

NATIONAL BUILDING CODE

Prepared under the joint sponsorship of the

NATIONAL HOUSING ADMINISTRATION
DEPARTMENT OF FINANCE

and the

CODES AND SPECIFICATIONS SECTION
NATIONAL RESEARCH COUNCIL
OF CANADA

Foreword

MANY years have elapsed since the preparation of a model building code for Canada was first discussed. Students of housing and building problems as well as those engaged in the construction industry have long realized that one of the important deterrents to technical progress and to an increase in the physical volume of construction has been the unsuitable nature of building regulations in many parts of the country. In many localities, codes have been deemed to be unduly restrictive in the materials and methods of construction permitted; in others, requirements in the matter of design have fallen behind the advance of building technology and modern concepts of healthful planning; while many communities in Canada, lacking qualified advice, have been unable to deal with the problem of building regulation at all.

These conditions have undoubtedly been reflected in increased costs and restricted output, together with lower standards of design and construction than would otherwise have been attainable.

With the entry of the Dominion Government into the housing field some six years ago, the need of national treatment of the matter of building regulation was at once recognized. Discussions with numerous trade and professional associations led to the conclusion that if a comprehensive model code could be prepared, its adoption by municipal authorities and others responsible for the regulation of building construction would be a major step in the solution of the problems faced by the construction industry and administrative authorities alike.

The preparation of such a model code was initiated four years ago under the joint sponsorship of the Department of Finance and the National Research Council. Those responsible for its direction were convinced that there were no insuperable technical problems and that if an authoritative document were prepared it would commend itself to those having jurisdiction in a field in which the function of a Dominion Government agency could be no more than advisory. Undertaken in times of peace in the expectation that it would be completed in little more than two years, the National Building Code has been delayed because of the demands made upon the secretariat as well as upon many committee members by the war. The fact that it has been successfully completed notwithstanding the difficulties faced is a tribute to the energy and initiative of those who have carried it on.

This Code is really a three-fold document setting down regulations in the distinct fields of construction requirements, regulations bearing upon fire protection, and requirements governed by considerations of health and sanitation. Owing to war conditions, these parts of the Code were published separately as completed, so that if any obstacle should have prevented their issue in consolidated form, the labours of the various committees would not have been lost. Fortunately it has been possible to complete the publication under one cover. As the work on the main Code progressed, the preparation of two ancillary documents

was undertaken. Model zoning and plumbing by-laws, both prepared by the Committee on Health and Sanitation, have been published and have, it is believed, already demonstrated their worth. For convenience of reference the Standard Plumbing By-law has been included as an appendix in this volume. The National Building Code, with these ancillary publications, represents the work of some sixty active committee members chosen for their individual knowledge in specialized fields, together with an advisory committee comprising representatives of about sixty professional and trade associations and government agencies throughout the country. The fact that it has been possible to reach finality in the face of such apparent diversity of interest is sufficient commentary on the goodwill and public spirit that have characterized the work of the various committees.

The complete personnel of the committees is given on another page. Those to whom much credit is due for the initiation and prosecution of the project include the Honourable C. A. Dunning, former Minister of Finance, and Honorary Chairman of the project; Lieut.-General A. G. L. McNaughton, President of the National Research Council, and Dean C. J. Mackenzie, Acting President of the National Research Council, who have served as Chairmen of the project; Mr. F. W. Nicolls, Director of Housing, Department of Finance, as Chairman of the Administrative Committee; the late Mr. J. Grove Smith, former Dominion Fire Commissioner, and one of the original members of the Administrative Committee; and Mr. A. F. Gill, Officer-in-Charge of the Codes and Specifications Section, National Research Council, General Secretary of the project.

(Sgd.) J. L. ILSLEY,

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November 25, 1941.

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Introduction

The National Building Code is divided into five parts. Part 1 deals with the administrative requirements; Part 2 comprises all the definitions used throughout the Code; Part 3 contains structural requirements; Part 4 contains regulations pertaining particularly to protection against loss of life and property from fire; and Part 5 contains regulations made necessary by considerations of health and sanitation. In addition to the Code itself there are eleven appendices. These consist of material which, it is believed, will be helpful in interpreting the requirements of the Code. It is not intended that the appendices be regarded as integral parts of the Code.

The Parts of the Code are divided into Sections, the Sections into Articles, and the Articles into Items. In some cases, Items are divided into Sub-items. In order to facilitate reference, a numerical system of designating Parts, Sections, Articles and Items has been adopted. For example, Item 4.12.4.2 is the second Item in Article 4.12.4; Article 4.12.4 is the fourth Article in Section 4.12 which in turn is the twelfth Section in Part 4 of the Code.

