{1}{2}$ inch less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball should roll down the invert of the pipe, and emerge at the lower end; and

b) by means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of light may be observed. If the pipe line is not straight, this will be apparent. The mirror will also indicate obstruction in the barrel.

5D.5.10.2.5 Test records

Complete records shall be kept of all tests carried out on sewers and drains both during construction and after being put into service.

5D.5.11 Maintenance

5D.5.11.1 General

Domestic drainage system shall be inspected at regular intervals. The system shall be thoroughly cleaned out at the same time and any defects discovered shall be made good.

5D.5.11.2 Cleaning of Drainage System

5D.5.11.2.1

Sewer maintenance crews, when entering a deep manhole or sewer where dangerous gas or oxygen deficiencies may be present, shall follow the following procedures:

- a) Allow no smoking or open flames and guard against sparks.
- b) Erect warning signs.
- c) Use only safety gas-proof, electric lighting equipment.
- d) Test the atmosphere for noxious gases and oxygen deficiencies (presence of hydrogen sulphide is detected using lead acetate paper and that of oxygen by safety lamps).
- e) If the atmosphere is normal, workmen may enter with a safety belt attached and with two men available at the top. For extended jobs, the gas tests shall be repeated at frequent intervals, depending on circumstances.
- f) If oxygen deficiency or noxious gas is found, the structure shall be ventilated with pure air by keeping open at least one manhole cover each on upstream and downstream side for quick exit of toxic gases or by artificial means. The gas tests shall be repeated and the atmosphere cleared before entering. Adequate ventilation shall be maintained during this work and the tests repeated frequently.
- g) If the gas or oxygen deficiency is present and it is not practicable to ventilate adequately before workers enter, a hose mask shall be worn and extreme care taken to avoid all sources of ignition. Workers shall be taught how to use the hose equipment. In these cases, they shall always use permissible safety lights (not ordinary flash lights), rubber boots or non-sparking shoes and non-sparking tools;
- h) Workmen descending a manhole shaft to inspect or clean sewers shall try each ladder step or rung carefully before putting the full weight on it to guard against insecure fastening due to corrosion of the rung at the

manhole wall. When work is going on in deep sewers, at least two men shall be available for lifting workers from the manhole in the event of serious injury; and

i) Portable air blowers, for ventilating manhole, are recommended for all tank, pit or manhole work where there is a question as to the presence of noxious gas, vapours or oxygen deficiency. The motors for these shall be of weather proof and flame-proof types; compression ignition diesel type (without sparking plug) may be used. When used, these shall be placed not less than 6 feet 6 inches away from the opening and on the leeward side protected from wind, so that they will not serve as a source of ignition for any inflammable gas which might be present. Provision should be made for ventilation and it should be of the forced type which can be provided by a blower located at ground level with suitable flexible ducting to displace out air from the manhole.

5D. 5.11.2.2

The following operations shall be carried out during periodical cleaning of a drainage system.

- a) The covers of inspection chambers and manholes shall be removed and the side benching and channels scrubbed;
- b) The interceptive trap, if fitted, shall be adequately cleaned and flushed with clean water. Care shall be taken to see that the stopper in the rodding arm is securely replaced;
- c) All lengths of main and branch drains shall be rodded by means of drain rods and a suitable rubber or leather plunger. After rodding, the drains shall be thoroughly flushed with clean water. Any obstruction found shall be removed with suitable drain cleaning tools and the system thereafter shall be flushed with clean water;
- d) The covers of access plates to all gullies shall be removed and the traps plunged and flushed out thoroughly with clean water. Care shall be taken not to flush the gully deposit into the system;
- e) Any defects revealed as a result of inspection or test shall be made good;
- f) The covers or inspection chambers and gullies shall be replaced, bedding them in suitable grease or other materials; and
- g) Painting of ladders/rings in deep manholes and external painting of manhole covers shall be done with approved paints.
- h) In the case of WWTP built under the floor slab, it must have at least 2 feet space around the perimeter of the tank to enable regular inspection and maintenance. It must have at least 3 feet vertical space between the floor slab and cover slab of the tank to enable regular inspection and maintenance.

5D.5.11.3

All surface water drains shall be periodically rodded by means of drain rods and a suitable rubber or leather plunger. After rodding, they shall be thoroughly

flushed with clean water. Any obstruction found shall be removed with suitable drain cleaning tools.

5D.5.11.4

All sub-soil drains shall be periodically examined for obstruction at the open joints due to the roots of plants or other growths.

5D.6 SOLID WASTE MANAGEMENT

5D.6.1 General

5D.6.1.1

Efficient collection and disposal of domestic garbage from a building or activity area is of significant importance to public health and environmental sanitation and, therefore, an essential part of the construction of the built environment. Notwithstanding the provisions given herein, the solid waste management shall have to comply with relevant statutory Rules and Regulations in force from time- to-time. In this regard, the provisions of the following shall govern the procedures for handling, treatment, etc of solid wastes as applicable to the concerned building occupancy:

- a) Manufacture, Storage and Import of Hazardous Chemical Rules, 1989;
- b) Bio-Medical Waste (Management and Handling Rules, 1998; and
- c) Municipal Solid Wastes (Management and Handling) Rules, 2000.

5D.6.1.2

The provisions relating to solid waste management given in 6.2 are applicable to wastes in general, and specifically exclude the hazardous chemical wastes and bio-medical waste.

5D.6.2 Solid Waste Management Systems

5D.6.2.1

In designing a system dealing with collection of domestic garbage for a built premises/community/ environment, the aim shall be to provide speedy and efficient conveyance as an essential objective for design of the system. The various available systems may be employed in accordance with 6.2.1 to 6.2.3, which may be adopted individually or in combination as appropriate in specific situations.

5D.6.2.2 Refuse Chute System

5D.6.2.2.1

Refuse chute system is a convenient and safe mode of collection of domestic solid wastes from buildings exceeding 3 storeys. The internal diameter of the chute shall be at least 1 ft.

The access to the refuse chute shall be provided from well ventilated and well illuminated common corridor or lobby and preferably it should not be located opposite or adjacent to entry of individual flats or lift.

5D.6.2.2.2 Opening for feeding of refuse chute

Opening, with top or bottom hinged shutters with appropriate lockable latch, shall be provided for convenient accessing of the refuse chute by users.

5D.6.2.2.3 Refuse collection chamber

The collection chamber may be located in ground floor or basement level, provided appropriate arrangement is made for (a) drainage of the collection pit by gravity flow to ensure its dryness, (b) an appropriate ramp access is provided for convenient removal of garbage from the collection pit, and (c) satisfactory ventilation for escape of gas and odour. The floor of the chamber shall be provided with drainage through a 4 inches diameter trap and screen to prevent any solid matters flowing into the drain and the drain shall be connected to the sewer line. The floor shall be finished with smooth hard surface for convenient cleaning.

The height of the collection chamber and vertical clearance under the bottom level of garbage chute shall be such that the garbage trolley can be conveniently placed.

The collection chamber shall be provided with appropriate shutter to prevent access of all scavenging animals like the cattle, dogs, cats, rats, etc.

5D.6.2.2.4 Material for chute

The chute may be of masonry or suitable non-corrosive material. Further the material should be rigid with smooth internal finish, high ductility and alkali/acid resistant properties.

5D.6.2.2.5 Size of trolley

The size of the garbage trolley shall be adequate for the daily quantity of garbage from a chute. For working out quantity of garbage, a standard of approximately 0.75 kg/person may be taken.

5D.6.2.3 Dumb-Waiter

In high rise buildings with more than 8 storeys, electrically operated dumb-waiters may be used for carrying domestic garbage in packets or closed containers. For handling of garbage by dumb-waiters in a building, a garbage chamber shall have to provided either at ground floor or basement level and the provisions of garbage collection chamber for chute as given in 6.2.2 shall apply.

5D.6.2.3.1 Shutters for dumb-waiter

The shutters for dumb-waiter and garbage collection chamber shall be provided with shutters with same consideration as in the case of garbage chute. However, the dumb-waiter shall be made child-proof.

5D.6.2.3.2 Sorting of garbage to remove toxic matters from garbage

Before feeding the garbage to compost pits the following objects need to be removed:

- a) inert matters like glass, metals, etc chemicals, medicines, batteries of any kind;
- b) polythene and plastic materials; and

c) any other non-biodegradable material.

These separated items shall be handled separately, and may be scrapped or recycled, etc as appropriate.

5D.6.2.4

Bin center system is a simple, convenient, safe, affordable and sustainable mode of collection of domestic waste from buildings regardless of storeys. Preferably it should be located at the back and side of the building provided that the bins are accessible for removal of garbage.

5D.6.2.4.1

The size should be adequate to store two days quantity of garbage volume. A standard of approximately 1.65 lb / person may be taken.

5D.6.2.4.2

The structure may be built of RCC, brick work or any other non-porous material. The structure should be water tight and well ventilated. It must be covered with hinged shutter for convenience accessing to the user.

5D.6.3 Garbage Collection system

Location

5D. 6.3.1 Garbage Chute System (GCS)

5D.6.3.1.1

Garbage Chute System is a convenient and safe means of collection of domestic joined wastes (Garbage) from high rise building when properly designed, constructed, operated and maintained.

5D.6.3.1.2

The access to the garbage chute shall be provided from a well ventilated and well illuminated common corridor.

5D.6.3.1.3

It should not be located opposite or/and adjacent to entry of individual apartments or lifts.

Construction

5D. 6.3.2

Free standing garbage chute may be used. The chute must rise vertically through the building up to the roof level and properly vented.

5D.6.3.2.1

The chute must be provided with close-fitting access hopper at every floor.

5D.6.3.2.2

For reducing the risk of blockage in the chute, the diameter of the chute should not be less than 2 feet.

5D.6.3.2.3

The diameter of the vent pipe should not be less than 9 inches.

5D.6.3.2.4

The chute is required to have smooth, non-absorbent, non-combustible surfaces and non-crackable surfaces the chute may be constructed of glazed fireclay, masonry or concrete pipes.

5D.6.3.3 Occupants using chute

5D.6.3.3.1

Occupants should have not more than 30 m to walk to the point of access to the chute. For reasons of hygiene and maintenance, more than 6 dwellings/apartments should not share one access hopper.

5D.6.3.4 Garbage handling

5D.6.3.4.1

Wastes shall be collected and securely wrapped in 'garbage bags' when discarding it through the access hopper into the chute, and down into the container located at the lowest end of the chute at ground level.

5D.6.3.5 Container / Garbage Trolley

5D.6.3.5.1

The container is housed in a garbage collecting chamber with proper shutter to prevent all scavenging animals like dogs, rodents, flies and rats etc. from gaining access to the chamber. The floor of the chamber shall be properly drained.

5D.6.3.5.2

It is preferable that the container is fitted with appropriate wheels, as a trolley, for easy maneuver to and from the collection chamber by the garbage handlers.

5D.6.3.5.3

The size of the container/garbage trolley shall be adequate for the daily quantity of garbage generated from the apartments it serves.

A minimum of 2 containers/ garbage trolleys would be adequate for storing garbage from the chute for at least one day.

5D.6.4 Service lift handling system

5D.6.4.1

In this case a service lift is provided for the occupants to use the lift for transporting the daily garbage to the bin center located at ground level.

Note: All wastes should be securely wrapped in garbage bags.

5D.6.4.2 The following should be noted and due consideration given;

- a) Provision of garbage bin centre.
- b) Disposal of garbage from the premises.
- c) Proper maintenance of garbage bin in healthy environment condition.

Good Practices (9-1(2) to 9-1(34)) Shown in NBC of India

LIST OF STANDARDS

The following list records those standards which are acceptable as 'good practice' and 'accepted standards' in the fulfillment of the requirements of the Code. The latest version of a standard shall be adopted at the time of enforcement of the Code. The standards listed may be used by the Authority as a guide in conformance with the requirements of the referred clauses in the Code.

IS No.	Title	IS No.	Title
(3) 2041 : 1995	Specification for steel plates for pressure vessels used at moderate and low temperature (<i>second revision</i>)	(Part 2) : 1975	Laying and jointing polyethylene (PE) pipes
804 : 1967	Specification for rectangular pressed steel tanks (<i>first revision</i>)	(Part 3) : 2003	Laying and jointing of UPVC pipes (<i>first revision</i>)
(4) 3076 : 1985	Specification for low density polyethylene pipes for potable water supplies (<i>second revision</i>)	(12) 783 : 1985	Code of practice for laying of concrete pipes (<i>first revision</i>)
4984 : 1995	Specification for high density polyethylene pipes for potable water supplies (<i>fourth revision</i>)	3114 : 1994	Code of practice for laying of cast iron pipes (<i>second revision</i>)
4985 : 2000	Specification for unplasticized PVC pipes for potable water supplies (<i>third revision</i>)	5822 : 1994	Code of practice for laying of welded steel pipes for water supply (<i>second revision</i>)
(5) 2065 : 1983	Code of practice for water supply in buildings (<i>second revision</i>)	6530 : 1972	Code of practice for laying of asbestos cement pressure pipes
(6) 3114 : 1994	Code of practice for laying of cast iron pipes (<i>second revision</i>)	7634	Code of practice for plastics pipe, work for potable water supplies:
(7) 782 : 1978	Specification for caulking lead (<i>third revision</i>)	(Part 2) : 1975	Laying and jointing polyethylene (PE) pipes
(8) 5822 : 1994	Code of practice for laying of welded steel pipes for water supply (<i>second revision</i>)	(Part 3) : 2003	Laying and jointing of UPVC pipes (<i>first revision</i>)
(9) 6530 : 1972	Code of practice for laying of asbestos cement pressure pipes	(13) 2692 : 1989	Specification for ferrules for water services (<i>second revision</i>)
(10) 783 : 1985	Code of practice for laying of concrete pipes (<i>first revision</i>)		
(11) 7634	Code of practice for plastics pipe, work for potable water supplies:	2082 : 1993	Stationary storage type electric water heaters (<i>third revision</i>)
		(15) 7558 : 1974	Code of practice for domestic hot water installations
		(16) 6295 : 1986	Code of practice for water supply and drainage in high altitudes and/or sub-zero temperature regions (<i>first revision</i>)
		(17) 771	Specification for glazed fire-clay sanitary appliances:
		(Part 1) : 1979	General requirements (<i>second revision</i>)
		(Part 2) : 1985	Specific requirements of kitchen and laboratory sinks (<i>third revision</i>)

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
(Part 3/Sec 1) : 1979	Specific requirements of urinals, Section 1 Slab urinals (<i>second revision</i>)	(Part 3) : 1994	Specific requirements of squatting pans (<i>fourth revision</i>)
(Part 3/Sec 2) : 1985	Specific requirements of urinals, Section 2 Stall urinals (<i>third revision</i>)	(Part 4) : 1994	Specific requirements of wash basins (<i>third revision</i>)
(Part 4) : 1979	Specific requirements of postmortom slabs (<i>second revision</i>)	(Part 5) : 1994	Specific requirements of laboratory sinks (<i>third revision</i>)
(Part 5) : 1979	Specific requirements of shower trays (<i>second revision</i>)	(Part 6) : 1995	Specific requirements of urinals and partition plates (<i>fourth revision</i>)
(Part 6) : 1979	Specific requirements of bed-pan sinks (<i>second revision</i>)	(Part 7) : 1995	Specific requirements of accessories for sanitary appliances (<i>third revision</i>)
(Part 7) : 1981	Specific requirements of slop sinks (<i>second revision</i>)	(Part 8) : 1995	Specific requirements of siphonic wash-down water-closets (<i>fourth revision</i>)
772 : 1973	Specification for general requirements for enamelled cast iron sanitary appliances (<i>second revision</i>)	(Part 9) : 1995	Specific requirements of bidets (<i>fourth revision</i>)
773 : 1988	Specification for enamelled cast iron water-closets railway coaching stock type (<i>fourth revision</i>)	(Part 14) : 1995	Specific requirements of integrated squatting pans (<i>first revision</i>)
774 : 1984	Specification for flushing cistern for water-closets and urinals (other than plastic cistern) (<i>fourth revision</i>)	(Part 15) : 1995	Specific requirements of universal water-closets (<i>first revision</i>)
775 : 1970	Specification for cast iron brackets and supports for washbasins and sinks (<i>second revision</i>)	(Part 16) : 2002	Specific requirements for wash-down wall mounted water-closets
1700 : 1973	Specification for drinking fountains (<i>first revision</i>)	(Part 17) : 2001	Specific requirements for wall mounted bidets
2326 : 1987	Specification for automatic flushing cisterns for urinals (<i>second revision</i>)	3489 : 1985	Specification for enamelled steel bath tubs (<i>first revision</i>)
2548	Specification for plastic seats and covers for water-closets:	6411 : 1985	Specification for gel-coated glass fibre reinforced polyester resin bath tubs (<i>first revision</i>)
(Part 1) : 1996	Thermoset seats and covers (<i>fifth revision</i>)	7231 : 1994	Specification for plastic flushing cisterns for water-closets and urinals (<i>second revision</i>)
(Part 2) : 1996	Thermo plastic seats and covers (<i>fifth revision</i>)	8718 : 1978	Specification for vitreous enamelled steel kitchen sinks
2556	Specification for vitreous sanitary appliances (vitreous china):	8727 : 1978	Specification for vitreous enamelled steel washbasins
(Part 1) : 1994	General requirements (<i>third revision</i>)	9076 : 1979	Specification for vitreous integrated squatting pans for marine use
(Part 2) : 1994	Specific requirements of wash-down water-closets (<i>fourth revision</i>)	11246 : 1992	Specification for glass fibre reinforced polyester resins (GRP) squatting pans (<i>first revision</i>)

IS No.	Title	IS No.	Title
13983 : 1994	Specification for stainless steel sinks for domestic purposes		pipe fittings, gutters and gutter fittings, and roofing fittings:
(18) 651 : 1992	Specification for salt glazed stoneware pipes and fittings (<i>fifth revision</i>)	(Part 1) : 1994	Pipes and pipe fittings (<i>second revision</i>)
3006 : 1979	Specification for chemically resistant salt glazed stoneware pipes and fittings (<i>first revision</i>)	(Part 2) : 1994	Gutters and gutter fittings (<i>second revision</i>)
		(Part 3) : 1994	Roofing accessories (<i>second revision</i>)
(19) 458 : 2003	Specification for precast concrete pipes (with and without reinforcement) (<i>fourth revision</i>)	6908 : 1991	Specification for asbestos cement pipes and fittings for sewerage and drainage (<i>first revision</i>)
784 : 2001	Specification for prestressed concrete pipes (including specials) (<i>second revision</i>)	(22) 404 (Part 1) : 1993	Specification for lead pipes: Part I For other than chemical purposes (<i>third revision</i>)
1916 : 1989	Specification for steel cylinder with concrete lining and coating (<i>first revision</i>)	(23) 13592 : 1992	Specification for UPVC pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system
4350 : 1967	Specification for concrete porous pipes for under drainage	14333 : 1996	Specification for high density polyethylene pipe for sewerage
7319 : 1974	Specification for perforated concrete pipes	14735 : 1999	Specification for unplasticized polyvinyl chloride (UPVC) injection moulded fittings for soil and waste discharge system for inside and outside buildings including ventilation and rain water system
(20) 1536 : 2001	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage (<i>fourth revision</i>)		
1537 : 1976	Specification for vertically cast iron pressure pipes for water, gas and sewage (<i>first revision</i>)	(24) 2470	Code of practice for installation of septic tanks:
1538 : 1993	Specification for cast iron fittings for pressure pipes for water, gas and sewage (<i>third revision</i>)	(Part 1) : 1985	Design criteria and construction (<i>second revision</i>)
3989 : 1984	Specification for centrifugally cast (spun) spigot and socket-soil, waste and ventilating pipes and fittings and accessories (<i>second revision</i>)	(Part 2) : 1985	Secondary treatment and disposal of septic tank effluent (<i>second revision</i>)
		5611 : 1987	Code of practice for waste stabilization ponds (facultative type) (<i>first revision</i>)
7181 : 1986	Specification for horizontally cast iron double flanged pipes for water, gas and sewage (<i>first revision</i>)	(25) 5329 : 1983	Code of practice for sanitary pipe work above ground for buildings (<i>first revision</i>)
(21) 1592 : 2003	Specification for asbestos cement pressure pipes and joints (<i>fourth revision</i>)	(27) 5455 : 1969	Specification for cast iron steps for manholes
1626	Specification for asbestos cement building pipes and	(28) 1726 : 1991	Specification for cast iron manhole covers and frames (<i>third revision</i>)

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
12592 : 2002	Specification for precast concrete manhole covers and frames (<i>first revision</i>)		of glazed stoneware pipes (<i>first revision</i>)
(29) 4111 (Part 1) : 1986	Code of practice for ancillary structures in sewerage system: Part 1 Manholes (<i>first revision</i>)	6530 : 1972	Code of practice for laying of asbestos cement pressure pipes
(30) 14961 : 2001	Guidelines for rain water harvesting in hilly areas by roof water collection system	(32) 1729 : 2002	Specification for cast iron ductile iron drainage pipes and pipe fittings for grand non-pressure pipe line socket and spigot series (<i>second revision</i>)
(31) 783 : 1985	Code of practice for laying of concrete pipes (<i>first revision</i>)	(33) 2064 : 1993	Code of practice for selection, installation and maintenance of sanitary appliances (<i>second revision</i>)
1742 : 1983	Code of practice for building drainage (<i>second revision</i>)	(34) 6924 : 1973	Code of practice for the construction of refuse chutes in multi-storeyed buildings
3114 : 1994	Code of practice for laying of cast iron pipes (<i>second revision</i>)		
4127 : 1983	Code of practice for laying		

Annex A

Detailed Structural and explanatory notes

CPCprov code 86724

Structure Notes

Hierarchy

Section: 8 – Business services; agricultural, mining and manufacturing services

Division : 86 – Legal, accounting, auditing and book-keeping services; taxation services; market research and public opinion polling services; management and consulting services; architectural, engineering and other technical services

Group: 867 – Architectural, engineering and other technical services

Class: 8672 – Engineering services

Subclass: 86724 - Engineering design services for the construction of civil engineering works

Explanatory note

Engineering design services for the construction of civil engineering works, such as bridges and viaducts, dams, catchment basin, retaining walls, irrigation systems, flood control works, tunnels, highways and streets including interchanges and related works, locks, canals, wharves and harbours works, water supply and sanitation works such as water distribution systems, water, sewage, industrial and solid waste treatment plants and other civil engineering project.

Design services consists of one or a combination of the following: preliminary plans,

Specifications and cost estimates to define the engineering design concept; final plans, Specifications and cost estimates, including working drawings,

Specifications regarding materials to be used, method of installation, time limitations and other Specifications necessary for tender submission and construction and expert advice to the client at the time of calling for and accepting tenders; service during the construction phase. Included are engineering design services for buildings if they are an integral part of the engineering design for a civil engineering work.

This code corresponds to the following:

ISIC Rev.3 code(s)7421

MYANMAR

NATIONAL

BUILDING

CODE

2016

PART 6 & PART 7

MYANMAR
NATIONAL
BUILDING
CODE
2016

PART 6
BUILDING MATERIALS

MYANMAR NATIONAL BUILDING CODE

PART 6: BUILDING MATERIALS

6.1 SCOPE

This Part of the Code covers the requirements of building materials and components, and criteria for accepting of new or alternative buildings materials and components.

6.2 MATERIALS

Every material used in fulfilment of the requirements of this Part, unless otherwise specified in the Code or Duly Approved, shall conform to the relevant ASTM or Indian Standards. A list of the ‘accepted standards’ is given at the end of this Part of Code.

Remark :

- Building Materials included in this Myanmar National Building Code are temporarily referring to the ASTM and IS.
- Ministry of Construction and Ministry of Education are collaborating in the preparation of the National Standards and Specifications for Building Materials.
- Before the National Level Standards and Specifications are officially established, all Building Materials should be conformed to relevant reference to the ASTM and IS.

6.3 NEW OR ALTERNATIVE MATERIALS

6.3.1The provisions of this Part are not intended to prevent the use of any material not specifically prescribed under 6.2. Any such material may require the approval of the Concerned Authority or a Committee appointed by the Authority, provided it is well established that the material is satisfactorily acceptable for the purpose it is intended. The Authority or the Committee concerned shall take into account the following parameters, with respect to the use of new or alternative building materials.

The prerequisite of the specified material, in addition to meeting those in the standards on its usage, shall also take into account their suitability in different geo-climatic condition.

- a) General appearance;
- b) Dimension and dimensional stability;
- c) Structural stability including strength properties;

- d) Fire resistant ;
- e) Durability;
- f) Thermal properties;
- g) Mechanical properties;
- h) Acoustical properties;
- i) Optical properties;
- j) Biological effect;
- k) Environmental aspects;
- l) Working condition ;
- m) Ease of handling; and
- n) Consistency and workability.

For establishing the performance of the Material/component, laboratory/field tests, and field trials, are required. The study of historical data is also recommended.

6.3.2 Approval in writing by the Authority or the Concerned Committee appointed for the purpose of evaluating the approval of material shall be obtained by the owner of the material or his agent before any new, alternative or equivalent material is put to use. The Authority or The Committee appointed by them shall base such approval on the principle set in paragraph 6.3.1 and shall require that tests be made (*see 7.1*) or sufficient evidence or proof be submitted. All expenses incurred shall be duly borne by the owner or his agent.

6.4 STORAGE OF MATERIALS

All building materials shall be stored on the construction site with all the necessary measures taken to prevent deterioration, the loss or impairment of their structural or other essential properties. (*See Part -7 Construction Practices and Safety*)

6.5 METHODS OF TEST

6.5.1 Every test of material required in this Part or by the Authority shall be carried out in accordance with the ASTM Standard or Indian Standard method of test. In case where testing facilities or methods of tests for either the ASTM or Indian Standards are not available, the same shall conform to the methods of tests approved by the Authority.. Laboratory tests shall be conducted by recognized laboratories acceptable to the Authority.

6.5.2 The manufacturer/supplier shall duly testify that materials conform to the requirements of the specifications and if requested shall produce a certificate to this effect either to the purchaser

or his representative. When such test certificate is not available, the specimen of the material shall be subjected to all the required tests.

Following are the Myanmar Standards for various building materials and components, to be complied with in fulfilment of the requirements of the Code. The list has been arranged in alphabetical order as follows:

- 1) Aluminium and Other Light Metals and Their Alloys
- 2) Bitumen and Tar Products
- 3) Builder's Hardware
- 4) Building chemicals
- 5) Blocks, Bricks, Tiles and Masonry
- 6) Cement and Concrete
- 7) Doors Windows and Ventilators
- 8) Electrical Wiring, Fittings and Accessories
- 9) Floor Covering, Roofing and Other Finishes
- 10) Glass and Glazing
- 11) Gypsum Based Materials
- 12) Paints and Allied Products
- 13) Polymers, Plastic and Geosynthetics/Geotextiles
- 14) Sanitary Appliances and Water Fittings
- 15) Stones
- 16) Structural Steel, Reinforcing Steel, Prestressing Steel and Others
- 17) Thermal Insulation Materials
- 18) Wood Based Materials
- 19) Welding Electrodes and Wires
- 20) Wire Ropes and Wire Products

6.5.2.1 Aluminium and Other Light Metals and Their Alloy

Std: No.	Title
ASTM B 209-14	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 221-12e1	Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod and Wire

ASTM B308/B308M-10	Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM B313/B313M-09	Standard Specification for Aluminum and Aluminum-Alloy Round Welded Tubes
ASTM B361-08	Standard Specification for Factory-Made Wrought Aluminum and Aluminum-Alloy Welding Fittings
ASTM B 429	Specification for aluminium-alloy extruded structural pipe and tube
ASTM B 491	Specification for aluminium and aluminium-alloy extruded round tubes for general-purpose applications
ASTM B 557	Standard test method for tension testing wrought and cast aluminium and magnesium-alloy products
ASTM E 34	Test method for chemical analysis of aluminium and aluminium-base alloys
IS 1254	Specification for corrugated aluminium sheet
IS 1284	Specification for wrought aluminium and aluminium alloys bolt and screw stock for general engineering purposes

6.5.2.2 Bitumen and Tar Products

a) Specifications

Std: No.	Title
ASTM D 450	Specification for coal-tar pitch used in roofing, damp proofing and waterproofing
ASTM D 490	Specification for road tar
ASTM D 977	Specification for emulsified asphalt
ASTM D 2026	Specification for cutback asphalt (Slow-curing type)
IS 73	Specification for paving bitumen
IS 218	Specification for creosote oil for use as wood preservatives
IS 454	Specification for cutback bitumen from waxy crude
IS 702	Specification for industrial bitumen

b) Methods for testing tar and bituminous materials

Std: No.	Title
ASTM D 4	Standard test method for bitumen content
ASTM D 5	Standard test method for penetration for bituminous materials
ASTM D 6	Standard test method for loss on heating of oil and asphaltic compounds
ASTM D 20	Standard test method for distillation of road tars
ASTM D 36	Standard test method for softening point of bitumen (Ring-and-ball apparatus)
ASTM D 70	Standard test method for density of semi-solid bituminous materials (Pycnometer Method)
ASTM D 92	Standard test method for flash and fire points by Cleveland Open Cup tester
ASTM D 95	Standard test method for water in petroleum products and bituminous materials by distillation
ASTM D 113	Standard test method for ductility of bituminous materials
ASTM D 139	Standard test method for float test for bituminous materials
ASTM D 140	Standard practice for sampling of bituminous materials
ASTM D 243	Standard test method for residue of specified penetration
ASTM D 1188	Standard test method for bulk specific gravity and density of compacted bituminous mixtures using coated samples
ASTM D 1754	Standard test method for effects of heat and air on Asphaltic Materials (<i>Thin-Film Oven test</i>)
ASTM D 2042	Standard test method for solubility of asphalt materials in trichloroethylene
ASTM D 3205	Standard test method for viscosity of asphalt with cone and plate viscometer
IS 1207	Determination of equiviscous temperature
IS 9381	Determination of FRAASS breaking point of bitumen

IS 10512	Determination of wax content in bitumen
IS 15172	Determination of curing index for cutback bitumen
IS 15173	Determination of breaking point for cationic bitumen emulsion

6.5.2.3 Builder's Hardware

Std: No.	Title
ASTM A 90	Standard test method for weight (mass) of coating on iron and steel articles with zinc or zinc-alloy coatings
ASTM A 153	Standard specification for zinc coating (hot-dip) on iron and steel hardware
ASTM A 394	Specification for steel transmission tower bolts, zinc-coated and bare
IS 205	Specification for non-ferrous metal butt hinges
IS 206	Specification for tee and strap hinges
IS 208	Specification for door handles
IS 281	Specification for mild steel sliding door bolts for use with padlock
IS 362	Specification for parliament hinges
IS 363	Specification for hasps and staples
IS 364	Specification for fanlight catch
IS 452	Specification for door springs, rattail type
IS 453	Specification for double acting spring hinges
IS 729	Specification for drawer locks, cupboard locks and box locks
IS 1341	Specification for steel butt hinges
IS 1823	Specification for floor door stoppers
IS 2209	Specification for mortice locks (vertical type)
IS 2681	Specification for non-ferrous metal sliding door bolts for use with padlock
IS 3564	Specification for door closers (hydraulically regulated)
IS 3818	Specification for continuous (piano) hinges
IS 3828	Specification for ventilator chains
IS 4621	Specification for indicating bolts for use in public baths and lavatories

IS 4992	Specification for door handles for mortice locks (vertical type)
IS 5187	Specification for flush bolts
IS 5899	Specification for bathroom latches
IS 6318	Specification for plastic window stays and fasteners
IS 7534	Specification for sliding locking bolts for use with padlock
IS 9106	Specification for rising butt hinges
IS 9131	Specification for rim locks
IS 9460	Specification for flush drop handles for drawers
IS 9899	Specification for hat, coat and wardrobe hooks
IS 10019	Specification for mild steel stays and fasteners
IS 10342	Specification for curtain rail system
IS 12817	Specification for stainless steel butt hinges
IS 12867	Specification for PVC handrail covers

6.5.2.4 Building Chemicals

a) Chemical and Mineral Admixtures

Std:No.	Title
ASTM C 233	Test method for air-entraining admixtures for concrete
ASTM C 260	Specification for air-entraining admixtures for concrete
ASTM C 494/C494M	Specification for chemical admixtures for concrete
ASTM C 618	Specification for coal fly ash and raw or calcined natural pozzolan for use as a mineral admixture in concrete
ASTM C 989	Specification for ground granulated blast-furnace slag for use in concrete and mortars.
ASTM C 1017	Specification for chemical admixtures for used in producing flowing concrete.
ASTM C 1240	Specification for use of silica fume as a mineral admixture in hydraulic cement concrete, mortar and grout.

b) Special Concrete Production Materials

Std:No.	Title
ASTM C 330	Specification for Lightweight Aggregates for Structural Concrete
ASTM C 331	Specification for Lightweight Aggregates for Concrete Masonry Units
ASTM C 332	Specification for Lightweight Aggregates for Insulating Concrete
ASTM C 869	Specification for Foaming Agents Used in Making Preformed foam for Cellular Concrete
ASTM C 979	Specification for pigments for integrally coloured concrete
ASTM C 1107	Specification for packaged dry, hydraulic-cement grout (Non Shrink)

c) Concrete Curing Materials

Std:No.	Title
ASTM C 171	Specifications for sheet materials for curing concrete
ASTM C 309	Specification for liquid membrane-forming compounds for curing concrete
ASTM C 1315	Specification for liquid membrane-forming compounds having special properties for curing and sealing concrete

d) Waterproofing and Damp-proofing Materials

ASTM D 41	Specification for asphalt primer used in roofing, damp proofing and waterproofing
ASTM D 43	Specification for coal tar primer used in roofing, damp proofing and waterproofing
ASTM D 173	Specification for bitumen-saturated cotton fabrics used in roofing and waterproofing

ASTM D 449	Specification for asphalt used in damp proofing and water proofing
ASTM D 450	Specification for coal tar pitch used in roofing, damp proofing and waterproofing
ASTM D1327	Specification for bitumen-saturated woven burlap fabrics used in roofing and waterproofing
ASTM D 1668	Specification for glass fabrics (woven and treated) for roofing and waterproofing

e) Epoxy Compound Materials

ASTM C 881	Specification for epoxy-resin-base bonding systems for concrete
ASTM C 884	Test method for thermal compatibility between concrete and an epoxy- resin overlay

6.5.2.5 Blocks, Bricks, Tiles and Masonry

Std: No.	Title
ASTM C 55	Specification of concrete bricks
ASTM C 62	Standard specification for building brick (solid masonry units made from clay or shale)
ASTM C 67	Standard test methods for sampling and testing brick and structural clay tile
ASTM C 140	Standard test methods for sampling and testing concrete masonry units and related units
ASTM C 216	standard specifications for facing brick (Solid masonry units made from clay or shale)
ASTM C 652	Standard specification for hollow brick (hollow masonry units made from clay or shale)
ASTM C 902	Standard specification for pedestrian and light traffic paving brick

ASTM C 1209	terminology of concrete masonry units and related units
AST M C 1232	Terminology of masonry
ASTM C 1272	Standard specification for heavy vehicular paving brick
ASTM C 1634	Specification of concrete facing bricks
IS 2117	Guide for manufacture of handmade common burnt clay building bricks
IS 2222	Specification for burnt clay perforated building bricks
IS 3495	Method of test for burnt clay building bricks
IS 3583	Specification for common burnt clay paving bricks
IS 4885	Specification for sewer bricks
IS 5454	Method of sampling of clay building bricks
IS 11650	Guide for manufacture of common burnt clay building bricks by semi-mechanized process
IS 13757	Specification of burnt clay fly ash bricks

Remarks

Note:

- (a) Where non-load bearing structures or structures which are not important (eg; non-load bearing wall, drain, fencings, etc.,) the use of bricks which do not meet the standard specification given in the MNBC may be utilized. However, the suitability of the bricks shall be duly endorsed by the authority concerned.
- (b) Bricks used for structures other than those given in (a), i.e. Bricks used for load bearing structures, must duly meet the standard specified in MNBC.

6.5.2.6 Cement and Concrete

a) Aggregates

Std: No.	Title
ASTM C 29/ C 29 M	Standard test method for bulk density (“unit weight”) and voids in aggregate
ASTM C- 33	Standard Specified for concrete aggregates
ASTM C 35	Specification for inorganic aggregates for use in gypsum plaster

ASTM C 40	Standard test method for organic impurities in fine aggregates for concrete
ASTM C 66	Specification for sand for use in lime plaster
ASTM C 88	Standard test method for soundness of aggregates by use of sodium sulphate or magnesium sulfate
ASTM C 127	Test method for density, relative density (specific gravity), and absorption of coarse aggregate
ASTM C 128	Test method for density, relative density (specific gravity), and absorption of fine Aggregate
ASTM C 136	Standard test methods for sieve analysis of fine and coarse aggregates
ASTM C 144	Standard specification for aggregate for masonry mortar
ASTM C 294	Standard descriptive nomenclature for constituents of concrete aggregates
ASTM C 330	Standard specification for lightweight aggregates for structural concrete.
ASTM C 331	Standard test methods for sampling and testing fly ash or natural pozzolans for use in Portland cement concrete
ASTM C 1260	Test method for potential alkali reactivity of aggregates (mortar-bar method)
ASTM C 1293	Standard test method for determination for length change of concrete due to alkali-silica reaction.
ASTM D 75	Practice for sampling aggregates

b) Cement

Std: No.	Title
ASTM C 91	Specification for masonry cement
ASTM C 150	Specification for portland cement
ASTM C 595	Specification for blended hydraulic cement

ASTM C 845	Specification for expansive hydraulic cement.
ASTM C 1157	Standard performance specification for hydraulic cement
IS 1489	Specification for portland pozzolana cement (calcined clay based)
IS 6452	Specification for high alumina cement for structural use
IS 8041	Specification for rapid hardening portland cement
IS 8042	Specification for white portland cement
IS 8043	Specification for hydrophobic portland cement
IS 12330	Specification for sulphate resisting portland cement
IS 12600	Specification for low heat portland cement

c) Water

Std: No.	Title
ASTM C 1602	Standard specification for mixing water used in the production of hydraulic cement

d) Pozzolans

Std: No.	Title
ASTM C 311	Standard test methods for sampling and testing fly ash or natural pozzolans for use in Portland cement concrete
ASTM C 618	Standard specification for coal fly ash and raw or calcined natural pozzolan for use in concrete
ASTM C 989	Standard specification for ground granulated blast-furnace slag for use in concrete and mortars
ASTM C 1240	Specification for silica fume used in cementitious mixtures
ASTM C 1709	Standard guide for evaluation or alternative supplementary cementitious materials (ASCM) for use in concrete

IS 12870

Methods of sampling calcined clay pozzolana

e) Concrete

Std: No.

Title

ASTM C 94/C94M

Standard specification for ready mixed concrete

ASTM C 172

Standard practice for sampling freshly mixed concrete.

ASTM C 685

Standard specification for concrete made by volumetric batching and continuous mixing.

IS 1343

Code of practice for prestressed concrete

f) Cement and concrete sampling and methods of test

Std: No.

Title

ASTM C 31/C 31M

Standard practice for making and curing concrete test specimens in the field

ASTM C 39/C39M

Test method for compressive strength of cylindrical concrete specimens

ASTM C 42/42M

Standard test method for obtaining and testing drilled cores and sawed beams of concrete

ASTM C 78

Standard test method for flexural strength of concrete (using simple beam with third-point loading)

ASTM C109/C109M

Standard test method for compressive strength of hydraulic cement mortars (using 2-in or 50mm cube specimens)

ASTM C 114

Test methods for chemical analysis of hydraulic cement

ASTM C 115

Test method for fineness of portland cement by the turbidimeter

ASTM C143/C143M

Test method for slump of hydraulic-cement concrete

ASTM C 151

Standard test method for autoclave expansion of Portland cement

ASTM C 172

Standard practice for sampling freshly mixed concrete

ASTM C 183	Standard practice for sampling and the amount of testing of hydraulic cement
ASTM C 185	Standard test method for air content of hydraulic cement mortar
ASTM C 186	Standard test method for heat of hydration of hydraulic cement
ASTM C187	Standard test method for normal consistency of hydraulic cement
ASTM C 188	Standard test method for density of hydraulic cement
ASTM C191	Standard test method for time of setting of hydraulic cement by Vicat needle
ASTM C192/C192M	Standard test method for making, and curing concrete test specimens in the laboratory
ASTM C 204	Test method for fineness of hydraulic cement by air permeability apparatus
ASTM C 232	Standard test methods for bleeding of concrete
ASTM C 403	Standard test method for time of setting of concrete mixtures by penetration resistance
ASTM C 451	Standard test method for early stiffening of hydraulic cement (paste method)
ASTM C 452	Standard test method for potential expansion of portland-cement mortars exposed to sulphate
ASTM C 496	Standard test Method for splitting tensile strength of cylindrical concrete specimens
ASTM C 512	Standard test method for creep of concrete in compression
ASTM C 567	Standard test method for density of structural light weight concrete
ASTM C 900	Test method for pull out strength of hardened concrete
ASTMC 944	Method of test for abrasion resistance of concrete or mortar surfaces by the rotating-cutter method
ASTM 1218/1218M	Standard test method for water-soluble chloride in mortor and concrete
ASTM C 1314	Standard test method for compressive strength of masonry prisms

ASTM C 1583	Standard test method for tensile strength of concrete surfaces and the bond strength or tensile strength of concrete repair and overlay materials by direct tension (pull-off method)
ASTM C 1709	Standard guide for evaluation of alternative supplementary cementitious materials (ASCM) for use in concrete
IS 516	Methods of test for strength of concrete
IS 8425	Determination of fineness by specific surface by Blaine air permeability method
IS 13311(Part 1)	Ultrasonic pulse velocity
IS 13311(Part 2)	Rebound hammer

g) Cement matrix products

Std: No.	Title
ASTM C 62	Specification for soil-based blocks used in general building construction
ASTM C 90	Standard specification for loadbearing concrete masonry units
ASTM C 129	Standard Specification for non-load bearing concrete masonry units
ASTM C 145	Specification of solid load bearing masonry units
ASTM C 157	Standard test method for length change of hardened hydraulic-cement mortar and concrete
ASTM C 220	Specification for flat asbestos-cement sheets
ASTM C 270	Specifications for mortar for unit masonry
ASTM C 426	Standard Test method for linear drying shrinkage of concrete masonry units
ASTM C 458	Standard test method for organic fiber content of asbestos-cement products
ASTM C 476	Specification for grout for masonry

ASTM C 626	Methods for estimating the thermal neutron absorption cross section of nuclear graphite
ASTM C 746	Specification for corrugated asbestos cement sheets for bulkheading
ASTM E 447	Test method for compressive strength of masonry prisms

h) Lime

Std No	Title
ASTM C 5	Specification for quicklime for structural purposes
ASTM C 25	Test methods for chemical analysis of limestone, quicklime, and hydrated lime
ASTM C 50	Standard practice for sampling, sample preparation, packaging, and marking of lime and limestone products
ASTM C 110	Standard test methods for physical testing of quicklime, hydrated lime, and limestone
ASTMC 141	Standard specification for hydraulic hydrated lime for structural purposes
ASTM C 206	Specification for finishing hydrated lime
ASTM C 207	Specification for hydrated lime for masonry purposes

6.5.2.7 Doors, Windows and Ventilators

a) Wooden doors, windows and ventilators

Std: No.	Title
ASTM E 152	Methods for fire test of door assemblies
ASTM E 283	Standard test method for determining rate of air leakage through exterior windows, curtain walls, and doors under specified pressure differences across the specimen
ASTM E 330	Standard test method for structural performance of exterior windows, curtain walls and doors by uniform static air pressure difference

ASTM E 331	Test method for water penetration of exterior windows, curtain walls, and doors by uniform static air pressure difference
ASTM E 547	Standard test method for water penetration of exterior windows, curtain walls and doors by cyclic static air pressure differential
ASTM E 783	Standard test method for field measurement of air leakage through installed exterior windows and doors
ASTM E 1886	Standard test method for performance of exterior windows, curtain walls, doors, and storm shutters impacted by missile(s) and exposed to cyclic pressure differentials
ASTM E 1996	Standard specification for performance of exterior windows, glazed curtain walls, doors, and storm shutters impacted by windborne debris in hurricanes
ASTM E 2068	Test method for determination of operating force of sliding windows and doors
ASTM F 842	Standard test methods for measuring the forced entry resistance of sliding door assemblies, excluding glazing impact
IS 1003	Specification for timber panelled and glazed shutters
Part 1	Door shutters
Part 2	Window and ventilator shutters
IS 1141	Code of practice for seasoning of timber
IS 1826	Specification for venetian blinds for windows
IS 2191	Specification for wooden flush door shutters (cellular and hollow core type)
Part 1	Plywood face panels
Part 2	Particleboard face panels and hard board face panels
IS 2202	Specification for wooden flush door shutters (solid core type)
Part 1	Plywood face panels
Part 2	Particle board face panels and hard board face panels
IS 4020	Method of test for door shutters

Part-1	General
Part-2	Measurement of dimensions and squareness
Part-3	Measurement of general flatness
Part-4	Local planeness test
Part-5	Impact indentation test
Part-6	Flexure test
Part-7	Edge loading test
Part-8	Shock resistance test
Part-9	Buckling resistance test
Part-10	Slamming test
Part-11	Misuse test
Part-12	Varying humidity test
Part-13	End immersion test
Part-14	Knife test
Part-15	Glue adhesion test
Part-16	Screw withdrawal resistance test
IS 4021	Specification for timber door, window and ventilator frames
IS 4913	Code of practice for selection, installation and maintenance of timber doors and windows
IS 4962	Specification for wooden side sliding doors
IS 6198	Specification for ledged, braced and battened timber shutters
IS 6523	Specification for precast reinforced concrete door, window frames

b) Metal doors, windows and ventilators

Std: No.	Title
IS 1038	Specification for steel doors, windows and ventilators
IS 1361	Specification for steel windows for industrial buildings

IS1948	Specification for aluminium doors, windows and ventilators
IS1949	Specification for aluminium windows for industrial buildings
IS 4351	Specification for steel door frames
IS 6248	Specification for metal rolling shutters and rolling grills
IS 7452	Specification for hot rolled steel sections for doors, windows and ventilators
IS 10451	Specification for steel sliding shutters
IS 10521	Specification for collapsible gates

c) Plastic doors and windows

Std: No.	Title
ASTM D 638	Standard test method for tensile properties of plastics
IS 14856	Specification for glass fibre reinforced (GRP) panel type door shutters for internal use
IS 15380	Specification for moulded raised high density fibre (HDF) panel doors

6.5.2.8 Electrical Wiring, Fittings and Accessories

Std: No.	Title
IS 371	Specification for ceiling roses
IS 374	Specification for electric ceiling type fans and regulators
IS 418	Specification for tungsten filament general service electric lamps
IS 1258	Specification for bayonet lamp holders
IS1293	Specification for plugs and socket outlets rated voltage up to and including 250 V and rated current up to and including 16 amperes
IS 1534	Specification for ballasts for fluorescent lamps: Part 1 for switch start circuits

IS 1554	PVC insulated (heavy duty) electric cables:
Part 1	For working voltages upto and including 1 100 V
Part 2	For working voltages from 3.3 kV upto and including 11 kV
IS 1777	Specification for industrial luminaire with metal reflectors
IS 1985	General purpose luminaires
Part 5	Particular requirements, Section 2
IS 1985	Recessed luminaires
Part 5	Particular requirements, Section 3
IS 1987	Luminaires for road and street lighting
Part 5	Particular requirements, Section 4
IS 1987	Portable general purpose luminaires
Part 5	Particular requirements, Section 5
IS 1987	Flood light
IS 2086	Specification for carriers and bases used in re-wirable type electric fuses up to 650 V
IS 2148	Specification for flameproof enclosures “d” for electrical apparatus for explosive gas atmospheres
IS 2206	Specification for flameproof electric lighting fittings
Part 1	Well glass and bulkhead types
Part 2	Fittings using glass tubes
Part 3	Fittings using fluorescent lamps and plastic covers
Part 4	Portable flame-proof handlamps and approved flexible cables
IS 2215	Specification for starters for fluorescent lamps
IS 2412	Specification for link clips for electrical wiring
IS 2418	Specification for tubular fluorescent lamps for general lighting services:
Part 1	Requirements and tests
Part 2	Standard lamp data sheets

Part 3	Dimensions of G-5 and G-13 bi-pin caps
Part 4	Go and no-go gauges for G-5 and G-13 bi-pin caps
IS 2667	Specification for fittings for rigid steel conduits for electrical wiring
IS 2675	Specification for enclosed distribution fuse boards and cut outs for voltages not exceeding 1000 V
IS 3287	Specification for industrial lighting fittings with plastic reflectors
IS 3323	Specification for bi-pin lamp holders for tubular fluorescent lamps
IS 3324	Specification for holders for starters for tubular fluorescent lamps
IS 3419	Specification for fittings for rigid non-metallic conduits
IS 3480	Specification for flexible steel conduits for electrical wiring
IS 3528	Specification for waterproof electric lighting fittings
IS 3553	Specification for watertight electric lighting fittings
IS 3837	Specification for accessories for rigid steel conduits for electrical wiring
IS 3854	Specification for switches for domestic and similar purposes
IS 4012	Specification for dust-proof electric lighting fittings
IS 4013	Specification for dust-tight electric lighting fittings
IS 4160	Specification for interlocking switch socket outlet
IS 4615	Specification for switch socket outlets (non-interlocking type)
IS 4649	Specification for adaptors for flexible steel conduits
IS 5077	Specification for decorative lighting outfits
IS 6538	Specification for three-pin plugs made of resilient material
IS 8030	Specification for luminaires for hospitals

IS 8828	Specification for circuit-breakers for over current protection for household and similar installation
IS 9537	Specification for conduits for electrical installations:
Part 1	General requirements
Part 2	Rigid steel conduits
Part 3	Rigid plain conduits for insulating materials
Part 4	Pliable self-recovering conduits for insulating materials
Part 5	Pliable conduits of insulating materials
Part 6	Pliable conduits of metal or composite materials
Part 8	Rigid non-threadable conduits of aluminium alloy
IS 9926	Specification for fuse wires used in rewirable type electric fuses up to 650 V
IS 10322	Specification for luminaires:
Part 1	General requirements
Part 2	Constructional requirements
Part 3	Screw and screw less terminations
Part 4	Methods of tests
Part 5	Particular requirements, Section 1
IS 11037	Electronic type fan regulators
IS 13010	AC watt-hour meters, Class 0.5, 1 and 2
IS 13779	AC static watt hour meters (Class 1 and 2)
IS 13947	Specification for low-voltage
Part 3	Switchgear and control gear: Part 3 switches, disconnectors, switch disconnectors and fuse combination units
IS 14763	Conduit for electrical purposes, outside diameters of conduits for electrical installations and threads for conduits and fittings
IS 14768	Conduit fittings for electrical installations:

Part 1	General requirements
Part 2	Metal conduit fittings
IS 14772	Enclosures for accessories for household and similar fixed electrical installations
IS 14927	Cable trunking and ducting systems for electrical installations
Part 1	General requirements
Part 2	Cable trunking and ducting systems intended for mounting on walls or ceilings
IS 14930	Conduit systems for electrical installations:
Part 1	General requirements
Part 2	Particular requirements for conduit system buried underground
IS 15368	Cable reels for household and similar purposes

6.5.2.9 Floor Covering, Roofing and Other Finishes

a) Flooring

Std: No.	Title
ASTM F 710	Standard practice for preparing concrete floors to receive resilient flooring
IS 3670	Code of practice for construction of timber floors
IS 5766	Code of practice for laying burnt clay brick flooring
IS 13801	Specification for chequered cement concrete tiles

b) Flooring compositions

Std: No.	Title
ASTM F 1066	Specification for vinyl composition floor tile
IS 9162	Methods of tests for epoxy resin, hardness and epoxy resin compositions for floor topping

IS 9197	Specification for epoxy resin, hardness and epoxy resin compositions for floor topping

c) Linoleum flooring

Std: No.	Title
ASTM F 2034	Specification for sheet linoleum floor covering
ASTM F 2195	Specification for linoleum floor tile
IS 9704	Methods of tests for linoleum sheets and tiles

d) Ceramic and other finishings

Std: No.	Title
ASTM C 57	Specification for structural clay floor tile
ASTM C 212	Standard specification for structural clay facing tile
ASTM C 373	Determination of water absorption, bulk density, apparent porosity, and apparent specific gravity of fired white ware products, ceramic tiles, and glass tiles
ASTM C 424	Standard test method for crazing resistance of fired glazed white wares by autoclave treatment
ASTM C 484	Standard test method for thermal shock resistance glazed ceramic tile
ASTM C 648	Standard test method for breaking strength of ceramic tile
ASTM C 1026	Standard test method for measuring the resistance of ceramic and glass tile to freeze-thaw cycling
ASTM C 1027	Standard test method for determining visible abrasion resistance of glazed ceramic tile
ASTM C 1028	Standard test method for determining the static coefficient of friction of ceramic tile and other like surfaces by the horizontal dynamometer pull-meter method
IS 3951	Specification for hollow clay tiles for floors and roofs
IS 4457	Specification for ceramic unglazed vitreous acid resisting tile
IS13630	Method of test for ceramic tiles

IS 13630	Determination of moisture expansion using boiling water (unglazed tiles)
IS 13630	Determination of linear thermal expansion
IS 13630	Determination of modulus of rupture
IS 13630	Determination of chemical resistance (Glazed tiles)
IS 13630	Determination of chemical resistance (Unglazed tiles)
IS 13630	Determination of resistance to surface abrasion (Glazed tiles)
IS 13630	Determination of scratch hardness of surface according to Mohs'
IS 13711	Sampling and basis for acceptance of ceramic tiles

e) Roofing

Std: No.	Title
ASTM C 1167	Specification for clay roofing tiles
ASTM C 1492	Specification for concrete roof tile
ASTM D 312	Specification for asphalt used in roofing
ASTM D 41	Specification for asphalt primer used in roofing, damp proofing waterproofing
ASTM D 2822	Specification for asphalt roof cement
ASTM D 2823	Specification for asphalt roof coatings, asbestos containing
ASTM D 3746	Test method for impact resistance of bituminous roofing systems
ASTM D 4022	Specification for coal tar roof cement, asbestos containing
ASTM D 4434	Specification for poly (vinyl chloride) sheet roofing
ASTM E 108	Standard test methods for fire test of roof coverings
IS 277	Specification for galvanized steel sheets (plain and corrugated)
IS 459	Specification for corrugated and semi-corrugated asbestos cement sheets
IS 6250	Specification for roofing slate tiles

IS 1464	Specification for clay ridge and ceiling tiles
IS 2690	Specification for burnt clay flat terracing tiles
Part -1	Machine made
Part-2	Hand made
IS 12583	Specification for corrugated bitumen roofing sheets
IS 12866	Specification for plastic translucent sheets made from thermosetting polyester resin (glass fibre reinforced)
IS 13317	Specification for clay roofing camty tiles, half round and flat tiles

f) Wall covering / finishing

Std: No.	Title
ASTM C 34	Specification for structural clay load-bearing wall tile
ASTM C 52	Specification for gypsum partition tile or block
ASTM C 56	Specification for structural clay non-load bearing tile
ASTM C 126	Specification for ceramic glazed structural clay facing tile, facing brick, and solid masonry units
IS 15418	Specification for finished wall papers, wall vinyl and plastic wall coverings in roll form

6.5.2.10 Glass and Glazing

Std: No.	Title
ASTM C 1036	Specification for flat glass
ASTMC 1172	Specification for laminated architectural flat glass
ASTM C 1369	Standard Specification for Secondary Edge Sealants for Structurally Glazed Insulating Glass Units
ASTM C 1503	Specification for silvered flat glass mirrors
ASTM E 773	Test method for accelerated weathering of sealed insulating glass units

ASTM E 774	Specification for classification of the durability of sealed insulating glass units
ASTM E 1300	Standard practice for Determining load resistance of glass in buildings
ASTM E 2188	Standard test method for insulating glass unit performance
ASTM E 2189	Standard test method for testing resistance to fogging in insulating glass units
ASTM F 1642	Standard test method for glazing and glazing systems subject to air blast loadings
IS 5437	Specification for figured rolled and wired glass
IS 14900	Specification for transparent float glass

6.5.2.11 Gypsum Board and Plaster

Std: No.	Title
ASTM C 22	Standard specification for gypsum
ASTM C28/C28M	Standard specification for gypsum plasters
ASTM C 36	Standard specification for Gypsum wallboard
ASTM C 37	Gypsum lath
ASTM C 59	Gypsum casting plaster and gypsum moulding plaster
ASTM C 61	Gypsum Keene's cement
ASTM C 79	Standard specification for treated core and non-treated core Gypsum sheathing
ASTM C 442	Standard specification for gypsum backing board, gypsum core board, and gypsum shaft liner board
ASTM C 473	Method of tests for gypsum and gypsum panel products
ASTM C 557	Standard specification for Adhesives for fastening gypsum wall board to wood framing
ASTM C 587	Gypsum veneer plaster

ASTM C 588	Gypsum base for veneer plasters
ASTM C 630	Water resistant gypsum backing board
ASTM C 631	Standard specification for bonding compounds for interior gypsum plastering
ASTM C 645	Standard specification for non-structural steel framing members
ASTM C 931	Standard specification for exterior gypsum soffit board
ASTM C 932	Standard specification for sulphate-applied bonding compounds for exterior plastering
ASTM C 955	Standard specification for load-bearing (transverse and axial) steel studs, runners (tracks), and bracing or bridging for screw application of gypsum panel products and metal plaster bases
ASTM C 960	Predecorated gypsum board
ASTM C 1002	Standard specification for steel drill screws for the application of gypsum panel products or metal plaster bases
ASTM C 1047	Standard specification for accessories of gypsum wallboard and gypsum veneer base
ASTM C 1177	Standard specification for glass mat gypsum substrate for use as sheathing
ASTM C 1178	Standard specification for glass mat water-resistant gypsum backing panel
ASTM C 1278	Fibre reinforced gypsum panels Standard specification for fiber-reinforced gypsum panels
ASTM C 1395	Gypsum ceiling board
ASTM C 1396	Standard specification for gypsum board
ASTM F 547	Standard terminology of nails for use with wood and wood-base materials
ASTM F 1667	Standard specification for driven fasteners: nails, spikes and staples

6.5.2.12 Paints and Allied Products

a) Specifications for water based paints and pigments

Std: No.	Title
IS 427	Specification for distemper, dry, colour as required
IS 428	Specification for distemper, washable
IS 5410	Specification for cement paint, colour as required
IS 5411	Specification for plastic emulsion paint:
Part-1	For interior use
Part -2	For exterior use

b) Ready mixed paints, enamels and powder coatings

Std: No	Title
ASTM D 5382	Standard guide to evaluation of optical properties of powder coatings
IS 101	Methods of sampling and test for paints, varnishes and related products
Part -1/ Sec 1	Test on liquid paints (general and physical), Section 1 sampling
Part 1/Sec 2	Test on liquid paints (general and physical), Section 2 Preliminary examination and preparation of samples for testing
Part 1/Sec 3	Test on liquid paints (general and physical) section 3 preparation of panels
Part 1/Sec 4	Test on liquid paints (general and physical), Section 4 Brushing test
Part -1/Sec 5	Test on liquid paints (general and physical), Section 5 Consistency
Part 1/Sec 6	Test on liquid paints (general and physical), Section 6 Flash point
Part 1/Sec 7	Test on liquid paints (general and physical), Section 7 Mass per 10 liters

Part 2/ Sec 1	Test on liquid paints (chemical and examination), Section 1 Water content
Part 2/ Sec 2	Test on liquid paints (chemical examination), Section 2 Volatile matter
Part 3/Sec 1	Tests on paint film formation, Section 1 Drying time
Part 3/Sec 2	Tests on paint film formation, Section 2 Film thickness
Part 3/ Sec 4	Tests on paint film formation, Section 4 Finish
Part 3/Sec 5	Tests on paint film formation, Section 5 Fineness of grind
Part 4/ Sec 1	Optical test, section 1 opacity
Part 4/Sec 2	Optical test, section 2 colour
Part 4/Sec 3	Optical test, section 3 light fastness test
Part 4/Sec 4	Optical test, Section 4 Gloss
Part 5/Sec 1	Mechanical test on paint films, Section 1 Hardness tests
Part 5/Sec 2	Mechanical test on paint films, Section 2 Flexibility and adhesion
Part 5/Sec 3	Mechanical test on paint films, Section 3 Impact resistance
Part 5/Sec 4	Mechanical test on paint films, Section 4 Print free test
Part 6/Sec 1	Durability tests, section 1 resistance to humidity under conditions of condensation
Part 6/Sec 2	Durability tests, section 2 keeping properties
Part 6/Sec 3	Durability tests, section 3 moisture vapour permeability
Part 6/Sec 4	Durability tests, section 4 degradation of coatings (pictorial aids for evaluation)
Part 6/Sec 5	Durability tests, section 5 accelerated weathering test
Part 7/Sec 1	Environmental tests on paint films, section 1 resistance to water
Part 7/Sec 2	Environmental tests on paint films, section 2 resistance to liquid
Part 7/Sec 3	Environmental tests on paint films, section 3 resistance to heat
Part 7/Sec 4	Environmental tests on paint films, section 4 resistance to bleeding of pigments

Part 8/Sec 1	Tests for pigments and other solids, section 1 residue on sieve
Part 8/Sec 2	Environmental tests on paint films, section 2 pigments and non-volatile matter
Part 8/Sec 3	Environmental tests on paint films, section 3 ash content
Part 8/Sec 4	Environmental tests on paint films, section 4 phthalic anhydride
Part 8/Sec 5	Environmental tests on paint films, section 5 lead restriction test
Part 8/Sec 6	Environmental tests on paint films, section 8 volumes solids
Part 9/Sec 1	Tests for lacquers and varnish, Section 1 acid value
Part 9/Sec 2	Tests for lacquers and varnish, Section 2 rosin test
IS 104	Specification for ready mixed paint, brushing, zinc chrome, priming
IS 109	Specification for ready mixed paint, brushing, priming, plaster to Indian Standard colours No 361
IS 123	Specification for ready mixed paint, brushing, finishing semigloss, for general purposes, to Indian Standard colour No 445, 446, 448, 449, 451 and 473 and red oxide (colour unspecified)
IS 133	Specification for enamel, interior (a) undercoating, (b) finishing
IS 137	Specification for ready mixed paint, brushing, matt or egg-shell flat, finishing, interior, to Indian Standard colour, as required
IS 158	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, and heat resisting
IS 168	Specification for ready mixed paint, air-drying semi-glossy/matt, for general purposes
IS 341	Specification for black Japan, Types A , B and C
IS 2074	Specification for ready mixed paint and air drying red oxide-zinc chrome, priming
IS 2075	Specification for ready mixed paint, stoving, red oxide-zinc chrome, priming

IS 2339	Specification for aluminium paint for general purposes, in dual container
IS 2932	Specification for enamel, synthetic exterior, (a) undercoating, (b) finishing
IS 2933	Specification for enamel, exterior, (a) undercoating (b) finishing
IS 3536	Specification for ready mixed paint, brushing, wood primer
IS 3539	Specification for ready mixed paint, undercoating, for use under oil finishes, to Indian Standards colours, as required
IS 3585	Specification for ready mixed paint, aluminium, brushing, priming, water resistant, for wood work
IS 3678	Specification for ready mixed paint, thick white, for lettering
IS 8662	Specification for enamel, synthetic, exterior (a) undercoating, (b) finishing, for railway coaches
IS 11883	Specification for ready mixed paint, brushing, red oxide, priming for metals
IS 13183	Specification for aluminium paints, heat resistant
IS 13213	Specification for polyurethane full gloss enamel (two pack)

c) Thinners and solvents

Std: No	Title
IS 324	Specification for ordinary denatured spirit
IS 14314	Specification for thinner general purposes for synthetic paints and varnishes
IS 82	Methods of sampling and test for thinners and solvents for paints

d) Varnishes and lacquers

Std: No	Title
IS 337	Specification for varnish, finishing, interior

IS 347	Specification for varnish, shellac, for general purposes
IS 348	Specification for French polish
IS 524	Specification for varnish, finishing, exterior, synthetic
IS 525	Specification for varnish, finishing, exterior and general purposes
IS 642	Specification for varnish medium for aluminium paint

6.5.2.13 Polymers, Plastic and Geosynthetics/Geotextiles

Std: No.	Title
IS 1998	Methods of test for thermosetting synthetic resin bonded laminated sheets
IS 2036	Specification for phenolic laminated sheets
IS 2046	Specification for decorative thermosetting synthetics resin bonded laminated sheets
IS 2076	Specification for unsupported flexible vinyl film and sheeting
IS 2508	Specification for low density polyethylene films
IS 6307	Specification for rigid PVC sheets
IS 9766	Specification for flexible PVC compound
IS 10889	Specification for high density polyethylene films
IS 12830	Specification for rubber based adhesives for fixing PVC tiles to cement
IS 13162	Methods of test for geotextiles
ASTM D 4354	Standard practice for sampling of Geosynthetics for testing
ASTM D 4355	Standard test method for deterioration of geotextiles from exposure to ultraviolet light and water (Xenon-arc type apparatus)
ASTM D 4491	Standard test methods for water permeability of geotextiles by permittivity
ASTM D 4533	Standard test method for trapezoid tearing strength of geotextiles

ASTM D 4595	Standard test method for tensile properties of geotextiles by the wide-width strip method
ASTM D 4751	Standard test method for determining apparent opening size of a geotextile
ASTM D 4833	Standard test method for index puncture resistance of geotextiles, geomembranes, and related products
ASTM D 4886	Standard test method for abrasion resistance of geotextiles (sand paper/sliding block method)
ASTM D 5199	Standard test method for measuring nominal thickness of geotextiles and geomembranes
ASTM D 5261	Standard test method for measuring mass per unit area of geotextiles
ASTM D 5262	Standard test method for evaluating the unconfined tension creep behavior of geosynthetics
ASTM D 5321	Standard test method for determining the coefficient of soil and geosynthetics and geosynthetics friction by the direct shear method
IS 13262	Specification for pressure sensitive adhesive tapes with plastic base
IS 13325	Method of test for the determination to tensile properties of extruded polymer geogrids using the wide strip
IS 14182	Specification for solvent cement for use with unplasticized polyvinyl chloride plastic pipe and fittings
IS 14443	Specification for polycarbonate sheets
IS 14643	Specification for unsintered polytera fluorethy (PTFE) tape for thread sealing applications
IS 14715	Specification for woven jute geotextiles
IS 14753	Specification for poly (methyl) methacrylate (PMMA) (Acrylic) sheets

IS 14986	Jute geo-grid for rain water erosion control in road and railway embankments and hill slopes
IS 15060	Tensile test for joint/seams by wide width method of geotextiles

6.5.2.14 Sanitary Appliances and Water Fittings

Std: No.	Title
IS 404	Specification for lead pipes: part 1 for other than chemical purposes
IS 458	Specification for precast concrete pipes (with and without reinforcement)
IS 651	Specification for salt glazed stoneware pipes and fittings
IS 748	Specification for prestressed concrete pipes
IS 771	Specification for glazed fire-clay sanitary appliances:
Part 1	General requirements
Part 2	Specification requirements of kitchen and laboratory sinks
Part 3	Specification requirements of urinals, Section 1 slab urinals
Part 3/sec 2	Specification requirements of urinals, Section 2 stall urinals Part 4 Specification requirements of postmortom slabs
Part 5	Specific requirements of shower trays
Part 6	Specific requirements of bed-pan sinks
Part 7	Specific requirements of slop sinks
IS 772	Specification for general requirements for enamelled cast iron sanitary appliances
IS 773	Specification for enamelled cast iron water-closets railway coaching stock type
IS 774	Specification for flushing cistern for water-closets and urinals (other than plastic cistern)

IS 775	Specification for cast iron brackets and supports for washbasins and sinks
IS 782	Specification for caulking lead
IS 804	Specification for rectangular pressed steel tanks
IS 1276	Specification for cast iron manholes covers and frames
IS 1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS 1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
IS 1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS 1592	Specification for asbestos cement pressure pipes and joints
IS 1626	Specification for asbestos cement building pipes and pipe fittings, gutter fittings, and roofing fittings
Part 1	Pipes and pipe fittings
Part 2	Gutters and gutter fittings
Part 3	Roofing accessories
IS 1700	Specification for drinking fountains
IS 1729	Specification for cast iron ductile iron drainage pipes and pipe fittings for grand non-pressure pipe line socket and spigot series
IS 1916	Specification for steel cylinder with concrete lining and coating
IS 2041	Specification for steel plates for pressure vessels used at moderate and low temperature
IS 2082	Stationary storage type electric water heaters
IS 2326	Specification for automatic flushing cisterns for urinals
IS 2548	Specification for plastic seats and covers for water-closets:
Part 1	Thermoset seats and covers
Part 2	Thermo plastic seats and covers

IS 2556	Specification for vitreous sanitary appliances
Part 1	General requirements
Part 2	Specific requirements of wash-down water-closets
Part 3	Specific requirements of squatting pans
Part 4	Specific requirements of wash basins
Part 5	Specific requirements of laboratory sinks
Part 6	Specific requirements of urinals and partition plates
Part 7	Specific requirements of accessories for sanitary appliances
Part 8	Specific requirements of siphonic wash-down water-closets
Part 9	Specific requirements of bidets
Part 14	Specific requirements of integrated squatting pans
Part 15	Specific requirements of universal water-closets
Part 16	Specific requirements for wash-down wall mounted water-closets
Part 17	Specific requirements for wall mounted bidets
IS 2692	Specification for ferrules for water services
IS 3006	Specification for chemically resistant salt glazed stone wear pipes and fittings
IS 3076	Specification for low density polyethylene pipes for potable water supplies
IS 3489	Specification for enameled steel bath tubs
IS 3989	Specification for centrifugally cast (spun) spigot and socket-soil, waste and ventilating pipes and fittings and accessories
IS 4350	Specification for concrete porous pipes for under drainage
IS 4984	Specification for high density polyethylene pipes for potable water supplies
IS 4985	Specification for unplasticized PVC pipes (uPVC) for potable water supplies
	Specification for PVC pipes fittings for portable water supply

	Specification for PP-R fittings for portable water supply
	Specification for PVC fittings for drainage system
	Specification for GI pipes
	Specification for MS pipe
	Specification for Blacksteel pipe
IS 5455	Specification for cast iron steps for manholes
IS 6411	Specification for gel-coated glass fiber reinforced polyester resin bath tubs
IS 6784	Method for performance testing of water meters (domestic type)
IS 6908	Specification for asbestos cement pipes and fittings for sewerage and drainage
IS 7181	Specification for horizontally cast iron double flanged pipes for water, gas and sewage
IS 7231	Specification for plastic flushing cisterns for water-closets and urinals
IS 7319	Specification for perforated concrete pipes
IS 8718	Specification for vitreous enameled steel kitchen sinks
IS 8727	Specification for vitreous enameled steel washbasins
IS 8931	Specification for copper alloy fancy single taps, combination tap assembly and stop valves for water services
IS 9076	Specification for vitreous integrated squatting pans for marine use
IS 9338	Specification for cast iron screw-down stop valves and stop and check valves for water works purposes
IS 9739	Specification for pressure reducing valves for domestic water supply systems
IS 9758	Specification for flush valves and fittings for water closets and urinals
IS 11246	Specification for glass fiber reinforced polyester resins (GRP) squatting pans

IS 12592	Specification for precast concrete manhole covers and frame
IS 13114	Specification for forged brass gate, globe and check valves for water works purposes
IS 13592	Specification for UPVC pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system
IS 13983	Specification for stainless steel sinks for domestic purposes
IS 14333	Specification for high density polyethylene pipe for sewerage
IS 14735	Specification for unplasticized polyvinyl chloride (UPVC) injection moulded fittings for soil and waste discharge system for inside and outside buildings including ventilation and rain water system

6.5.2.15 Stones

a) Specifications

Std: No.	Title
ASTM C 568	Specification for limestone (slabs & tiles)
ASTMC 503	Specification for marble (blocks, slabs & tiles)
ASTMC 615	Standard specification for granite dimension stone
ASTM C 1364	Standard specification for architectural cast stone
IS 3620	Specification for laterite stone block for masonry
IS 3622	Specification for sand stones (slabs and tiles)
IS 9394	Specification for stone lintels

b) Methods of testing

Std: No.	Title
ASTM C 97	Standard test methods for absorption and bulk specific gravity of dimension stone
ASTM C99/C99M	Test method for modulus of rupture of dimension stone
ASTM C110	Test methods for physical testing of quicklime, hydrated lime, and limestone
ASTM C170/C170M	Test method for compressive strength of dimension stone
ASTM C 241	Standard test method for abrasion resistance of stone subjected to foot traffic
ASTM C 880	Standard test method for flexural strength of dimension stone
ASTM C 1195	Standard test method for absorption of architectural cast stone
IS 1121	Tests for determination of strength properties of natural building stones - Transverse strength - Tensile strength - Shear strength
IS 1122	Test for determination of true specific gravity of natural building stones
IS 1123	Methods of identification of natural building stones
IS 1125	Test for determination of weathering of natural building stones
IS 1126	Test for determination of durability of natural building stones
IS 1200	Methods of measurements of building and civil engineering works stone masonry
IS 4121	Test for determination of water transmission rate by capillary action through natural building stones
IS 4122	Test for surface softening of natural building stones by exposure to acidic atmosphere
IS 5218	Test for toughness of natural building stones

6.5.2.16 Structural Steel, Reinforcing Steel, Pre stressing steel and Others

Std: No.	Title
ASTM A 36	Standard specification for carbon structural steel
ASTM A 53	Standard specification for Pipe, Steel, Black & Hot –Dipped, Zinc-coated, Welded and Seamless
ASTM A 82	Standard specification for steel wire, plain, for concrete reinforcement
ASTM A 123	Standard specification for zinc (hot-dip galvanized) coatings on iron and steel products
ASTM A 194,	Specification for carbon and alloy steel nuts for bolts for high pressure or high temperature service, or both
ASTM A 242	Specification for high strength low alloy structural steel
ASTM A 276	Specification for stainless steel bars and shapes
ASTM A 283	Specification for low and intermediate tensile strength carbon steel plates
ASTM A 320	Specification for alloy/steel bolting materials for low-temperature service
ASTM A 325/A325M	Standard specification for high-strength bolts for structural steel joints
ASTM A 370	Standard test methods and definitions for mechanical testing of steel products
ASTM A 416	Standard specification for Steel Strand, Uncoated Seven-wire for Prestressed Concrete
ASTM A 421	Standard specification for Stress-Relieved Steel Wire for Prestressed Concrete
ASTM A 423/A423M	Standard specification for seamless and electric-welded low-alloy steel tubes

ASTM A 492	Standard specification for stainless steel rope wire
ASTM A 496 M	Standard specification for steel wire, deformed, for concrete reinforcement
ASTM A 500	Standard specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 501	Standard specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 510	Specification for general requirements for wire rods, coarse round wire, carbon steel
ASTM A 526	Standard specification for steel sheet, zinc-coated (galvanized) by the hot-dip process, commercial quality
ASTM A 555/A555M	Standard specification for general requirements of stainless steel wire and wire rods
ASTM A 563	Specification for carbon and alloy steel nuts
ASTM A 568/A568M	Standard Specification for steel, sheet, carbon, and high-strength, low-Alloy, hot-rolled and cold-rolled, general requirement
ASTM A 572	Standard specification for high-strength low-alloy columbium-vanadium structural steel
ASTM A 580/A580M	Specification for stainless steel wire
ASTM A 588/A588M	Standard specification for High-Strength Low-Alloy Structural Steel
ASTM A 615/615M	Standard specification for deformed bar and plain billet steel bar for concrete reinforcement
ASTM A 653	Specification for galvanized steel sheets
ASTM A 666	Standard specification for annealed or cold-worked austenitic stainless steel sheet, strip, plate, and flat bar
ASTM A 706/A706M	Standard specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
ASTM A 722/722M	Standard specification for uncoated high-strength steel bars for prestressing concrete

ASTM A 759/A759M	Standard specification for carbon steel crane rails
ASTM A 767/A767M	Standard specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A775/A775M	Standard Specification for epoxy-coated reinforcing steel bars
ASTM A852/A852M	Standard specification for quenched and tempered low-alloy structural steel plate with 70 ksi (485 MPa) minimum yield strength to 4 in (100 mm) thick
ASTM A934/A934M	Standard specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A 955	Standard specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement
ASTM A 996/A996M	Standard specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A992/A992M	Standard specification for steel for structural shapes for use in building framing
ASTM A 1044	Standard specification for Steel Stud Assemblies for Shear Reinforcement of Concrete
ASTM A1267	Specification for expended metal steel sheets for general purposes
ASTM F 436	Specification for hardened steel washers
IS 432	Specification for hollow mild steel sections for structural use
IS 1148	Specification for hot- rolled steel rivet bars (up to 40 mm diameter)for structural purposes
IS 1363	Specification for hexagonal wire netting for general purposes
IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement
IS 8081	Specification for slotted sections

6.5.2.17 Thermal Insulation Materials

Std: No.	Title
ASTM C 163	Practice for mixing thermal insulating cement samples
ASTM C 165	Test method for measuring compressive properties of thermal insulations
ASTM C 166	Test method for covering capacity and volume change upon drying of thermal insulating cement
ASTM C 195	Specification for mineral fiber thermal insulating cement
ASTM C 196	Specification for expanded or exfoliated vermiculite thermal insulating cement
ASTM C 578	Specification for rigid, cellular polystyrene thermal insulation
IS 3677	Specification for unbonded rock and slag wool for thermal insulation
IS 4671	Specification for expanded polystyrene for thermal insulation purposes
IS 6598	Specification for cellular concrete for thermal insulation
IS 7509	Specification for thermal insulating cement
IS 8154	Specification for performed calcium silicate insulation for temperature up to 650°C
IS 8183	Specification for bonded mineral wool
IS 9403	Method of test for thermal conductance and transmittance of built up sections by means of guarded hot box
IS 9489	Method of test for thermal conductivity of materials by means of heat flow meter
IS 9490	Method of determination for thermal conductivity of insulation materials (water calorimeter method)
IS 9742	Specification for sprayed mineral wool thermal insulation
IS 9743	Specification for thermal insulation finishing cements
IS 9842	Specification for preformed fibrous pipe insulation

IS 3144	Method of test for material wool thermal insulation material
IS 11128	Specification for spray applied hydrated calcium silicate thermal insulation
IS 11129	Method of test for tumbling friability of preformed block-type thermal insulation
IS 11239	Method of test for rigid cellular thermal insulation materials
Part-1	Dimensions
Part -2	Apparent density
Part -3	Dimensional stability
Part -4	Water vapour transmission rate
Part -5	Volume percent of open and closed cells
Part -6	Heat distortion temperature
Part -7	Coefficient of linear thermal expansion at low temperatures
Part -8	Flame height, time of burning and loss of mass
Part – 9	Water absorption
Part – 10	Flexural strength
Part -11	Compressive strength
Part -12	Horizontal burning characteristics
Part -13	Determination of flammability by oxygen index
IS 11307	Specification for cellular glass block and pipe thermal insulating
IS 11308	Specification for thermal insulating castables (hydraulic setting) for temperature up to 250°C
IS 12436	Specification for preformed rigid polyurethane (PUR) and polyisocyanurate (Pir) foams for thermal insulation
IS 13204	Specification for rigid phenolic foams for thermal insulation
IS 13286	Method of test for surface spread of flame for thermal insulation materials

6.5.2.18 Wood Based Materials

Std: No.	Title
ASTM D 9	Terminology relating to wood and wood-based products
ASTM D 25	Specification for round timber piles
ASTM D 38	Test methods for sampling wood preservatives prior to testing
ASTM D 143	Test methods for small clear specimens of timber
ASTM D 198	Test methods of static tests of lumber in structural sizes
ASTM D 245	Practice for establishing structural grades and related allowable properties for visually graded lumber
ASTM D 246	Test method for distillation of creosote and creosote-coal tar solutions
ASTM D 390	Specification for coal-tar creosote for the preservative treatment of piles, poles, and timbers for marine, land, and freshwater use
ASTM D1036	Test methods of static tests of wood poles
ASTM D 1037	Test methods for evaluating properties of wood-base fiber and particle panel materials
ASTM D 1038	Terminology relating to veneer and plywood
ASTM D 1110	Test methods for water solubility of wood
ASTM D 1165	Nomenclature of commercial hardwoods and softwoods
ASTM D 1166	Test method for methoxyl groups in wood and related materials
ASTM D 1554	Terminology relating to wood-base fiber and particle panel materials
ASTM D 1666	Test methods for conducting machining tests of wood and wood-base panel materials
ASTM D 1760	Specification for pressure treatment of timber products
ASTM D 1761	Test methods for mechanical fasteners in wood
ASTM D 1990	Practice for establishing allowable properties for visually-graded dimension lumber from in-grade tests of full-size specimens

ASTM D 2017	Method of accelerated laboratory test of natural decay resistance of woods
ASTM D 2164	Methods of testing structural insulating roof deck
ASTM D 2394	Methods for simulated service testing of wood and wood-base finish flooring
ASTM D 2395	Test methods for density and specific gravity (relative density) of wood and wood-based materials
ASTM D 2481	Test method for accelerated evaluation of wood preservatives for marine services by means of small size specimens
ASTM D 2719	Test methods for structural panels in shear through-the-thickness
ASTM D 2898	Test methods for accelerated weathering of fire-retardant-treated wood for fire testing
ASTM D 2899	Practice for establishing allowable stresses for round timber piles
ASTM D 2915	Practice for evaluating allowable properties for grades of structural lumber
ASTM D 3043	Test methods for structural panels in flexure
ASTM D 3044	Test method for shear modulus of wood-based structural panels
ASTM D 3200	Specification and test method for establishing recommended design stresses for round timber construction poles
ASTM D 3499	Test method for toughness of wood-based structural panels
ASTM D 3500	Test methods for structural panels in tension
ASTM D 3501	Test methods for wood-based structural panels in compression
ASTM D 3737	Practice for establishing allowable properties for structural glued laminated timber (glulam)
ASTM D 4442	Test methods for direct moisture content measurement of wood and wood-base materials
ASTM D 4444	Test methods for use and calibration of hand-held moisture meters
ASTM D 4761	Test methods for mechanical properties of lumber and wood-base structural material

ASTM D 4933	Guide for moisture conditioning of wood and wood-based materials
ASTM D 5456	Specification for evaluation of structural composite lumber products
ASTM D 5516	Test method for evaluating the flexural properties of fire-retardant treated softwood plywood exposed to elevated temperatures
ASTM D 5536	Practice for sampling forest trees for determination of clear wood properties
ASTM D 5651	Test method for surface bond strength of wood-base fiber and particle panel materials
ASTM D 6815	Specification for evaluation of duration of load and creep effects of wood and wood-based products

IS 1708

Part 3	Determination of volumetric shrinkage
Part 4	Determination of radial and tangential shrinkage and fibre situation point
Part 5	Determination of static bending strength
Part 6	Determination of static bending strength under two point loading
Part 7	Determination of impact bending strength
Part 8	Determination of compressive strength parallel to grain
Part 9	Determination of compressive strength perpendicular to grain
Part 10	Determination of hardness under static indentation
Part 11	Determination of shear strength parallel to grain
Part 12	Determination of tensile strength parallel to grain
Part 13	Determination of tensile strength perpendicular to grain
Part 15	Determination of nail and screw holding power
Part 18	Determination of torsional strength

6.5.2.19 Welding Electrodes and Wires

Std: No.	Title
IS 814	Specification for covered electrodes for manual metal arc welding of carbon and carbon manganese steel
IS 1278	Specification for filler rods and wires for gas welding
IS 1395	Specification for low and medium alloy steel covered electrodes for manual metal arc welding
IS 2879	Mild steel for metal arc welding electrodes
IS 3613	Acceptance tests for wire flux combinations for submerged arc welding of structural steel
IS 4972	Specification for resistance spot welding electrodes
IS 5206	Covered electrodes for manual arc welding of stainless steel and other similar high alloy steel
IS 5511	Specification for covered electrodes for manual arc welding cast iron
IS 5897	Specification for aluminium and aluminium alloy welding rods and wires and magnesium alloy welding rods
IS 5898	Specification for copper and copper alloy bare solid welding rods and electrodes
IS 6419	Specification for welding rods and bare electrodes for gas shielded arc welding of structural steel
IS 7280	Specification for bare wire electrodes for submerged arc welding of structural steel
IS 8363	Specification for bare wire electrodes for electroslag welding of steels
IS 10631	Stainless for welding electrode core wire

6.5.2.20**Wire Ropes and Wire Products**

Std: No.	Title
ASTM A844/A844M	Standard specification for Epoxy coated steel wire and welded wire fabric for reinforcement
IS 278	Specification for galvanized steel barbed wire for fencing
IS 2140	Specification for stranded galvanized steel wire for fencing
IS 2266	Specification for steel wire ropes for general engineering purposes
IS 2365	Specification for steel wire suspension ropes for lifts, elevators and hoists
IS 2721	Specification for galvanized steel wire chain link fences fabric
IS 6594	Specification for technical supply condition for wire ropes and strands
IS 12776	Specification for galvanized strand for earthing

**MYANMAR
NATIONAL
BUILDING
CODE
2016**

PART 7

**CONSTRUCTIONAL PRACTICES AND
SAFETY**

This Part of the Code covers the constructional planning, management and practices in buildings; storage, stacking and handling of materials and safety of personnel during construction operations for all elements of a building and demolition of buildings.