Since a comprehensive building code is necessarily a somewhat lengthy and involved publication, some further explanation of the arrangement of the National Building Code may be helpful.

There are two alternative methods of arranging a building code. One method makes use of occupancy chapters, i.e., all regulations relating to any particular occupancy are brought together in one place. Thus, for example, all regulations referring to schools are collected in a chapter headed "Schools". Such an arrangement makes a building code easy to use but unfortunately it involves a great deal of repetition and hence greatly increases the physical bulk of the code. The second arrangement includes no occupancy chapters but assembles under one heading all regulations dealing with a particular subject. Thus, for example, all regulations dealing with exits are collected in a single chapter headed "Exits". Such an arrangement avoids repetition, makes a code more compact, and at the same time leads to a more consistent treatment of the various subjects. On the other hand, this arrangement is not quite so convenient from the point of view of the architect or builder using the code.

In order to restrict this National Building Code to a reasonable size, the second arrangement has been adopted. To meet the objection that this makes the Code difficult to use, particular attention has been given to indexing and it is hoped that the completeness of the index may compensate for the absence of occupancy chapters. In any case, it may be pointed out that in the most recent codes which follow the first arrangement, the occupancy chapters consist of little more than a series of cross-references to other parts of the Code.

If the reader of the Code is interested in a general subject such, for example, as "Exits", he will turn to Section 4.6 which contains all regulations relating to exits; but if his interest is in putting up a particular

building such as a school, reference to the index will indicate where there are special regulations applicable to schools. Compliance with all general regulations, such as the structural requirements given in Part 3, will of course be necessary.

The Code is intended to be suitable for adoption "in toto" by municipalities desiring to use a building code. It should be pointed out, however, that the powers of municipalities, with respect to building control, vary in the different provinces and consequently it is very desirable that municipalities obtain legal advice before adopting the Code. This is particularly true in the case of the administrative requirements given in Part 1.

It is essential that municipalities using the Code establish a proper system of fire zones since the type of construction permitted for certain occupancies depends upon their location with respect to such zones. Attention is directed to the footnote on page 212 dealing with this matter.

Attention is also drawn to the usage that has been adopted in connection with discretionary powers belonging to the municipality. To avoid any tendency towards illegal delegation of municipal authority, all discretionary powers should be placed in the hands of the "authority having jurisdiction". In the Code this authority is defined as "the person authorized by municipal enactment to administer the regulations contained in the Code".

With the increasing need of professional advice for the proper interpretation of regulations in the building field, smaller communities are often at a disadvantage because it is not usual for them to have in their employ persons with the necessary professional training. In small municipalities this difficulty may be met economically by retaining a firm of engineers or architects on a consulting basis to advise the permanent officials from time to time on technical problems which arise in connection with the Code.

In the past, building codes have frequently impeded the introduction of new and improved methods of construction. The National Building Code will not have this effect. Article 3.1.3 makes provision in general terms for the introduction of new materials and methods of construction. This will be supplemented by the publication from time to time of revisions and additions to the Code. Suggestions for such revisions and additions should be addressed to "The Officer in Charge, Codes and Specifications Section, National Research Council, Ottawa, Canada". They will receive careful consideration by the Administrative Committee, which is being continued under the auspices of the National Research Council for the purpose of maintaining the National Building Code as a 'living code'. In this way it is hoped that the Code will continue to meet the changing needs of Canadian municipalities.

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PARTS 1 AND 2
OF THE
NATIONAL BUILDING CODE

PART 1. ADMINISTRATION
PART 2. DEFINITIONS

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N.R.C. NO. 1068 (BOOK 1)

PART I

ADMINISTRATION

Note: For Definitions, see Part 2.

SECTION 1.1 GENERAL PROVISIONS

1.1.1 Short Title.—This by-law may be cited as the “Building By-law” and is hereinafter referred to as “this Code”.

1.1.2 Interpretation.—Wherever applicable, the provisions of this Code shall also apply to *structures* other than buildings and the term “buildings” shall be understood to include such other *structures*.

The headings which appear at the beginning of Sections, Articles, Items, or Sub-items of this Code shall be deemed to be a part of such Sections, Articles, Items, or Sub-items, respectively.

Where in this Code such terms as “proper”, “adequate”, “sufficient”, “ample”, “suitable”, “substantial”, “necessary”, “dangerous” and the like, or derivatives thereof, are used, they shall be understood to mean proper, adequate, and so forth to the satisfaction or in the opinion of the *authority having jurisdiction* (see Article 1.2.1) and such terms as “where practicable”, “where required”, “as far as possible” shall have a like significance.

1.1.3 Standard Specifications and Regulations.—All standard specifications and regulations adopted, wholly or in part, in this Code are hereby declared to be a part of this Code. Whenever dated specifications or regulations are cited, subsequent editions may be used subject to permission from the *authority having jurisdiction*.

1.1.4 Tests.—The cost of any test that may be required by this Code or by the *authority having jurisdiction* shall be paid by the person wishing to use the material, device, or construction in question.

SECTION 1.2 BUILDING OFFICIALS*

1.2.1 Authority Having Jurisdiction.**—The provisions of this Code shall be enforced by one or more officials appointed by the Municipal Council, and any official appointed in this manner to enforce any regulation contained in this Code is referred to in this Code as the *authority having jurisdiction*.

*It is recommended that wherever possible a Board of Appeal be established in addition to the officials referred to in Section 1.2 and a suggested organization for such a Board is given in Appendix A. This has not been included in the Code because it is considered that many municipalities may not find it possible to establish a Board of Appeal.

**The term “*authority having jurisdiction*” is used in preference to a term such as “Building Inspector” since it is considered that some municipalities may find it convenient to authorize different officials to enforce different portions of the Code, for example, Part 4, Fire Protection, might be considered within the jurisdiction of the Fire Chief, whereas Part 5, Requirements Bearing on Health and Sanitation, might be considered within the jurisdiction of the Health Officer.

The *authority having jurisdiction* shall have recognized technical qualifications and practical experience commensurate with the type of work involved (see also Item 3.4.2.1).

Neither the *authority having jurisdiction* nor any member of his staff shall be employed or engaged, directly or indirectly, in any branch of the building business, or have any financial interest in connection with the construction or repair of buildings, or the supply of building materials unless such interest or connection is publicly disclosed.

1.2.2 Records.—The *authority having jurisdiction* shall keep proper records of all applications received, permits and orders issued, inspections and tests made, reports received and made, and retain copies of all papers and documents connected with the administration of his duties.

1.2.3 Inspection.—The *authority having jurisdiction* or his authorized representative may at all reasonable hours enter into or upon any building or premises for the purpose of ascertaining whether or not the provisions of this Code are being complied with.

1.2.4. Occupancy of Street.—The *authority having jurisdiction* is hereby authorized to issue permits for the temporary occupancy of any street for building purposes or for the demolition of buildings, or for the construction of temporary and *detached structures* and for any other special purpose.

SECTION 1.3 APPLICATION

1.3.1 New Buildings.—No building or any part of any building shall hereafter be constructed except in conformity with the provisions of this Code.

1.3.2 Existing Buildings.—Nothing in this Code shall require the removal, *alteration*, or abandonment of, nor prevent continuance of the use or occupancy of an *existing* building, unless in the opinion of the *authority having jurisdiction* such building constitutes a hazard to safety or adjacent property.

1.3.3 Building Permits Issued Prior to Adoption of this Code.—Nothing in this Code shall require any change in the plans, construction or designated use of a building for which a building permit has been issued at the date of enactment of this Code.

1.3.4 Alterations, Additions, Repairs, and Changes of Use or Occupancy

1.3.4.1 General.—Except as provided in Item 1.3.4.2, all *alterations*, additions, repairs, made hereafter whether to *existing* buildings or to buildings hereafter erected shall conform to the requirements of this Code and no change of use or occupancy shall be made except as herein permitted. (See Item 1.4.2.2.)

1.3.4.2 Non-conforming Buildings.—The following provisions shall apply when *alterations*, additions, repairs, or changes of use or occupancy are made to *existing* buildings which for any reason whatsoever do not conform to the requirements of this Code.

(a) **Major Alterations and Repairs.**—If alterations and repairs in excess of 50 per cent of the assessed value of an *existing* building are made to such building within any period of 2 years, the entire building shall be made to conform with the requirements given herein for new buildings. Any *existing* building, which for any reason whatsoever, requires repairs, at any one time, in excess of 50 per cent of the assessed value thereof, not deducting from such value any loss caused by fire or any other reason, shall be made to conform to the requirements of this Code or shall be demolished. (See also Item 4.4.2.3.)