CONSTRUCTION PRACTICES AND SAFETY

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7.1 CONSTRUCTIONAL PRACTICE

7.1.1 GENERAL

This approved code of practice should be followed unless there is an alternative course of action, which achieves the same or better standard of health and safety in the workplace.

7.1.2 PLANNING, MANAGEMENT AND PRACTICES

7.1.2.1 Planning Aspects

Construction planning aspects aim to identify and develop various stages of project execution on site which should be consistent with the management considerations. Planning aspects evolve out of the objectives of project and requirements of the final completed constructed facility. These objectives could relate to the final constraints, cost considerations, quality standards, safety standards, environmental considerations and health considerations. Construction practices would, and then have to satisfy these objectives during construction phase of the project. Having established objectives of the construction phase, planning determines processes, resources (including materials, equipments, human and environmental) and monitoring system to ensure that the practices are appropriately aligned. Adequate knowledge about pre-construction phase evolution of project, especially related to customer's requirements, is an essential prerequisite for construction planning.

7.1.2.1.1 Preconstruction Phase

a) Besides the design aspects, preconstruction phase should also address all the issues related to the implementation of the design at the site through suitable construction strategy. During the design stage, the site conditions should be fully understood with anticipated difficulties and avoid the risk of subsequent delays and changes after the construction has started.

b) The selection of construction methods, building systems and materials, components, manpower and equipments and techniques are best done in the preconstruction phase. Such selection is influenced by the local conditions like terrain, climate, vulnerability for disasters, etc.

c) Construction in busy localities of cities needs special considerations and meticulous planning due to restricted space, adjoining structures, underground utilities, traffic restrictions, noise and other environmental pollution and other specific site constraints.

d) The constructability aspects of the proposed construction methods needs to be carefully evaluated at the planning stage to ensure ease of construction besides optimizing the construction schedule and achieving quality, reliability and maintainability of the constructed facilities.

e) Constructional practices in hilly regions needs to take into considerations the problem of landslides, slope stability, drainage, etc, besides ensuring no adverse impact on the fragile environmental conditions.

f) Durability of constructions in corrosive atmospheric conditions like coastal regions and aggressive ground situations with high chlorides and sulphates should also be taken care of with appropriate constructional practices.

g) Constructional practices in disaster prone areas need specific planning. The type of construction, use of materials, construction techniques require special considerations in such areas.

h) Adverse weather conditions have strong bearing on construction phase. Situations wherein constructions are to be carried out in adverse weather conditions, such as heavy and continuous rain fall, extreme hot or cold weather, dust storms, etc, the practice have to address the relevant aspects.

Accordingly, suitable design and field operations should be adapted or redefined in anticipation of these aspects. Some of these aspects are:

- 1) Site layout which enables accessibility in adverse weather.
- 2) Adequate protected storage for weather sensitive materials/equipments.
- 3) Protections to personnel from extreme hot/control conditions.
- 4) Scheduling to allow maximization of outdoor activities during fair weather conditions.
- 5) Special design and construction provisions for activities in extreme temperature condition like hot or cold weather concreting, staple of false work in extreme wind conditions (gusts).
- 6) Adequate lighting for shorter days in winter/night work.
- 7) Design for early enclosure.

7.1.2.1.2 Resource Planning

Resource planning aims to identify requirement, availability and regulatory/control processes related to resources. Resource planning is a generic expression but the actual process of planning is specific to the resources considered. In construction phases, the resources could be categorized as materials, manufactured products, equipments for construction, installation and fabrication, human resources as a part of overall organization, information resources, such as, reference standards and other practice documents, environmental conditions for work on site and infrastructure facilities. Therefore, the resource planning encompasses identification, estimation, scheduling and allocation of resources. Resource planning needs to establish a control system for controlling consumption monitoring, corrective action and resource reappropriations in the event of favorable deviation. Organizational capability, commitment to the project requirements and other constraints such as time and cost, need to be considered as inputs while planning resources.

Techniques of management and planning, such as, Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM) (see Annex A) may be used. Non-availability of basic building materials (brick, stone aggregate, etc) within reasonable lead would influence the constructional practice by alternative materials. The constructional practices also get decided by the local skills of the manpower for constructional activities. The equipment selection would also be governed by the site constraints. Therefore, as, the resource planning is critical to the project viability itself, the inputs to the resource planning need to be validated appropriately and established for such management. Resource planning should establish a proper system of data collection so as to facilitate effective resources control mechanism. Resource planning responsibility has to be specifically defined in the overall organizational setup.

7.1.2.1.3 Construction Phase

7.1.2.1.3.1 Organizational Structure

The site management should be carried out through suitable site organization structure with roles and responsibilities assigned to the construction personnel for various construction related functions. Safety management is one of the important components of site management.

7.1.2.1.3.2 Site Layout

The layout of the construction site should be carefully planned keeping in view the various requirements to construction activities and the specific constraints in terms of its size, shape, topography, traffic and other restrictions, in public interest. A well planned site layout would enable safe smooth and efficient construction operations. The site layout should take into considerations the following factors:

- (a) Easy access and exit, with proper parking of vehicle and equipments during construction.
- (b) Properly located material stores for easy handling and storage.
- (c) Adequate stack areas for bulk construction materials.

- (d) Optimum location of plants and equipments (batching plants, etc).
- (e) Layout of temporary services (water, power, power suppression unit, hoists, cranes, elevators, etc).
- (f) Adequate yard lighting and lighting for night shifts.
- (g) Temporary buildings; site office and shelter for workforce with use combustible materials as far as possible including emergency medical aids.
- (h) Roads for vehicular movement with effective drainage plan.
- (i) Construction safety with emergency access and evacuations and security measures.
- (j) Fabrication yards for reinforcement assembly, concrete precasting and shattering materials.
- (k) Fencing, barricades and signage.

7.1.2.1.3.3 Access for Fire fighting equipment vehicles

Access for firefighting equipment shall be provided to the construction site at the start of construction and maintained until all construction work is completed.

- a) Free access from the street to fire hydrants/static water tanks, where available, shall be provided and maintained at all times.
- b) No materials for construction shall be placed within 3.0 m of hydrants/static water tanks.
- c) During building operations, free access to permanent, temporary or portable first-aid firefighting equipment shall be maintained at all times.

7.1.2.1.3.4 Access to the upper floors during construction

In all buildings over two stories high, at least one stairway shall be provided in usable condition at all times. This stairway shall be extended upward as each floor is completed. There shall be a handrail on the staircase.

7.1.2.1.3.5 Construction Strategy and construction sequence

Construction strategy and construction methods are to be evolved at the planning and design stage specific to the conditions and constraints of the project site and implemented by the site management personnel to ensure ease of construction and smooth flow of construction activities. Sites of high water table conditions with aggressive chemical contents of subsoil needs special design considerations. Buildings with basement in sites of high water table should be planned with dewatering scheme with appropriate construction sequence, Duration of dewatering should continue till sufficient dead loads are achieved to stabilize the buoyancy loads with adequate factor of safety. The construction sequence should be planned taking into consideration the following aspects:

- (a) Availability of resources (men, material and equipment);
- (b) Construction methods employed including prefabrication;
- (c) Planned construction time;
- (d) Design requirements and load transfer mechanism;
- (e) Stability of ground like in hilly terrain;
- (f) Ensuring slope stability with retaining structure before the main construction;
- (g) Installation and movement of heavy equipments like cranes and piling equipments;
- (h) Effect of weather; and
- (j) Minimum time to be spent below ground level working.

7.1.2.1.4 Scope Management

Construction management efforts should ensure that the project features and functions that characterize the project scope remain as established during the design finalization stage. Accordingly, construction phase practices need to be oriented to manage the project scope. As a part of overall project scope management functions, the processes of scope planning, scope definition and scope

verification are associated with the preconstruction phase of the project. The scope monitoring and the change control are critical to the construction phase leading to serious implications on the time and cost aspects. In this respect, consolidated brief of the project established at the end of the design completion is an essential reference for scope baseline.

7.1.2.2 Construction Management

Construction phase of the project transfers the project conceived on paper in the form of plans and designs, into reality by use of resources like materials, machines and men through one or more construction agencies. To fulfill the construction scope with quality, in time and under safe conditions within a reasonable cost, it is desired that the project is planned for managing construction for amalgamation of above resources for their optimum use and its continuous monitoring. Agencies managing the supervision and/or construction are desired to plan and document a management system with clear cut responsibilities and for managing various parameters like scope, time, quality, health, safety and environment and cost for implementation, monitoring and control for their effectiveness. This may be preferably inline with proven National/International documentation system covering all aspects of monitoring and controls. Various parameters to be managed during construction are as below.

7.1.2.2.1 Time Management

Considering the importance of time in a project, it is desirable that project is completed in the defined time schedule to get its fruitful benefits. The system planned should cover total schedule of completion with one or more construction agencies, number of vendors, identification of total resources, timely availability of all inputs, including critical ones, its processing during construction of a project. The system should include a periodic review of a project with all parameters as well as catch up plans in case of delay identified for controls and reporting from time to time. The system planned should preferably be computer friendly and simple to follow for implementation, monitoring and controls and for reporting from time-to-time.

7.1.2.2.2 Quality Management

Quality of a project should be planned for all activities from inception to completion. It is desirable that the system planned gives adequate assurance and controls that it shall meet project quality objectives. The system shall cover review of existing requirements, subcontracting, materials, processes and controls during process, auditing, training of personnel, final inspection and acceptance. All activities shall be planned and controlled. Quality systems approach may be referred for planning, suitable to a particular project for implementation.

7.1.2.2.3 Health, Safety and Environment

Each project affects the safety and health of the workmen and surroundings during construction. Various activities having impact on health, safety and environment need to be identified with their likely effect and proposed preventive corrective actions, together with the concerned statutory obligations. The system planned for health, safety and environment shall address and cover the above including use of personnel protective equipments by all concerned and reporting on their monitoring and controls during project implementation.

7.1.2.2.4 Cost Management

To keep the project under viable proposition, it is desired that cost of the project during construction are monitored and controlled through a documentation system. The various parameters which may affect the basic cost, escalations, cost due to variation in scope and quantities, etc need to be monitored at a defined frequency. The system planned may be in line with a proven cost control

method or similar in nature and cost incurred vis-a-vis cost sanctioned and cost anticipated to be reported and controlled from time to time.

7.1.2.3 Construction Control and Practices

7.1.2.3.1 Professional services and responsibilities

The responsibility of professionals with regard to planning designing and supervision of building construction work, etc and that of the owner shall be in accordance with 'Planning and Administration'. All applications for permits and issuance of certificates, etc shall be as given in 'Planning and Administration'. Employment of trained workers shall be encouraged for building construction activity.

7.1.2.3.2 Construction of All Elements

Construction of all elements of a building shall be in accordance with Suffix [7(1)]. It shall also be ensured that the elements of structure satisfy the appropriate fire resistance requirements as specified in 'Fire and Life Safety', and quality of building materials/components used shall be in accordance with 'Building Materials'.

7.1.2.3.2.1 Construction for Foundation

a) Excavations near footings or foundations

Excavations for any purpose shall not remove lateral support from any footing or foundation without first underpinning or protecting the footing or foundation against settlement or lateral translation.

b) Placement of backfill.

The excavation outside the foundation shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or a controlled low-strength material (CLSM). The backfill shall be placed in lifts and compacted, in a manner that does not damage the foundation or the waterproofing or damp proofing material.

Exception: Controlled low-strength material need not be compacted.

c) Site grading

The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5-percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall. If physical obstructions or plot lines prohibit 10 feet (3048 mm) of horizontal distance, a 5-percent slope shall be provided to an approved alternative method of diverting water away from the foundation. Swales used for this purpose shall be sloped a minimum of 2 percent where located within 10 feet (3048 mm) of the building foundation. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped a minimum of 2 percent away from the building.

Exception: Where climatic or soil conditions warrant, the slope of the ground away from the building foundation is permitted to be reduced to not less than one unit vertical in 48 units horizontal (2-percent slope). The procedure used to establish the final ground level adjacent to the foundation shall account for additional settlement of the backfill.

d) Grading and fill in flood hazard areas

In flood hazard areas, grading or fill shall not be approved:

- 1) Unless such fill is placed, compacted and sloped to minimize shifting, slumping and erosion during the rise and fall of flood water and, as applicable, wave action.

- 2) In floodways, unless it has been demonstrated through hydrologic and hydraulic analyses performed by a registered design professional in accordance with standard engineering practice that the proposed grading or fill, or both, will not result in any increase in flood levels during the occurrence of the design flood.
- 3) In flood hazard areas subject to high-velocity wave action, unless such fill is conducted and/or placed to avoid diversion of water and waves toward any building or structure.
- 4) Where design flood elevations are specified but floodways have not been designated, unless it has been demonstrated that the cumulative effect of the proposed flood hazard area encroachment, when combined with all other existing and anticipated flood hazard area encroachment, will not increase the design flood elevation more than 1 foot (305 mm) at any point.

e) Compacted fill materials

Where footings will bear on compacted fill material, the compacted fill shall comply with the provisions of an approved report, which shall contain the following:

1. Specifications for the preparation of the site prior to placement of compacted fill material.
2. Specifications for material to be used as compacted fill.
3. Test method to be used to determine the maximum dry density and optimum moisture content of the material to be used as compacted fill.
4. Maximum allowable thickness of each lift of compacted fill material.
5. Field test method for determining the in-place dry density of the compacted fill.
6. Minimum acceptable in-place dry density expressed as a percentage of the maximum dry density determined in accordance with Item 3.
7. Number and frequency of field tests required to determine compliance with Item 6.

Exception: Compacted fill material less than 12 inches (305 mm) in depth need not comply with an approved report.

The compaction shall be verified by a qualified inspector approved by the building official.

f) Controlled low-strength materials (CLSM)

Where footings will bear on controlled low-strength material (CLSM), the CLSM shall comply with the provisions of an approved report, which shall contain the following:

1. Specifications for the preparation of the site prior to placement of the CLSM.
2. Specifications for the CLSM.
3. Laboratory or field test method(s) to be used to determine the compressive strength or bearing capacity of the CLSM.
4. Test methods for determining the acceptance of the CLSM in the field.
5. Number and frequency of field tests required to determine compliance with item 4.

7.1.2.3.2.1.1 Footing and Foundation

(a) Depth of footings

The minimum depth of footings below the undisturbed ground surface shall be 12 inches (305mm).

(b) Frost protection

Except where otherwise protected from frost, foundation walls, piers and other permanent supports of buildings and structures shall be protected by one or more of the following methods:

1. Extending below the frost line of the locality

2. Erecting on solid rock.

Exception: Free-standing buildings meeting all of the following conditions shall not be required to be protected

Footings shall not bear on frozen soil unless such frozen condition is of a permanent character.

(c) Isolated footings

Footings on granular soil shall be so located that the line drawn between the lower edges of adjoining footings shall not have a slope steeper than 30 degrees (0.52 rad) with the horizontal, unless the material supporting the higher footing is braced or retained or otherwise laterally supported in an approved manner or a greater slope has been properly established by engineering analysis.

(d) Shifting or moving soils

Where it is known that the shallow subsoil are of a shifting or moving character, footings shall be carried to a sufficient depth to ensure stability.

7.1.2.3.2.1.2 Footings on or adjacent to slopes

The placement of buildings and structures on or adjacent to slopes steeper than one unit vertical in three unit horizontal (33.3-percent slope).

a) Building clearance from ascending slopes

In general, buildings below slopes shall be set a sufficient distance from the slope to provide protection from slope drainage, erosion and shallow failures. The following criteria will be assumed to provide this protection. Where the existing slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the toe of the slope shall be assumed to be at the intersection of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees (0.79 rad) to the horizontal. Where a retaining wall is constructed at the toe of the slope, the height of the slope shall be measured from the top of the wall to the top of the slope.

b) Footing setback from descending slope surface

Footings on or adjacent to slope surfaces shall be founded in firm material with an embedment and set back from the slope surface sufficient to provide vertical and lateral support for the footing without detrimental settlement. Where the slope is steeper than 1 unit vertical in 1 unit horizontal (100-percent slope), the required setback shall be measured from an imaginary plane 45 degree (0.79 rad) to the horizontal, projected upward from the toe of the slope.

c) Pools

The setback between pools regulated by this code and slopes shall be equal to one-half the building footing setback distance required by this section. That portion of the pool wall within a horizontal distance of 7 feet (2134 mm) from the top of the slope shall be capable of supporting the water in the pool without soil support.

7.1.2.3.2.2 Construction Using Masonry

7.1.2.3.2.2.1 Soaking of Brick

Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of the bricks. Wetting the bricks assists in removing the dirt, sand and dust from them. Further, it prevents the suction of water from the wet mortar, as otherwise the mortar is likely to dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use, as they are likely to slip on the mortar bed and there will be difficulty in ensuring plumbness of the wall. Moreover, proper adhesion of bricks to mortar will not be possible if the bricks are too wet.

The period of soaking may be easily found at site by a field test in which the brick soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in the construction work. If the bricks are soaked for the required time in water that is frequently changed, the soluble salt in the brick will be leached out, and subsequent efflorescence will be reduced.

When bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place, where they are not again spoiled by dirt, earth, etc.

7.1.2.3.2.2 Laying of Brick

Brick shall be laid on a full bed of mortar when laying, the bricks shall be slightly pressed so that the mortar gets into all the pores of the brick surface to ensure proper adhesion. Cross joints and wall joints shall be properly flushed and packed with mortar so that no hollow spaces are left. Properly filled joints ensure maximum strength and resistance to penetration of moisture which takes place mainly through joints. In the case of thick walls (two-brick thick and over), the joints shall be grouted at every course in addition to bedding and flushing with mortar. The course at the top of the plinth and sills at the top of the wall just below the roof slab or floor slab and at the top of the parapet, shall be laid with bricks on edge (applicable only in the case of traditional bricks); and at corners and dead ends the bricks shall be properly radiated and keyed into position by using cut-bricks.

Bricks with 20 mm deep frog shall be used frog-down. Bricks with 10 mm deep frog shall be used either frog-up or frog-down.

The courses shall be aligned and care shall be taken to keep the perpend.

The brickwork shall be built in uniform layers; corners and other advanced work shall be racked back. No part of a wall during its construction shall rise more than one meter above the general construction level, to avoid unequal settlement and also improper jointing.

The face joints shall be finished either by jointing or by pointing as specified.

Toothing may be done where future extension is contemplated but shall not be used as an alternative to racking back.

a) Walls

All quoins shall be accurately constructed and the height of the courses checked with storey rods as the work proceeds. In general, quoin bricks shall be headers and stretchers in alternate courses, the bond being established by placing a quoin closer next to the queen header.

Acute and obtuse quoins shall be bonded, where practicable, in the same way as square quoins. Obtuse quoins shall be formed with squints showing a three-quarter brick on one face and a quarter brick on the other.

b) Plasters

These shall be set out as to avoid broken bond. The depth of reveals and rebates shall, where practicable, conform to standard brick sizes in order to avoid cutting of bricks and thereby weakening the work. The arrangement of bond at quoins at jambs of openings shall be symmetrical. Partition for half-brick partitions to be keyed into main walls.

c) Arches

Arches shall be turned with ordinary bricks over time. For face work, the bricks shall be either specially manufactured bricks or ordinary bricks cut and rubbed to shape in order to obtain uniform radial joints.

Flat arches may be used for the sake of appearance, but for purpose of carrying loads of the wall above they shall be used in condition with relieving arches, or with lintels placed.

In the construction of a flat arch, though the extrados is perfectly level; the intrados is given a slight camber to allow for any slight settlement or to correct the apparent sagging of a horizontal line, the usual allowance being about 1 mm rise at the centre for every 100 mm of span.

Large arches in masonry shall be constructed in accordance with IS 2118:1980.

d) Fixing of Frame

Where door or window frames of timber are fixed in the openings, the fixing shall be done, generally with hold-fasts of adequate size and strength securely embedded in the brickwork or in chases later filled up by cement mortar or concrete. Hold-fasts shall be fixed in the brickwork for a sufficient length and then burned up at end into a cross joint, thus avoiding indiscriminate cutting of bricks. Iron hold-fasts shall be given a protective coat of bitumen to avoid rusting. Woodwork faces in contact with brickwork shall be treated with wood preservative to prevent attack from insects and termites.

The frames shall preferably fixed simultaneously as the masonry work proceed as, this construction will ensure, proper bond without gaps between the masonry and the frames.

e) Reinforced Brickwork

Reinforcement in half-brick partition walls may be in the form of mild steel flats or hoop iron, expanded mesh, or mild steel bars or fabric. These are generally used in every third or fourth courses of the brickwork. They shall be securely anchored at their ends where the partitions bond.

In this cast of round bars used as reinforcement, the diameter shall not exceed 8 mm. Flat bars and similar reinforcement shall not have a thickness exceeding 8 mm. The thickness of reinforced brick wall shall be not less than 100 mm.

The crushing strength of the bricks used in reinforced brick masonry shall be not less than 7.5 N/mm^2 .

The mortar used for reinforced brickwork shall generally be rich, dense, cement mortar of mix about 1:4. Lime mortars shall not be used.

The inlaid steel reinforcement shall be completely embedded in mortar. Overlaps in the reinforcement, if any, shall not be less than 300 mm.

The mortar covering in the direction of joints shall be not less than 15 mm.

The mortar interposed between the reinforcement bars and the brick shall be not less than 5 mm thick.

In the case where the reinforcements cross inside a joint, the diameter of the reinforcement shall not exceed 5 mm, unless specially shaped bricks are used to permit larger reinforcement.

f) Protection against Damage

Care shall be taken during construction that edges of jambs, sills, heads, etc, are not damaged.

In inclement weather, newly built work shall be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away.

Curing in hot and dry weather, the mortar is likely to dry up before it has attained its final set and may crumble. This shall be prevented by keeping the brickwork constantly wet for at least seven days, except in the case of brickwork with mud mortar for which no such curing is required.

g) Provision for Service Installations

To facilitate taking service lines later without inordinate cutting of completed work, sleeves and chases shall be provided during the construction itself. Such sleeves shall slope down outwards in external walls so that their surface cannot form channels for the easy passage of water inside.

h) Cavity Walls

As the main object of providing a continuous cavity in an external wall is to prevent rain penetrating to the inner face, care shall be exercised during construction that the cavity is continuous and free from obstruction. As far as possible, mortar droppings shall be prevented from falling down the cavity by the use of laths or by hay bands which shall be drawn up the cavity as the work proceeds. Any mortar which may unavoidably fall on the wall-ties be removed daily and temporary openings shall be provided to permit the daily removal of mortar droppings from the bottom of the cavity.

Special precautions as laid down shall be taken in building flues adjacent to cavities.

Bond in building hollow walls of half-brick thickness, only stretcher bond shall be used, unless purpose made snap header are available. When header bricks are cut and used, they are either likely to protrude into the cavity and form ledges for mortar droppings to collect or they may be so short as to weaken the structure.

The outer and inner leaves shall be tied by means of wall ties. The wall ties shall preferably be bedded with a right fall towards the exterior part of the wall.

At the base of the cavity wall, the foundations and basement shall be solidly constructed up to 300 mm above the ground level. The air cavity shall begin not less than 200 mm below the upper floor surface of the ground floor and the cavity shall be continued without interruption up to the roof.

i) Ventilation

In order to keep the cavity dry, air slot shall be provided above the ground floor level and below the eave level of the roof to extent of 500 mm area of vents to every 20 m area of the wall.

The following precautions shall be observed at the top of the cavity:

Parapets - If the top of a hollow party wall ends with a parapet, the cavity shall be carried up to the full height of the wall or stopped at the roof-fleshing level.

Eaves - If a roof projects over the top of the wall, the cavity shall be closed at the top.

Party Walls - In a hollow party wall, the top of a cavity shall be closed *just* above the uppermost ceiling level and the courses over shall be continued in solid brickwork.

A sound-insulating material shall be interposed between the hollow wall and the solid brickwork.

At the points where the two leaves of the hollow wall come into contact (for example, at windows and doors), they shall be separated by a water-tight membrane.

Above the lintels of doors and windows, damp-proof membrane shall be inserted slopping downwards and outwards.

At solid jambs a vertical damp-proof course shall be inserted between the outer and inner parts of the wall.

7.1.2.3.2.2.3 Concrete-Block Masonry Work in Foundation and Basement

Construction of Masonry

For single storeyed houses, the hollow of blocks in the foundation and basement masonry shall be filled up with sand and only the top foundation course shall be of solid blocks. But for two or more storeyed houses generally solid concrete blocks should preferably be used in foundation courses, plinth, and basement walls. If hollow blocks are used, their hollows must be filled up with concrete comprising one part of cement, three parts of sand and six parts of gravel or crushed stone of 5 to 20 mm size. In special cases, the hollows may be left unfilled if so approved by the appropriate authority.

In damp soils to prevent the rise of moisture from the ground due to capillary action, the foundation and basement masonry shall be laid in richer mortar. In addition, a damp-proof course shall be provided which may consist of a 25mm layer of 1:2 cement mortars, or an approved type of bituminous course.

7.1.2.3.2.2.4 Laying Concrete Block Masonry in Superstructure

a) Use of Mortar in Masonry

Hollow concrete block masonry in superstructure shall be laid in composite mortar comprising one part of cement, one part of lime of sand depending upon the grading of sand. Lesser proportion of sand should be adopted if the sand to be used is either not properly graded or is rather fine and nine to ten parts.

b) Horizontal (Bedding) Joints

Mortar shall be spread over then tire top surface of the block including front and rear shells as well as the webs to a uniform layer of one centimeter thickness. Normally full mortar bedding shall be adopted as it enables fuller utilization of the load-carrying capacity of the blocks. But where the walls carry light loads, such as panel walls, in a framed structure ‘ face-shell ’bedding may be used. In this type of bedding the mortar is spread only over the front and rear shells and not on the webs, which helps to arrest the seepage of water through the joints penetrating to the interior surface of the walls.

c) Vertical (Cross) Joints

For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied either to the unit already placed on the wall or to the next unit to be laid alongside of it. But it will be more convenient to apply mortar on the edges of the succeeding unit when it is standing vertically and then placing it horizontally well-pressed against the previously laid unit. However, whatever the method used for applying mortar, care must be taken to produce well compacted vertical joints. In the case of two cell blocks, there is a slight depression on their vertical sides, which may also be filled up with mortar where it is considered necessary to secure greater lateral rigidity.

Mortar shall not be spread so much ahead of the actual laying of the units that it tends to stiffen and lose its plasticity, thereby resulting in poor bond. For most of the work, the joints, both horizontal and vertical, shall be one centimeter thick. Except in the case of extruded-joint construction described later in (d), the mortar shall be raked out from the joint with a trowel to a depth of about one centimeter as each course is laid so as to ensure good bond for the plaster.

When the mortar has stiffened somewhat, it shall be firmly compacted with a jointing tool. This compaction is important, since mortar, while hardening has a tendency to shrink slightly and thus pull away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after the mortar has stiffened to effect intimate contact between the mortar and the masonry unit and obtain a weather-tight joint.

It may be necessary to add mortar, particularly to the vertical joints, to ensure that they are well-filled.

d) Operation for Laying Block Masonry

First Course –The first course of concrete masonry shall be laid with great care, making sure that it is properly aligned, leveled and plumbed, as this will assist the mason in laying succeeding courses to obtain a straight and truly vertical wall. Before laying the first course, the alignment of the wall shall be marked on the foundation footings. The blocks for this course shall first be laid dry that is without mortar over the footing, along a string lightly stretched between properly located corners of the wall in order to determine the correct position of the blocks including those of the cross-walls joining it and also adjust their spacing. When the blocks are set in proper position, the two corner blocks shall be removed, a full mortar bed spread on the footing and these blocks laid back in place

truly level and plumb. The string shall then be stretched tightly along the faces of the two corner blocks and the faces of the intermediate ones adjusted to coincide with the line. There after each block shall be removed and re-laid over a bed of mortar. After every three or four blocks have been laid, their correct alignment level and verticality shall be carefully checked.

The construction of walls may be started either at the corners first or started from one end proceeding in the other direction. If the corners of the wall are built first, they shall be built four or five courses higher than the centre of the wall. As each course is laid at the corner, it shall be checked for alignment and level and for being plumb. Each block shall be carefully checked with a level or straight-edge to make certain that the faces of the block are all in the same plane. This precaution is necessary to ensure truly straight and vertical walls. The use of a storey-rod or course-pole, which is simply a board with markings 20 cm apart, provides an accurate method of finding the top of the masonry for each course. All mortar joints shall be one centimeter thick. Each course, in building the corners, shall be stepped back by a half-block and the horizontal spacing of the block shall be checked by placing a mason's level diagonally across the corners of the block.

When filling in the wall between the corners, a mason's line shall be stretched from corner to corner for each course and the top outside edge of each block shall be laid to this line. The manner of handling or gripping the block shall be such as to position the block properly with minimum adjustment. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block or it will stiffen and lose its plasticity. As each block is laid, excess mortar extruding from the joints shall be cut off with the trowel and thrown back on the mortar board to be reworked into the fresh mortar. If the work is progressing rapidly, the extruded mortar cut from the joints may be applied to the vertical face shells of the block just laid. Should there be any delay long enough for the mortar to stiffen on the block, the mortar shall be removed to the mortar board and reworked. Dead mortar that has been picked up from the scaffold or from the floor shall not be used.

Closure Block -When installing the closure block, all edges of the opening and all four vertical edges of the closure block shall be buttered with mortar. The closure block shall be carefully lowered into place. If any of the mortar falls out leaving an open joint, the closure block shall be removed, fresh mortar applied and the operation repeated.

e) Provisions for Door and Window Frames

A course of solid concrete block masonry shall be provided under doors and window openings or a 10 cm thick precast concrete sill-block under windows. The solid course shall extend for at least 20 cm beyond the opening on either side.

For jambs of very large doors and windows either solid concrete blocks shall be provided or, if hollow units are used, the hollows shall be filled in with concrete of mix 1:3: 6.

Mild steel bar holdfasts should be so fastened to the door or window frames that these occur at block course level and their ends are embedded in a hollow which shall be filled up with 1:3:6 cement concrete.

f) Provisions for Lintels

Lintels may consist of either a single precast unit or a number of units. They shall be appropriately reinforced. In-situ concrete used for forming a composite lintel with the use of a number of units, shall preferably be of the same mix as of the concrete that is used in the precast units and the composite unit shall also be appropriately reinforced. Where openings occur close to one another a continuous lintel shall be provided.

g) Provision for Roof

The course immediately below the roof slab shall be built with solid blocks. Alternatively, U-shaped units may be used and filled in with 1:3: 6 concrete later on.

The top of the roof course shall be finished smooth with a thin layer of 1:3 cement mortars and covered with a coat of crude oil, or craft or oil paper to ensure free movement of the roof.

Where the roof slab projects beyond the external wall face, it shall be provided with a drip.

h) Intersecting Walls

All walls wherever they meet or intersect shall be bonded or tied securely.

1) **Bearing Walls** - When two bearing walls meet intersect and the courses are to be laid up at the same time, a true masonry bond between at least 50 percent of the units at the intersection is necessary.

When such intersecting bearing walls are laid up separately, pockets with 20 cm maximum vertical spacing shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets.

2) **Non-bearing Walls** - Meeting or intersecting non-bearing walls shall be bonded in a manner approved by a specialist experienced on such construction. Either of the two methods recommended for bearing walls may be used.

i) Pilasters and Piers

The side walls of long buildings shall be stiffened at regular intervals with pilasters which are about twice the thickness of the wall. Piers often support the ends of long roof trusses such as may be used in machine shed and other buildings. The top courses of block in the pier may be filled with concrete. Hollow concrete block shall not be used for isolated piers unless their hollows are filled up with concrete. The unsupported height of piers shall not exceed eighteen times their least horizontal direction.

7.1.2.3.2.2.5 Rendering and Other Finishes

a) External Renderings

As hollow concrete blocks are almost invariably made of lean concrete mixes they will not be impervious and will become damp when exposed to rain. The exterior surface of all hollow concrete block walls shall, therefore, be made waterproof by treating the walls with different types of renderings depending upon the intensity of rainfall, nature of exposure or other reasons. Renderings shall not be applied to the walls when these are wet or in monsoon. The walls must be treated only after they are fully dried. Satisfactory efficiency of the performance of any rendering depends entirely on the surface bond developed between the rendering and the wall. Extreme care shall therefore be taken to ensure effective bond with the wall by preparing the surface, roughening it if necessary, raking out the joints to a depth of at least 10 mm, cleaning the surface of all loose particles and dust, and lightly moistening it with water just prior to applying the rendering to prevent absorption of water from it. The plaster finishes shall be applied in accordance with IS: 2402-1963 Code of Practice for External Rendered Finishes. The sand used for the plaster finish shall be graded from 3 mm downwards. The plaster shall not be finished smooth, but provided with a coarse finish by means of a wooden float.

In localities where rainfall is heavy or the walls are exposed to sea weather, concrete block masonry shall be rendered with two coats each of 6 to 12 mm thickness of cement mortar as specified by the engineer; the base coat being of 1:3 mix and the finishing coat of 1: 3 **or** 1: 4 mix depending upon the severity of the exposure.

In moderate rainfall areas, concrete block masonry shall be rendered with at least one coat of 6 to 12 mm thickness of either 1:4 cement mortar or 1:1: 6 cement-lime-sand mortar.

In areas of scarce rainfall, the exterior surface of concrete block masonry may only be pointed with 1:3 cement mortar, and white or color washed.

Where for architectural or other reasons it is necessary to have the concrete block surface exposed, the walls shall either be built with block having richer facing mixture or treated with two coats of approved quality of cement-based paint. In either case the walls in heavy or moderate rainfall areas shall be pointed with 1: 2 cement mortars.

b) Internal Renderings

As machine-made concrete blocks are of uniform size, walls built with them provide a very even surface. Where it is desired to have the block surface exposed, the walls may only be flush pointed and painted with any approved quality of paint including cement paint. Otherwise the interior surface on walls shall be plastered with one coat of 6 to 12 mm thickness of either 1: 4 cement mortar or 1:1: 6 cement-lime-sand mortar. Where a very smooth finish is desired a second coat of 2 to 3 mm thickness of lime near finish may be applied.

c) Waterproofing Basement Walls below Ground Level

The portion of walls below ground level shall be waterproofed by application of 12 mm thick cement plaster 1:3 mix put on in two coats. The plaster shall be started on the outside of the wall just below the ground line and continued down the wall and across the edge formed by the projection of the footing. In case the subsoil is wet, the plaster shall be coated with asphalt.

7.1.2.3.2.2.6 Laying the Blocks

Gypsum blocks shall preferably not be wetted before laying. Where, however, the suction of the block surfaces in contact with the mortar is so great as to make wetting necessary, only these faces may be wetted using a suitable brush and with the minimum quantity of water.

a) Coursing and Bonding

Gypsum block partitions shall be built in half bond in true level and regular courses.

b) Mortar Joints

The joints shall be as thin as possible. Where the partition is to be plastered, the joint shall be left roughly flush or they may be slightly raked out. If the partition is not to be plastered, the joints shall be neatly finished flush with the face as the work proceeds and care shall be taken to keep the faces clean and free from mortar splashing and stains.

c) Frames for Doors and Other Openings

Where possible frames shall have their posts extending from floor to ceiling to secure a positive fixing to the surrounding structure at both ends and shall have a groove or channel at least 15 mm deep to receive the ends of the blocks.

d) Lintels

The lintel over an opening not more than 0.5 m wide may consist of a single gypsum block having 100 mm bearing at each end.

Where no other support is provided, the lintel over an opening not more than 1.2 m wide may consist of three unreinforced gypsum blocks cut to form a jack-arch. The bearing at each end shall be not less than 350 mm and the bottom side of the key block shall be not more than 500 mm.

The lintel over an opening not more than 1.8 m wide shall consist of gypsum blocks having the upper and lower core holes filled with gypsum mortar and reinforced with 10 mm steel bars. The minimum bearing at each end shall be 100 mm.

Lintels over an opening more than 1.8 m wide shall be a separate lintel designed to support the superincumbent load and having a bearing of not less than 100 mm at each end.

e) Treatment at Heads Partitions

At the ceiling the partitions shall be securely wedged and pinned to the structure above unless special methods of edge isolation are adopted. If the cutting of a cored block exposes the core holes or leaves only a thin shell on top, the core shall be filled solid with mortar before the block is laid. It is essential that the joints in the partition are hardened before any wedging or pinning up is down.

f) Dwarf Partitions

At the head of dwarf partitions lateral supports shall always be provided either by using a capping rail of sufficient rigidity or by staying it to the adjacent main structure.

7.1.2.3.2.2.7 Finishing

Gypsum block partitions shall normally be finished with a rendering of gypsum plaster not less than 6 mm thick. Where the partition is not to be rendered, it shall be cleaned down and any defects made good with neat gypsum plaster or with mortar.

7.1.2.3.2.2.8 Repairing Brickwork

Defects and cracking in brickwork may be due to one or several causes

Where proper materials and workmanship are used, brickwork will need little maintenance.

If, however, defects occur, they may be due to the following causes:

- a) Sulphate attack on mortars and renderings,
- b) Use of unsound materials,
- c) Corrosion of embedded iron or steel,
- d) Crystallization of salts from the bricks, and
- e) Defects due to shrinkage on drying.

And to execute effective repairs, it is necessary to know the cause of damage. The effect of defect in a wall must be judged in relation to the building as a whole and the general soundness of its construction and the particular function of the wall is called upon to serve. The nature of repairs mainly depends on whether it is structural damage or surface cracking only. At times even wide cracks may not seriously affect the stability of the structure provided the brickwork is not distorted or is not much out of plumb.

Before deciding the course of treatment be adopted to following factors shall be considered:

- 1) The type of foundation on which the wall is constructed;
- 2) The position and bonding of cross walls and other connecting structural members;
- 3) Whether the wall is true to plumb;
- 4) Whether floors, roofs, upper walls, etc, are liable to exert thrust or restraint to further movement; and
- 5) The aesthetic effect of the crack over the building as a whole.

a) Treatment of Structural Damage

Where walls become unsafe due to differential movements resulting from seasonal fluctuations in the moisture content of subsoil or due to the presence of filled materials below the foundations, the work may require special measure such as providing reinforced concrete band at plinth level, lintel level, top level, etc, and lowering ground-water table.

For damages other than mentioned in above one of the following treatments may be adopted:

- 1) To provide tie rods passing through the floor or at roof level anchoring the damaged wall to another wall or structural member that is sound or has tendency to move in the opposite direction.
- 2) To build buttresses, keyed into the damaged wall so as to give thrust against the wall in the required direction. It shall be ensured that the buttresses rest on firm soil without giving way to settlements or movements.
- 3) In case the wall is noticed to be out of plumb, the damaged or bulged portion of the wall shall be dismantled and rebuilt with mortar of the same proportion of the adjoining portion.

b) Treatment of Cracks across Wall

These cracks are more or less diagonal cracks and either follow the vertical and horizontal joints alternately or pass straight down through alternate vertical joints and this intervening bricks and mortar beds. In these cases one of the following methods may be adopted:

1) If the cracks are of such nature that they are likely to encourage the penetration of rain if they are not repaired, it is necessary to cut out and replace the cracked bricks.

2) If the cracks are wide, the two portions can be stitched by inserting bond stone or precast reinforced concrete blocks at suitable intervals. The cracks shall then be grouted. Sufficient care has to be taken in preparing the precast concrete blocks so that the patched surface will match with the surrounding surface. In repairing cracks with mortar it is important to secure satisfactory adhesion between the masonry of the existing work and the new bricks and also not to use too strong a mortar mix. Otherwise shrinkage of the new rich mortar may cause a fresh crack to develop. To promote adhesion, the brickwork shall be wetted before the mortar is filled in.

If a number of cracks have appeared in a single wall and the cracks cross each other these cracks cannot be effectively repaired. The walls in such cases have no strength and it is advisable to dismantle the entire wall and reconstruct the same, supporting the structure above in a suitable manner. In case the diagonal cracks have occurred in a localized place of the wall, the brickwork at the damaged place and around shall be dismantled and rebuilt. While dismantling such portions, care shall be taken to relieve the load on the wall by providing props at suitable places. The props or supports for the structure above the work under repair shall not be removed till the rebuilt masonry has attained enough strength.

Where the cracks are likely to continue to widen for sometime after initial development (such as in the case of cracks due to ground movement in shrinkable clay sub-soil) it would be advisable not to repair the cracks with mortar. If filling is found necessary to prevent the penetration of moisture or rain, oil based mastic shall be applied by caulking or by a gun.

c) Surface cracks

Where the mortar in the joints has become damaged without dislocating the brickwork, which may be due to initial usage of poor mortar, improper filling or action of frost or fire or unknown elements of nature, the joints shall be raked thoroughly to a depth of at least 20 mm and the raked joints caulked with mortar and the brickwork pointed. Care shall be taken to avoid the usage of a strong mortar for caulking purposes. The patch work shall be properly cured.

7.1.2.3.2.3 Construction Using Bamboo

a) Bamboo being a versatile resource characterized by high strength, low mass and ease of working with simple tools, it is desirable to increasingly make appropriate use of this material.

b) Bamboo can be cut and split easily with very simple hand tools. Immature bamboos are soft, pliable and can be molded to desired shape. It takes polish and paint well.

c) While it is possible to work with bamboo simply using, a few basic tools, such as, a machete, hack saw, axe, hatchet, sharpening tools, adze, chisel (20 mm), chill, wood rasps, steel rod, and pliers, will greatly increase the effectiveness of the construction process.

d) For providing safety to the structure against fire, bamboo may be given fire retardant treatment using following chemicals: a few drops of concentrated HCL shall be added to the solution to dissolve the precipitated salts:

Ammonium phosphate	3 parts
Boric acid	3 parts
Copper sulphate	1 part
Zinc chloride	5 parts
Sodium dichromate	3 parts
Water	100 parts

e) Bamboo indirect contact with ground, bamboo on rock or preformed concrete footing, bamboo incorporated into concrete or bamboo piles may form the foundation structure.

f) The floor of bamboo may be at ground level with covering of bamboo matting, etc. In elevated floors, bamboo members become an integral part of structural framework of building. The floor will comprise structural bamboo elements and bamboo decking.

7.1.2.3.2.4 Site Preparation

While preparing the site for construction, bush and other wood, debris, etc, shall be removed and promptly disposed for so as to minimize the attendant hazards. Temporary buildings for construction offices and storage shall be so located as to cause the minimum fire hazards and shall be construction from noncombustible material as far as possible.

7.1.2.3.5 Construction Using Concrete

7.1.2.3.5.1 Mixing and Placing of Pneumatic Mortar

a) **Mixing**-The aggregate and cement should be mixed in an approved mechanical mixer and delivered from an approved mechanical digester. The minimum amount of water should be injected into the mixture as this will ensure maximum density of the mortar.

b) **Placing**-The pneumatic mortar should be applied with an approved nozzle by a skilled operator. The velocity of the material leaving the nozzle should be maintained uniform and should be such as to produce minimum rebound of sand.

c) **Cutting** - Immediately after pneumatic mortar has been placed it should be protected against premature drying by shading from strong sunshine and shielding from the wind. As soon as it has hardened just sufficiently to avoid damage it should be thoroughly wetted and there after kept wet continuously for at Least seven days. Adequate protection against fluctuations in temperature by shading and shielding shall also be given.

7.1.2.3.5.2 Construction of Floors

a) Floors Founded on the Ground

The ground should be covered with an at least 75 mm thick plain concrete. Floors cast on the ground should be in not less than two layers, the bottom layer of which may comprise or replace the plain concrete screed. The screed forms an integral part of the floor slab forming one of the two layers then the mix for screed.

A layer of building paper or other suitable material should be laid between successive layers.

The layers, other than the plain concrete screed, if used; should be placed in panels, the sides of which should not exceed 7.5 m in the case of reinforced slabs and 4.5 m in the case of plain slabs. The tendency for the development of cracks in the upper layer of paving slab or a reservoir floor is greatly diminished if the reinforcement is discontinuous through the joints and it is recommended that the floor panels be laid in chessboard fashion (all the ‘ black ’ or all the ‘ white ’ squares first). The edges of the panels in the bottom layer may be butt jointed and the panels in the various layers should be arranged to break joint.

b) Suspended Floors

Floors which are not directly supported on the ground should be cast in panels, the sides of which should not exceed 7.5 m. At joints in suspended floors, the surface of the panels for a width not less than the thickness of the panel on each side of the joint should be primed and painted with at least two coats of bituminous or other approved paint.

c) Junction of Floor and Walls

Where the wall is designed to be monolithic with the bottom slab, a suitable arrangement of reinforcement and form-work shall be made to facilitate the form-work to fit tightly and avoid leakage of cement paste from newly deposited concrete as such leakage if allowed to take place is very liable to cause porosity in the finished concrete. One such arrangement is by providing a continuous up stand section of the wall cast at the same time, as, and integrally with, the slab; the height of this up

stand must be sufficient to enable the next lift off form-work fit tightly and avoid leakage of the cement paste from the newly deposited concrete construction.

7.1.2.3.5.3 Construction of Walls

In all cases where the reinforcing steel is discontinuous at vertical contraction joints, the walls should be constructed in alternate panels with as long a pause as practicable before the concrete is placed in the intervening panels.

Where the reinforcement is continuous through vertical joints in walls, construction in alternate panels may result in a greater tendency to the development of cracks in those panels which are cast between two earlier placed panels, the existence of which increases restraint of the natural shrinkage of the intermediate panel.

The height of any lift should not exceed 2 m unless special precautions are taken to ensure through compaction throughout by mechanical vibration or by other suitable means.

All vertical joints should extend the full height of the wall in unbroken alignment.

7.1.2.3.5.4 Surface Finish to Prestressed Concrete Cylindrical Tanks

The circumferential prestressing wires of a cylindrical tank should be covered with a protective coat, which may be pneumatic mortar, having a thickness that will provide a minimum cover of 40 mm over the wires.

7.1.2.3.5.5 Formwork

Bolts passing completely through liquid-retaining slabs for the purpose of securing and aligning the form-work should not be used unless effective precautions are taken to ensure watertightness after removal.

Lining of Tanks - The type of liquid to be stored should be considered in relation to the possibility, of corrosion of the steel. Provision of an impermeable protective lining should be considered for resistance to the effects of corrosive liquids. Certain natural waters exhibit corrosive characteristics and in such cases it is important to obtain a dense impermeable concrete and with a higher cement content. An increased cover to the steel is also desirable. Use of sulphate resisting Portland cement, pozzolana cement, and blast-furnace slag cement may in certain cases be advantageous.

7.1.2.3.5.6 Placement, Protection and Curing

Placement and Finishing-

Forms, reinforcement, and sub grade shall be sprinkled with cool water just prior to placement of concrete. The area around the work shall be kept wet to the extent possible to cool the surrounding air and increase its humidity, thereby reducing temperature rise and evaporation from the concrete. When temperature conditions are critical, concrete placement may be restricted to the evenings or night when temperatures are lower and evaporation is less.

Speed of placement and finishing helps to minimize problems in hot weather concreting. Delays contribute to loss of workability and lead to use of additional mixing water to offset such loss. Ample personnel shall be employed to handle and place concrete immediately on delivery. On flat work; all steps in finishing shall be carried out promptly. Delays in finishing air-entrained concrete pavement in hot weather may lead to formation of a rubbery surface which is impossible to finish without leaving ridges that impair the riding qualities of pavement.

Concrete shall be placed in layers thin enough and in areas small enough so that the time interval between consecutive placements is reduced and vibration or other working of the concrete will ensure complete union of adjacent portions. If cold joints tend to form or if surfaces set and dry too rapidly, or if plastic shrinkage cracks tend to appear, the concrete shall be kept moist by means of fog sprays, wet burlap, cotton mats, or other means. Fog sprays applied shortly after placement and

before finishing have been found to be particularly effective in preventing plastic shrinkage cracks when other means have failed.

All placement procedures shall be directed to keep the concrete as cool as practicable and to ensure its setting and hardening under temperature conditions which are reasonably uniform and, under moisture conditions, which will minimize drying. Concrete, whether delivered by a truck or otherwise, shall reach the forms at a temperature not higher than 40°C, and whatever is practicable shall be done to minimize temperature increased using placing, consolidation, finishing, and curing operations. At protection and curing since, hot weather leads to rapid drying of concrete, protection and curing are far more critical than during cold weather. Particular attention shall be paid to having all surfaces protected from drying. Immediately after consolidation and surface finish, concrete shall be protected from evaporation of moisture, without letting ingress of external water, by means of wet (not dripping) gunny bags, hessian cloth, etc. Once the concrete has attained some degree of hardening sufficient to withstand surface damage (approximately 12 hour after mixing), moist curing shall commence. The actual duration of curing shall depend upon the mix proportions, size of the member as well as the environmental conditions; however in any case it shall not be less than 10 days. Continuous curing is important, because volume change due to alternate wetting and drying promote the development of surface cracking.

Reliance shall not be placed on the protection afforded by forms for curing in hot weather. If possible, water shall be applied to formed surfaces while forms are still in place and unformed surfaces shall be kept moist by wet curing. The covering material shall be kept soaked by spraying. Steeply sloping and vertical formed surfaces shall be kept completely and continuously moist prior to and during form removal by applying water to top surfaces so that it will pass down between the form and the concrete.

On exposed unformed concrete surfaces, such as pavement slabs, wind is an important factor in the drying rate of concrete. For example, other conditions being equal, a gentle wind of 15 km/h will cause four or more times as much evaporation from a flat surface as still air. Hence windbreakers shall be provided as far as possible.

On hardened concrete and on flat surfaces in particular, curing water shall not be much cooler than the concrete because of the possibilities of thermal stresses and resultant cracking. At the termination of curing with water, an effort shall be made to reduce the rate of drying by avoiding air circulation. This can be accomplished by delay in removal of wet covers until they are dry.

7.1.2.3.6 Construction Using Steel

7.1.2.3.6.1 Connections

a) General - As much of the work of fabrication as is reasonably practicable shall be completed in the shops where the steel work is fabricate.

b) Rivet& Close Tolerance Bolts, High Strength Friction Grip Fasteners, Black Bolts and Welding

Where a connection is subject to impact or vibration or to reversal of stress (unless such reversal is due solely to wind) or where for some special reason, such as continuity in rigid framing or precision in alignment of machinery-slipping of bolts is not permissible! Then rivets, close tolerance bolts; high strength friction grip fasteners or welding shall be used. In all other cases bolts in clearance holes may be used provided that due allowance is made for any slippage.

c) Composite Connections

In any connection which takes a force directly communicated to it and which is made with more than one type of fastening, only rivets and turned and fitted bolts may be considered as acting together to share the load. In all other connections sufficient number of one type of fastening shall be provided to communicate the entire load for which the connection is designed.

d) Members Meeting at a Joint

For triangulated frames designed on the assumption of pin jointed connections, members meeting at a joint shall, where practicable, have their centroidal axes meeting at a point; and wherever practicable the centre of resistance of a connection shall be on the line of action of the load so as to avoid an eccentricity moment on the connections.

However, where eccentricity of members or of connections is present, the members **or** the connections shall provide adequate resistance to the induced bending moments.

Where the design is based on non-intersecting members at a joint all stresses arising from the eccentricity of the members shall be calculated and the stresses kept within the limits specified in the appropriate clause of this code.

e) Bearing Brackets

Wherever practicable, connections of beams to columns shall include a bottom bracket and top cleat. Where web cleats are not provided, the bottom bracket shall be capable of carrying the whole of the load.

f) Gussets

Gusset plates shall be designed to resist the shear, direct and flexural stresses acting on the weakest or critical section. Re-entrant cuts shall be avoided as far as practicable.

g) Packing

1) Rivets or Bolts through Packing

Number of rivets or bolts carrying calculated shear through a packing shall be increased above the number required by normal calculations by 2.5 percent for each 2.0 mm thickness of packing except that, for packing having a thickness of 6 mm or less, no increase need be made. For double shear connections packed on both sides, the number of additional rivets or bolts required shall be determined from the thickness of the thicker packing. The additional rivets or bolts should preferably be placed in an extension of the packing.

2) Packing in Welded Construction

Where a packing is used between two parts, the packing and the welds connecting it to each part shall be capable of transmitting the load between the parts. Where the packing is too thin to carry the load or permit the provision of adequate welds, the load shall be transmitted through the welds alone, the welds being increased in size by an amount equal to the thickness of the packing.

3) Packing Subjected to Direct Compression only

Where properly fitted packing are subjected to direct compression only.

h) Separators and Diaphragms

Where two or more rolled steel joists or channels are used side by side to form a girder, they shall be connected together at intervals of not more than 1 500 mm except in the case of grillage beams encased in concrete, where suitable provision shall be made to maintain correct spacing. Bolts and separators may be used provided that in beams having a depth of 300 mm or more, not fewer than 2 bolts are used with each separator. When loads are required to be carried from one beam to the other or are required to be distributed between the beams, diaphragms shall be used, designed with sufficient stiffness to distribute the load.

i) Lug Angles

Lug angles connecting a channel-shaped member shall, as far as possible, be disposed symmetrically with respect to the section of the member.

In the case of angle members, the lug angles and their connections to the gusset or other supporting member shall be capable of developing a strength not less than 20 percent in excess of the

force in the outstanding leg of the angle, and the attachment of the lug angle to the angle member shall be capable of developing 40 percent in excess of that force.

In the case of channel members and the like, the lug angles and their connection to the gusset or other supporting member shall be capable of developing strength of not less than 10 percent in excess of the force not accounted for by the direct connection of the member, and the attachment of the lug angles to the member shall be capable of developing 20 percent in excess of that force.

In no case shall fewer than two bolts or rivets be used for attaching the lug angle to the gusset or other supporting member.

The effective connection of the lug angle shall, as far as possible terminate at the end of the member connected, and the fastening of the lug angle to the timber shall preferably start in advance of the direct connection of the member to the gusset or other supporting member.

7.1.2.3.6.2 Shop Erection

The steel work shall be temporarily shop erected complete or as arranged with the inspector so that accuracy of fit may be checked before dispatch. The parts shall be shop assembled with sufficient numbers of parallel drifts to bring and keep the parts in place.

In the case of (parts drilled or punched, through steel jigs with bushes resulting in all similar parts being interchangeable) , the steel work may be shop erected in such position as arranged with the inspector.

Packing – All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

7.1.2.3.6.3 Inspection and Testing

The inspector shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of this standard.

Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

The manufacturer shall guarantee compliance with the provisions of this standard, if required to do so by the purchaser.

Should any structure or part of a structure be found not to comply with any of the provisions of this standard, it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for test, except in cases where the purchaser or his authorized representative considers the defect as rectifiable.

Defects which may appear during fabrication shall be made good with the consent of and according to the procedure laid down by the inspector.

All gauges and templates necessary to satisfy the inspector shall be supplied by the manufacturer. The inspector may, at his discretion, check the test results obtained at the manufacturer's works by independent tests at the Government Test House or elsewhere, and should the material so tested be found to be unsatisfactory, the costs of such tests shall be borne by the manufacturer, and if satisfactory, the costs shall be borne by the purchaser.

7.1.2.3.6.4 Site Erection

Plant and Equipment - The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of the engineer.

Storing and Handling - All structural steel should be so stored and handled at the site that the members are not subjected to excessive stresses and damage.

Setting Out - The positioning and leveling of all steelwork, the plumbing of stanchions and the placing of every part of the structure with accuracy shall be in accordance with the approved drawings and to the satisfaction of the engineer.

7.1.2.3.6.5 Security During Erection

During erection, the steelwork shall be securely bolted or otherwise fastened and, when necessary, temporarily braced to provide for all load to be carried by the structure during erection including those due to erection equipment and its operation.

No riveting, permanent bolting or welding should be done until proper alignment has been obtained.

7.1.2.3.6.6 Field Connections

a) Field riveting - Rivets driven at the site shall be heated and driven with the same care as those driven in the shop.

b) Field bolting - Field bolting shall be carried out with the same care as required for shop bolting.

c) Field welding - All field assembly and welding shall be executed in accordance with the requirements for shop fabrication excepting such as manifestly apply to shop conditions only. Where the steel has been delivered painted, the paint shall be removed before field welding, for a distance of at least 50 mm on either side of the joint.

7.1.2.3.6.7 Painting after Erection

Before painting of such steel which is delivered unpainted, is commenced, all surfaces to be painted shall be dry and thoroughly cleaned from all loose scale and rust.

The specified protective treatment shall be completed after erection. All rivet and bolt heads and the site welds shall be cleaned. Damaged or deteriorated paint surfaces shall first be made good with the same type of paint as the shop coat. Where specified, surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Where the steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds and site rivets or bolts, but subject to the approval of the engineer protection may be completed by painting on site. Bolts which have been galvanized or similarly treated are exempted from this requirement.

7.1.2.3.6.8 Bedding of Stanchion Bases and Bearings of Beams and Girders on Stone, Brick or Concrete (Plain or Reinforced)

Bedding shall be carried out with portland cement, grout or mortar or fine cement concrete.

For multi-storeyed buildings, this operation shall not be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, leveled and plumbed and sufficient floor beams are in position.

Whatever method is employed the operation shall not be carried out until the steelwork has been finally leveled and plumbed the stanchion bases being supported meanwhile by steel wedges; and immediately before grouting, the space under the steel shall be thoroughly cleaned.

Bedding of structure shall be carried out with grout or mortar which shall be of adequate strength and shall completely fill the space to be grouted and shall either be placed under pressure or by ramming against fixed supports.

7.1.2.3.6.9 Construction of Steel Chimney

a) Erection Tolerance

The variation in the eccentricity of the axis of chimney from the vertical at any level shall not exceed 1/1,000 of the height, at that particular section.

b) Clearance

Where a chimney passes through a roof or other part of a building, provision shall be made to accommodate the movement of the chimney and to limit the transfer of heat. Normally, an air gap of 50 mm is desirable. Flexible heat resistant packing may be used to fill the gap, if necessary

c) Sealing

Riveted chimneys shall be caulked, specially if condensation is likely to occur.

d) Gas Tightness

No gaskets shall be used in jointing flanges on structural steels.

NOTE — Liquid sealants are recommended to ensure gas tightness and prevent corrosion in the meeting faces.

e) Erection Tension

The amount of pretensioning applied to the guy ropes on site shall be in accordance with the appropriate design considerations and may be measured with a suitable instrument. The tension in the guys after erection shall be not less than 15 percent nor more than 30 percent of the calculated maximum tension due to wind.

7.2 STORAGE, STACKING AND HANDLING OF MATERIALS

7.2.1 GENERAL

7.2.1.1 Planning and Storage Layout

a) For any site, there should be proper planning of the layout for stacking and storage of different materials, components and equipments with proper access and proper maneuverability of the vehicles carrying the material. While planning the layout, the requirements of various materials, components and equipments at different stages of construction shall be considered.

b) Materials shall be segregated as to kind, size and length and placed in neat, orderly piles that are safe against falling. If piles are high they shall be stepped back at suitable intervals in height. Piles of materials shall be arranged so as to allow a passageway of not less than 1 m width in between the piles or stacks for inspection or removal. All passageways shall be kept clear of dry vegetation.

c) Materials shall be stored, stacked and handled in such a manner as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

d) Materials shall be stacked on well drained, firm and unyielding surface. Materials shall not be stacked so as to impose any undue stresses on walls or other structures.

e) Materials shall be stacked in such a manner as not to constitute a hazard to passerby. At such places the stacks shall have suitable warning signs in daytime and red lights on and around them at night.

- f) Stairways, passageways and gangways shall not become obstructed by storage of building materials, tools or accumulated rubbish.

7.2.1.2 Protection Against Atmospheric Agencies

Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric actions, such as rain, sun, winds and moisture, to avoid deterioration.

7.2.1.3 Manual Handling

When heavy materials have to be handled manually each workman shall be instructed by his foreman or supervisor for the proper method of handling such materials. Each workman shall be provided with suitable equipment for his personal safety as necessary. Supervisors shall also take care to assign enough men to each such job depending on the weight and the distance involved.

7.2.1.4 Protection Against Fire and Other Hazards

- a) Materials, like timber, bamboo, coal, paints, etc, shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials like kerosene and petrol, shall be stored in accordance with the relevant rules and regulations so as to ensure the desired safety during storage. Stacks shall not be piled so high as to make them unstable under fire fighting conditions and in general they shall not be more than 4.5m in height. **The provisions given in Suffix [7(2)].**
- b) Materials which are likely to be affected by subsidence of soil like precast beams, slabs and timber of sizes shall be stored by adopting suitable measures to ensure unyielding supports.
- c) Materials liable to be affected by floods, tides, etc shall be suitably stored to prevent their being washed away or damaged due to floods, tides, etc.

7.2.2 STORAGE, STACKING AND HANDLING OF MATERIALS

7.2.2.1 General

The storage stacking and handling of materials generally used in construction shall be as given in 7.2.2.2 to 7.2.2.3.1, which have been summarized in the form of a check list in Annex B. Exposure to asbestos fibers/dust is known to be harmful to health of human beings.

7.2.2.2 Cement

- (a) Storage and Stacking — Cement shall be stored at the work site in a building or a shed which is dry, leak proof and as moisture-proof as possible. The building or shed for storage should have minimum number of windows and close fitting doors and these should be kept closed as far as possible. Cement received in bags shall be kept in such a way that the bags are kept free from the possibility of any dampness or moisture coming in contact with them. Cement bags shall be stacked off the floor on wooden planks in such a way as to keep them about 150 mm to 200 mm clear above the floor. The floor may comprise lean cement concrete or two layers of dry bricks laid on a well consolidated earth. A space of 600 mm minimum shall be left around between the exterior walls and the stacks. In the stacks the cement bags shall be kept close together to reduce circulation of air as such as possible. Owing to pressure on bottom layer of bags sometimes 'warehouse pack' is developed in these bags. This can be removed easily by

rolling the bags when cement is taken out for use. Lumped bags, if any, should be removed and disposed off.

The height of stack shall not be more than 10 bags to prevent the possibility of lumping up under pressure. The width of the stack shall be not more than four bags length or 3.0 m. In stacks more than 8 bags high, the cement bags shall be arranged alternately length-wise and cross-wise so as to tie the stacks together and minimize the danger of toppling over. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received; a table showing date of receipt of cement shall be put on each stack to know the age of cement.

For extra safety during monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a water proofing membrane such as polyethylene, which shall close on the top of the stack. Care shall be taken to see that the waterproofing membrane is not damaged any time during the use.

Cement in gunny bags, paper bags and polyethylene bags shall be stored separately. In case cement is received in drums, these shall be stored on plane level ground, as far as possible near the concrete mixing place. After taking out the required quantity of cement, the lid of the drum shall be securely tied to prevent ingress of moisture. In case cement is received in silos, the silos shall be placed near the concrete batching plant. Proper access shall be provided for the replacement of silos.

Different types of cements shall be stacked and stored separately.

(b) Handling — Hooks shall not be used for handling cement bags unless specifically permitted by the engineer-in-charge. For information regarding bulk handling of cement, see 7.2.2.4.

7.2.2.3 Lime

7.2.2.3.1 Quicklime Before Stacking

(a) Storage and stacking — Quicklime should be slaked as soon as possible. If unavoidable it may be stored in compact heaps having only the minimum of exposed area. The heaps shall be stored on a suitable platform and covered to avoid direct contact with rain or being blown away by wind. In case quick lime is stored in a covered shed, a minimum space of 300 mm should be provided around the heaps to avoid bulging of walls. Unslaked lime shall be stored in a place inaccessible to water and because of fire hazards, shall be segregated from the combustible materials.

(b) Handling — See 7.2.2.4

7.2.2.3.2 Hydrated Lime

(a) Storage and stacking — Hydrated lime is generally supplied in containers, such as jute bags lined with polyethylene or craft paper bags. It should be stored in a building to protect the lime from dampness and to minimize warehouse deterioration. The building should be with a concrete floor and having least ventilation to eliminate draughts through the walls and roof. In general, the recommendations given in 7.2.2 for storing of cement shall be applicable for hydrated lime. When air movement is reduced to a practical minimum, hydrated lime can be stored for up to three months without appreciable change.

b) Handling — See 7.2.2.4.

7.2.2.3.3 Dry Slaked Lime

(a) Storage and stacking — The lime shall be stored in a dry and closed godown.

(b) Handling — See 7.2.2.4.

7.2.2.4 Handling of Cement and Lime

Workmen, handling bulk cement or lime shall wear protective clothing, respirators, and goggles; shall be instructed in the need of cleanliness to prevent dermatitis, and shall be provided with hand cream, petroleum jelly, or similar preparation for protection of exposed skin.

Bulk cement stored in silos or bins may fail to feed to the ejection system. When necessary to enter a silo or bin for any purpose, the ejection system employed shall be shutdown and locked out electrically as well as mechanically. When necessary for a workman to enter such storage area, he shall wear a life-line, with another workman outside the silo or hopper attending the rope.

7.2.2.5 Masonry Unit

(a) Stones — Stones of different sizes, types and classification shall be stored separately. Stones shall be stacked on dry firm ground in a regular heap not more than 1.0 m in height. Veneering stones shall be stacked against vertical support on a firm dry ground in tiers, up to a height of 1.2 m. A distance of about 0.8 m shall be kept between two adjacent stacks.

(b) Bricks — Bricks shall be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These shall not be dumped at site. In the case of bricks made from clays containing lime **Kankar**, the bricks in stack should be thoroughly soaked in water (docked) to prevent lime bursting. Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting, the stacks shall be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of each truckload shall be put in one stack. Bricks of different types, such as, clay bricks, clay fly ash bricks, fly ash lime bricks, sand lime (calcium silicate) bricks shall be stacked separately. Bricks of different classifications from strength consideration and size consideration (such as, conventional and modular) shall be stacked separately. Also bricks of different types, such as, solid, hollow and perforated shall be stacked separately

(c) Blocks — Blocks are available as hollow and solid concrete blocks, hollow and solid light weight concrete blocks, autoclave aerated concrete blocks, concrete stone masonry blocks and soil based blocks. Blocks shall be unloaded one at a time and stacked in regular tiers to minimize breakage and defacement. These shall not be dumped at site. The height of the stack shall not be more than 1.2 m, the length of the stack shall not be more than 3.0 m, as far as possible and the width shall be of two or three blocks. Normally blocks cured for 28 days only should be received at site. In case blocks cured for less than 28 days are received, these shall be stacked separately. All blocks should be water cured for 10 to 14 days and air cured for another 15 days; thus no blocks with less than 28 days curing shall be used in building construction. Blocks shall be placed close to the site of work so that least effort is required for their transportation. The date of manufacture of the blocks shall be suitably marked on the stacks of blocks manufactured at factory or site.

(d) Handling — Brick stacks shall be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall be permitted

7.2.2.6 Floors, Wall and Roof Tiles

(a) Storage and Stacking — Floor, wall and clay roof tiles of different types, such as, cement concrete tiles (plain, coloured and terrazzo) and ceramic tiles (glazed and unglazed) shall be stacked on regular platform as far as possible under cover in proper layers and in tiers and they shall not be dumped in heaps. In the stack, the tiles shall be so placed that the mould surface of one faces that of another. Height of the stack shall not more than 1.0 m. Tiles of different quality, size and thickness shall be stacked separately to facilitate easy removal for use in work. Tiles when supplied by manufacturers packed in wooden crates shall be stored in crates. The crates shall be opened one at a time as and when required for use.

(b) Handling — Ceramic tiles and roof tiles are generally supplied in cartons which shall be handled with care to avoid breakage. It is preferable to transport these at the site on platform trolleys.

7.2.2.7 Aggregate

(a) Storage and Stacking — Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or a floor of bricks, or a thin layer of lean concrete shall be made so as to prevent the mixing with clay, dust, vegetable and other foreign matter. Stacks of fine and coarse aggregate shall be kept in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. On a large job it is desirable to construct dividing walls to give each type of aggregates its own compartment. Fine aggregates shall be stacked in a place where loss due to the effect of wind is minimum.

(b) Handling — When withdrawals are made from stock piles, no over hang shall be permitted. Employees required to enter hoppers shall be equipped with safety belts and life-lines, attended by another person. Machine driven hoppers, feeders, and loaders shall be locked in the off position prior to entry electrically as well as mechanically.

7.2.2.8 Pulverized Fuel Ash/Fly Ash

(a) Storage and Stacking — Fly ash shall be stored in such a manner as to permit easy access for proper inspection and identification of each consignment. Fly ash in bulk quantities shall be stored in stack similar to fine aggregates, avoiding any intrusion of foreign matter. Fly ash in bags shall be stored in stacks not more than 10 bags high.

(b) Handling — See 7.2.2.4.

7.2.2.9 Timber

(a) Storage and Stacking — Timber shall be stored in stacks upon well treated and even surfaced beams, sleepers or brick pillars so as to be above the ground level by at least 150 mm to ensure that the timber will not be affected by accumulation of water under it. Various members shall preferably be stored separately in different lengths, and material of equal lengths shall be piled together in layers with wooden battens, called crossers, separating one layer from another. The crossers shall be of sound wood, straight and uniform in thickness. In case, where separate crossers are not available smaller sections of the available structural timber may be employed in their place. In any layer an air space of about 25 mm shall be provided between adjacent members. The longer pieces shall be placed in the bottom layers and shorter pieces in the top layers but one end of the stack shall be in true vertical alignment. The crossers in different layers shall be in vertical alignment. The most suitable width and height of a stack are recommended to be about 1.5 m and 2.0 m. Distance between adjacent stacks is recommended to be at least 450 mm.

In case the stacking with the help of battens is not possible, the timber may be close piled in heaps on raised foundations with the precautions specified above. The stacks shall be protected from hot dry winds or direct sun and rain. Heavy weights, such as metal rails or large sections of wood, are recommended to be placed on the top of the stack to prevent distortion or warping of the timber in the stack. In case timber is to be stored for about a year or more, to prevent end-cracking in the material, the ends of all members shall be coated with coal tar, aluminium lead paints (hardened gloss oil), microcrystalline wax or any other suitable material.

(b) Care must be taken that handler or workmen are not injured by rails, straps, etc, attached to the used timber. This applies particularly to planks and formwork for shuttering.

7.2.2.10 Bamboo

- a) The site shall be properly inspected and termite colonies or mounds if detected shall be destroyed. All refuse and useless cellulosic materials shall be removed from the site. The ground may then be disinfected by suitable insecticides. The area should have good drainage.
- b) Bamboo may preferably be stacked on high skids or raised platform atleast 300 mm above ground. Storage under cover reduces the liability to fungal attack. Good ventilation and frequent inspection are important.
- c) Bamboo dries by air-seasoning under cover in the storage yards from 6 to 12 weeks time.

7.2.2.11 Partially Prefabricated Wall and Roof

(a) Storage and Stacking — The wall components comprise blocks, sills, lintels, etc. The blocks shall be stacked in accordance with 7.2.2.5(c). These shall be stacked on plane level ground having a floor of bricks or a thin layer of lean concrete. The roof components such as precast RC joists, prefabricated brick panels, RC planks, channel units, cored units, waffle units, L-panel, single tee and double tee sections, ferrocement panels, etc shall be unloaded as individual components. These shall be stacked on plane level ground having a floor of bricks or a thin layer of lean concrete. RC planks, prefabricated brick panels and ferrocement panels shall be stacked against a brick masonry wall in slightly inclined position on both sides of the wall. Channel units, cored units and L-panels shall be stacked one over the other up to five tiers. The waffle units shall be stacked upside down as individual units. The RC joists, single tee and double tee sections shall be stacked as individual units one adjacent to the other. The distance between any two adjacent stacks shall not be less than 450 mm.

(b) Handling — The components shall be handled by holding the individual component by holding a specified points so that the stresses due to handling are minimized.

7.2.2.12 Steel

(a) Storage and Stacking — For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colours. Steel reinforcement shall be stored in a way as to prevent distortion and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting. Bars of different classification, sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths as to minimize wastage in cut from standard lengths. In case of long storage or in coastal areas, reinforcement bars shall be stacked above ground level by at least 150 mm and a coat of cement wash shall be given to prevent scaling and rusting. Structural steel of different sections, sizes and lengths

shall be stored separately. It shall be stored above ground level by at least 150 mm upon platforms, skids or any other suitable supports to avoid distortion of sections. In case of coastal areas or in case of long storage, suitable protective coating of cement wash shall be given to prevent scaling and rusting.

(b) Handling — Tag lines shall be used to control the load in handling reinforcements or structural steel when a crane is employed. Heavy steel sections and bundles shall be lifted and carried with the help of slings and tackles and shall not be carried on the shoulders of the workmen.

7.2.2.13 Aluminium Sections

(a) Storage and Stacking — Aluminium sections of different classification, sizes and lengths shall be stored separately, on a level platform under cover.

(b) Handling — The aluminium sections shall not be pulled or pushed from the stack nor shall be sided over each other, to protect the anodizing layer.

7.2.2.14 Doors, Windows and Ventilators

(a) Storage and Stacking — Metal and plastic doors, windows and ventilators shall be stacked upright (on their sills) on level ground preferably on wooden battens and shall not come in contact with dirt or ashes. If received in crates they shall be stacked according to manufacturer's instructions and removed from the crates as and when required for the work. Metal and plastic frames of doors, windows and ventilators shall be stacked upside down with the kick plates at the top. These shall not be allowed to stand for long in this manner before being fixed so as to avoid the door frames getting out of shape and hinges being strained and shutters drooping. During the period of storage of aluminium doors, windows and ventilators, these shall be protected from loose cement and mortar by suitable covering, such as tarpaulin. The tarpaulin shall be hung loosely on temporary framing to permit circulation of air to prevent moisture condensation. All timber and other lignocellulosic material based frames and shutters shall be stored in a dry and clean covered space away from any infestation and dampness. The storage shall preferably be in well-ventilated dry rooms. The frames shall be stacked one over the other distances to keep the stack vertical and straight. These cross battens should be of uniform thickness and placed vertically one above the other. The door shutters shall be stacked in the form of clean vertical stack one over the other and at least 80 mm above ground on pallets or suitable beams or rafters. The top of the stack shall be covered by a protecting cover and weighted down by means of scantlings or other suitable weights. The shutter stack shall rest on hard and level surface. If any timber or other lignocelluloses material based frame or shutter becomes wet during transit, it shall be kept separate from the undamaged material. The wet material may be dried by stacking in shade with battens in between adjacent boards with free access of dry air. Separate stacks shall be built up for each size, each grade and each type of material. When materials of different sizes, grades and types are to be stacked in one stack due to shortage of space, the bigger size shall be stacked in the lower portion of the stacks. Suitable pallets or separating battens shall be kept in between the two types of material. Precast concrete door and window frames shall be stored in upright position adopting suitable measures against risk of subsidence of soil/support.

(b) Handling — While unloading, shifting, handling and stacking timber or other lignocellulosic material based, metal and plastic door and window frames and shutters, care shall be taken that the pieces are not dragged one over the other as it may cause damage to their surface particularly in case of the decorative shutters. The pieces should be lifted and carried preferably flat avoiding damage to corners or sides.

7.2.2.15 Roofing Materials

7.2.2.15.1 Roofing sheets shall be stored and stacked in such a manner as not to damage them in any way. Damaged sheets shall not be stacked with sound materials. All damaged sheets shall be salvaged as early as possible.

7.2.2.15.2 Asbestos Cement Sheet

(a) Storage and stacking — Asbestos cement sheets shall be stacked to a height of not more than 1.0 m on firm and level ground, with timber or other packing beneath them. If stacked in exposed position, they shall be protected from damage by the winds. Reference may be made to Suffix 7[3].

(b) Handling — Not more than two sheets shall be first pushed forward along the valley line say about one fourth of the sheet length and preferably carried by two workmen. Asbestos cement sheets shall be lowered or raised gently and not thrown.

7.2.2.15.3 CGI Sheets

(a) Storage and stacking — CGI sheets shall be stacked in not more than 100 sheets per stack built solidly. Bundles shall be so laid that the corrugations run in the same directions in every course. One end of the stack shall be raised by 100 mm to 150 mm to allow water flowing freely. If the sheets are not to be used immediately, these shall be stacked under roof cover.

(b) Handling — In bulk handling of CGI sheets, workmen shall be provided with suitable hand protection.

7.2.2.16 Boards

7.2.2.16.1 Gypsum Boards

(a) Storage and stacking — Gypsum boards shall be stored flat in a covered clean and dry place.

(b) Handling — See 7.2.2.15.2 (b)

7.2.2.16.2 Plywood, Fiber Board etc

(a) Storage and Stacking — Plywood, fiber board, etc, shall not be stored in the open and exposed to direct sun and rain. The boards shall be stacked on a flat **dunnage**, on the top of which a wooden frame shall be constructed with battens of 50 mm x 25 mm (Min) in such a way that it supports all four edges and corners of the boards with intermediate battens placed at suitable intervals to avoid warping. If required, the stack shall be adequately raised above ground level to ensure that it will not be affected by accumulation of water under it. The board shall be stacked in a solid block in a clear vertical alignment. The top sheet of each stack shall be suitably weighed down to prevent warping, wherever necessary.

(b) Handling — The board shall be unloaded and stacked with utmost care avoiding damage to the corners and surface. In case of decorative plywood and decorative boards, the surfaces of which are likely to get damaged by dragging one sheet over another, it is advisable that these are lifted as far as possible in pairs facing each other.

7.2.2.17 Plastic and Rubber Flooring Sheets and Tiles

(a) Storage and Stacking — Plastic and rubber sheets have tendency to break-down during storage. Plastic and rubber sheets shall be stored according to manufacturer's instructions. The coolest store room available shall be utilized for the storage of the sheets. The store rooms where the sheets are stored shall be well ventilated and direct light should not be allowed to fall on them. The sheets shall

be stored away from electric generators, electric motors, switchgears and other such electrical equipment as they produce harmful gases as they produce harmful order in their vicinity. Contamination of the sheets with vegetable and mineral oils; greases; organic solvents; acids and their fumes; alkalies; dust and grit shall be prevented. Where greasy contamination occurs this shall be removed immediately with petrol and the sheets and tiles thoroughly wiped dry and dusted with chalk. Undue stretch and strain, kinks, sharp bends or folds of the sheets and tiles shall be avoided. In case of long storage, the sheets shall be turned over periodically and treated with chalk powder, if necessary.

(b) Handling — while handling plastic and rubber sheets, workmen shall lift the sheets and carry them flat to avoid sharp bends or folds of the sheets.