(b) **Changed Use.**—If the *existing* use or occupancy of an *existing* building is changed to a use or occupancy which would not be permitted in a similar building hereafter erected, the entire building shall be made to conform with the requirements given herein for new buildings; provided, however, that if the building is adequate to carry the loadings prescribed in Section 3.6 for the proposed occupancy and if the Requirements bearing on Health and Sanitation as set forth in Part 5 are fulfilled, then, notwithstanding the fact that the building may not conform to all the requirements of this Code, the *authority having jurisdiction* may permit the proposed change of occupancy, if in his opinion the proposed occupancy is no more hazardous on the basis of life and internal fire hazard than the *existing* occupancy, and provided further that if the use or occupancy of only a portion or portions of an *existing* building is changed and such portion or portions are separated as and when specified in Item 4.2.3.3 of this Code, then only such portion or portions of the building need to be made to comply with the requirements of this Code. (See also Item 1.4.2.2.)

(c) **Increases in Height.**—The number of *storeys* in any *existing* building shall not be increased unless the building and all *existing* or proposed additions and *alterations* are made to comply with all the requirements of this Code.

(d) **Increases in Area.**—Any addition having an area exceeding 50 per cent of the *area* of the *existing* building shall be separated from it by construction not less fire resistive than a 'special occupancy separation', (see Item 4.2.3.3) unless the building and all existing or proposed additions and *alterations* are made to comply with all the requirements of Part 4 (Fire Protection) of this Code.

(e) **Increases in Population.**—In no case shall a change of occupancy involving an increase in population on any *floor-area* or in any *storey* be permitted unless the *exits* comply or are made to comply with Section 4.6. The use of a room or rooms as a *dwelling unit* on a *floor-area* or in a *storey* where no *dwelling unit* previously existed shall be considered as an increase in population.

(f) **Structural Alterations and Repairs.**—Where any *alteration* or repair is made to the structural portion of any building, such structural portion or such part thereof as may be deemed necessary by the *authority having jurisdiction* shall be made to conform to the requirements of this Code for new buildings.

(g) **Non-structural Alterations and Repairs.**—Minor non-structural *alterations*, repairs, and changes may be made with the same materials of which the building is constructed; except as provided for roof coverings in Article 4.11.2.

SECTION 1.4 BUILDING PERMITS AND OCCUPANCY PERMITS

1.4.1 Building Permits

1.4.1.1 General.—A building permit shall be obtained from the *authority having jurisdiction* by the owner or his authorized agent for the excavation, erection, *alteration*, reconstruction, removal, or wrecking of, or repairs to, any building or part of any building which it is proposed to construct, and for any addition or *alteration* to a building. No such work shall be commenced until a building permit has been obtained.

1.4.1.2 Application for a Building Permit.—The applicant for a building permit shall file with the *authority having jurisdiction* a signed statement as to the use or purpose for which such building is intended, together with duplicate copies of the plans of same, drawn to a scale of not less than one-eighth of an inch to a foot, showing the actual dimensions, including the dimensions of the *lot* to be built upon, all *structures existing* upon the said *lot* with the heights and dimensions of same, the heights and dimensions of the proposed *structures*, and other such information as may be necessary to provide for the enforcement of this Code. In the case of a *commercial or industrial building* the drawing submitted shall show the *live loads* per square foot of area for which the building is designed.

Before the issue of a building permit, drawings showing the size and composition of all structural members may be required by the *authority having jurisdiction* who may also require the submission of calculations pertaining to the design.

1.4.1.3 Granting of Building Permits.—The application, plans, and specifications filed by an applicant for a building permit shall be examined by the *authority having jurisdiction* and if it appears to him that such plans and specifications are in conformity with the requirements of this Code and all other laws or ordinances applicable thereto, the *authority having jurisdiction* shall issue the building permit upon receipt of the required permit fee.

Neither the granting of a building permit, approval of plans and specifications, or inspections made by the *authority having jurisdiction*, or his assistants, during the erection of a *structure* shall in any way relieve the owner, or his agents, from full responsibility for the carrying out of the work in strict accordance with this Code, or for the stability of the *structure*.

1.4.1.4 Approval in Part.—Nothing in this Code shall be construed to prohibit the *authority having jurisdiction* from issuing a building permit for the construction of part of a building when application and *approved* plans for that part are presented for the same before the complete plans and specifications for the entire building have been submitted and *approved*.

1.4.1.5 Alterations to Plans.—No person shall erase, alter, or modify any drawings or specifications upon which a building permit has been granted by the *authority having jurisdiction*, unless the *authority having jurisdiction* has agreed to such changes.