7.2.2.18 Glass Sheets

(a) Storage and Stacking — It is important that all glass sheets whether stored in crates or not shall be kept dry. Suitable covered storage space shall be provided for the safe storage of the glass sheets. The glass sheets shall be lifted and stored on their long edges and shall be put into stacks of not more than 25 panes, supported at two points by fillets of wood at about 300 mm from each end. The first pane laid in each stack shall be so placed that its bottom edge is about 25 mm from the base of the wall or other support against which the stack rests. The whole stack shall be as close and as upright as possible. To prevent slipping on smooth floor, the floor shall be covered with gunny bags. The glass sheets of different sizes, thickness and type shall be stacked separately. The distance between any two stacks shall be of the order of 400 mm.

(b) Handling — Workmen handling glass panes, waste glass pieces and fiber glass shall be provided with suitable hand protection. In removing glass sheets from crates, due care shall be taken to avoid damages. Glass edges shall be covered or otherwise protected to prevent injuries to workmen.

7.2.2.19 Cast Iron, Galvanized Iron and Asbestos Cement Pipes and Fittings

(a) Storage and Stacking — The pipes shall be unloaded where they are required, when the trenches are ready to receive them. Storage shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes placed length-wise and cross-wise in alternate layers. The pyramid stack is advisable in smaller diameter pipes for conserving space in storing them. The height of the stack shall not exceed 1.5 m. Each stack shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars or suppliers wherever possible. Cast iron detachable joints and fittings shall be stacked under cover and separated from the asbestos cement pipes and fittings. Rubber rings shall be kept clean, away from grease, oil, heat and light.

(b) Handling — Pipes in the top layer shall be handled first. At a time only one pipe shall be handled by two labourers while conveying to the actual site and shall be carried on shoulders. Fittings shall be handled individually.

7.2.2.20 Polyethylene Pipes

(a) Storage and Stacking — Black polyethylene pipes may be stored either under cover or in the open. Natural polyethylene pipes, however, should be stored under cover and protected from direct sunlight. Coils may be stored either on edge or stacked flat one on top of the other, but in either case they should not be allowed to come into contact with hot water or steam pipes and should be kept away from hot surface. Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set. Storage of pipes in heated areas exceeding 27°C should be avoided.

(b) Handling — Removal of pipe from a pile shall be accomplished by working from the ends of the pipe.

7.2.2.21 Unplasticized PVC Pipes

(a) Storage and Stacking — Pipes should be stored on a reasonably flat surface free from stones and sharp projections so that the pipe is supported throughout its length. The pipe should be given adequate support at all times. In storage, pipe racks should be avoided. Pipe should not be stacked in large piles especially under warm temperature conditions as the bottom pipes may distort thus giving rise to difficulty in jointing. Socket and spigot pipes should be stacked in layers with sockets placed at alternate ends of the stacks to avoid lopsided stacks. It is recommended not to store a pipe inside another pipe. On no account should pipes be stored in a stressed or bend condition or near a source of heat. Pipes should not be stacked more than 1.5 m high. Pipes of different sizes and classes should be stacked separately. In tropical conditions, pipes should be stored in shade. In very cold weather, the impact strength of PVC is reduced making it brittle. The ends of pipe should be protected from abrasion particularly those specially prepared for jointing either spigot or socket solvent welded joints or soldered for use with couplings. If due to unsatisfactory storage or handling a pipe become brittle in very cold weather.

(b) Handling — Great care shall be exercised in handling these pipes in wintry conditions as these come brittle in very cold weather.

7.2.2.22 Pipes of Conducting Materials

(a) Storage and Stacking — Pipes shall be stacked on solid level sills and contained in a manner to prevent spreading or rolling of the pipe. Where quantity storage is necessary, suitable packing shall be placed between succeeding layers to reduce the pressure and resulting spreading of the pile. In stacking and handling of pipes and other conducting materials, the following minimum safety distances shall be ensured from the overhead power lines:

11 kV and below	1.40 m
Above 11 and below 33 kV	3.60 m
Above 33 and below 132 kV	4.70 m
Above 132 and below 275 kV	5.70 m
Above 275 and below 400 kV	6.50 m

(b) Handling — Removal of pipes from a pile shall be accomplished by working from the ends of the pipe. During transportation, the pipes shall be so secured as to insure against displacement.

7.2.2.23 Piles and Poles

(a) Storage and Stacking — Piles and poles shall be carefully stacked on solid, level sills so as to prevent rolling or spreading of the pile. The storage area shall be maintained free of vegetation and flammable materials.

(b) Handling — When placing piles or poles on the stack, workmen shall work from the ends of the piles/poles. Similar precautions shall be observed in removal of piles/poles from the stack. Tag lines shall be used to control piles and poles when handling for any purpose. In stacking and handling of piles and poles, precautions shall be followed.

7.2.2.24 Paints, Varnishes and Thinners

(a) Storage and Stacking — Paints, varnishes, lacquers, thinners and other flammable materials shall be kept in properly sealed or closed containers. The containers shall be kept in a well ventilated location, free from excessive heat, smoke, sparks or flame. The floor of the paint stores shall be made up of 100 mm

thick loose sand. Paint materials in quantities other than required for daily use shall be kept stocked under regular storage place. Where the paint is likely to deteriorate with age, the manner of storage shall facilitate removal and use of lots in the same order in which they are received. Temporary electrical wirings/fittings shall not be installed in the paint store. When electric lights, switches or electrical equipment are necessary, they shall be of explosion proof design.

(b) Handling — Ventilation adequate to prevent the accumulation of flammable vapours to hazardous levels of concentration shall be provided in all areas where painting is done. When painting is done in confined spaces where flammable or explosive vapours may develop, any necessary heat shall be provided through duct work remote from the source of flame. Sources of ignition, such as open flame and exposed heating elements, shall not be permitted in area or rooms where spray painting is done nor shall smoking be allowed there.

Care should be taken not to use any naked flame inside the paint store. Buckets containing sand shall be kept ready for use in case of fire. Fire extinguishers when required shall be of foam type conforming to **Suffix [7(4)]**.

Each workman handling lead based paints shall be issued ½ liter milk per day for his personal consumption.

7.2.2.25 Bitumen, Road Tar, Asphalt, etc

(a) Storage and Stacking — Drums or containers containing all types of bitumen, road tar, asphalt, etc, shall be stacked vertically on their bottoms in up to three tiers. Leaky drums shall be segregated.

Empty drums shall be stored in pyramidal stacks neatly in rows.

(b) Handling — See 7.3.14.3.1.2 and 7.3.14.3.4

7.2.2.26 Bituminous Roofing Felts

(a) Storage and Stacking — Bituminous roofing felts shall be stored away from other combustible materials and shall be kept under shade.

(b) Handling — Bituminous roofing felts should be handled in a manner to prevent cracking and other damages.

7.2.2.27 Flammable Materials

(a) Storage and Stacking — In addition to the requirements as laid down in 7.2.1.4 the following provisions shall also apply:

1) Outdoor storage of drums requires some care to avoid contamination because moisture and dirt in hydraulic brake and transmission fluid, gasoline, or lubricants may cause malfunction or failure of equipment, with possible danger to personnel. The storage area should be free of accumulations of spilled products, debris and other hazards

2) Compressed gases and petroleum products shall not be stored in the same building or close to each other. Storage of petroleum products should be as per Petroleum Rules.

(b) Handling — Petroleum products delivered to the job site and stored there in drums shall be protected during handling to prevent loss of identification through damage to drum markings, tags, etc. Unidentifiable petroleum products may result in improper use, with possible fire hazard, damage to equipment or operating failure.

Workmen shall be required to guard carefully against any part of their clothing becoming contaminated with flammable fluids. They shall not be allowed to continue work when their clothing becomes so contaminated.

7.2.2.28 Water

Water to be stored for construction purposes shall be stored in proper tanks to prevent any organic impurities. The aggregate capacity of storage tanks shall be determined after taking into account the requirements of fire fighting.

7.2.2.29 Sanitary Appliances

(a) Storage and Stacking — All sanitary appliances shall be carefully stored under cover to prevent damage. When accepting and storing appliances, consideration shall be given to the sequence of removal from the store to the assembly positions. Vitreous fittings shall be stacked separately from the metal ones.

(b) Handling — Bigger sanitary appliances shall be handled one at a time. Traps, water seals and gullies shall be handled separately. While handling sanitary fittings they shall be free from any oil spillings, etc. The hands of the workers shall also be free from any oily substance. Before lowering the appliances in their position the supporting brackets, pedestals, etc, shall be checked for their soundness and then only the fixtures are attached.

7.2.2.30 Other Materials

Polymeric materials such as coatings, sheeting, reflective surfacing/sheeting, etc shall be stored as per the manufacturers' instructions. Special precautions shall be taken in case of storage, handling and usage of toxic materials. Small articles like screws, bolts, nuts, door and window fittings, polishing stones, protective clothing, spare parts of machinery, linings, packings, water supply and sanitary fittings, and electrical fittings, insulation board, etc, shall be kept in suitable and properly protected containers or store rooms. Valuable small materials shall be kept under lock and key.

7.2.2.31 Special Considerations

- a) Materials constantly in use shall be relatively nearer the place of use.
- b) Heavy units like precast concrete members shall be stacked near the hoist or the ramp.
- c) Materials which normally deteriorate during storage shall be kept constantly moving, by replacing old materials with fresh stocks. Freshly arrived materials shall never be placed over materials which had arrived earlier.
- d) Appropriate types of fire extinguishers shall be provided at open sites where combustible materials are stored and for each storage shed/room where flammable/combustible materials are stored. **For guidance regarding selection of the appropriate types of fire extinguishers reference may be made to Suffix [7(4)].** It is desirable that a minimum of two extinguishers are provided at each such location.
- e) Workers handling excavated earth from foundation, particularly if the site happens to be reclaimed area or marshy area or any other infected area, shall be protected against infection affecting their exposed body portions.
- f) Stairways, walkways, scaffolds, and access ways shall be kept free of materials, debris and obstructions. The engineer-in-charge/the foreman shall initiate and carry out a programme requiring routine removal of scrap and debris from scaffolds and walkways.
- g) Where stacking of the materials is to be done on road side berms in the street and other public place, the owner shall seek permission from the Authority for such stacking and also for removing the remnants of the same after the construction is over, so as to avoid any hazard to the public.

7.2.3 UNLOADING RAIL/ROAD WAGONS AND MOTOR VEHICLES

7.2.3.1 Loading and Unloading Rail/Road Wagons

- a) Appropriate warning signals shall be displayed to indicate that the wagons shall not be coupled or moved.
- b) The wheels of wagons shall always be sprigged or chained while the wagons are being unloaded. The brakes alone shall not be depended upon.
- c) Special level bars shall preferably be used for moving rail wagons rather than ordinary crow bars.
- d) Where gangplanks are used between wagons and platforms of piles (heaps), cleats at lower end of gangplank, or pin through end of gangplanks, shall be used to prevent sliding. If gangplank is on a gradient, cleats or abrasive surface shall be provided for the entire length.
- e) When rail/road wagons are being loaded or unloaded near passageways or walkways, adequate warning signals shall be placed on each end of the wagon to warn pedestrians.

7.2.3.2 Loading and Unloading From Motor Vehicles

- a) The motor vehicles shall be properly blocked while being loaded or unloaded; brakes alone shall not be depended upon to hold them.
- b) When motor vehicles are being loaded or unloaded near passageways or walkways, adequate warning signs shall be placed on each end of the vehicle to warn the pedestrians.

7.2.3.3 Handling Heavy/Long Items

- a) Loading and unloading of heavy items, shall, as far as possible, be done with cranes or gantries. The workman shall stand clear of the material being moved by mechanical equipment. The slings and the ropes used shall be of adequate load carrying capacity, so as not to give way and result in accidents.
- b) While heavy and long components are being manually loaded into motor vehicle, wagons, trailer, etc, either wooden sleepers or steel rails of sufficient length and properly secured in position shall be put in a gentle slope against the body of the wagon/vehicle at 3 or 4 places for loading. These long items shall be dragged, one by one, gently and uniformly along these supports by means of ropes, being pulled by men with feet properly anchored against firm surface. As soon as the items come on the floor of the vehicle, the same may be shifted by crowbars and other suitable leverage mechanism, but not by hands to avoid causing accident to the workmen.
- c) Similar procedure see 7.2.3.3(b) shall be followed for manual unloading of long or heavy items.

7.3 SAFETY IN CONSTRUCTION OF ELEMENTS OF A BUILDING

7.3.1 GENERAL

- a) The provisions of this Section shall apply to the erection/alteration of the various parts of a building or similar structure. The construction of the different elements shall conformed to 7.1.2.3.2.
- b) Nothing herein stated shall be construed to nullify any rules, regulations, safety standards or statutes of the local state governments. The specific Rules, Regulations and Acts pertaining to the protection of the public or workmen from health and other hazards wherever specified by the Local/State Authority or in the Acts of the Government take precedence over whatever is herein specified in case of a doubt or dispute.

c) Safety Management

- 1) The safety of personnel engaged in building construction should be ensured through a well planned and well organized mechanism. For this, depending on the size and complexity of building construction project, safety committee shall be constituted to efficiently manage all safety related affairs. The site in-charge or his nominee of a senior rank shall head the committee and a safety officer shall act as member-secretary. The meetings of the safety committee shall be organized regularly say fortnightly or monthly depending on the nature of the project, however, emergency meetings shall be called as and when required. The safety committees shall deal with all the safety related issues through well structured agenda, in the meetings and all safety related measures installed at the site and implementation thereof shall be periodically reviewed.
- 2) Notwithstanding the guidelines given in 7.3.1, all provisions given in relevant Act/Rules/Regulations as amended from time to time shall be followed.

7.3.2 TERMINOLOGY

For the purpose of this Part the following definitions shall apply.

7.3.2.1 Authority Having Jurisdiction — The Authority which has been created by a statute and which for the purpose of administering the Code/Part, may authorize a committee or an official to act on its behalf; hereinafter called the ‘Authority’.

7.3.2.2 Construction Equipment — All equipment, machinery, tools and temporary retaining structures and working platforms, that is, tools, derricks, staging, scaffolds, runways, ladders and all material, handling equipment including safety devices.

7.3.2.3 Floor Hole — An opening measuring less than 300 mm but more than 25mm in its least dimension, in any floor, platform, pavement, or yard, through which materials but not persons may fall; such as, a belt hole, pipe opening or slot opening.

7.3.2.4 Floor Opening — An opening measuring 300 mm or more in its least dimension, in any floor, platform, pavement or yard through which person may fall; such as hatch way, stair or ladder opening, pit or large manhole.

7.3.2.5 Guard Railing — A barrier erected along exposed edges of an open side floor opening, wall opening, ramp, platform, or catwalk or balcony, etc, to prevent fall of persons.

7.3.2.6 Materials Handing Hoists — A platform, bucket or similar enclosure exclusively meant for the lifting or lowering of construction material the hoists being operated from a point outside the conveyance.

7.3.2.7 Pile Rig — The complete pile driving equipment comprising piling frame, leader, hammer, extractor winch and power unit. Complete pile driving rig may be mounted on rafts or pontoon or rails. Pile rig may also be a mobile unit mounted on trailers or trucks, or a special full revolving rig for raking piles.

7.3.2.8 Platform — A working space for persons, elevated above the surrounding floor or ground, such as balcony or platform for the operation of machinery and equipment.

7.3.2.9 Scaffold — A temporary erection of timber or metal work used in the construction, alteration or demolition of a building, to support or to allow the hoisting and lowering of workmen, their tools and materials.

7.3.2.10 Toe Board — A vertical barrier erected along exposed edge of a floor opening, wall opening, platform, catwalk or ramp to prevent fall of materials or persons.

7.3.2.11 Wall Hole — An opening in any wall or partition having height of less than 750 mm but more than 25 mm and width unrestricted.

7.3.2.12 Wall Opening — An opening in any wall or partition is having both height of at least 750 mm and width of at least 450 mm.

7.3.3 TEMPORARY CONSTRUCTION, USE OF SIDE WALLS AND TEMPORARY ENCROACHMENTS

7.3.3.1 Temporary Construction

The plans and specifications of temporary constructions, which are likely to interfere with facilities or right of way provided by the Authority, shall be submitted to the Authority for approval showing clearly the layout, design and construction.

Temporary structure shall apply to the following types of structures:
(a) Structures with roof or walls made of straw, hay, mat, canvas cloth or other like materials not adopted for permanent or continuous occupancy.
(b) Site-work sheds, truck-runways, trestles, footbridges, etc.

7.3.3.2 For detailed information regarding fire safety aspects in respect of construction, location, maintenance and use of temporary structures, reference may be made to **Suffix [7(5)]**.

7.3.3.3 Special permits shall be obtained for the storage of the materials on side walks and highways. It shall be ensured that the material dump or the storage shed does not create a traffic hazard, nor it shall interfere with the free flow of the pedestrian traffic. Special permits shall also be obtained for the use of water and electricity from the public facilities. Whenever such utilities are made use of, adequate safety precautions regarding drainage and elimination of contamination and hazards from electricity shall be taken.

7.3.3.4 In order to ensure safety for the adjoining property, adequate temporary protective guards are to be provided. In case these protective devices project beyond the

property, the consent of the Authority and that of the owner of the adjoining property shall be obtained.

7.3.4 TESTING

7.3.4.1 Tests

No structure, temporary support, scaffolding or any construction equipment during the construction or demolition of any building or structure shall be loaded beyond the allowable loads and working stresses as provided for in Structural Design **Suffix [7(6)]**.

Whenever any doubt arises about the structural adequacy of a scaffolding, support or any other construction equipment, it shall be tested to two and a half times the superimposed dead and imposed loads to which the material or the equipment is subjected to and the member/material shall sustain the test load without failure if it is to be accepted.

7.3.4.2 Notwithstanding the test mentioned above, if any distress in any member is visible, the member shall be rejected.

7.3.5 INSPECTION AND RECTIFICATION OF HAZARDOUS DEFECTS

- a) The Authority shall inspect the construction equipment and if during the inspection, it is revealed that unsafe/illegal conditions exist, the Authority shall intimate the owner and direct him to take immediate remedial measures to remove the hazard/violation.
- b) The owner shall proceed to rectify the defect, hazardous condition or violation within 24 h of the receipt of the notice from the Authority. The Authority shall have full powers to rectify the unsafe condition and all expenses incurred in this connection is payable by the owner of the property. Illegal encroachments and non-payment of money due, in respect of the rectification of unsafe conditions may vest a lien on the property with the Authority.
- c) When the strength and adequacy of any scaffold or other construction equipment is in doubt or when any complaint is made, the Authority shall get the same inspected before use.

7.3.6 FOUNDATIONS

7.3.6.1 General

The distribution of the supporting foundation shall be such as to avoid any harmful differential settlement of the structure. The type and design of the foundation adopted shall ensure safety to workmen during construction and residents of the neighboring property. Sufficient care shall be taken in areas, where withdrawal of ground water from surrounding areas could result in damages to such foundations. During the construction of the foundation, it shall be ensured that the adjoining properties are not affected by any harmful effects.

7.3.6.2 Adjoining Properties

The person causing excavation shall, before starting the work, give adequate notices in writing to the owner of the adjoining properties, safety of which is likely to be affected due to excavation. After having given such notices, wherein details regarding the type of protective works that are anticipated to be incorporated in the excavation are shown, written permission shall be obtained for such excavation from the adjoining property owners. Where necessary, the person causing excavation shall make adequate provision to protect the safety of adjacent property. If on giving such notices and the precautionary measures having been approved by the Authority, the adjoining property owner still refuses to give necessary facilities to the person causing excavation for protecting/providing both temporary and permanent supports to such property, the responsibility for

any damage to the adjoining property shall be that of the adjoining property owner. The person causing excavation shall be absolved of responsibility for any loss of property or life in the adjoining property.

In driven piles vibration is set up which may cause damage to adjoining structures or service lines depending on the nature of soil condition and the construction standard of such structures and service lines. Possible extent of all such damages shall be ascertained in advance, and operation and mode of driving shall be planned with appropriate measures to ensure safety. Where in the vicinity of a site where bored or driven piling works are to be carried out there are old structures which are likely to be damaged, tell-tales shall be fixed on such structures to watch their behavior and timely precautions taken against any undesirable effect.

7.3.6.3 During construction, inspection shall be made by the engineer-in-charge to ensure that all protective works carried out to safe-guard the adjoining property are sufficient and in good order to ensure safety.

7.3.6.4 Before carrying out any excavation work/pile driving, the position, depth and size of underground structures, such as water pipes, mains, cables or other services in the vicinity to the proposed work, may be obtained from the Authority to prevent accidents to workmen engaged in excavation work and calamities for the general public. Prior to commencement of excavation detailed data of the type of soils that are likely to be met with during excavation shall be obtained and the type of protective works by way of shoring timbering, etc, shall be decided upon for the various strata that are likely to be encountered during excavation. For detailed information regarding safety requirements during excavation reference may be made to **Suffix [7(7)]**.

7.3.7 GENERAL REQUIREMENTS AND COMMON HAZARDOUS DURING EXCAVATION

7.3.7.1 Location of Machinery and Tools

Excavating machinery consisting of both heavy and light types shall be kept back from the excavation site at a distance which would be safe for such type of equipment. Heavy equipment, such as excavating machinery and road traffic shall be kept back from the excavated sites at a distance of not less than the depth of trench or at least 6 m for trench deeper than 6 m. Care shall also be taken to keep excavating tools and materials far away from the edge of trench to prevent such items being inadvertently knocked into the trench.

7.3.7.2 Excavated Materials

Excavated materials shall be kept back from the edges of the trench to provide clear berm of safe width. Where this is not feasible, the protective works designed for the trenches shall take into consideration, the additional load due to overburden of materials.

7.3.7.2.1 Other Surcharges

Proximity of buildings, piles of lumber, crushed rocks, sand and other constructional materials, large trees, etc, may impose surcharges on the side of the trench to cause sliding, etc. Under these conditions additional protective works shall be provided to support the sides of the trench.

7.3.7.3 Types of Strata

Adequate precautions, depending upon the type of strata met with during excavation (like quick sand, loose fills and loose boulder) shall be taken to protect the workmen during excavation. Effect of climatic variations and moisture content variations on the materials under excavation shall be

constantly watched and precautions taken, where necessary, immediately to prevent accidents at work site.

7.3.7.4 Overhang and Slopes

During any excavation, sufficient slopes to excavated sides by way of provision of steps or gradual slopes shall be provided to ensure the safety of men and machine working in the area.

7.3.7.5 Blasting

Blasting for foundation of building is prohibited unless special permission is obtained from the Authority. Where blasting technique has to be resorted to, prior inspection for the stability of slopes shall be carried out. After blasting, overhangs or loose boulders shall be cleared by expert workers carrying out blasting prior to continuation of the excavation by normal working parties.

7.3.7.5.1 Burrowing

Burrowing or mining or what is known as ‘gophering’ shall not be allowed. In any trench where such methods have been followed, the cavities felt shall be eliminated by cutting back the bare slope before removing any further material from the section of the trench.

7.3.7.6 Health Hazards

Where gases or fumes are likely to be present in trenches, sufficient mechanical ventilation, to protect the health and safety of persons working there, shall be provided. If necessary, the personnel working there shall be provided with respiratory protective equipment when work in such unhealthy conditions has to be carried out. The precautionary measures provided shall be inspected by the local health authorities prior to commencement of the work.

7.3.7.7 Safety of Materials

Materials required for excavation, like ropes, planks for gangways and walkways, ladders, etc, shall be inspected by the engineer-in-charge who shall ensure that no accident shall occur due to the failure of such materials (see Part 6 ‘Building Materials’).

7.3.7.8 Fencing and Warning Signals

Where excavation is going on, for the safety of public and the workmen, fencing shall be erected, if there is likelihood of the public including cattle frequenting the area. Sufficient number of notice boards and danger sign lights shall be provided in the area to avoid any member of public from inadvertently falling into the excavation. When excavations are being done on roads, diversion of the roads shall be provided with adequate notice board and lights indicating the diversion well ahead. Where necessary, recourse may be had for additional precautionary measures by way of watchmen to prevent accident to the general public, especially during hours of darkness.

7.3.7.9 Effect of Freezing and Thawing

Due to expansion of water when freezing, rock fragments, boulders, etc, are frequently loosened. Therefore, the side walls of the excavation shall be constantly watched for signs of cracks during a thaw. When depending in whole or in part on freezing to support the side walls, great care shall be taken during thaws to provide suitable bracing or remedy the condition by scaling of the loose material from the sides.

7.3.7.10 Vibrations from Nearby Sources

Vibration due to adjacent machinery, vehicles, railroads, blasting, piling and other sources require additional precautions to be taken.

7.3.7.11 Precautions While Using Petroleum Powered Equipment

At the site of excavation, where petroleum powered equipment is used, petroleum vapours are likely to accumulate at lower levels and may cause fire explosion under favorable circumstances. Care should, therefore, be taken to avoid all sources of ignition in such places.

7.3.8 PILING AND OTHER DEEP FOUNDATIONS

7.3.8.1 General

7.3.8.1.1 Safety Programme

All operations shall be carried out under the immediate charge of a properly qualified and competent foreman who shall also be responsible for the safety arrangements of the work.

For work during night, lighting of at least 100 lux intensity shall be provided at the work site.

Every crane driver or hoisting appliance operator shall be competent to the satisfaction of the engineer-in-charge and no person under the age of 21 years should be in-charge of any hoisting machine including any scaffolding winch, or give signals to operator.

Working in compressed air, in case of deep foundations, requires several precautions to be observed to safeguard the workmen against severe hazards to life, compressed air disease and related ailments. **For detailed information regarding safety requirements, reference may be made to Suffix [7(8)].**

7.3.8.2 Piling Rig

- a) Pile drivers shall not be erected in dangerous proximity to electric conductors. If two pile drivers are erected at one place these shall be separated by a distance at least equal to the longest leg in either rig.
- b) The frame of any rig shall be structurally safe for all anticipated dead, live or wind loads. Whenever there is any doubt about the structural strength, suitable test shall be carried out by the foreman and the results of the test recorded. No pile driving equipment shall be taken into use until it has been inspected and found to be safe.
- c) Pile drivers shall be firmly supported on heavy timber sills, concrete beds or other secure foundation. If necessary, to prevent danger, pile drivers shall be adequately guyed. When the rig is not in use, extra precautionary measures for stability, such as securing them with minimum four guys, shall be adopted to prevent any accidents due to wind, storm, gales and earthquake.
- d) Access to working platforms and the top pulley shall be provided by ladders. Working platforms shall be protected against the weather.
- e) In tall driven piling rigs or rigs of similar nature where a ladder is necessary for regular use, the ladder shall be securely fastened and extended for the full height of the rig.
- f) Exposed gears, fly wheels, etc, shall be fully enclosed.

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- g) Pile driving equipment in use shall be inspected by a competent engineer at regular intervals not exceeding three months. A register shall be maintained at the site of work for recording the results of such inspected pile lines and pulley blocks shall be inspected by the foreman before the beginning of each shift, for any excess wear or any other defect.
- h) Defective parts of pile drivers, such as sheaves, mechanism slings and hose shall be repaired by only competent person and duly inspected by foreman-in-charge of the rig and the results recorded in the register. No steam or air equipment shall be repaired while it is in operation or under pressure. Hoisting ropes on pile drivers shall be made of galvanized steel.
- i) Steam and air lines shall be controlled by easily accessible shut-off valves. These lines shall consist of armoured hose or its equivalent. The hose of steam and air hammers shall be securely lashed to the hammer so as to prevent it from whipping if a connection breaks. Couplings of sections of hose shall be additionally secured by ropes or chains.
- j) When not in use the hammer shall be in dropped position and shall be held in place by a cleat, timber or any other suitable means.
- k) For every hoisting machine and for every chain rig hook, shackle, swivel and pulley block used in hoisting or as means of suspension, the safe working loads shall be ascertained. In case of doubt, actual testing shall be carried out and the working load shall be taken as half of the tested load. Every hoisting machine and all gears referred to above shall be plainly marked with the safe working load. In case of a hoisting machine having a variable safe working load, each safe working load together with the conditions under which it is applicable shall be clearly indicated. No part of any machine or any gear shall be loaded beyond the safe working load except for the purpose of testing.
- l) Motor gearing, transmission, electrical wiring and other dangerous parts of hoisting appliances should be provided with efficient safe guards. Hoisting appliances shall be provided with such means as will reduce, to the minimum, the risk of accidental descent of the load and adequate precautions shall be taken to reduce to the minimum, the risk of any part of suspended load becoming accidentally displaced. When workers are employed on electrical installations which are already energized, insulating mats and wearing apparel, such as gloves, etc, as may be necessary, shall be provided. Sheaves on pile drivers shall be guarded so that workers may not be drawn into them.
 - When loads have to be inclined:
 - (a) They shall be adequately counter-balanced, and
 - (b) The tilting device shall be secured against slipping.
- m) Adequate precautions shall be taken to prevent a pile driver from overturning if a wheel breaks.
- n) Adequate precautions shall be taken by providing stirrups or by other effective means, to prevent the rope from coming out of the top pulley or wheel.
- o) Adequate precautions shall be taken to prevent the hammer from missing the pile.

- p) If necessary, to prevent danger, long piles and heavy sheet piling should be secured against falling.
- q) Wherever steam boilers are used, the safety regulations of boilers shall be strictly followed and safety valves shall be adjusted to 7N/cm² in excess of working pressure accurately.
- r) Where electricity is used as power for piling rig, only armoured cable conforming to the relevant EI standard shall be used.
- s) All checks as given in any manuals issued by the manufacturers shall be carried out.

7.3.8.3 Operation of Equipment

- a) Workers employed in the vicinity of pile drivers shall wear helmets conforming to the **Suffix [7(9)]**.
- b) Piles shall be prepared at a distance at least equal to twice the length of the longest pile from the pile driver.
- c) Piles being hoisted in the rig should be so slung that they do not have to be swung round, and may not inadvertently, swing or whip round. A hand rope shall be fastened to a pile that is being hoisted to control its movement. While a pile is being guided into position in the leads, workers shall not put their hands or arms between the pile and the inside guide or on top of the pile, but shall use a rope for guiding.
- d) Before a good pile is hoisted into position it shall be provided with an iron ring or cap over the driving end to prevent brooming. When creosoted wood piles are being driven, adequate precautions shall be taken, such as the provision of personal protective equipment and barrier creams, to prevent workers receiving eye or skin injuries from splashes of creosote.
- e) When piles are driven at an inclination to the vertical, if necessary, to prevent danger, these should rest in a guide.
- f) No steam or air shall be blown down until all workers are at a safe distance.

7.3.9 WALLS

7.3.9.1 General

Depending on the type of wall to be constructed the height of construction per day shall be restricted to ensure that the newly constructed wall does not come down due to lack of strength in the lower layers. Similarly, in long walls adequate expansion/crumple joints shall be provided to ensure safety.

7.3.9.2 Scaffold

Properly designed and constructed scaffolding built by competent workmen shall be provided during the construction of the walls to ensure the safety of workers. The scaffolding may be of timber, metal or bamboo sections and the materials in scaffolding shall be inspected for soundness, strength, etc, at site by the engineer-in-charge prior to erection of scaffolds. Steel scaffolds intended for use in normal building construction work shall conform to **Suffix [7(10)]**. Bamboo and timber scaffolds shall be properly tied to the junctions with coir ropes of sufficient strength or mechanical joints to

ensure that joints do not give way due to the load of workmen and material. Joining the members of scaffolds only with nails shall be prohibited as they are likely to get loose under normal weathering conditions. In the erection or maintenance of tall buildings, scaffoldings shall be of noncombustible material especially when the work is being done on any building in occupation. After initial construction of the scaffolding, frequent inspections of scaffolding.

The platforms, gangways and runways provided on the scaffoldings shall be of sufficient strength and width to ensure safe passage for the workmen working on the scaffolding. The joints provided in these gangways, platforms, etc, shall be such as to ensure a firm foot-hold to the workmen. Where necessary, cross bars shall be provided to the full width of gangway or runway to facilitate safe walking. **For detailed information regarding safety requirements for erection, use and dismantling of scaffolds, reference may be made to Suffix [7(11)].**

7.3.9.2.1 The engineer-in-charge shall ensure by frequent inspections that gangways of scaffolding have not become slippery due to spillage of material. Loose materials shall not be allowed to remain on the gangways. Where necessary, because of height or restricted width, hand-rails shall be provided on both sides. Workers shall not be allowed to work on the scaffolding during bad weather and high winds.

7.3.9.2.2 In the operations involved in the erection or maintenance of outside walls, fittings, etc, of tall buildings, it is desirable to use one or more net(s) for the safety of the workmen when the workmen are required to work on scaffoldings.

7.3.9.3 Ladders

All ladders shall be constructed of sound materials and shall be capable of carrying their intended loads safely. The ladders shall have not only adequate strength but rigidity as well. If a ladder shows tendency to spring, a brace shall be attached to its middle and supported from some other non-yielding fixed object. No ladder having a missing or defective rung or one which depends for its support solely on nails, shall be used. Ladders shall not be used as guys, braces or skids or for any other purpose for which they are not intended. They shall not be used in horizontal position as runways. They shall not be overcrowded. Wherever possible, ladders shall not be spliced. Where splicing is unavoidable, it shall be done only under the supervision of engineer-in-charge. Ladders leading to landings or walkways shall extend at least 1 m above the landing and shall be secured at the upper end. To prevent slipping, a ladder shall be secured at the bottom end. If this cannot be done, a person shall be stationed at the base whenever it is in use.

As a further precaution, the pitch at which a lean-to-ladder is used shall be such that the horizontal distance of its foot from the vertical plane of its top shall be not more than one quarter of its length. If the surface of the floor on which the ladder rests is smooth or sloping, the ladder shall be provided with non-slip bases. If the use of a ladder is essential during strong winds, it shall be securely lashed in position. No ladder shall be placed or leant against window pane, sashes or such other unsafe or yielding objects, nor placed in front of doors opening towards it. If setup in driveways, passageways or public walkways, it shall be protected by suitable barricades. When ascending or descending, the user shall face the ladder, use both his hands and place his feet near the ends of the rungs rather than near the middle. It is dangerous to lean more than 30 cm to side in order to reach a larger area from a single setting of the ladder. Instead, the user shall get down and shift the ladder to the required position.

Metal ladders shall not be used around electrical equipment or circuits of any kind where there is a possibility of coming in contact with the current. Metal ladders shall be marked with signs reading **‘CAUTION: DO NOT USE NEAR ELECTRICAL EQUIPMENT’**.

Wooden ladders shall be inspected at least once in a month for damage and deterioration. Close visual inspection is recommended in preference to load testing. This condition is particularly applicable to rope and bamboo ladders wherein fraying of ropes and damage to bamboo is likely to occur due to materials falling on them. When a ladder has been accidentally dropped it shall be inspected by the engineer-in-charge prior to use. Overhead protection shall be provided for workmen under ladder. For detailed information regarding safety requirements for use of ladders, reference may be made to **Suffix [7(12)]**.

7.3.9.4 Opening in Walls

Whenever making of an opening in the existing wall is contemplated, adequate supports against the collapse or cracking of the wall portion above or roof or adjoining walls shall be provided.

7.3.9.4.1 Guarding of Wall Openings and Holes

Wall opening barriers and screens shall be of such construction and mounting that they are capable of withstanding the intended loads safely. **For detailed information may be made to Suffix [7(13)]**. Every wall opening from which there is a drop of more than 1.2 m shall be guarded by one of the following:

- (a) Rail, roller, picket fence, half door or equivalent barrier — The guard may be removable but should preferably be hinged or otherwise mounted so as to be conveniently replaceable. Where there is danger to persons working or passing below on account of the falling materials, a removable toe board or the equivalent shall also be provided. When the opening is not in use for handling materials, the guards shall be kept in position regardless of a door on the opening. In addition, a grab handle shall be provided on each side of the opening. The opening should have a sill that projects above the floor level at least 25 mm.
- (b) Extension platform into which materials may be hoisted for handling, shall be of full length of the opening and shall have side rails or equivalent guards.

- 7.3.9.4.2** Every chute wall opening from which there is a drop of more than 1.2 m shall be guarded by one or more of the barriers specified in **7.3.9.4.1** or as required by the conditions.

7.3.9.5 Projection from Walls

Whenever projections cantilever out of the walls, temporary formwork shall be provided for such projections and the same shall not be removed till walls over the projecting slabs providing stability load against overturning are completely constructed.

7.3.10 COMMON HAZARDS DURING WALLING

7.3.10.1 Lifting of Materials for Construction

Implements used for carrying materials to the top of scaffoldings shall be of adequate strength and shall not be overloaded during the work. Where workmen have to work below scaffoldings or ladder, overhead protection against the falling materials shall be provided. Care shall be taken in carrying large bars, rods, etc, during construction of the walls to prevent any damage to property or injury to workmen.

7.3.10.2 Haulage of Materials

- a) In case of precast columns, steel beams, etc, proper precautions shall be taken to correctly handle, use and position them with temporary arrangement of guys till grouting of the base.
- b) Manila or sisal rope shall not be used in rainy season for hoisting of heavy materials as they lose their strength with alternate wetting and drying.

7.3.10.3 Electrical Hazards

No scaffolding, ladder, working platform, gangway runs, etc, shall exist within 3.0 m from any uninsulated electric wire.

7.3.10.4 Fire Hazards

Gangways and the ground below the scaffolding shall be kept free from readily combustible materials including waste and dry vegetation at all times.

- 7.3.10.4.1** Where extensive use of blow torch or other flame is anticipated scaffoldings, gangways, etc, shall be constructed with fire resistant materials. A portable dry powder extinguisher of 3.0 kg capacity shall be kept handy.

7.3.10.5 Mechanical Hazards

Care shall be taken to see that no part of scaffolding or walls is struck by truck or heavy moving equipment and no materials shall be dumped against them to prevent any damage. When such scaffoldings are in or near a public thoroughfare, sufficient warning lights and boards shall be provided on the scaffoldings to make them clearly visible to the public.

7.3.10.6 Fragile Materials

During glazing operations, adequate precautions shall be taken to ensure that the fragments of fragile materials do not cause any injury to workmen or general public in that area by way of providing covering to such material, side protection at work site, etc.

7.3.11 ROOFING

- 7.3.11.1** Prevention of accidental falling of workmen during the construction of roofs shall be ensured by providing platforms, catch ropes, etc. If the materials are to be hoisted from the ground level to the roof level, adequate precautions shall be taken by way of correct technique of handling, hoists of sufficient strength to cater for the quantity of stores to be hoisted and prevention of overloading such hoists or buckets, prevention of overturning of hoists or buckets. Where in a multi-storeyed building, the floor of one storey is to be used for storage of materials for the construction of roofs, it shall be ensured that the quantum of stores kept on the floor along with the load due to personnel engaged in the construction work shall not exceed the rated capacity of the floors.

- 7.3.11.2** While roofing work is being done with corrugated galvanized iron or asbestos cement sheets, it shall be ensured that joints are kept secured in position and do not slip, thus causing injury to workmen. Workers should not be allowed to walk on asbestos cement sheets but should be provided with walking boards. While working with tiles, it shall be ensured that they are not kept loose on the roof site resulting in falling of tiles on workmen in lower area. In slopes of more than 30° to

the horizontal, the workmen shall use ladders or other safety devices to work on the roof.

7.3.11.3 If any glass work is to be carried out in the roof, it shall be ensured that injury to passerby due to breaking of glass is prevented. During wet conditions, the workmen shall be allowed to proceed to work on a sloping roof, only if the engineer-in-charge has satisfied himself that the workmen are not likely to slip due to wet conditions.

7.3.11.4 In any type of flat roof construction, any formwork provided shall be properly designed and executed to ensure that it does not collapse during construction. During actual construction of roof, frequent inspection of the formwork shall be carried out to ensure that no damage has occurred to it.

7.3.11.5 While using reinforcement in roofs, it shall be ensured that enough walking platforms are provided in the reinforcement area to ensure safe walking to the concreting area. Loose wires and unprotected rod ends shall be avoided.

7.3.11.6 Guarding of Floor Openings and Floor Holes

- a) Every temporary floor opening shall have railings, or shall be constantly attended by someone. Every floor hole into which persons can, accidentally fall shall be guarded by either
 - (1) A railing with toe board on all exposed sides, or
 - (2) A floor hole cover the adequate strength and it should be hinged in place. When the cover is not in place, the floor hole shall be constantly attended by someone or shall be protected by a removable railing.
- b) Every stairway floor opening shall be guarded by a railing on all exposed sides, except at entrance to stairway. Every ladder way floor opening or platform shall be guarded by a guard railing with toe board on all exposed sides (except at entrance to opening), with the passage through the railing either provided with a swinging gate or so offset that a person can not walk directly into the opening.
- c) Every open-sided floor or platform 1200 mm or more above adjacent floor or ground level shall be guarded by a railing (or the equivalent) on all open sides, except where there is entrance to ramp, stair-way, or fixed ladder. The railing shall be provided with a toe board beneath the open sides wherever
 - (1) Persons may pass;
 - (2) There is moving machinery; or
 - (3) There is equipment with which falling materials could create a hazard.

For detailed information, reference may be made to Suffix [7(13)].

7.3.12 ADDITIONAL SAFETY REQUIREMENTS FOR ERECTION OF CONCRETE FRAMED STRUCTURES (HIGH-RISE BUILDINGS)

7.3.12.1 Handling of Plant

7.3.12.1.1 Mixers

- a) All gears, chains and rollers of mixers shall be properly guarded. If the mixer has a charging skip the operator shall ensure that the workmen are out of danger before the skip is lowered. Railings shall be provided on

the ground to prevent anyone walking under the skip while it is being lowered.

- b) All cables, clamps, hooks, wire ropes, gears and clutches, etc, of the mixer, shall be checked and cleaned, oiled and greased, and serviced once a week. A trial run of the mixer shall be made and defects shall be removed before operating a mixer.
- c) When workmen are cleaning the inside of the drums, and operating power of the mixer shall be locked in the off position and all fuses shall be removed and a suitable notice hung at the place.

7.3.12.1.2 Cranes

- a) Crane rails where used shall be installed on firm ground and shall be properly secured. In case of tower cranes, it shall be ensured that the level difference between the two rails remains within the limits prescribed by the manufacturer to safeguard against toppling of the crane.
- b) Electrical wiring which can possibly touch the crane or any member being lifted shall be removed, or made dead by removing the controlling fuses and in their absence controlling switches.
- c) All practical steps shall be taken to prevent the cranes being operated in dangerous proximity to a live overhead power line. In particular, no member of the crane shall be permitted to approach within the minimum safety distances as laid down in **7.2.2.22 (a)**. If it becomes necessary to operate the cranes with clearances less than those specified above, it shall be ensured that the overhead power lines shall invariably be shut off during the period of operation of cranes. Location of any underground power cables in the area of operation shall also be ascertained and necessary safety precautions shall be taken.
- d) Cranes shall not be used at a speed which causes the boom to swing.
- e) A crane shall be thoroughly examined at least once in a period of 6 months by a competent person who shall record a certificate of the check.
- f) The operator of the crane shall follow the safe reach of the crane as shown by the manufacturer.
- g) No person shall be lifted or transported by the crane on its hook or boom.
- h) Toe boards and limit stops should be provided for wheel barrows on the loading/unloading platforms. Material should be loaded securely with no projections.
- i) Concrete buckets handled by crane or overhead cableway shall be suspended from deep throated hooks, preferably equipped with swivel and safety latch. In the concrete buckets, both bottom drop type and side drop type, closing and locking of the exit door of the bucket shall always be checked by the man-in-charge of loading concrete in the bucket to avoid accidental opening of the exit door and consequent falling of concrete.

- j) Interlocking or other safety devices should be installed at all stopping points of the hoists. The hoists shaft way should be fenced properly.
- k) When the buck or other members being lifted are out of sight of the crane operator, a signalman shall be posted in clear view of the receiving area and the crane operator.
- l) A standard code of hand signals shall be adopted in controlling the movements of the crane, and both the driver and the signaler shall be thoroughly familiar with the signals. The driver of the crane shall respond to signals only from the appointed signaler but shall obey stop signal at any time no matter who gives it.
- m) If a traveling gantry crane is operating over casting beds, a warning signal which sounds automatically during travel should be provided to avoid accidents to workmen crossing or standing in the path of the moving loads.

7.3.12.1.3 Trucks

When trucks are being used on the site, traffic problems shall be taken care of. A reasonably smooth traffic surface shall be provided. If practicable, a loop road shall be provided to permit continuous operation of vehicles and to eliminate their backing. If a continuous loop is not possible, a turnout shall be provided. Backing operations shall be controlled by a signalman positioned so as to have a clear view of the area behind the truck and to be clearly visible to the truck driver. Movement of workmen and plant shall be routed to avoid crossing, as much as possible, the truck lanes.

7.3.12.2 Formwork

- a) Formwork shall be designed after taking into consideration spans, setting temperature of concrete, dead load and working load to be supported and safety factor for the materials used for formwork.
- b) All timber formwork shall be carefully inspected before use and members having cracks and excessive knots shall be discarded.
- c) As timber centering usually takes an initial set when vertical load is applied, the design of this centering shall make allowance for this factor.
- d) The vertical supports shall be adequately braced or otherwise secured in position that these do not fall when the load gets released or the supports are accidentally hit.
- e) Tubular steel centering shall be used in accordance with the manufacturer's instructions. When tubular steel and timber centering is to be used in combination necessary precautions shall be taken to avoid any unequal settlement under load.
- f) A thorough inspection of tubular steel centering is necessary before its erection and members showing evidence of excessive resting, kinks, dents or damaged welds shall be discarded. Buckled or broken members shall be replaced. Care shall also be taken that locking devices are in good working order and that coupling pins are effectively aligned to frames.
- g) After assembling the basic unit, adjustment screws shall be set to their approximate final adjustment and the unit shall be level and plumb so that when additional frames are installed the tower shall be in level and plumb. The centering

frames shall be tied together with sufficient braces to make a rigid and solid unit. It shall be ensured that struts and diagonals braces are in proper position and are secured so that frames develop full load carrying capacity. As erection progresses, all connecting devices shall be in place and shall be fastened for full stability of joints and units.

- h) In case of timber posts, vertical joints shall be properly designed. The connections shall normally be with bolts and nuts. Use of rusted or spoiled threaded bolts and nuts shall be avoided.
- i) Unless the timber centering is supported by a manufacturer's certificate about the loads it can stand, centering shall be designed by a competent engineer.
- j) Centering layout shall be made by a qualified engineer and shall be strictly followed. The bearing capacity of the soil shall be kept in view for every centering job. The effect of weather conditions as dry clay may become very plastic after a rainfall and show marked decrease in its bearing capacity.
- k) Sills under the supports shall be set on firm soil or other suitable material in a pattern which assures adequate stability for all props. Care shall be taken not to disturb the soil under the supports. Adequate drainage shall be provided to drain away water coming due to rains, washing of forms or during the curing of the concrete to avoid softening of the supporting soil.
- l) All centering shall be finally, inspected to ensure that:
 - (1) Footings or sills under every post of the centering are sound
 - (2) All lower adjustment screws or wedges are snug against the legs of the panels
 - (3) All upper adjustment screws or heads of jacks are in full contact with the formwork.
 - (4) Panels are plumb in both directions.
 - (5) All cross braces are in place and locking devices are in closed and secure position.
 - (6) In case of balconies, the props shall be adequate to transfer the load to the supporting point.
- m) During pouring of the concrete, the centering shall be constantly inspected and strengthened, if required, wedges below the vertical supports tightened and adjustment screws properly adjusted as necessary. Adequate protection of centering shall be secured from moving vehicles or swinging loads.
- n) Forms shall not be removed earlier than as laid down in the specifications and until it is certain that the concrete has developed sufficient strength to support itself and all loads that will be imposed on it. Only workmen actually engaged in removing the formwork shall be allowed in the area during these operations. Those engaged in removing the formwork shall wear helmets, gloves and heavy soled shoes and approved safety belts if adequate footing is not provided above 2 m level. While cutting any tying wires in tension, care shall be taken to prevent backlash which might hit a workman.

The particular order in which the supports are to be dismantled should be followed according to the instructions of the site engineer.

7.3.12.3 Ramps and Gangways

- a) Ramps and gangways shall be of adequate strength and evenly supported. They shall either have a sufficiently flat slope or shall have cleats fixed to the surface to prevent slipping of workmen. Ramps and gangways shall be kept free from grease, mud, snow or other slipping hazards or other obstructions leading to tripping and accidental fall of a workman.
- b) Ramps and gangways meant for transporting materials shall have even surface and be of sufficient width and provided with skirt boards on open sides.

7.3.12.4 Materials Hoists

- a) The hoist should be erected on a firm base, adequately supported and secured. All materials supporting the hoist shall be appropriately designed and strong enough for the work intended and free from defects.
- b) The size of the drum shall match the size of the rope. Not less than two full turns of rope shall remain on the drum at all times. Ropes shall be securely attached to the drum.
- c) All ropes, chains and other lifting gear shall be properly made of sound materials, free from defects and strong enough for the work intended. They shall be examined by a competent person who shall clearly certify the safe working load on each item and the system.
- d) Hoist ways shall be protected by a substantial enclosure at ground level, at all access points and wherever persons may be struck by any moving part.
- e) Gates at access points should be at least 2 m high wherever possible. Gates shall be kept closed at all times except when required open for immediate movement of materials at that landing place.
- f) All gates shall be fitted with electronic or mechanical interlocks to prevent movement of the hoist in the event of a gate being opened.
- g) Winches used for hoists shall be so constructed that a brake is applied when the control lever or switch is not held in the operating position (dead-man's handle).
- h) The hoist tower shall be tied to a building or structure at every floor level or at least every 3 m. The height of the tower shall not exceed 6 m after the last tie or a lesser height as recommended by the manufacturer. All ties on a hoist tower shall be secured using right angled couples.
- i) The hoist shall be capable of being operated only from one position at a time. It shall not be operated from the cage. The operator shall have a clear view of all levels or, if he has not, a clear and distinct system of signaling shall employed.
- j) All hoist platform shall be fitted with guards and gates to a height of at least 1 m, to prevent materials rolling/falling from the platform.
- k) Where materials extend over the height of the platform guards, a frame shall be fitted and the materials secured to it during hoisting/lowering. (Care should be taken to ensure that neither the frame nor materials interfere or touch any part of the hoisting mechanism.)

- l) The platform of a goods hoist shall carry a notice stating:
 - (1) the safe working load; and
 - (2) that passengers shall not ride on the hoist.
- m) All hoist operators shall be adequately trained and competent, and shall be responsible for ensuring that the hoist is not overloaded or otherwise misused.
- n) All hoists shall be tested and thoroughly examined by a competent person before use on a site, after substantial alteration, modification or repair of hoists, and at least every 6 months.
- o) Every hoist shall be inspected at least once each week by a competent person and a record of these inspections kept.

7.3.12.5 Prestressed Concrete

- a) In pre-stressing operations, operating, maintenance and replacement instructions of the supplier of the equipment shall be strictly adhered to.
- b) Extreme caution shall be exercised in all operations involving the use of stressing equipment as wires/strands under high tensile stresses become a lethal weapon.
- c) During the jacking operation of any tensioning element(s) the anchor shall be kept turned up close to anchor plate, wherever possible, to avoid serious damage if a hydraulic line fails.
- d) Pulling-headers, bolts and hydraulic jacks/rams shall be inspected for signs of deformation and failure. Threads on bolts and nuts should be frequently inspected for diminishing cross section. Choked units shall be carefully cleaned.
- e) Care shall be taken that no one stands in line with the tensioning elements and jacking equipment during the tensioning operations and that no one is directly over the jacking equipment when deflection is being done. Signs and barriers shall be provided to prevent workmen from working behind the jacks when the stressing operation is in progress.
- f) Necessary shields should be put up immediately behind the prestressing jacks during stressing operations.
- g) Wedges and other temporary anchoring devices shall be inspected before use.
- h) The prestressing jacks shall be periodically examined for wear and tear.

7.3.12.6 Erection of Prefabricated Members

- a) A spreader beam shall be used wherever possible so that the cable can be as perpendicular to the members being lifted as practical. The angle between the cable and the members to be lifted shall not be less than 60° (1.047 rad).
- b) The lifting wires shall be tested for double the load to be handled at least once in six months. The guy line shall be of adequate strength to perform its function of controlling the movement of members being lifted.

- c) Temporary scaffolding of adequate strength shall be used to support precast members at predetermined supporting points while lifting and placing them in position and connecting them to other members.
- d) After erection of the member, it shall be guyed and braced to prevent it from being tipped or dislodged by accidental impact when setting the next member.
- e) Precast concrete units shall be handled at specific picking points and with specific devices. Girders and beams shall be braced during transportation and handled. In such a way as to keep the members upright.
- f) Methods of assembly and erection specified by the designer, shall be strictly adhered to at site. Immediately on erecting any unit in position, temporary connections or supports as specified shall be provided before releasing the lifting equipment. The permanent structural connections shall be established at the earliest opportunity.

7.3.12.7 Structural Connections

- a) When reliance is placed on bond between precast and in-situ concrete the contact surface of the precast units shall be suitably prepared in accordance with the specifications.
- b) The packing of joints shall be carried out in accordance with the assembly instructions.
- c) Leveling devices, such as wedges and nuts which have no load bearing function in the completed structure shall be released or removed as necessary prior to integrating the joints.
- d) If it becomes necessary to use electric power for in-situ work, the same should be stepped down to a safe level as far as possible.

7.3.12.8 Workmen working in any position where there is a falling hazard shall wear safety belts or other adequate protection shall be provided.

7.3.13 ADDITIONAL SAFETY REQUIREMENTS FOR ERECTION OF STRUCTURAL STEEL WORK

7.3.13.1 Safety Organization

The agency responsible for erecting the steel work should analyze the proposed erection scheme for safety; the erection scheme should cover safety aspects right from the planning stage up to the actual execution of the work.

7.3.13.2 Safety of Work Persons

- a) While engaging persons for the job the supervisor should check up and make sure that they are skilled in the particular job they have to perform.
 - 1) The personnel protective equipment (helmets, goggles etc.,) shall be worn properly and at all times during the work and shall conform to the **Suffix [7(9)]**.

- 2) The safety goggles shall be used while performing duties which are hazardous to eye like drilling, cutting and welding. The goggles used shall conform to the **Suffix [7(15)]** and should suit individual workers.
 - 3) The welders and gas cutters shall be equipped with proper protective equipment like gloves, safety boots, aprons and hand shields. The filter glass of the hand shield shall conform to **Suffix [7(16)]** and should be suitable to the eyes of the particular worker.
 - 4) When the work is in progress, the area shall be cordoned off by barricades to prevent persons from hitting against structural components, or falling into excavated trenches or getting injured by falling objects.
 - 5) Warning signs shall be displayed where necessary to indicate hazards, for example (a) '**440 VOLTS**', (b) '**DO NOT SMOKE**', (c) '**MEN WORKING AHEAD**', etc. Hand lamps shall be of low voltage preferably 24 V to prevent electrical hazards.
 - 6) All electrically operated hand tools shall be provided with double earthing.
- b) Anchors for guys or ties shall be checked for proper placement. The weight of concrete in which the anchors are embedded shall be checked for uplift and sliding.
- 1) Split-end eye anchors shall only be used in good, solid rock.
 - 2) The first load lifted by a guy derrick shall be kept at a small height for about 10 min and the anchors immediately inspected for any signs or indications of failure.
- c) When a number of trusses or deep girders is loaded in one car or on one truck, all but one being lifted shall be tied back unless they have been tied or braced to prevent their falling over and endangering men unloading.
- d) The erection gang shall have adequate supply of bolts, washers, rivets, pins, etc, of the correct size. Enough number of bolts shall be used in connecting each piece using a minimum of two bolts in a pattern to ensure that the joint will not fail due to dead load and erection loads. All splice connections in columns, crane girders, etc, shall be completely bolted or riveted or welded as specified in the drawing before erection.
- e) Girders and other heavy complicated structural members may require special erection devices like cleats and hooks, which can be shop assembled and bolted or riveted or welded to the piece and may be left permanently in the place after the work.
- f) If a piece is laterally unstable when picked at its centre, use of a balance beam is advisable, unless a pair of bridles slings can be placed far enough apart for them to be safe lifting points. The top flange of a truss, girder or long beam may be temporarily reinforced with a structural member laid flat on top of the member and secured temporarily.
- g) On deep girders, and even on some trusses, a safety 'bar' running their full length will aid the riggers, fitters and others employed on the bottom flange or bottom

chord to work with greater safety. This can be a single 16 mm diameter wire rope through vertical stiffeners of such members about 1 m above the bottom flange and clamped at the ends with wire rope clamps. If the holes cannot be provided, short eye bolts can be welded to the webs of the girder at intervals to be removed and the surface chipped or ground to leave it smooth after all work on the piece has been completed.

- h) Safety belts shall always be available at work spot to be used whenever necessary. The rope shall be chemically treated to resist dew and rotting. These shall not be tied on sharp edges of steel structures. They shall be tied generally not more than 2 m to 3 m away from the belt.
- i) On a guy derrick or climbing crane job, the tool boxes used by the erection staff shall be moved to the new working floor each time the rig is changed. On a mobile crane job, the boxes shall be moved as soon as the crane starts operating in a new area too far away for the men to reach the boxes conveniently. While working a tall and heavy guy derrick, it is advisable to control tension in guys by hand winches to avoid jerks, which may cause an accident.
- j) The proper size, number and spacing of wire rope clamps shall be used, depending on the diameter of the wire rope. They shall be properly fixed in accordance with **Suffix [7(17)]**. They shall be checked as soon as the rope has been stretched, as the rope, especially if new, tends to stretch under the applied load, which in turn may cause it to shrink slightly in diameter. The clamps shall then be promptly tightened to take care of this new condition. In addition, the clamps shall be inspected frequently to be sure that they have not slipped and be tight enough.
- k) When the men can work safely from the steel structure itself, this preferable to hanging platforms or scaffolds, as it eliminates additional operations, which in turn, reduces the hazard of an accident.
- l) To aid men working on floats or scaffolds, as well as men in erection gangs, or other gangs using small material, such as bolts and drift pins, adequate bolt baskets or similar containers with handles of sufficient strength and attachment to carry the loaded containers, shall be provided.
- m) The men should be trained to use such containers, and to keep small tools gathered up and put away in tool boxes when not in use. Material shall not be dumped overboard when a scaffold is to be moved. Rivet heaters shall have safe containers or buckets for hot rivets left over at the end of the day.
- n) During the erection of tall buildings, it is desirable to use nylon nets at a height of 3 m to 4 m to provide safety to men, The safety net should be made from man or machine-made fiber ropes which are UV stabilized and conforming to the **Suffix [7(18)]**.

o) Safety against Fire

A fire protection procedure is to be set up if there is to be any flame cutting, burning, heating, riveting or any operation that could start a fire. For precautions to be observed during welding and cutting operations, reference may be made to **Suffix [7(19)]**

- 1) The workers should be instructed not to throw objects like hot rivets, cigarette stubs, etc, around.

- 2) Sufficient fire extinguishers shall be placed at strategic points. Extinguishers shall always be placed in cranes, hoists, compressors and similar places. Where electrical equipments are involved, CO₂ or dry powder extinguishers shall be provided **Suffix [7(4)]**.

p) Riding on a load, tackle or runner shall be prohibited.

- q) The load shall never be allowed to rest on wire ropes. Ropes in operation should not be touched. Wire rope with broken strand shall not be used for erection work. Wire ropes/manila ropes conforming to **Suffix [7(20)]** shall be used for guying.

r) Lifting Appliances

Precautions as laid down shall be followed.

s) Slings

- 1) Chains shall not be joined by bolting or wiring links together. They shall not be shortened by tying knots. A chain in which the links are locked, stretched or do not move freely shall not be used. The chain shall be free of kinks and twists. Proper eye splices shall be used to attach the chain hooks.
- 2) Pulley blocks of the proper size shall be used to allow the rope free play in the sheave grooves and to protect the wire rope from sharp bends under load. Idle sling should not be carried on the crane hook along with a loaded sling. When idle slings are carried they shall be hooked.
- 3) While using multi legged slings, each sling or leg shall be loaded evenly and the slings shall be of sufficient length to avoid a wide angle between the legs.

t) Riveting Operations

1) Handling rivets

Care shall be taken while handling rivets so that they do not fall, strike or cause injury to men and material below. Rivet catchers shall have false wooden bottoms to prevent rivets from rebounding.

2) Riveting dollies

Canvas, leather or rope slings shall be used for riveting dollies. Chain shall not be used for the purpose.

3) Riveting Hammers

Snap and plungers of pneumatic riveting hammers shall be secured to prevent the snap from dropping out of place. The nozzle of the hammer shall be inspected periodically and the wire attachment renewed when worn.

4) Fire Protection

The rivet heating equipment should be as near as possible to the place of work. A pail of water shall always be kept ready for quenching the fire during riveting operations and to prevent fires when working near inflammable materials.

u) Welding and Gas Cutting

- 1) For safety and health requirements in electric gas welding and cutting operations, reference may be made to **Suffix [7(21)] and Suffix [7(25)]**.

- 2) All gas cylinders shall be used and stored in the upright position only and shall be conveyed in trolleys. While handling by cranes they shall be carried in cages. The cylinders shall be marked 'full' or 'empty' as the case may be. Gas cylinders shall be stored away from open flames and other sources of heat. Oxygen cylinders shall not be stored near combustible gas, oil, grease and similar combustible materials. When the cylinders are in use, cylinder valve key or wrench shall be placed in position. Before a cylinder is moved, cylinder valve shall be closed. All cylinder valves shall be closed when the torches are being replaced or welding is stopped for some reason. The cylinder valve and connections shall not be lubricated.
- 3) Gas cutting and welding torches shall be lighted by means of special lighters and not with matches. The cables from welding equipment should be placed in such a way that they are not run over by traffic. Double earthing shall be provided. Before undertaking welding operations near combustible materials, suitable blanketing shall be provided and fire extinguishers kept nearby. Welding shall not be undertaken in areas where inflammable liquids and gases are stored.
- 4) Gas lines and compressed air lines shall be identified by suitable colour codes for easy identification, to avoid confusion and to prevent fire and explosion hazards.

7.3.13.3 Safety of Structures

- a) The structure itself should be safeguarded during its erection. The first truss of the roof system shall be guyed on each side before the hoisting rope is detached from it. After the subsequent trusses and roof purlins are erected, protective guides shall be firmly established and the required wind bracings shall be erected to prevent the whole structure being blown over by a sudden gale at night. Bracing and guying precautions shall be taken on every structure until it is complete. Guying shall be specifically done for trusses and structural components which after their erection form an erection device, on structures used for temporary material storage overloading shall be avoided.
- b) Erection of columns shall be immediately followed by vertical bracing between columns before the roof structure is erected.

7.3.14 MISCELLANEOUS ITEMS

7.3.14.1 Staircase Construction

While staircase is under construction, depending on the type of construction, namely, concrete or brickwork, etc, suitable precautions shall be taken by way of support, formworks, etc, to prevent any collapse. Workmen or any other person shall not be allowed to use such staircases till they are tested and found fit for usage by the Authority/engineer-in-charge. Till the permanent handrails are provided, temporary provisions like ropes, etc, shall be provided on staircases prior to commencement of use of such staircases.

7.3.14.2 Lift

Till the installation of the lift is completed, lift wells shall be protected with check boards or railings together with notice boards, danger lights, etc, to prevent persons accidentally falling into the wells. The handrails provided shall be capable of withstanding pressure exerted due to normal bumping of an individual against the same.

7.3.14.3 Construction Involving the Use of Hot Bituminous Tar Materials

7.3.14.3.1 Safety Programme

7.3.14.3.1.1 General

On all major works, an experienced and competent foreman or supervisor shall be placed in-charge of the work, and shall be made responsible for the strict observance of the safety rules. He shall stock the necessary protective equipment, fire extinguishing equipment, first-aid kit, etc. He shall also keep a record of the accidents taking place on any particular job, with reasons thereof, and shall suggest suitable remedial measures to the management for prevention thereof.

7.3.14.3.1.2 Protective covering

Workers engaged on jobs involving handling of hot bitumen, tar, and bituminous mixtures shall use protective wears, such as boots and gloves, preferably of asbestos or otherwise of rubber goggles and helmet. No workers shall be permitted to handle such materials without wearing the needed protective covering.

7.3.14.3.1.3 Fire fighting arrangements

When heating and handling of hot bituminous materials is to be done in the open, sufficient stocks of clean dry sand or loose earth shall be made available at the work site to cope with any resultant fires. When such materials are not available, nor are any suitable type of fire extinguishers provided at the work site in the open, and reliance has to be on using water for fighting any fire, the water supply available should be in abundance and the water shall be applied to the fire in the form of spray. When heating of bituminous materials is carried out in enclosed spaces, sufficient number of properly maintained dry powder fire extinguisher or foam extinguisher conforming to accepted good standards shall be kept in readiness on the work site.

7.3.14.3.2 Sprayer, Spreader/Paver

7.3.14.3.2.1 Sprayer

The sprayer shall be provided with a fire resisting screen. The screen shall have an observation window. Piping for hot tar and bitumen shall be adequately insulated to protect workers from injury by burns. Flexible piping work under positive pressure shall be of metal which shall be adequately insulated. Workers shall not stand facing the wind directions while spraying hot binder, lest it may fall on them causing burns.

7.3.14.3.2.2 Spreader/Paver

Spreaders in operation shall be protected by signals, signs or other effective means. People should be warned against walking over hot mixture laid. Gravel spreaders shall always keep a safe distance from sprayer. Elevated platforms on spreaders shall be protected by suitable railing and be provided with an access ladder.

7.3.14.3.3 Equipment for Heating of Bitumen and Tars

- a) Tanks, vats, kettles, pots, drums and other vessels for heating tar, bitumen and other bituminous materials shall be:
 - (1) Adequately resistant to damage by heat, transportation, etc;
 - (2) Capable of holding a full load without danger of collapse, bursting or distortion;
 - (3) Provided with a close fitting cover suitable for smothering a fire in the vessel or protection from rain; and
 - (4) Leak proof, and provided with suitable outlets which can be controlled for taking out the hot material.
- b) Suitable indicator gauges shall be used to ascertain level and temperature of the material in the boiler. No account shall workers be allowed to peep into the boiler for this purpose. For ascertaining levels, in small plants, dipstick may also be used.

- c) Gas and oil-fired bitumen and tar kettles or pots shall be equipped with burners, regulators and safety devices of types approved by the Authority. Heating appliances for vessels shall distribute the heat uniformly over the heating surface so as to avoid overheating. In case of bituminous mixtures using mineral aggregates filler together with bitumen, it is preferable to have some means for stirring as well. Only vessels heated by electricity shall be used inside buildings. Tar boilers shall never be used on combustible roof.
- d) Buckets for hot bitumen, bituminous materials of tar shall have:
 - (1) The bail or handle firmly secured, and
 - (2) A second handle near the bottom for tipping.
- e) Bitumen or tar boilers mounted on wheels for easy transport or towing shall preferably be provided with hand pumps for spraying purposes.
- f) Vessels in operation shall be kept at a safe distance from combustible materials. When vessels are used in confined spaces, the gases, fumes and smoke generated shall be removed by exhaust ventilation or by forced ventilations. Vessels that are being heated shall not be left unattended. Pieces of bituminous material shall not be thrown into the hot vessels so as to cause splashing. Covers shall be kept closed when vessels are not in use. Containers shall not be filled with hot bitumen or tar to a level that might cause danger when they are carried or hoisted. Enough space shall be left in vessels for expansion of binder when heated.
- g) Bitumen/Tar shall be kept dry and to avoid fire due to foaming, boiler shall have a device that prevents foam from reaching the burners or antifoaming agents shall be used to control the same. Alternatively to avoid fire due to foaming, the heating shall be at low temperature till the water entrapped, if any, is completely evaporated. Any water present in the boiler shall also be drained before using it for heating binders. No open light shall be used for ascertaining the level of binder in boilers. If a burner goes out, the fuel supply shall be cutoff and the heating tube shall be thoroughly blown out by the fan so as to prevent a back fire.
- h) Cutbacks shall not be heated over an open flame unless a water jacket is used. While they are being heated the vessel shall be kept open.
- i) Piping shall not be warmed with burning rags and instead blow-lamps or similar devices shall be used.
- j) Spilled bitumen or tar shall be promptly cleaned up around boilers.
- k) Inspection openings shall not be opened while there is any pressure in the boiler.
- l) When tanks are cleaned by steam, adequate precautions shall be taken to prevent any built up of pressure.

7.3.14.3.4 Handling Bitumen/Tar

Bitumen/tar shall not be heated beyond the temperature recommended by the manufacturer of the product. While discharging heated binder from the boiler, workers shall not stand opposite to the

jet so as to avoid the possibility of hot binder falling on them. The container shall be handled only after closing the control valve. While handling hot bitumen/tar, workers shall exercise scrupulous care to prevent accidental spillage thereof. The buckets and cans in which the hot material is carried from boiler shall be checked before use to ensure that they are intact and safe. Mops and other applicators contaminated with bituminous materials shall not be stored inside buildings. Safety requirement shall be in accordance with **Suffix [7(22)]**.

7.3.14.4 Timber Structure

Preventive measures against hazards in work places involving construction of timber structures shall be taken in accordance with **Suffix [7(23)]**

7.3.15 FINISHES

7.3.15.1 Painting, Polishing and Other Finishes

Only the quantity of paint, thinner and polish required for the day's work should be kept at the work spot.

- a) All containers of paint, thinner and polish which are not in actual use should be closed with tight fitting lids and kept at a safe place away from the actual work site.
- b) A 5 kg dry powder fire extinguisher conforming to Suffix [7(24)] shall be kept handy.
- c) Metal receptacles with pedal operated metal lids shall be kept handy at the work site for depositing used cotton rags/waste. The contents of such receptacles shall be disposed off before the end of each day's work at a safe place, preferably by burning under proper supervision.
- d) All containers of paint shall be removed from the work site and deposited in the paint store before the close of day's work. Used paintbrushes shall be cleaned and deposited in the store along with the containers.
- e) Some paints/polishing and finishing materials are injurious to the health of workmen. Adequate protective clothing, respiratory equipment, etc, shall be provided for the use of workmen during such operations where necessary.

7.3.16 FRAGILE FIXTURES

- 7.3.16.1** It shall be ensured that sufficient number of workmen and equipment are provided to carry the fragile fixtures like sanitary fittings, glass panes, etc, to prevent injury to workmen due to accidental dropping of such fixtures.

7.3.17 ELECTRICAL INSTALLATIONS AND LIFTS

7.3.17.1 Temporary Electrical Wiring

- a) Frayed and/or bare wires shall not be used for temporary electrical connections during construction. All temporary wiring shall be installed and supervised by a competent electrician. Adequate protection shall be provided for all electrical wiring laid on floor which may have to be crossed over by construction machinery or by the workmen. All flexible wiring connecting the electrical appliances shall have adequate mechanical strength and shall preferably be enclosed in a flexible metal sheath. Overhead wires/cables shall be so laid that they leave adequate head room.

- b) All electrical circuits, other than those required for illumination of the site at night, shall be switched off at the close of day's work. The main switch board from which connections are taken for lighting, power operated machinery, etc, shall be located in an easily accessible and prominent place. No articles of clothing nor stores shall be kept at the back of or over the board or anywhere near it. One 3 kg/4.5 kg CO₂ extinguisher or one 5 kg dry powder extinguisher shall be provided near the switch board.

7.3.17.2 Permanent Electrical Installations

Besides the fire safety measures for electrical installations covered under 7.3.17.1 safety in electric installations in buildings and installations of lifts shall be in accordance with **Part 5C** 'Building Services'.

7.3.18 GENERAL REQUIREMENTS

7.3.18.1 Sanitation

- (a) Adequate toilet facilities shall be provided for the workmen within easy access of their place of work. The total number to be provided shall be not less than one per 30 employees in any one shift.
- (b) Toilet facilities shall be provided from the start of building operations, and connection to a sewer shall be made as soon as practicable.
- (c) Every toilet shall be so constructed that the occupant is sheltered from view and protected from the weather and falling objects.
- (d) Toilet facilities shall be maintained in a sanitary condition. A sufficient quantity of disinfectant shall be provided.
- (e) An adequate supply of drinking water shall be provided, and unless connected to a municipal water supply, samples of the water shall be tested at frequent intervals by the Authority.
- (f) Washing facilities shall be installed, and when practicable shall be connected to municipal water supply and shall discharge to a sewer.
- (g) Natural or artificial illumination shall be provided.

7.3.18.2 Fire Protection

- a) In addition to the provision of fire extinguishers, as specified in this Part of the Code, other fire extinguishing equipment shall also be provided and conveniently located within the building under construction or on the building site, as required by the Authority.
 - 1) All fire extinguishers shall be maintained in a serviceable condition at all times in accordance with **Suffix [7(4)]** and all necessary guidelines regarding fire protection at workplaces followed in accordance with **Suffix [7(2)]**.
 - 2) It shall be ensured that all workmen and supervisory staff are fully conversant with the correct operation and use of fire extinguishers provided at the construction site.
 - 3) Telephone number of local fire brigade should be prominently displayed near each telephone provided at construction site.
 - 4) Watch and ward services should be provided at construction sites during holidays and nights.

- b) Access shall be provided and maintained at all times to all fire fighting equipment, including fire hose, extinguishers, sprinkler valves and hydrants.
 - 1) Approach roads for fire fighting should be planned, properly maintained and kept free from blockage. Width of approach road should be not less than 5 m to facilitate fire fighting operations.
 - 2) Emergency plan and fire order specifying the individual responsibility in the event of fire should be formulated and mock drills should be practiced periodically in case of large and important construction sites to ensure upkeep and efficiency of fire fighting appliances.
 - 3) Periodical inspection should be carried out to identify any hazard and proper records maintained and follow up action taken.
 - 4) Evaluation facilities and fire exits should be provided at all locations susceptible to fire hazards.
- c) Where the building plans require the installation of fixed fire fighting equipment, such as hydrants, stand pipes, sprinklers and underground water mains or other suitable arrangements for provision of water shall be installed, completed and made available for permanent use as soon as possible, but in any case not later than the stage at which the hydrants, etc, are required for use as specified.
 - 1) A stand pipe system (landing valves), permanent in nature shall be installed and made available before the building has reached the height of 15 m above the grade, and carried up with each floor.
 - 2) The standpipe (landing valve/internal fire hydrant) and its installation shall conform to the **Suffix [7(26)]**.
 - 3) The standpipe shall be carried up with each floor and securely capped at the top. Top hose outlets, should at all times, be not more than one floor below the floor under construction.
 - 4) A substantial box, preferably of metal, should be provided and maintained near each hose outlet. The box should contain adequate lengths of hose to reach all parts of the floor as well as a short branch fitted with 12 mm or 20 mm nozzle.
- d) Close liaison shall be maintained with the local fire brigade, during construction of all buildings above 15 m in height and special occupancies, like educational; assembly, institutional, industrial, storage, hazardous and mixed occupancies with any of the aforesaid occupancies having area more than 500 m² on each floor.
- e) It is desirable that telephone system or other means of inter-communication system be provided during the construction of all buildings over 15 m in height or buildings having a plinth area in excess of 1000 m².
- f) All work waste, such as scrap timber, wood shavings, sawdust, paper, packing materials and oily waste shall be collected and disposed of safely at the end of each day's work. Particular care shall be taken to remove all waste accumulation in or near vertical shaft openings like stairways, lift-shaft, etc.

- g) An independent water storage facility shall be provided before the commencement of construction operations for fire-fighting purposes. It shall be maintained and be available for use at all times.
- h) Fire walls and exit stairways required for a building should be given construction priority. Where fire doors, with or without automatic closing devices, are stipulated in the building plans they should be hung as soon as practicable and before any significant quantity of combustible material is introduced in the building.
- i) As the work progresses, the provision of permanent stairways, stairway enclosures, fire walls and other features of the completed structure which will prevent the horizontal and vertical spread of fire should be ensured.

7.3.18.3 Clothing

- a) It shall be ensured that the clothes worn by the workmen be not of such nature as to increase the chances of their getting involved in accident to themselves or to others. As a rule, wearing of loose garments shall be prohibited.
- b) Workmen engaged in processes which splash liquid or other materials which will injure the skin shall have enough protective clothing to cover the body.
- c) Individuals engaged in work involving use of naked flames (such as welding) shall not wear synthetic fiber or similar clothing which increases the risk of fire hazards.

7.3.18.4 Safety Measure Against Fall Prevention

Persons working at heights may use safety belts and harnesses. Provision of cat-walks, wire mesh, railings reduces chances of fall-ladder and scaffoldings, stagings etc, should be anchored on firm footing and should be secured and railing should be provided as far as possible. All accesses should be barricaded to prevent accidental fall **in Suffix [7(27)]**.

7.3.18.5 Falling Materials Hazard Prevention

Preventive measures against falling materials hazards in work places shall be taken **in Suffix [7(28)]**.

7.3.18.6 Disposal of Debris

Preventive measures against hazards relating to disposal of debris shall be taken **in Suffix [7(29)]**.

7.3.19 CONSTRUCTION MACHINERY

- a) Specification and requirements of construction machinery used in construction or demolition work shall conform to **Suffix [7(30)]**.
- b) For safety requirements for working with construction machinery, reference may be made to **Suffix [7(31)]**.
- c) Petroleum powered air compressors, hoists, derricks, pumps, etc, shall be so located that the exhausts are well away from combustible materials. Where the exhausts are

pipes to outside the building under construction, a clearance of at least 150 mm shall be maintained between such piping and combustible material.

7.4 MAINTENANCE MANAGEMENT, REPAIRS, RETROFITTING AND STRENGTHENING OF BUILDINGS

7.4.1 MAINTENANCE MANAGEMENT

7.4.1.1 Maintenance management of building is the art of preserving over a long period what has been constructed. Whereas construction stage lasts for a short period, maintenance continues for comparatively very large period during the useful life of building. Inadequate or improper maintenance adversely affects the environment in which people work, thus affecting the overall output. In the post construction stage the day to day maintenance or upkeep of the building shall certainly delay the decay of the building structure. Though the building may be designed to be very durable it needs maintenance to keep it in good condition.

7.4.1.2 Terminology

For the purpose of this Section, the following definitions shall apply.

- 7.4.1.2.1 Maintenance** — The combination of all technical and associated administrative actions intended to retain an item in or restore it to a state in which it can perform its required function.
- 7.4.1.2.2 Maintenance Management** — The organization of maintenance within an agreed policy. Maintenance can be seen as a form of ‘steady state’ activity.
- 7.4.1.2.3 Building Fabric** — Elements and components of a building other than furniture and services.
- 7.4.1.2.4 Building Maintenance** — Work undertaken to maintain or restore the performance of the building fabric and its services to provide an efficient and acceptable operating environment to its users.
- 7.4.1.2.5 House Keeping** — The routine recurring work which is required to keep a structure in good condition so that it can be utilized at its original capacity and efficiency along with proper protection of capital investment, throughout its economic life.
- 7.4.1.2.6 Owner**— Person or body having a legal interest in a building. This includes freeholders, leaseholders or those holding a sub-lease which both bestows a legal right to occupation and gives rise to liabilities in respect of safety or building condition. In case of lease or sub- leaseholders, as far as ownership with respect to the structure is concerned, the structure of a flat or structure on a plot belongs to the allottee/lessee till the allotment/lease subsists.
- 7.4.1.2.7 Confined Space** — Space which may be inadequately ventilated for any reason and may result in a deficiency of oxygen, or a build-up of toxic gases, e.g. closed tanks, sewers, ducts, closed and unventilated rooms, and open topped tanks particularly where heavier than air gases or vapours may be present.

7.4.1.3 Building Maintenance

7.4.1.3.1 General

Any building (including its services) when built has certain objectives and during its total economic life, it has to be maintained. Maintenance is a continuous process requiring a close watch and taking immediate remedial action. It is interwoven with good quality of house keeping. It is largely governed by the quality of original construction. The owners, engineers, constructors, occupants and the maintenance agency are all deeply involved in this process and share a responsibility. Situation in which all these agencies merge into one is ideal and most satisfactory. There are two processes envisaged, that is, the work carried out in anticipation of failure and the work carried out after failure. The former is usually referred to as preventive maintenance and the latter as corrective maintenance. The prime objective of maintenance is to maintain the performance of the building fabric and its services to provide an efficient and acceptable operating environment to its users.

7.4.1.3.1.1 Maintenance in general term can be identified in the following broad categories.

- (a) Cleaning and servicing** — This is largely of preventive type, such as checking the efficacy of rain water gutters and servicing the mechanical and electrical installations. This covers the house keeping also.
- (b) Rectification and repairs** — This is also called periodical maintenance work undertaken by, say, annual contracts and including external replastering, internal finishing etc.
- (c) Replacements** — This covers major repair or restoration such as reproofing or re-building defective building parts.

7.4.1.3.2 Factors Affecting Maintenance

7.4.1.3.2.1 Maintenance of the buildings is influenced by the following factors:

- (a) Technical factors** — These include age of building, nature of design, material specifications, past standard of maintenance and cost of postponing maintenance.
- (b) Policy** — A maintenance policy ensures that value for money expended is obtained in addition to protecting both the asset value and the resource value of the buildings concerned and owners.
- (c) Financial and economic factors** see (7.4.1.9)
- (d) Environmental** - All buildings are subject to the effects of a variety of external factors such as air, wind precipitation, temperature etc. which influence the frequency and scope of maintenance.

The fabric of building can be adversely affected as much by the internal environment as by the elements externally. Similar factors of humidity, temperature and pollution should be considered. Industrial buildings can be subject to many different factors subject to processes carried out within.

Swimming pool structures are vulnerable to the effects of chlorine used in water.

- (e) User** — The maintenance requirements of buildings and their various parts are directly related to the type and intensity of use they receive.

7.4.1.3.2.2 Influence of design

The physical characteristics, the life span and the aesthetic qualities of any building depend on the considerations given at the design stage. All buildings, however well designed and conscientiously built, will require repair and renewal as they get older. However, for better performance of the building envelop, the following are the ways to minimize troubles at the later stage.

- (a) Minimize defects during construction and design,
- (b) Detail and choose materials during construction so that the job of maintenance is less onerous.

7.4.1.3.2.2.1 In addition to designing a building for structural adequacy, consideration should also be given to environmental factors such as moisture, natural weathering, corrosion and chemical action, user wear and tear, pollution, flooding, subsidence, earthquake, cyclones etc.