If, during the progress of the work, it is desired to deviate from the plans filed with the application for a building permit in any manner affecting the construction or other essentials of the building, notice of such desired *alterations* shall first be made in writing to the *authority having jurisdiction*, and his written approval shall be obtained before such *alterations* shall be commenced.

1.4.1.6 Building Permit Limitations.—Any building permit issued by the *authority having jurisdiction* under the provisions of this Code shall expire when no building construction is started within six months from the date of issuance.

Building permits shall be subject to revocation when construction is discontinued for a period of one year, or when, in the opinion of the *authority having jurisdiction*, the completion of the construction has been unduly delayed. Such revocation shall not be rescinded until the plans and incomplete construction are made to comply with all the requirements of this Code at the time of rescinding such revocation.

1.4.1.7 Requirements after Issuance of Building Permits.—Reasonable notice shall be given to the *authority having jurisdiction* of the intention to commence any work authorized by a building permit, so as to enable the *authority having jurisdiction* to make such inspections as he may consider necessary. In addition, when *concrete* is to be placed, reasonable notice shall be given to the *authority having jurisdiction* who may also require notice to be given of the intention to carry out any other constructional operations, such, for example, as the driving of piles or the covering up of structural framing.

1.4.2 Occupancy Permits

1.4.2.1 New Buildings.—No building hereafter constructed shall be occupied in any part thereof until an occupancy permit has been issued by the *authority having jurisdiction*. Such permit shall show the use to which the building may be put and the maximum allowable floor loads for each floor thereof. In the case of *commercial and industrial buildings*, occupancy permits shall not be issued until the floor load signs required by Article 3.6.7 have been installed.

A temporary occupancy permit may be issued by the *authority having jurisdiction* for the temporary use of a portion of a building prior to the completion and use of the entire building.

1.4.2.2 Changes of Occupancy.—No change shall be made in the use or occupancy of any building or part thereof until a permit for the proposed occupancy has been issued by the *authority having jurisdiction*. Such occupancy permit shall be issued by the *authority having jurisdiction*, if it is found that the building complies with the provisions of this Code for the proposed occupancy or, in the case of an *existing* building, if the conditions prescribed in Item 1.3.4.2 (b) are fulfilled.

SECTION 1.5 DANGEROUS BUILDINGS

Whenever, in the opinion of the *authority having jurisdiction*, any building or part thereof, is, by reason of its dilapidated state, faulty construction, or otherwise, in an unsafe condition as regards danger from fire or risk of accident, the *authority having jurisdiction* may give to the owner of such building, or his agent, notice in writing specifying wherein such unsafe condition exists, and upon receipt of such notice, the said owner, or his agent, shall forthwith put such building, or part thereof, in a safe condition or demolish same.

When, in the opinion of the *authority having jurisdiction*, any building, or part thereof, is in such condition that immediate precautionary measures must be taken in order to avert an accident, the *authority having jurisdiction* may pull down, repair or renew any such building, or part thereof, at the expense of the owner, whether or not notice has first been given to such owner or his agent, and such expense may be recovered from such owner by action or may be recovered in like manner as municipal taxes.

SECTION 1.6 ENFORCEMENT OF CODE, OFFENCES, AND PENALTIES

1.6.1 Enforcement of Provisions of Code.—Without prejudice to the operation of any other law, it shall be the duty of the *authority having jurisdiction* to take the necessary measures to institute proceedings against any person who contravenes any of the provisions of this Code.

1.6.2 Offences and Penalties

1.6.2.1 Every one who contravenes any of the provisions of this Code or any requirements or obligations imposed on him by virtue of this Code, or who interferes with or obstructs any person in the discharge of his duties under this Code shall be guilty of an offence and liable on summary conviction to a fine not exceeding fifty dollars and costs, and, in addition, the Justice may order that such person carry out the requirements or obligations imposed on him by virtue of this Code, for the contravention of which he has been convicted, within a time to be fixed by such order.

1.6.2.2 The conviction of any person for an offence under the provisions of Item 1.6.2.1 shall not relieve such person from the duty of carrying out the requirements or obligations imposed on him by virtue of the provisions of this Code, and if such requirements or obligations are not complied with in accordance with an order made under the provisions of Item 1.6.2.1, the *authority having jurisdiction*, under the provisions of this Code, may, where he deems it necessary and advisable, enter upon the premises in respect of which a conviction has been made and carry out, at the expense of the convicted person, the requirements or obligations referred to in the said order, and the expense, if not paid on demand, may be recovered with costs in a Court of competent jurisdiction, or if such expense is owing to the municipality it may be recovered as aforesaid or in the same manner as a debt due for municipal taxes on the land where the expense was incurred.