7.4.1.3.2.2.2 A list of common causes for maintenance problems is given in Annex C for guidance. However, no such list is likely to be entirely comprehensive.

7.4.1.3.3 Maintenance Policy

The policy should cover such items as the owner's anticipated future requirement for the building taking account of the building's physical performance and its functional suitability. This may lead to decisions regarding:

- (a) the present use of the building anticipating any likely upgradings and their effect on the life cycles of existing components or engineering services; and
- (b) a change of use for the building and the effect of any conversion work on the life cycles of existing components or engineering services.

7.4.1.3.4 Maintenance Work Programmes

The programming of maintenance work can affect an owner or his activities in the following ways:

- (a) maintenance work should be carried out at such times as are likely to minimize any adverse effect on output or function.
- (b) programme should be planned to obviate as far as possible any abortive work. This may arise if upgrading or conversion work is carried out after maintenance work has been completed or if work such as rewiring is carried out after redecoration.
- (c) any delay in rectifying a defect should be kept to a minimum only if such delay is likely to affect output or function. The cost of maintenance increases with shortening response times.
- (d) maintenance work, completed or being carried out should comply with all statutory and other legal requirements.

7.4.1.3.5 Maintenance Guides

An owner responsible for a large number of buildings may have established procedures for maintenance. When an owner is responsible for the maintenance of only one building or a small number of buildings, the preparation of a guide tailored to suit each particular building, can offer significant advantages. Such a guide should take into account the following:

- (a) type of construction and residual life of the building, and
- (b) environment and intensity of use see (7.4.1.3.2)

The guide may form part of a wider manual covering operational matters.

7.4.1.3.6 Planning of Maintenance Work

Work should take account of the likely maintenance cycle of each building element and be planned logically, with inspections being made at regular intervals. Annual plans should take into account subsequent years' programmes to incorporate items and to prevent additional costs. It should be stressed that the design of some buildings can lead to high indirect costs in maintenance contracts and therefore, careful planning can bring financial benefits. Decisions to repair or replace should be taken after due consideration.

7.4.1.3.7 Feedback

7.4.1.3.7.1 Feedback is normally regarded as an important procedure of providing information about the behavior of materials and detailing for the benefit of the architect/engineer designing new buildings, which will result in lessening maintenance costs. It is an equally valuable source of information for the persons responsible for maintenance. Every maintenance organization should develop a sample way of communicating it's know how, firstly for benefit of others in the organization and secondly for the benefit of the building industry as a whole. There should be frank and recorded dialogue on an on-going basis between those who occupy and care for buildings and those who design and construct them.

7.4.1.3.7.2 Feedback should aim at the following:

- (a) User satisfaction,
- (b) Continuous improvement, and
- (c) Participation by all.

7.4.1.3.7.3 Source of information

The information on feedback can be obtained from the following:

- (a) Occupants,
- (b) Inspections,
- (c) Records, and
- (d) Discussions.

7.4.1.3.8 Means of Effecting Maintenance

7.4.1.3.8.1 Responsibility

Some maintenance work will be carried out by the occupier of a building or by the occupier's representative. In the case of leasehold or similar occupation not all maintenance may be the responsibility of occupier. Responsibility of common areas may be clearly defined.

7.4.1.3.8.2 Maintenance work sub-divided into major repair, restoration, periodical and routine or day-to-day operations will be undertaken by one of the following:

- (a) Directly employed labour,
- (b) Contractors, and
- (c) Specialist contractors under service agreement or otherwise.

7.4.1.3.8.3 The merits of each category for typical maintenance work must be considered because optimum use of resources appropriate to tasks in a given situation is an important element of policy.

- 7.4.1.3.8.4** The success of contracting out depends on the nature of the services, conditions in which contracting is undertaken (the tendering process), how the contract is formulated and subsequent monitoring of service quality. The important consideration in the decision to contract out is whether a contractor can ensure a socially desirable quantity and quality of service provision at a reasonable cost to the consumers.

7.4.1.4 Access

7.4.1.4.1 General

All maintenance activities including any preliminary survey and inspection work require safe access and in some situations this will have to be specially designed. Maintenance policy, and maintenance costs, will be much influenced by ready or difficult access to the fabric and to building services. Special precautions and access provisions may also need to be taken for roof work or for entry into confined spaces such as ducts or voids.

7.4.1.4.2 Access Facilities

- 7.4.1.4.2.1** Permanent accessibility measures should be provided at the design stage only for all the areas for safe and proper maintenance. It is a matter on which those experienced in the case of the building can make an important contribution at design stage in the interest of acceptable maintenance costs.

- 7.4.1.4.2.2** A wide variety of temporary access equipment may appropriately be provided for maintenance work, ranging from ladders to scaffoldings or powered lift platforms.

- 7.4.1.4.2.3** Wherever possible it is better to provide permanent access facilities such as fixed barriers, ladders, and stairways. When such permanent access facilities are provided necessary arrangement may be included in maintenance plans for their regular inspection, maintenance and testing.

- 7.4.1.4.2.4** All personnel employed for carrying out maintenance should be provided with the necessary protective clothing and equipment and instructed in its use.

- 7.4.1.4.2.5** When physical access is not possible in situations such as wall cavities, drains etc, inspections may be made with the aid of closed circuit television or optical devices such as endoscopes.

7.4.1.4.3 Access to Confined Spaces

7.4.1.4.3.1 Ventilation

Special precautions need to be taken when entering a confined space. Such confined spaces should be adequately ventilated, particularly before being entered, to ensure that they are free from harmful concentrations of gases, vapours and other airborne substances and that the air is not deficient in oxygen.

7.4.1.4.3.2 Lighting

Good lighting is necessary in order that maintenance work can be carried out satisfactorily. This is particularly important in confined spaces. When the normal lighting is inadequate it should be supplemented by temporary installations. These should provide general and spot illumination as appropriate.

7.4.1.5 Records

7.4.1.5.1 General

Good records can save owners and users/occupiers much unnecessary expense and reduce potential hazards in exploration work when faults arise.

7.4.1.5.2 Use of Building Records

7.4.1.5.2.1 All personnel involved in the maintenance of the building should be made aware of the existence of the building records.

7.4.1.5.2.2 Known hazardous areas should be explicitly marked on the records as well as being marked on site and should be pointed out to such personnel together with any system of work adopted for use in such areas.

7.4.1.5.2.3 Records are of value only if they are kept up to date and arrangements for this should be included in any provision that may be made for records.

7.4.1.5.2.4 Records should be readily accessible for use and the place of storage should take into account the form of the records and the conditions needed to keep them from damage of any kind. It is recommended that a duplicate set of records is kept in a secure place other than building itself and is kept up to date.

7.4.1.5.3 Maintenance Records

Following should be typical contents of the maintenance records:

- (a) A brief history of property, names and addresses of consultants and contractors.
- (b) Short specifications, constructional processes, components, material finishes, hidden features, special features etc.
- (c) “As built” plans and as subsequently altered with sections, elevations and other detailed drawings.
- (d) Foundation and structural plans/sections such as concrete reinforcement drawings.
- (e) Detail specification of all materials incorporated, for example, concrete mix, species and grades of timber etc. Potentially hazardous materials and types or methods of construction that under some circumstances may become hazardous may be identified.
- (f) Information on housekeeping and routine maintenance with details of internal and external surfaces and decorations, schedule of cleaning, inspection and maintenance.
- (g) Means of operating mechanical, electrical and plumbing installations.
- (h) Description of renovations, extensions, adaptations and repair to each element.
- (i) All plant, machinery and propriety articles including manufacturers, trade literature and instructions for installation, use and maintenance.
- (j) Methods of work used in construction such as assembly of prefabricated units.
- (k) All information related to fire such as:
 - (1) Location and service arrangements of all fire alarm and call points;

- (2) Location and service arrangements of all extinguishers, hose reels and other fire fighting installations;
- (3) Location of all fire compartment walls, doors, floors and screens;
- (4) Location of all areas of exceptional fire hazard;
- (5) Fire escape routes;
- (6) Details of application of any fire protection treatment; and
- (7) Location details and description of any installation for smoke control or protection of escape routes.
- (l) There should be a wall chart showing at a glance the various operations which have to be undertaken. Line drawings of buildings are always useful.
- (m) Records of security measures should be known to authorized personnel only.
- (n) Where no records exist, information should be slowly built up as it becomes available during the course of maintenance work.
- (o) Use of computers for storing information may be preferred.

7.4.1.5.4 Mechanical Records

7.4.1.5.4.1 Documentation

Documentation should record the following as installed:

- (a) The location, including level if buried, of all public service connections (for example, fuel gas and coldwater supplies) together with the points of origin and termination, size and materials of pipes, line pressure and other relevant information;
- (b) the layout, location and extent of all piped services showing pipe sizes, together with all valves for regulation, isolation and other purposes as well as the results of all balancing, testing and commissioning data;
- (c) the location, identity, size and details of all apparatus and all control equipment served by, or associated with, each of the various services together with copies of any test certificates for such apparatus where appropriate. The information with respect to size and details may be presented in schedule form;
- (d) the layout, location and extent of all air ducts showing dampers and other equipment, acoustic silencers, grilles, diffusers or other terminal components. Each duct and each terminal component should be marked with its size, the air quantity flowing and other relevant balancing data, and
- (e) The location and identity of each room or space housing plant, machinery or apparatus.

7.4.1.5.4.2 Drawings

Drawings should record the following as installed:

- (a) detailed general arrangements of boiler houses, machinery spaces, air handling plants, tank rooms and other plant or apparatus, including the location, identity, size and rating of each apparatus. The information with respect to the size and rating can be presented in schedule form;
- (b) Isometric or diagrammatic views of boiler houses, plant rooms, tank rooms and similar machinery, including valve identification charts. It is useful to frame and mount a copy of such drawings on the wall of the appropriate room, and

- (c) comprehensive diagrams that show power wiring and control wiring and/or pneumatic or other control piping including size, type or conductor or piping used and identifying the terminal points of each.

7.4.1.5.5 Electrical Records

Documentation should record the following including locations, as installed:

- (a) main and submain cables, showing origin, route, termination, size and type of each cable; cables providing supplies to specialist equipment, for example, computers, should be identified separately; and
- (b) lighting conduits and final sub circuit cables, showing origin, route, termination and size of each, together with the number and size of cables within each conduit. The drawings should indicate for each conduit or cable, whether it is run on the surface or concealed, for example, in a wall chase, in a floor screed, cast in-situ, above a false ceiling etc.

These drawings should also indicate the locations of lighting fittings, distribution boards, switches, draw-in- boxes and point boxes, and should indicate circuitry:

- (a) location and purpose of each emergency lighting fitting including an indication of the circuit to which it is connected;
- (b) single and three phase power conduits and final sub-circuit cables showing; locations of power distribution boards, motors, isolators, starters, remote control units, socket outlets and other associated equipment.
- (c) other miscellaneous equipment, conduits and cables;
- (d) lightning conductor, air terminals, conductors, earth electrodes and test clamps;
- (e) location of earth tapes, earth electrodes and test points other than those in (f); and
- (f) cables providing earth circuits for specialist equipment, for example computers, should be identified separately,

Documentation should also include, when applicable.

- (a) distribution diagrams or schedules to show size, type and length (to within 1m) of each main and sub main cable, together with the measured earth continuity resistance of each;
- (b) schedule of lighting fittings installed stating location, manufacturer and type or catalogue number together with the type or manufacturer's reference, voltage and wattage of the lamp installed;
- (c) schedule of escape and emergency lighting fittings installed stating location, manufacturer, type or catalogue number together with the type or manufacturer's reference, voltage and wattage of the lamp installed. For battery systems the position of the battery, its ampere hour rating and battery system rated endurance in hours should be stated;
- (d) records of smoke detectors, sprinklers, fire precautions;
- (e) incoming supply details; the type of system, voltage, phases, frequency, rated current and short circuit level, with the details of the supply protection and time of operation as appropriate;
- (f) main switchgear details; for purpose made equipment this should include a set of manufacturers' drawings and the site layout;
- (g) transformer, capacitor and power plant details; the leading details should be given, for example, for transformers the V.A rating, voltages and type of cooling; and
- (h) Completion certificate

7.4.1.6 Inspections

7.4.1.6.1 General

Regular inspections are actual part of the procedures for the maintenance of buildings. They are needed for a variety of purposes and each purpose requires a different approach if it is to be handled with maximum economy and efficiency. A more detailed inspection covering all parts of a building is needed to determine what work should be included in cyclic and planned maintenance programme.

7.4.1.6.2 Frequency of Inspection

Inspection should be carried out at the following frequencies:

- (a) **Routine** — Continuous regular observations should be undertaken by the building user as part of the occupancy of building. Feedback resulting from this type of observation should be encouraged.
- (b) **General** — Visual inspections of main elements should be made annually under the supervision of suitably qualified personnel at appropriate times.
- (c) **Detailed** — The frequency of full inspection of the building fabric by suitably qualified personnel should not normally exceed a 5 year period.

7.4.1.6.2.1 Inspection schedule

The preparation of a specific schedule should be encouraged. Once prepared, it can be used for subsequent inspections.

7.4.1.6.3 Inspection of Engineering Services

Engineering services generally have a shorter life expectancy than building fabric and because of their dynamic function should be subjected to more frequent inspections and maintenance.

7.4.1.6.3.1 Inspection of services should be carried out for three purposes as follows:

- (a) to check if maintenance work is required,
- (b) to check if maintenance work is being adequately carried out, and
- (c) for safety reasons to comply with statutory requirements and if required, with recommendations of other relevant organizations.

7.4.1.6.3.2 The frequency of inspections for purpose (a) will depend upon types of plant and system manufacturer's recommendations and subjective judgment. Frequencies for purpose (b) should be carried out on an annual basis.

7.4.1.6.3.3 Method of inspection

The limited life of building services means it is important to record their residual life so that their replacement can be budgeted for, and inspection methods should be arranged accordingly. A checklist of items of plant to be inspected should be considered. Detailed specifications of how inspections should be carried out are necessary because a simple visual inspection is unlikely to show whether plant is operating correctly and efficiently.

Inspections frequently necessitate the use of appropriate instruments by competent persons. An example of this is the inspections carried out to check compliance with statutory requirements.

When instruments are used it is important that adequate training is provided in the use of the instruments and the interpretation of the results.

7.4.1.6.4 Records of all inspections should be kept.

7.4.1.6.5 Inspection Report

Inspection report may be prepared in the format as given in Annex D.

7.4.1.7 Maintenance of Electrical Appliances

7.4.1.7.1 Planning of Maintenance Work

7.4.1.7.1.1 If the authorized person has complete knowledge of the electrical appliances to be worked upon, then safety will be more assured. If the person attending to the job is not technically competent to handle the job then more careful planning is required before hand.

7.4.1.7.1.2 Repetitive nature of jobs involve little or no pre-planning whereas infrequent nature of jobs may need careful planning even if the person attending the job is technically competent.

7.4.1.7.1.3 Planned routine maintenance will facilitate continued safe and acceptable operation of an electrical system with a minimum risk of breakdown and consequent interruption of supply.

7.4.1.7.1.4 As far as the electrical equipments/installations are concerned, it is not possible to lay down precise recommendations for the interval between the maintenance required. The recommendation for frequency of maintenance in this regard from the manufacturer is more relevant. The manufacturer should be requested to specify minimum maintenance frequency under specified conditions. These intervals depend greatly upon the design of the equipment, the duties that it is called onto perform and the environment in which it is situated.

7.4.1.7.2 Following two types of maintenance are envisaged

7.4.1.7.2.1 Routine maintenance

Routine maintenance of the electrical equipments goes along with the regular inspections of the equipments. Inspections shall reveal the undue damage and excessive wear to the various components. Examination of the equipment shall reveal any need for conditioning of the contact system, lubrication and adjustment of the mechanisms.

7.4.1.7.2.2 Post fault maintenance

When there is a breakdown in the system and certain parts are identified for the replacement and then the maintenance/repair of the defective part away from the operating environment is covered under post fault maintenance.

7.4.1.7.3 Guidelines for the Maintenance of Electrical Appliances

7.4.1.7.3.1 Uninterrupted and hazard free functioning of the electrical installations are the basic parameters of maintenance. The equipment should be restored to correct working conditions. Special attention should be paid to the items and settings that might have been disturbed during the operational phase. Loose and extraneous equipment or wiring give rise to potential safety hazards. All covers and locking arrangements should be properly checked and secured to achieve original degree of protection.

- 7.4.1.7.3.2** Guidelines to be followed for the maintenance of electrical equipments to ensure their smooth functioning are given in Annex E.

7.4.1.8 Operating and Maintenance Manuals

The engineering services within buildings frequently are dynamic, involving complex systems of integrated plant items. Operation of such plant can require detailed knowledge and direction. Maintenance can also require extensive information to be available. It is, therefore, important to have suitable operating and maintenance manuals to provide the necessary guidance. These should be included as part of the contractual requirements for new installations and should ideally be prepared as reference documents for existing installations where no such information exists.

- 7.4.1.9** For details on labour management concerning building maintenance, reference shall be made to **Suffix [7(32)]**.

- 7.4.1.10** For details on financial management concerning building maintenance, reference shall be made to **Suffix [7(33)]**.

7.4.2 PREVENTION OF CRACKS

- 7.4.2.1** Cracks in buildings are of common occurrence. A building component develops cracks whenever stress in the component exceeds its strength. Stress in a building component could be caused by externally applied forces, such as dead, imposed, wind or seismic loads, or foundation settlement or it could be induced internally due to thermal movements, moisture changes, chemical action, etc.

- 7.4.2.2** Cracks could be broadly classified as structural or non-structural. Structural cracks are those which are due to incorrect design, faulty construction or overloading and these may endanger the safety of a building. Extensive cracking of an RCC beam is an instance of structural cracking. Non-structural cracks are mostly due to internally induced stresses in building materials and these generally do not directly result in structural weakening. In course of time, however, sometime non-structural cracks may, because of penetration of moisture through cracks or weathering action, result in corrosion of reinforcement and thus may render the structure unsafe. Vertical cracks in a long compound wall due to shrinkage or thermal movement is an instance of non-structural cracking. Non-structural cracks, normally do not endanger the safety of a building, but may look unsightly, or may create an impression of faulty work or may give a feeling of instability. In some situations, cracks may, because of penetration of moisture through them, spoil the internal finish, thus adding to cost of maintenance. It is, therefore, necessary to adopt measures of prevention or minimization of these cracks.

7.4.3 REPAIRS AND SEISMIC STRENGTHENING OF BUILDINGS

7.4.3.1 General Principles and Concepts

7.4.3.1.1 Non-structural/Architectural Repairs

- 7.4.3.1.1.1** The buildings affected by earthquake may suffer both non-structural and structural damages. Nonstructural repairs may cover the damages to civil and electrical items including the services in the building. Repairs to non-structural components need to be taken up after the structural repairs are carried out. Care should be taken about the connection details of architectural components to the main structural components to ensure their stability.

7.4.3.1.1.2 "Non-structural and architectural components get easily affected/dislocated during the earthquake. These repairs involve one or more of the following:

- a) Patching up of defects such as cracks and fall of plaster;
- b) Repairing doors, windows, replacement of glass panes;
- c) Checking and repairing electric conduits / wiring;
- d) Checking and repairing gas pipes, water pipes and plumbing services;
- e) Re-building non-structural walls, smoke chimneys, parapet walls, etc;
- f) Re-plastering of walls as required;
- g) Rearranging disturbed roofing tiles;
- h) Relaying cracked flooring at ground level; and
- i) Redecoration — white washing, painting, etc.

Architectural repairs as stated above do not restore the original structural strength of structural components in the building and any attempt to carry out only repairs to architectural/nonstructural elements neglecting the required structural repairs may have serious implications on the safety of the building. The damage would be more severe in the event of the building being shaken by the similar shock because original energy absorption capacity of the building would have been reduced.

7.4.3.1.2 Structural Repairs

7.4.3.1.2.1 Prior to taking up of the structural repairs and strengthening measures, it is necessary to conduct detailed damage assessment to determine:

- a) The structural condition of the building to decide whether a structure is amendable for repair; whether continued occupation is permitted; to decide the structure as a whole or a part require demolition, if considered dangerous;
- b) If the structure is considered amendable for repair then detailed damage assessment of the individual structural components (mapping of the crack pattern, distress location; crushed concrete, reinforcement bending yielding, etc). Non-destructive testing techniques could be employed to determine the residual strength of the members; and
- c) To work out the details of temporary supporting arrangement of the distressed member so that they do not undergo further distress due to gravity loads.

7.4.3.1.2.2 After the assessment of the damage of individual structural elements, appropriate repair methods are to be carried out component wise depending upon the extent of damage. The repair may consist of the following:

- a) Removal of portions of cracked masonry walls and piers and rebuilding them in richer mortar. Use of non-shrinking mortar will be preferable.
- b) Addition of reinforcing mesh on both faces of the cracked wall, holding it to the wall through spikes or bolts and then covering it, suitably, with cement mortar or micro concrete.
- c) Injecting cement or epoxy like material which is strong in tension, into the cracks in walls.
- d) The cracked reinforced cement elements may be repaired by epoxy grouting and could be strengthened by epoxy or polymer mortar application like shotcreting, jacking, etc.

7.4.3.1.3 Seismic Strengthening

The main purpose of the seismic strengthening is to upgrade the seismic resistance of a damaged building while repairing so that it becomes safer under future earthquake occurrences. This work may involve some of the following actions:

- a) Increasing the lateral strength in one or both directions by increasing column and wall areas or the number of walls and columns.
- b) Giving unity to the structure, by providing a proper connection between its resisting elements, in such a way that inertia forces generated by the vibration of the building can be transmitted to the members that have the ability to resist them. Typical important aspects are the connections between roofs or floors and walls, between intersecting walls and between walls and foundations.
- c) Eliminating features that are sources of weakness or that produce concentration of stresses in some members. Asymmetrical plan distribution of resisting members, abrupt changes of stiffness from one floor to the other, concentration of large masses and large openings in walls without a proper peripheral reinforcement are examples of defects of this kind.
- d) Avoiding the possibility of brittle modes of failure by proper reinforcement and connection of resisting members.

7.4.3.1.4 Seismic Retrofitting

Many existing buildings do not meet the seismic strength requirements of present earthquake codes due to original structural inadequacies and material degradation due to time or alterations carried out during use over the years. Their earthquake resistance can be upgraded to the level of the present day codes by appropriate seismic retrofitting techniques, such as mentioned in 7.4.3.1.3

7.4.3.1.5 Strengthening or Retrofitting Versus Reconstruction

7.4.3.1.5.1 Replacement of damaged buildings or existing unsafe buildings by reconstruction is, generally, avoided due to a number of reasons, the main ones among them being;

- a) higher cost than that of strengthening or retrofitting,
- b) preservation of historical architecture, and
- c) maintaining functional social and cultural environment.

In most instances, however, the relative cost of retrofitting to reconstruction cost determines the decision. As a thumb rule, if the cost of repair and seismic strengthening is less than about 50 percent of the reconstruction cost, the retrofitting is adopted. This may also require less working time and much less dislocation in the living style of the population. On the other hand reconstruction may offer the possibility of modernization of the habitat and may be preferred by well-to-do communities.

7.4.3.1.5.2 Cost-wise the building construction including the seismic code provisions in the first instance, works out the cheaper in terms of its own safety and that of the occupants. Retrofitting an existing inadequate building may involve as much as 4 to 5 times the initial extra expenditure required on seismic resisting features. Repair and seismic strengthening of a damaged building may even be 5 to 10 times as expensive. It is, therefore, very much safe as well as cost-effective to construct earthquake resistant buildings at the initial stage itself according to the relevant seismic codes.

7.4.3.2 For detail guidelines for repair and seismic strengthening of building, reference shall be made to **Suffix [7(34)]**.

- 7.4.3.3** For detail guidelines for improving earthquake resistance of low strength masonry buildings, reference shall be made to **Suffix [7(35)]**.
- 7.4.3.5** For detail guidelines for improving earthquake resistance of earthen buildings, reference shall be made to **Suffix [7(36)]**.

7.5 SAFETY IN DEMOLITION OF BUILDINGS

7.5.1 General

7.5.1.1 This Section lays down the safety requirements for carrying out demolition/dismantling work.

7.5.1.2 Planning

Before beginning the actual work of demolition a careful study shall be made of the structure which is to be pulled down and also of all its surroundings. This shall, in particular, include study of the manner in which the various parts of the building to be demolished are supported and how far the stage by stage demolition will affect the safety of the adjoining structure. A definite plan of procedure for the demolition work, depending upon the manner in which the loads of the various structural parts are supported, shall be prepared and approved by the engineer-in-charge and this shall be followed as closely as possible, in actual execution of the demolition work. Before the commencement of each stage of demolition, the foreman shall brief the workmen in detail regarding the safety aspects to be kept in view.

It should be ensured that the demolition operations do not at any stage, and endanger the safety of the adjoining buildings. Moreover, the nuisance effect of the demolishing work on the use of the adjacent buildings should be kept to the minimum.

No structure or part of the structure or any floor or temporary support or scaffold, side wall or any device for equipment shall be loaded in excess of the safe carrying capacity, in its then existing condition.

7.5.2 PRECAUTIONS PRIOR TO DEMOLITION

7.5.2.1 On every demolition job, danger signs shall be conspicuously posted all around the structure and all doors and openings giving access to the structure shall be kept barricaded or manned except during the actual passage of workmen or equipment. However, provisions shall be made for at least two independent exits for escape of workmen during any emergency.

7.5.2.2 During nights, red lights shall be placed on or about all the barricades.

7.5.2.3 Where in any work of demolition it is imperative, because of danger existing, to ensure that no unauthorized person shall enter the site of demolition outside hours; a watchman should be employed. In addition to watching the site he shall also be responsible for maintaining all notices, lights and barricades.

7.5.2.4 All the necessary safety appliances shall be issued to the workers and their use explained. It shall be ensured that the workers are using all the safety appliances while at work.

7.5.2.5 The power on all electrical service lines shall be shut off and all such lines cut or disconnected at or outside the property line, before the demolition work is started. Prior to cutting of such lines, the necessary approval shall be obtained from the electrical authorities concerned. The only exception will be any power lines required for demolition work itself.

7.5.2.6 All gas, water steam and other service lines shall be shut off and capped or otherwise controlled at or outside the building line, before demolition work is started.

7.5.2.7 All the mains and meters of the building shall be removed or protected from damage.

7.5.2.8 If a structure to be demolished has been partially wrecked by fire, explosion or other catastrophe, the walls and damaged roofs shall be shored or braced suitably.

7.5.2.9 Protection of the Public

7.5.2.9.1 Safety distances to ensure safety of the public shall be clearly marked and prominently sign posted. Every sidewalk or road adjacent to the work shall be closed or protected. All main roads, which are opened, shall be kept open to the public clear and unobstructed at all times. Diversions for pedestrians shall be constructed, where necessary for safety.

7.5.2.9.2 If the structure to be demolished is more than two storied or 7.5 m (24.6ft) high, measured from the side walk or street which cannot be closed or safely diverted, and the horizontal distance from the inside of the sidewalk to the structure is 4.5 m or less, a substantial sidewalk shed shall be constructed over the entire length of the sidewalk adjacent to the structure, of sufficient width with a view to accommodating the pedestrian traffic without causing congestion. The side walk shed shall be lighted sufficiently to ensure safety at all times. For detailed information reference maybe made to **Suffix 7(37)**.

A toe board of at least 1 m high above the roof of the shed shall be provided on the outside edge and ends of the sidewalk shed. Such boards may be vertical or inclined outward at not more than 45°.

Except where the roof of a sidewalk shed solidly abuts the structure, the face of the sidewalk shed towards the building shall be completely closed by providing sheating/planking to prevent falling material from penetrating into the shed.

The roof of sidewalk sheds shall be capable of sustaining a load of 73 N/mm². Only in exceptional cases, say due to lack of other space, the storing of material on a sidewalk shed may be permitted in which case the shed shall be designed for a load of 146 N/mm². Roof of Sidewalk shed shall be designed taking into account the impact of the falling debris. By frequent removal of loads it shall be ensured that the maximum load, at any time, on the roof of work shed is not more than 6000 N/mm². The height of sidewalk shed shall be such as to give a minimum clearance of 2.4 m (7.87ft).

Sidewalk shed opening, for loading purposes, shall be kept closed at all time except during actual loading operations.

The deck flooring of the sidewalk shed shall consist of plank of not less than 50 mm in thickness closely laid and deck made watertight. All members of the shed shall be adequately bracked and connected to resist displacement of members or distortion of framework

7.5.2.9.3 When the horizontal distance from the inside of the sidewalk to the structure is more than 4.5 m (14.76ft) and less than 7.5 m (24.6ft), a sidewalk shed or fence a substantial railing shall be constructed on the inside of the sidewalk or roadway along the entire length of the demolition side of the property with movable bars as may be necessary for the proper prosecution of the work.

7.5.3 PRECAUTIONS DURING DEMOLITION

7.5.3.1 Prior-to commencement of work, all material of fragile nature like glass shall be removed.

7.5.3.2 All openings shall be boarded up.

7.5.3.3 Dust shall be controlled by suitable means to prevent harm to workmen.

7.5.3.4 Stacking of materials or debris shall be within safe limits of the structural member. Additional supports, where necessary, shall be given.

- 7.5.3.5 Adequate natural or artificial lighting and ventilation shall be provided for the workmen.

7.5.4 SEQUENCE OF DEMOLITION OPERATIONS

- 7.5.4.1 The demolition work shall be proceeded within such a way that:
- a) It causes the least damage and nuisance to the adjoining building and the members of the public, and
 - b) It satisfies all safety requirements to avoid any accidents.
- 7.5.4.2 All existing fixtures required during demolition operations shall be well protected with substantial covering to the entire satisfaction of the rules and regulations of the undertakings or they shall be temporarily relocated.
- 7.5.4.3 Before demolition work is started, glazed sash, glazed doors and windows, etc, shall be removed. All fragile and loose fixtures shall be removed. The lath and all loose plaster shall be stripped off throughout the entire building. This is advantageous because it reduces glass breakage and also eliminates a large amount of dust producing material before more substantial parts of the buildings are removed.
- 7.5.4.4 All well openings which extend down to floor level shall be barricaded to a height of not less than 1 m above the floor level. This provision shall not apply to the ground level floor.
- 7.5.4.5 All floor openings and shafts not used for material chutes shall be floored over and be enclosed with guard rails and toe boards.
- 7.5.4.6 The demolition shall always proceed systematically storey by storey. In the descending order, all work in the upper floor shall be completed and approved by the engineer-in-charge prior to disturbance to any supporting member on the lower floor. Demolition of the structure in sections maybe permitted in exceptional cases if proper precautions are ensured to prevent injuries to persons and damage to property.

7.5.5 WALLS

- 7.5.5.1 While walls of sections of masonry are being demolished, it shall be ensured that they are not allowed to fall as single mass upon the floors of the building that are being demolished so as to exceed the safe carrying capacity of the floors. Overloading of floors shall be prevented by removing the accumulating debris through chutes or by other means immediately. The floor shall be inspected by the engineer-in-charge before undertaking demolition work and if the same is found to be incapable to carry the load of the debris, necessary additional precautions shall be taken so as to prevent any possible unexpected collapse of the floor.
- 7.5.5.2 Walls shall be removed part by part. Stages shall be provided for the men to work on if the walls are less than one and a half brick thick and dangerous to work by standing over them.
- 7.5.5.3 Adequate lateral bracing shall be provided for walls which are unsound. For detailed information reference may be made to **Suffix [7(37)]**.

7.5.6 FLOORING

- 7.5.6.1 Prior to removal of masonry or concrete floor adequate support centering shall be provided.

7.5.6.2 When floors are being removed, no workmen shall be allowed to work in the area, directly underneath and such area shall be barricaded to prevent access to it.

7.5.6.3 Planks of sufficient strength shall be provided to give workmen firm support to guard against any unexpected floor collapse.

7.5.6.4 When floors are being removed no person shall be allowed to work in an area directly underneath and access to such area shall be barricaded.

7.5.7 DEMOLITION OF STEEL STRUCTURES

7.5.7.1 When a derrick is used, care shall be taken to see that the floor on which it is supported is amply strong for the loading so imposed. If necessary, heavy planking shall be used to distribute the load to floor beam and girders.

7.5.7.2 Overloading of equipment shall not be allowed.

7.5.7.3 Tag lines shall be used on all materials being lowered or hoisted up and a standard signal system shall be used and the workmen instructed on the signals.

7.5.7.4 No person shall be permitted to ride the load line.

7.5.7.5 No beams shall be cut until precautions have been taken to prevent it from swinging freely and possibly striking any worker or equipment to any part of the structure being demolished.

7.5.7.6 All structural steel members shall be lowered from the building and shall not be allowed to drop.

7.5.8 CATCH PLATFORM

7.5.8.1 In demolition of exterior walls of multistory structures, catch platform of sufficient strength to prevent injuries to workers below and public shall be provided, when the external walls are more than 20 m (65.6ft) in height.

7.5.8.2 Catch platform shall be capable of sustaining a live load of not less than 6100 N/m²

7.5.8.3 Materials shall not be dumped on the catch platform nor shall they be used for storage of materials.

7.5.9 STAIRS, PASSAGEWAYS AND LADDERS

7.5.9.1 Stairs with railings, passageways and ladders shall be left in place as long as possible and maintained in a safe condition.

7.5.9.2 All ladders shall be secured against slipping out at the bottom and against movement in any direction at the top.

7.5.10 MECHANICAL DEMOLITION

When demolition is to be performed by mechanical devices, such as weight ball and power shovels, the following additional precautions may be observed:

- a) The area shall be barricaded for a minimum distance of 1.5% times the height of the wall,
- b) While the mechanical device is in operation, no workmen shall be allowed to enter the building being demolished,
- c) The device shall be so located as to avoid falling debris, and

- d) The mechanical device when being used shall not cause any damage to adjacent structure, power line, etc.

7.5.11 DEMOLITION OF CERTAIN SPECIAL TYPES AND ELEMENTS OF STRUCTURES

7.5.11.1 Roof Trusses

If a building has a pitched roof, the structure should be removed to wall plate level by hand methods. Sufficient purlins and bracing should be retained to ensure stability of the remaining roof trusses while each individual truss is removed progressively.

7.5.11.1.1 Temporary backing should be added, where necessary, to maintain stability. The end frame opposite to the end where dismantling is commenced, or a convenient intermediate frame should be independently and securely guyed in both directions before work starts.

7.5.11.1.2 The bottom tie of roof trusses should be cut until the principal rafters are prevented from making out ward movement.

7.5.11.1.3 Adequate hoisting gears suitable for the loads shall be provided. If during demolition any thing is to be put on the floor below the level of the truss, it shall be ensured that the floor is capable of taking the load.

7.5.11.2 Heavy Floor Beams

Heavy baulks of timber and steel beams should be supported before cutting at the extremities and should then be lowered gently to a safe working place.

7.5.11.3 Jack Arches

Where tie rods are present between main supporting beams, these should not be cut until after the arch or series of arches in the floor have been removed. The floor should be demolished in strips parallel to the span of the arch rings (at right angles to the main floor beams).

7.5.11.4 Brick Arches

Expert advice should be obtained and, at all stages of the demolition, the closest supervision should be given by persons fully experienced and conversant in the type of work to ensure that the structure is stable at all times. However, the following points may be kept in view.

7.5.11.4.1 On no account should the restraining influence of the abutments be removed before the dead load of the spandrel fill and the arch rings are removed.

7.5.11.4.2 A single span arch can be demolished by hand by cutting narrow segments progressively from each springing parallel to the span of the arch, until the width of the arch has been reduced to a minimum which can then be collapsed.

7.5.11.4.3 Where deliberate collapse is feasible, the crown may be broken by the demolition ball method working progressively from edges to the centre.

7.5.11.4.4 Collapse of the structure can be effected in one action by the use of explosives. Charges should be inserted into bore holes drilled in both arch and abutments.

7.5.11.4.5 In multi-span arches, before individual arches are removed, lateral restraint should be provided at the springing level. Demolition may then proceed as for single span; where explosives are used it is preferable to ensure the collapse of

the whole structure in one operation to obviate the chance of leaving unstable portion standing.

7.5.11.5 Cantilever (Not Part of a framed structure)

Canopies, cornices, staircases and balconies should be demolished or supported before tailing down load is removed.

7.5.11.6 In-situ Reinforced Concrete

Before commencing demolition, the nature and condition of the concrete, the condition and position of reinforcement, and the possibility of lack of continuity of reinforcement should be ascertained.

Demolition should be commenced by removing partitions and external non-load bearing cladding.

7.5.11.6.1 Reinforced Concrete Beams

A supporting rope should be attached to the beam. Then the concrete should be removed from both ends by pneumatic drill and the reinforcement exposed. The reinforcement should then be cut in such a way as to allow the beam to be lowered under control to the floor.

7.5.11.6.2 Reinforced Concrete Columns

The reinforcement should be exposed at the base after restraining wire guy ropes have been placed round the member at the top. The reinforcement should then be cut in such a way as to allow it to be pulled down to the floor under control.

7.5.11.6.3 Reinforced Concrete Walls

These should be cut into strips and demolished as for columns.

7.5.11.6.4 Suspended Floors and Roofs

The slab should be cut into strips parallel to the main reinforcement and demolished strip by strip. Where ribbed construction has been used, the principle of design and method of construction should be determined before demolition is commenced. Care should be taken not to cut the ribs inadvertently.

7.5.11.7 Precast Reinforced Concrete

Due precautions shall be taken to avoid toppling over of prefabricated units or any other part of the structure and whenever necessary temporary supports shall be provided.

7.5.11.8 Prestressed Reinforced Concrete

Before commencing of the demolition work, advice of an engineering expert in such demolition shall be obtained and followed.

7.5.12 LOWERING, REMOVAL AND DISPOSAL OF MATERIALS

7.5.12.1 Dismantled materials may be thrown to the ground only after taking adequate precautions. The material shall preferably be dumped inside the building. Normally such materials shall be lowered to the ground or to the top of the sidewalk shed where provided by means of ropes or suitable tackles.

7.5.12.2 Through Chutes

7.5.12.2.1 Wooden or metal chutes may be provided from removal of materials. The chutes shall preferably be provided at the centre of the building for efficient disposal of debris.

7.5.12.2.2 Chutes, if provided at an angle of more than 45° from the horizontal, shall be entirely enclosed on all the four sides, except for opening at or about the floor level for receiving the materials.

7.5.12.2.3 To prevent the descending material attaining a dangerous speed, chute shall not extend in an unbroken line for more than two-storeys. A gate or stop shall be provided with suitable means for closing at the bottom of each chute to stop the flow of materials.

7.5.12.2.4 Any opening into which workmen dump debris at the top of chute shall be guarded by a substantial guard rail extending at least 1 m above the level of the floor or other surface on which men stand to dump the materials into the chute.

7.5.12.2.5 A toe board or bumper, not less than 50 mm thick and 150 mm high shall be provided at each chute openings, if the material is dumped from the wheel barrows. Any space between the chute and the edge of the opening in the floor through which it passes shall be solidly planked over.

7.5.12.3 Through Holes in the Floors

7.5.12.3.1 Debris may also be dropped through holes in the floor without the use of chutes. In such a case the total area of the hole cut in any intermediate floor, one which lies between floor that is being demolished and the storage floor shall not exceed 25 percent of such floor area. It shall be ensured that the storage floor is of adequate strength to withstand the impact of the falling material.

7.5.12.3.2 All intermediate floor openings for passage of materials shall be completely enclosed with barricades or guard rails not less than 1.0 m high and at a distance of not less than 1.0 m from the edge of general opening. No barricades or guard rails shall be removed until the storey immediately above has been demolished down to the floor line and all debris cleared from the floor.

7.5.12.3.3 When the cutting of a hole in an intermediate floor between the storage floor and the floor which is being demolished makes the intermediate floor or any portion of it unsafe, then such intermediate floor shall be properly shored. It shall also be ensured that the supporting walls are not kept without adequate lateral restraints.

7.5.12.4 Removal of Materials

7.5.12.4.1 As demolition work proceeds, the released serviceable materials of different types shall be separated from the unserviceable lot at suitable time intervals and properly stocked clear of the spots where demolition work is being done.

7.5.12.4.2 The unserviceable lot obtained during demolition shall be collected in well-formed heaps at properly selected places, keeping in view safe conditions for workmen in the area. The height of each unserviceable lot shall be limited to ensure its toppling over or otherwise endangering the safety of workmen or passersby.

7.5.12.4.3 The unserviceable lot shall be removed from the demolition site to a location as required by the local civil authority. Depending on the space available at the demolition site, this operation of conveying lot to its final disposal location may have to be carried out a number of times during the demolition work. In any case, the demolition work shall not be considered as completed and the area declared fit

for further occupation till all the lot has been carried to its final disposal location and the demolition areas tidied up.

7.5.12.4.4 Materials which are likely to cause dust nuisance or undue environmental pollution in any other way, shall be removed from the site at the earliest and till then they shall be suitable covered. Such materials shall be covered during transportation also.

- 7.5.12.5**
- a) Glass and steel should be dumped or buried separately to prevent injury.
 - b) Workman should be provided with suitable protective gears for personal safety during works, life safety helmets, boots, hand gloves, goggles, special attire, etc
 - c) The work of removal of debris should be carried out during day. In case poor visibility artificial light may be provided.
 - d) The debris should first be removed from top. Early removal from bottom or sides of dump may cause collapse of debris, causing injuries.

7.5.13 MISCELLANEOUS

7.5.13.1 No demolition work should be carried out during night as far as possible, especially when the structure to be demolished is in an inhabited area. If such night work has to be done, additional precautions by way of additional red warning signals, working lights and watchmen, shall be provided to avoid any injury to workmen and public. Demolition work shall not be carried out during storm and heavy rain.

7.5.13.2 Warning devices shall be installed in the area to warn the workers in case of any danger.

7.5.13.3 Safety devices like industrial safety helmets conforming to the **Suffix [7(9)]** and goggles made of celluloid lens shall be issued to the workmen. Foreman-in-charge of the work areas shall ensure that all the workmen are wearing the safety devices before commencing any work.

7.5.13.4 Construction sheds and tool boxes shall be so located as to protect workers from injuries from the falling debris.

7.5.13.5 Where there is a likelihood of injuries to hands of workmen when demolishing RCC, steel structures, etc, gloves of suitable materials shall be worn by workmen.

7.5.13.6 Sufficient protection by way of both overhead cover and screens shall be provided to prevent injuries to the workmen and the public.

7.5.13.7 Safety belts or ropes shall be used by workmen when working at higher levels.

7.5.13.8 Grading of Plot

When a building has been demolished and no building operation has been projected or approved, the vacant plot shall be filled, graded and maintained in conformity to the established street grades at curb level. The plot shall be maintained free from the accumulation of rubbish and all other unsafe and hazardous conditions which endangers the life or health of the public and provisions shall be made to prevent the accumulation of water or damage to any foundations on the premises or the adjoining property.

7.5.14 FIRST-AID

7.5.14.1 A copy of all pertinent regulations and notices concerning accidents, injury and first-aid shall be prominently exhibited at the work site.

7.5.14.2 Depending on the scope and nature of the work, a person, qualified in first-aid shall be available at work site to render and direct first-aid to casualties. He shall maintain a list of individuals qualified to serve in first aid work. Enough first-aid kit, including a stretcher and cot with accessories shall be provided at site. A telephone may be provided to first-aid assistant with telephone numbers of the hospitals prominently displayed.

Complete reports of all accidents and action taken there on shall be forwarded to the competent authorities.

ANNEX A

(Section 1, Clause 7.1.2.1.2)

PROGRAMME EVALUATION AND REVIEW TECHNIQUE, AND CRITICAL PATH METHOD

A-0 INTRODUCTION

A-0.1 Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM) are modern management tools or devices, which have made it possible to achieve considerable savings in cost and time of construction. They can be used with advantage for demolition, constructional safety and fire protection measures, by including them in the list of activities (also called events) along-side with other 'events' of the project.

A-0.2 Advanced Planning

A-0.2.1 PERT and CPM enable us to achieve judicious employment and utilization of resources, such as labour, materials, and equipment by pre-determining the various stages, listing out the various activities and drawing out 'Arrow Network Diagram'.

A-0.3 Synchronization of Sub-Projects

A-0.3.1 Another extremely important advantage of CPM is that various factors influencing completion of a project can be scientifically planned to be coordinated such that the completion of various sub-projects and services, such as furniture, sewage, electricity and water supply synchronies.

A-1 PREPARATION OF CPM CAHART (LISTING OUT THE ACTIVITIES)

A-1.1 The most important step in preparation of CPM network is to list out the activities involved to the minutest details. For example, a few activities in case of a building project are given below:

- a) Planning and designing of building by architect, engineer and approved of plans by the Authority.
- b) Making the land available.
- c) Outlining detailed specifications.
- d) Procurement of materials, such as sand, cement, stone and timber; and plants, such as concrete mixer, vibrators, water pump for curing.
- e) Soil explorations and trial pits.
- f) Excavation in foundations, including demolition, if needed.
- g) Construction safety aspects specially in case of pile foundations.
- h) Blasting if required (for deep foundations).
- j) Fire protection measures.
- f) Excavation in foundations, including demolition, if needed.
- g) Construction safety aspects specially in case of pile foundations.
- h) Blasting if required (for deep foundations).
- j) Fire protection measures.

A-1.2 Time Needed for Each Activity

An assessment is to be made to find out the time needed for each activity and then to list out those activities, which can be executed concurrently (or simultaneously) with each other. For example, while designing of the building is in hand, correspondence for land purchase can also go on side by side; or while work in foundations is in progress, order for 'joinery' can be placed.

A-1.3 Critical Activity

It could be seen as to which of the activities are critical, that is which items are such that a single day's delay will mean overall delay on the project. Contrary to this, it will be seen from CPM Network that certain activities can be delayed to a certain extent without delaying the completion of the project. This is a very useful and valuable information for the 'Project Manager'. That is where resources scheduling becomes easier and economical and a time saver. It eliminates chances of idle labour and higher expenses which are results of haphazard planning.

A-2 UPDATING

A-2.1 In implementing the CPM, there could be gaps between the planned CPM and actual progress of position on ground. This should be checked periodically weekly, fortnightly or monthly depending on nature and size of project.

A-3 GENERAL

A-3.1 In case of projects being executed by contractors for the owners, or departments, it is recommended that it should be an essential condition of the contract to submit a CPM Chart along with the quoted tenders. This will ensure that the construction work will be according to a systematic engineer-like and well-knit plan of execution.

ANNEX B

(Section 2, Clause 7. 2.2.1)

CHECK LIST FOR STACKING AND STORAGE OF MATERIALS

Sr no	Material/Component	Base			Stack				Type of Cover		
		Firm Level Ground	Hard Floor	Off-Floor	Heaps	Tiers	Flat	Vertical	Open	Open but covered	Under shed
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Cement			♦		♦					♦
2	Lime										
	a) Quick lime		♦		♦					♦	
	b) Hydrated lime			♦		♦					♦
3	Stones and Aggregates										
	a) Stones, aggregates, fly ash and cinder	♦			♦				♦		
	b) Veneering stones	♦				♦		♦	♦		
4	Bricks and Blocks	♦				♦			♦		
5	Tiles										
	a) Clay and concrete floor, wall and roof tiles	♦				♦	♦		♦		
	b) Ceramic tiles		♦			♦	♦				♦
6	Partially Pre-fabricated Wall and Roof Components										
	a) RC planks, prefabricated brick panels and ferrocement panels	♦						♦	♦		
	b) Channel units, corncob units and L-panels										
	c) Waffle units, RC joists single tee and double tee	♦				♦			♦		
		♦					♦		♦		
7	Timber			♦		♦					♦
8	Steel	♦					♦		♦		
9	Aluminium Sections		♦				♦				♦
10	Doors, Windows and ventilators		♦					♦			♦
11	Roofing Sheets										
	a) AC	♦				♦	♦		♦		
	b) GI and Aluminium sheets	♦				♦	♦			♦	
	c) Plastic sheets			♦		♦	♦				♦
12	Boards like Plywood, Fibre Boards and Gypsum Boards			♦		♦	♦				♦

13	Plastic and Rubber Flooring										
	a) Sheets in rolls	♦						♦			♦
	b) Tiles	♦				♦	♦				♦
14	Glass Sheets		♦					♦			♦
15	Glass Bricks/Bolcks		♦			♦					♦
16	CI, GI and AC Pipes and Fittings										
	a) Pipes	♦				♦	♦		♦		
	b) CI and GI Fittings		♦				♦				♦
	c) AC Fittings		♦				♦		♦		
17	Polyethylene Pipes			♦		♦	♦				♦
18	Unplasticized PVC Pipes	♦				♦	♦		♦		
19	Bitumen, Road Tar, Asphalt, etc in Drums	♦				♦			♦		
20	Oil Paints		♦			♦					♦
21	Sanitary Appliances			♦			♦				♦

ANNEX C
(Section 4, Clause 7.4.1.3.2.2.2)
COMMON CAUSES FOR MAINTENANCE PROBLEMS

C-0 MAJOR CAUSES FOR MAINTENANCE PROBLEMS

C-1 FLOORS

- a) Poor quality construction which includes quality of construction material and workmanship
- b) Improper slopes, mainly in kitchen, bathrooms/toilets etc
- c) Lack of rounding at junctions of walls with floors
- d) Lack of damp proof course treatment in walls and particularly in sunken floors
- e) Poor design of buildings

C-2 ROOFS

- a) Inadequate roof slopes
- b) Inferior quality of construction
- c) Cracks on roof surfaces
- d) Inadequate provision of rain water spouts
- e) Blockages in grating/rain water pipes
- f) Worn out felts
- g) Bubbling up of tarfelt and separation of joints
- h) Leakage from the openings provided on the roof

C-3 PLUMBING

- a) Inadequate slopes in soil/waste pipes
- b) Improper lead joints
- c) Joints in walls
- d) Improper junctions of stacks
- e) Inadequate cleaning eyes at junction
- f) Inadequate slopes in sewage pipes
- g) Throwing of solid wastes in WC s
- h) Lack of periodical checking and cleaning
- i) Lack of motivation/education to users for proper use
- j) Overflow from service tanks
- k) Inferior quality of fittings and fixtures
- l) Inadequate design

C-4 DRAINAGE

- a) Improper surface dressing around buildings and improper upkeep of surroundings
- b) Growth of wild grass and vegetation
- c) Inadequate drainage system around the building
- d) Inadequate slope of the drain or drainage pipes
- e) Inadequate number of inspection chambers
- f) Theft of manhole etc.
- g) Throwing of solid waste in the open surface drains

C-5 ELECTRICAL

- a) Loose connections
- b) Improper earthing and earth connections
- c) Damages to wires, cables and other installations
- d) Under rated cables/wires and other installations

ANNEX D
(Section 4, Clause 7. 4.1.6.5)
FORMAT FOR INSPECTION REPORT

Date :
Building/Block :
.....

		Condition		
		Sound	Suspect	Defective
FLOORS & STAIRCASES				
Ground Floor				
Finish				
Skirting				
Structure				
Damp-proofing				
Ceiling				
Under floors, spaces, (Suspended floors)				
Termites/insects				
Upper Floors				
Finish				
Structure				
Ceiling				
Suspended ceiling				
Staircase				
Structure				
Treads				
Finishes				
Balustrade				
Soffits				
Finishes				
ROOFING				
Flat/Pitched				
Finish				
Insulation				
Structure				
Roof lights/glazing				
Parapets				
Cutters				
Rain Water Pipes				
Roof interiors (Pitched)				
Growth of Vegetation				
SANITARY INSTALLATION				
Plumbing				
Fittings/Pipings, WC's				
Taps				
Sinks				
Basins				
Urinals				
Cisterns				
Geysers				
Sewage Disposal				
Soil Pipes				
Manholes				
Sewerlines				
Drainage				
Gully chambers				

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Sewers				
Surface drains				
Inspection chambers				
Structural movement				
Failure of material				
Design or construction defects				
Overhead Tanks/Underground				
Sumps/terrace Tanks				
Septic Tanks				
Remarks				

ANNEX E

(Section 4, Clause 7.4.1.7.3.2)

GUIDELINES FOR MAINTENANCE OF ELECTRICAL EQUIPMENTS

E-1 In case of electrical appliances, manufacturer's instructions for the usage and maintenance of the equipment should be strictly followed.

E-2 The detailed/working drawings of all the components of electrical installations should always be available with the maintenance unit. Following records should be available.

- (a) Manufacture's name
- (b) Nameplate of the requirement and its salient features such as capacity, rating etc.
- (c) Manufacturer's recommendations regarding availability/usage of spare parts.
- (d) Manufacturer's recommendations for periodical maintenance and post fault maintenance.
- (e) Details of the maintenance operations performed in the past.

E-3 Care should be taken while selecting replacement parts. The spare parts should be correct and suitable, preferably as recommended by the manufacturer of the installation. During the placement of order for the supply of spare parts, nameplate particulars and serial number should be quoted.

E-4 The space where the equipment is kept should be clean and properly ventilated. Equipment should not be disturbed needlessly. Before cleaning, the equipment should be made dead. For internal cleaning a section cleaner should be used.

E-5 Covers and doors should not be left open unnecessarily during maintenance. Afterwards they should be promptly and correctly closed and locked.

E-6 Before removing the covers and connections, all covers and cable terminations should be marked to ensure correct replacements. Disturbed connections and temporary connections should be marked to facilitate re-connection. Temporary connections and markings should be removed before the installation is put to use.

E-7 Those connections which have not been disturbed should also be checked for soundness and overheating.

E-8 All insulations should be regularly checked. Solid insulations should be checked for cracks and other defects. Fibrous and organic insulations should be checked for sign of blistering, delamination and mechanical damage. For insulating oils the interval between tests should be carried out as per the recommendations of the manufacturer and keeping the adverse environmental conditions in mind.

E-9 It should be ensured that the earthing connections are sound and all contact screws are tight.

E-10 During the examination of interlocks it is necessary to take precautions to prevent danger to plant or persons in the event of malfunction or inadvertent operation. A person responsible for checking and maintaining any interlock system should have thorough knowledge of the extent, nature and function of the interlock.

E-11 If the equipment is ventilated then it should be ensured that the airflow is smooth and not restricted. If filters are provided, they should be cleaned or replaced as necessary.

E-12 The standby system for tripping and closing supplies should always be kept in good order. Indicators and alarms should be maintained in time with the manufacturer's instructions.

E-13 Tools, spares and instruments should be stored near to the installation. These should be regularly checked against an inventory.

E-14 Before the start of maintenance of the circuit switches it should be ensured that all incoming and outgoing main auxiliary circuits are dead and remain so during the maintenance. Overheating of the circuit switches is the root cause for faults. Overheating may be caused by inadequate ventilation, overloading, loose connection, insufficient contact force and malalignment.

E-15 Some circuit breakers are not intended to be maintained, such as miniature circuit breakers (MCBS). Such items should not be dismantled for maintenance. These should be renewed periodically.

E-16 For the maintenance of fuses periodical inspection should be done for correct rating, security, overheating and correct location/orientation. Element of renewable fuses should be renewed when the deterioration is apparent. The availability and correct replacement of fuse links should be ensured.

E-17 If a fuse link of certain rating has failed and is replaced, then all fuse-links of same rating apparently subjected to the fault should be destroyed and replaced by new fuse links.

E-18 In order to be reasonably sure that circuit breaker is capable of operation when required, these should be tripped and reclosed at regular intervals. Tripping should be proved manually and where possible electrically via the protective relay contacts. The leakage of oil, sign of corrosion, and any unusual smell which may indicate over-heating should be detected through inspections.

E-19 Timing devices are mostly designed for specialist maintenance. These should not be dismantled for maintenance or overhaul purposes unless specifically recommended by the manufacturers'. Actual timing periods should be verified with set values and application requirements.

E-20 In case of cable boxes and terminations, security of mounting and earthing should be examined. Exposed tails should be inspected for good conditions of insulation and freedom from moisture.

E-21 Battery cells should be inspected for shedding of active material, sedimentation and buckling of plates. Level of electrolyte should be regularly checked and the level should be corrected with distilled water.

The following list records those standards which are acceptable as 'accepted good practice' and 'accepted good standards' in the fulfillment of the requirements of the Code. The latest version of a standard shall be adopted at the time of enforcement of the Code. The standards listed may be used by the Authority as a guide in conformance with the requirement of the referred clause in the Code.

Suffixes

[7(1)] Components of Elements

1.1 Foundations

1.1.1 IS 1080: 1985

Code of practice for design and construction of shallow foundations on soils (other than raft, ring and shell) (Second Revision)

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1.1.2	IS 1904: 1986	Code of practice for design and construction of foundations in soils: General requirements (third revision)
1.1.3	IS 2911	Code of practice for design and construction of pile foundations
	IS 2911(Part-1Sec-1)	Concrete piles,Section 1 Driven cast-in-situ concrete piles(first revision)1979
	IS 2911(Part-1/Sec-2)	Concrete piles,Section2 Board cast in situ concrete piles(first revision)
	IS 2911(Part-2):1980	Timber piles(first revision)
	IS 2911(Part-3):1980	Under-reamed piles (first revision
	Part 1/1Sec 3:1979	Concrete piles, Section 3 Driven precast concrete piles (first revision)
	Part 1/Sec 4:1984	Concrete piles, Section 4 Bored precast concrete piles (first revision)
	Part 4:1985	Load test on piles (first revision)
1.1.4	IS 2974	Code of practice for design and construction of machine foundations
	IS 2974(Part-1):1982	Foundation for reciprocating type machines(secound revision)
	<u>Part 2:1980</u>	Foundations for impact type machines (hammer foundations) (first revision)
	IS 2974(Part-3):1992	Foundation for rotary type machines(medium and frequency)(2nd revision)
	IS 2974(Part-4):1979	Foundation for rotary type machines of low frequency (1st revision)
	IS 2974(Part-4):1980	Timber piles(first revision)
1.1.5	IS 9456: 1980	Code of practice for design and construction of conical and hyperbolic paraboloidal types of shell foundations
1.1.6	IS 9556: 1980	Code of practice for design and construction of diaphragm walls
1.1.7	IS 13094:1992	Guidelines for selecton of ground improvement techniques for foundation I weak soils
1.1.8	IS 15284(Part-1):2003	Design and construction for ground improvement part 1 stone columns
1.2	Masonry	
7.1.2.1	IS 1597	Code of practice for construction of stone masonry

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1.2.2	IS 1598	Rubble stone masonry(first revision)
1.2.3	IS 1599	Ashlar Masonary(first revision)
1.2.4	IS 1600	Code of practice for in-situ construction of wall in buildings with soil cement(1st revivion)
.1.2.5	<u>IS 2212:1991</u>	Code of practice for brickwork (first revision)
1.2.6	IS 2250:1981	Code of practice for preparation and use of masonry mortors(first revision)
1.2.7	<u>IS 2572:1963</u>	Code of practice for construction of hollow concrete block masonry
1.2.8	<u>IS 3630:1992</u>	Code of practice for construction of non-load bearing gypsum block partitions (first revision)
1.2.9	IS 4407:1967	Code of practice for reed walling
1.2.10	IS 4441:1980	Code of practice for use of silicate type chemical resistant mortors(first revision)
1.2.11	IS 4442:1980	Code of practice for use of sulphur type chenical resistant mortors(1st revision)
1.2.12	IS 4443:1980	Code of practice for use of resin type chenical resistant mortors(1st revision)
1.2.13	IS 6041:1985	Code of practice for construction of autoclayed cellular concrete block masonry
1.2.14	IS 6042:1969	Code of practice for construction of light weight concrete block masonry(1st revision)
1.3	Timber & Bamboo	
1.3.1	IS 1634:1992	Code of practice for design and construction of wood stair for houses(2nd revision)
1.3.2	IS 2366:1983	Code of practice for nail - jointed timber construction (1st revision)
1.3.3	IS 3670:1989	Code of practice for construction of timber floor(1st revision)

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1.3.4	IS 4913:1968	Code of practice for selection, installation, maintenance of timber & windows
1.3.5	IS 4983:1984	Code of practice for design and construction of nail laminated timber beams
1.3.6	IS 5390:1984	Code of practice for construction of timber ceilings (1st revision)
1.3.7	IS 11096:1984	Code of practice for design and construction of bolt jointed timber construction
1.3.8	IS 12506:1988	Code of practice for improved thatching of roof with wrought & fire retardant treatment.
1.4	Concrete	
1.4.1	IS 456:2000	Code of practice for plain and reinforced concrete (4th revision)
1.4.2	IS 457:1957	General construction plain & reinforced concrete for dams and other massive structures
1.4.3	IS 2502:1963	Code of practice for bending and fixing of bars for concrete reinforcement
1.4.4	IS 2541:1991	Code of practice for preparation and use of lime concrete (2nd revision)
1.4.5	IS 3370 Part-1 : 1965	Code of practice for concrete structures for the storage of liquids (general requirement)
1.4.6	IS 3370 Part-2 : 1965	Reinforced concrete structures
1.4.7	IS 3370 Part-3 : 1965	prestressed concrete structures
1.4.8	IS 3558:1983	Code of practice for use of immersion vibrators for consolidating concrete (1st revision)
1.4.9	IS 5817:1992	Code of preparation and use of lime pozzolana mixture concrete in buildings & roads.
1.4.10	IS 7246:1974	Recommendations for use of table vibrators for consolidating concrete
1.4.11	IS 7861 Part-1 : 1975	Code of practice for hot weather concreting

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	IS 7861 Part-2: 1981	Code of practice for cold weather concreting
1.4.12	IS 10262 : 1982	Recommended guidelines for concrete mix design
1.4.13	IS 10359:1982	Code of practice for manufacture and use of lime pozzolana concrete blocks for paving
1.4.14	IS 14687:1999	Guidelines for falsework for concrete structures
1.5	Steel	
1.5.1	IS 800 : 1984	Code of practice for general steel construction(2nd revision)
1.5.2	IS 801:1975	practice of cold formed light guage steel structural menbers in general building construction
1.5.3	IS 805:1968	Code of practice for use of steel in gravity water Tanks
1.5.4	IS 806:1968	Code of practice for use of steel tubes in general building construction(1st revision)
1.5.5	IS 4000 : 1992	Code of practice for high strength bolts in steel construction (1st revision)
1.5.6	IS 4180:1967	Code of practice for corrosion protection of light guage steel sections used in building
1.5.7	IS 6553 Part-1 : 1989	Code of practice for design and construction of steel chimneys – Mechanical aspects
	IS 6553 Part-2 : 1989	Code of practice for design and construction of steel chimneys – structure aspects
1.5.8	IS 8629:1977	Code of practice for protection of iron & steel structures from atmospheric corrosion
1.5.9	IS 9077:1979	Code practice for corrosion protection of steel reinforcement in RB & RCC construction
1.5.10	IS 9172	Recommended design practice for corrosion prevention of steel structures

1.6	Flooring & roofing	
1.6.1	IS 658:1982	Code of practice for maganesium oxychloride composition floors (2nd revision)
1.6.2	IS 1196:1978	Code of practice for laying bitumen mastic flooring (2nd revision)
1.6.3	IS 1197:1970	Code of practice for laying of rubber floors (1st revision)
1.6.4	IS 1198:1982	Code of practice for laying,fixing and maintenance of petroleum floor(1st revision)
1.6.5	IS 1443:1972	Code of practice for laying & finishing of cement concrete flooring tiles(1st revision)
1.6.6	IS 2118:1980	Code of practice for construction of jack arch type of building floora or roof(1st revision)
1.6.7	IS 2119:1980	Code of practice for construction of block cum concrete composite floora or roof(1st revision)
1.6.8	IS 2204:1962	Code of practice for construction of reinforced concrete shell roof(1st revision)
1.6.9	IS 2571 : 1970	Code of practice for laying in-situ cement concrete flooring(1st revision)
1.6.10	IS 2700:1987	Code of practice for roofing with wooden shingles (1st revision)
1.6.11	IS 2792:1964	Code of practice for design and construction of stone slab over joint floor
1.6.12	IS 2858:1984	Code of practice for roofing with Mangalore tiles (1st revision)
1.6.13	IS 3007 part 1:1999	Corrugated sheets(1st revision)
1.6.14	IS 3007 part 2:1999	Semi- corrugated sheets(1st revision)
1.6.15	IS 3670:1989	Code of practice for construction of timber floors (1st revision)
1.6.16	IS 5119 part1:1968	Code of practice for laying & fixing of sloped roof coverings part 1

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1.6.17	IS 5318 part1:1969	Code of practice for laying & flexible PVC sheet and tile flooring
1.6.18	IS 5389:1969	Code of practice for laying & hard wood parquet& wood block floors
1.6.19	IS 5766:1984	Code of practice for laying burnt clay brick Flooring
1.6.20	IS 5390:1984	Code of practice for construction of timber ceiling (1st revision)
1.6.21	IS 6061	Code of practice for construction of floor & roofs with joints & filler blocks
	IS 6061part1:1971	With hollow concrete filler blocks
	IS 6061part2:1981	With hollow clay filler blocks
	IS 6061part3:1981	Precast hollow clay blocks joints aand hollow clay filler blocks
	IS 6061part4:1981	With precast hollow clay block slab panels
1.6.22	IS 6332:1984	Code of practice for construction of floor & roofs using precast doubly-curved shell units (1st) of practice forconstruction of floor & roofs using precast doubly-curved shell units(1 st)
1.6.23	IS 9472:1980	Code of practice for laying mosaic parquet flooring
1.6.24	IS10297:1982	Code of practice for construction of floor & roofs using precast reinforced / prestressedconcrete ribbed
1.6.25	IS 10440:1983	Code of practice for construction of reinforced block & RBC floor & roof
1.6.26	IS 10505:1983	Code of practice for construction of floor & roofs using precast concrete waffle units
1.7	Finishes	
1.7.1	IS 1346	Code of Practice for Waterproofing of Roofs with Bitumen Felts

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1.7.2	IS 1414	Standard Code of practice for fixing of wall Coverings
1.7.3	IS 1477(part1)	Pretreatment(painting)1971
	IS 1477(part2)	Painting (first revision)197
1.7.4	IS 1609:1991	treatment using bitumen felts (second revision)
1.7.5	IS 1661: 1972	Code of practice for application of cement & cement lime finishes
1.7.6	IS 2114:1984	Code of practice for laying in-situ terrazzo floor finish(1st revision)
1.7.7	IS 2115	Code of practice for flat-roof finish: mud phuska(2nd revision)
1.7.8	IS 2338 : Part 1	Code practice for finishing of wood and wood based materials: Part1 Operations and workmanship
	IS 2338 : Part 2	Code practice for finishing of wood and wood based materials: Part 1 Schedules
1.7.9	IS 2394	Standard code of practice for application of lime plaster finish
1.7.10	IS 2395 : Part 1	Painting of Concrete, Masonry and Plaster Surfaces -Part 1 : Operations and Workmanship
	IS 2395 : Part 2	Code of practice for painting concrete, masonry and plaster surfaces: Part 2 Schedules
1.7.11	IS 3036:1992	Code of practice for laying lime concrete for a waterproofed roof finish
1.7.12	IS 3067	Code for general design details & preparatory work for damp-proofing & water-proofing of buildings
1.7.13	IS 3140	Code of practice for painting asbestos cement building products
1.7.14	IS 3548:1988	Code of Practice for Glazing in Buildings

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1.7.15	IS 4101 : Part 1	Code of practice for external facings and veneers: Part I Stone facing
	IS 4101 : Part 2	Code of Practice for External Facings and Veneers - Part II : Cement Concrete Facing
	IS 4101 : Part 3	Code of Practice for External Cladding - Part 3 : Wall Tiling and Mosaics
1.7.16	IS 4365:1967	Code practice for applation of bitumen mastic for waterproofing of roofs
1.7.17	IS 4597	Code for finishing of wood & wood based products with nitrocellulose and cold catalysed materials
1.7.18	IS 4631	Code of practice for laying of epoxy resin floor Toppings
1.7.19	IS 5491	Code of practice for laying of in-situ granolithic concrete floor topping
1.7.20	IS 6494:1988	Code of practice for water proofing of undergroundwater reserviors& swimming pool
1.7.21	IS 7198	Code of practice for damp-proofing using bitumen mastic
1.7.22	IS 7290	Recommendations for use of polyethylene film for water-proofing of roofs
1.7.23	IS 9918:1981	Code of practice for in-situ waterproof &dampproof treatment with glass fibre tissue
1.8	Piping	
1.8.1	IS 783:1985	Code of practice for laying of concrete pipes
1.8.2	IS 3114:1994	Code of practice for laying of cast iron pipes
1.8.3	IS 4127:1983	Code of practice for laying of glazed stoneware Pipes
1.8.4	IS 5329:1983	Code of practice for stainary pipe work above ground for buildings pipes

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1.8.5	IS 5822:1994	Code of practice for laying of welded steel pipes for water supply pipes
1.8.6	IS 6530:1972	Code of practice for laying of asbestos cement pressure pipes
1.8.7	IS 7634part 1	Code of practice for plastices pipe work for portable water supplies(choice of material..
	IS 7634part 2	Code of practice for plastices pipe work for portable water supplies(laying& joint.. .
	IS 7634part 3	Code of practice for plastices pipe work for portable water supplies(laying& joint.PVC
1.9	Measurement	
	IS:1200Part1	Method of measurement of building& civil work(Earthwork)
	IS:1200Part2	Method of measurement of building& civil Work(Concrete work)
	IS:1200Part3	Method of measurement of building& civil Work(brick work)
	IS:1200Part4	Method of measurement of building& civil Work (stone masonry work)
	IS:1200Part5	Method of measurement of building& civil Work (form work)
	IS:1200Part6	Method of measurement of building& civil Work (Refactory work)
	IS:1200Part7	Method of measurement of building& civil Work (Hardware work)
	IS:1200Part8	Method of measurement of building& civil Work (Steel work& iron work)
	IS:1200Part9	Method of measurement of building& civil Work (Roof covering work)

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	IS:1200Part10	Method of measurement of building& civil Work (Ceiling & linings work)
	IS:1200Part11	(Paving,floor finishes dado & skirting & pointing)
	IS:1200Part12	(Plastering & pointing)
	IS:1200Part13	White washing,colour washing& painting of building surfaces
	IS:1200Part14	Glazing
	IS:1200Part15	Painting,polishing,varnishing,etc
	IS:1200Part16	Laying of water& sewer lines including appurtenant items
	IS:1200Part17	Roadwork including appurtenant air field pavements
	IS:1200Part18	Demolation & dismantling
	IS:1200Part19	Water supply,plumbing & drains
	IS:1200Part20	Laying of gas &oil pipe lines
	IS:1200Part21	Woodwork & joinery
	IS:1200Part23	Piling
	IS:1200Part24	Well foundation
	IS 3861:2002	Method of measurement of plinth,carpet & rentable areas of building
1.10	Other	
1.10.1	IS1081:1960	Code of practice for fixing& glazing of metal(steel& aluminium)doors>window,ventilators
1.10.2	IS1649:1962	Code of practice for design&construction of fans for domestic heating appliances
1.10.3	IS1946:1961	Code of practice for use of fixing devices in walls,ceilings & floor
1.10.4	IS2470 part1	Code of practice for installation of septic tank(design criteria & construction)

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	IS2470 part2	Secondary treatment & disposal septictank Effluent
1.10.6	IS2527:1984	Code of practice for fixing rain water gutters & down pipes for roof
1.10.7	IS3414:1968	Code of practice for design & construction of joint in building
1.10.8	IS3548:1988	Code of Practice for Glazing in Buildings
1.10.9	IS3558:1983	Code of practice for use of immersion vibrators for consolidating concrete
1.10.10	IS4326:1993	Code of practice for earthquake resistance design & construction of building
1.10.11	IS3935:1966	Code of practice for composite construction
1.10.12	IS4913:1968	Code of practice for seletion, installation & maintenance of timber door & window
1.10.13	IS6313:part1	Code of practice for anti-termite measures in building(constructional measure)
	IS6313:part 2	Preconstructional chemical treatment measure
	IS6313:part 3	Treatment of exsisting building
1.10.14	IS6924:1973	Code of practice for construction of refuse chutes in multistoreyed buildings
1.10.15	IS7246:1974	Recommendation for use of table vibrator for consolidation concrete
1.10.16	IS8147:1976	Code of practice for used of alluminum alloys in Structures
[7(2)]	IS13416(Part5):1994	Recommendations for preventive measure against hazards at workplaces(fire)
[7(3)]	IS11769(Part1):1987	Guidelines for safe use of products containing asbestos
[7(4)]	IS2190:1992	Code of pratice for selection, installation & maintenance of portable first-aid fire extinguishers (3rd revesion)

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[7(5)]	IS8758:1993	Recommendations for fire precautionary measures in construction of temporary structures & pandals (1st revision)
[7(6)]		
	6.1 IS10439:1983	Code of practice patent glazing
	6.2 IS14687:1999	Guidelines for falsework for concrete structures
[7(7)]	IS3764:1992	Safety code for excavation work (1st revision)
[7(8)]	IS4138:1977	Safety code for working in compressed air (1st revision)
[7(9)]	IS 2925:1984	Specification for industrial safety helmets (2nd revision)
[7(10)]	IS2750:1964	Specification for steel scaffolding
[7(11)]	IS3696(Part1):1987	Safety code for scaffolds and ladders:Part 1 Scaffolds
[7(12)]	IS3696(Part2):1991	Safety code for scaffolds and ladders:Part 2 Ladders
[7(13)]	IS4912:1978	Safety requirements for floors & wall openings railing & toe boards(1st revision)
[7(14)]	IS11461:1985	Code of practice for compressor safety
[7(15)]	IS1179:1967	Specification for equipment for eye & face protection during welding (1st revision)
[7(16)]	IS5983:1980	Specification for eye-protectors(1st revision)
[7(17)]	IS2361:2002	Specification for bull-dog grips(3rd revision)
[7(18)]	IS11057:1984	Specification for industrial safety nets
[7(19)]	IS3016:1982	Code of practice for fire precautions in welding & cutting operations(1st revision)
[7(20)]		
	20.1 IS1084:1994	Specification for manila ropes(4th revision)
	20.2 IS2266:2002	Specification for steel wire ropes for general Engineer
[7(21)]	IS5916:1970	Code of practice for safety & health requirement in electric & gas welding& cutting

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[7(22)]	IS5916:1970	Safety code for construction involving use of hot bituminous materials
[7(23)]	IS13416(Part4):1992	Recommendation for preventive measure against hazards at workplace
[7(24)]	IS2171:1990	Specification for portable fire extinguishers, dry powder (3rd revision)
[7(25)]		
25.1	IS819:1957	Code of practice for resistance spot welding for light and mild steel
25.2	IS1261:1959	Code of practice for steam welding in mild steel
25.3	IS3016:1982	Code of practice for fire precautions in welding & cutting operation
25.4	IS 4138:1977	Safety code of blasting & related drilling Operations
25.5	IS 9595:1996	Recommendation for manual arc welding of carbon & carbon manganese steels
25.6	IS10178:1995	Recommendation procedure for CO ₂ gas shielded manual arc welding of structural steels
[7(26)]		
26.1	IS3488:1989	Code of practice for installation & maintenance of internal fire hydrants & steel on premises
26.2	IS5290:1993	Specification for landing valves
[7(27)]	IS13416part2:1992	Recommendation for preventive measures against hazards at work places
[7(28)]	IS13416part1:1992	Falling material hazards prevention
[7(29)]	IS13416part3:1992	Disposal of debris
[7(30)]		
30.1	IS 274(Part1):1981	Specification of shovels (general purpose)
30.2	IS 274(Part2):1982	(Heat-treated shovels)
30.3	IS 663:1980	Specification for adzes (2nd revision)

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30.4	IS 704:1984	Specification for crow bars & claw bars (2nd revision)
30.5	IS 841:1983	Specification for steel hammers(2 nd revision)
30.6	IS 844(Part2):1979	Specification for screw drivers(dimensions)
	IS 844(Part3):1979	Dimensions for screw drivers for recessed head Screws
30.7	IS 1630:1984	Specification for manson's tools for plaster work & pointing work
30.8	IS 1759:1986	Specification for POWRAHS(2nd revision)
30.9	IS 1791:1985	Specification for batch type concrete mixers
30.10	IS 1930:1995	Specification for chisels &guages(2nd revision)
30.11	IS 1931:2000	Specification for engineer's files(3rd revision)
30.12	IS 2028:2004	Specification for open jaw wrenches (4th revision)
30.13	IS 2029:1998	Specification for ring wrenches (spanners 4th revision)
30.14	IS 2030:1989	Specification for box spanners(2nd revision)
30.15	IS 2094(Part1):1996	Specification for heater for bitumen & emulsion(specification2nd revision)
	IS 2094(Part 2):1999	Bitumen sprayer)(3rd revision)
	IS 2094(Part 3):1999	Emulsion (third revision)
30.16	IS 2431:1963	Specification for roller steel wheel barrows(singke wheel type)
30.17	IS 2438:1963	Specification for roller pan mixer
30.18	IS 2439:1963	Specification for metal hand rollers (fixed welght type)
30.19	IS 2505:1992	Specification for concrete vibrators,immersion type(general requirements)
30.20	IS 2506:1985	General requirements for screed board concrete vibrators(1t revision)
30.21	IS 2514:1963	Specification for concrete vibrating tables

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30.22	IS 2587:1975	Specification for pipes vices(open side type& fixed type(1st revision)
30.23	IS 2588:1975	Specification for blacksmith's vices(1st revision)
30.24	IS 2722:1964	Specification for portable swing weigh batchers for concrete(single& double bucket type)
30.25	IS 2852:1998	Specification for carpenters augers(1st revision)
30.26	IS 3066:1965	Specification for hot asphalt mixing plants
30.27	IS 3251:1965	Specification for asphalt paver finisher
30.28	IS 3365:1965	Specification for floor polishing machines
30.29	IS 3559:1966	Specification For Pneumatic Concrete Breakers
30.30	IS 3587:1986	Specification for rasps (2nd revision)
30.31	IS 3650:1981	Specification for combination side cutting pliers(2nd revision)
30.32	IS 3938:1983	Specification for electric wire rope hoists (2nd revision)
30.33	IS 4003(Part1):1978	General purposes(specification for pipe wrenches)
30.34	IS 4003(Part2):1986	Heavy duty(first revision)
30.35	IS 4017:1992	Specification for carpenters squares(1st revision)
30.36	IS 4057:1986	Specification for carpenters adjustable metal bodied bench(1st revision)
30.37	IS 4095:1991	Specification for pincers(2nd revision)
30.38	IS 4183:1967	Specification for metal hammers
30.39	IS 4184:1967	Specification for steel wheel barrows (with two wheels)
30.40	IS 4508:1992	Specification for open ended slugging wrenches(spanners1st revision)
30.41	IS 4656:1968	Specification for form vibrators for concrete
30.42	IS 5066:1969	Specification for glass pliers
30.43	IS 5067:1969	Specification for fencing pliers

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30.44	IS 5087:1969	Specification for wire stripping pliers
30.45	IS 5098:1969	Specification for cross cut & rip saws
30.46	IS 5123:1969	Specification for tenon & dovetail saws
30.47	IS 5169:1986	Specification for hack-saw frames (frames 1st revision)
30.48	IS 5200:1998	Specification for bolt clippers(1st revision)
30.49	IS 5658:1990	Specification for snipenose pliers(1st revision)
30.50	IS 5663:1970	Specification for brick and mansoin's chisels
30.51	IS 5684:1970	Specification for pipe vices (chain type)
30.52	IS 5697:1970	Specification for ripping chisels
30.53	IS 5889:1994	Specification for vibratory plate compactor (1st evision)
30.54	IS 5890:1970	Specification for mobile hot mix asphalt plants,light duty
30.55	IS 5891:1971	Specification for hand-openended concrete mixer
30.56	IS 5995:1971	Specification for pipe grip pliers
30.57	IS 6007:1971	Specification for pipe vices(hinged type)
30.58	IS 6078:1986	Specification for line man's pliers (2nd revision)
30.59	IS 6087:1971	Specification for metal cuttind shears
30.60	IS 6118:1991	Specification for multiple slip jiont pliers (1st revision)
30.61	IS 6149:1984	Specification for single ended openjaw adjustibale wrenches(1st revision)
30.62	IS 6375:1991	Specification for wood splitting wedges (1st revision)
30.63	IS 6389:1998	Specification for combination wrenches with equal openings(2nd revision)
30.64	IS 6428:1972	Specification for pile frame
30.65	IS 6430:6985	Specification for mobile air compressor for Construction

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	30.66	IS 6433:1972	Specification for guniting equipment
	30.67	IS 6546:1989	Specification for claw hammers(1st revision)
	30.68	IS 6836:1973	Specification for hand snaps & set ups for solid Rivets
	30.69	IS 6837:1973	Specification for three wheel type pipe cutter
	30.70	IS 6841:1973	Specification for wrecking bars
	30.71	IS 6861:1973	Specification for engineers scrapers
	30.72	IS 6881:1973	Specification for link type pipe cutters
	30.73	IS 6891:1973	Specification for carpenter's auger bits
	30.74	IS 6892:1973	Specification for blackmist's brick-irons
	30.75	IS 7041:1973	Specification for carpenter's plain brace
	30.76	IS 7042:1973	Specification for carpenter's ratchet brace
	30.77	IS 7077:1973	Specification for bending bars
	30.78	IS 7958:1976	Specification for hand vices
	30.79	IS 8202:1994	Specification for carpenter's wooden bodied planes(1st revision)
	30.80	IS 8671:1977	Specification for nail puller
[7(31)]		IS 7293:1974	Safety code for working with construction Machinery
[7(32)]		IS15183(Part3):2002	Maintenance management for buildings Guidelines:Part3 Labour
[7(33)]		IS15183(Part2):2002	Maintenance management for buildings _ Guidelines:Part2 Finance
[7(34)]		IS13935:1993	Guidelines for repair & seismic strength masonry buildings
[7(35)]		IS13828:1993	Improving earthquake resistance of low strength masonry buildings
[7(36)]		IS13827:1993	Improving earthquake resistance of earthen Buildings
[7(37)]		IS4130:1991	Safety code for demolition of buildings (2nd revision)