1.6.2.3 The conviction of any person under the provisions of this section for failing to comply with any of the said requirements or obligations shall not operate as a bar to further prosecution under this section for the continued failure on the part of such person so to comply.

PART 2

DEFINITIONS

2.1.1 For the purposes of this Code the definitions and interpretations given in this Article shall govern:

A.S.T.M. shall mean American Society for Testing Materials.

Access, Direct. Access from any designated area to any designated *exit* shall be considered direct only when it does not involve passage through any other area.

Aggregate shall mean inert material, consisting of sand, pebbles, gravel, crushed stone, or similar materials, which is mixed with *cement* and water to produce *mortar* or *concrete*.

Aggregate, Coarse, shall mean *aggregate*, subject to specified tolerances, retained on a No. 4 sieve and of a maximum size generally not larger than 3 inches.

Aggregate, Fine, shall mean *aggregate*, subject to specified tolerances, passing through a No. 4 sieve.

Alcove shall mean any portion of a room, the walls, floors, and ceiling of which form a recess thereto, and access to which is either unobstructed or through an arched opening in a wall. The depth of an *alcove* shall mean the maximum horizontal distance perpendicular to the plane of the opening, from such opening to any wall of such *alcove*; the width shall mean the mean horizontal distance across such *alcove*, at right angles to the depth.

Alteration. See **Altered**.

Altered with reference to any building, shall mean a building in which a change is made from one type of occupancy to another; or to which any addition is made; or in which any *partition* is erected or structural change made.

Approved shall mean *approved* by the *authority having jurisdiction*.

Area of Building shall mean the maximum projected horizontal area of the building above ground including roofed porches and verandahs but excluding terraces, steps, cornices, *fire escapes* and exterior *stairways*, ramps and open loading platforms. Such area shall include air wells and all other spaces within a building excepting *inner* or *outer courts*.

Area, Gross, in reference to a structural *masonry unit*, shall mean the total area within the outer periphery, of any section perpendicular to the stress to be resisted.

Area, Net, in reference to a structural *masonry unit*, shall mean the minimum effective load-bearing area of the material composing the unit, included in any section perpendicular to the direction of the stress to be resisted.

Area of Concrete, Effective, shall mean the area of a section which lies between the centroid of the tensile reinforcement and the compression face of a *beam* or slab; the area of a *column* section inside the protective envelope assumed for fire-proofing or inside the outer circumference of the spiral reinforcement, if present, exclusive of any area occupied by longitudinal reinforcement.

Area of Reinforcement, Effective, shall mean the area obtained by multiplying the right cross-sectional area of the reinforcement by the cosine of the angle between its direction and that for which the effectiveness of the reinforcement is to be determined.

Ashlar shall mean *masonry units of stone or cast stone*, laid on level beds, such units being of substantially rectangular shape.

Ashlar Facing, Coursed, shall mean squared *stones* laid in regular courses and used for the facing of *masonry* walls.

Ashlar Facing, Random, shall mean squared *stones* of various sizes used for facing of *masonry* walls.

Assembly, Place of, shall mean a room, *floor-area*, or building designed, intended, or used to seat or accommodate 100 or more persons, and used as a place for meetings, entertainment, instruction, worship, recreation, or drill. (This term is not opposed in any way to *assembly room* as elsewhere defined. It merely distinguishes *assembly rooms* having capacities of less than 100 persons from all other *assembly rooms*.)

Authority Having Jurisdiction shall mean the Building Inspector, the Fire Chief, the Health Officer, or any other official authorized by municipal enactment to administer any regulation contained in this Code.

Automatic as applied to a *closure*, shall mean that the *closure* is so constructed and arranged that if open it will close automatically under certain predetermined conditions resulting from fire.

Basement shall mean that portion of a building between two floor levels which is partly underground but which has at least one-half of its height from finished floor to finished ceiling above *grade*.

Beam shall mean a structural member intended primarily to resist bending.

Block shall mean a structural *masonry unit* other than *brick*, *stone* or *facing-tile*, and shall include *cast stone* and structural tile.

Block, Cellular, shall mean a *block* having uniformly distributed pores throughout its mass.

Brick shall mean a substantially solid structural unit of maximum dimensions approximately 8 by 4 by 2½ inches. For the purposes of this Code "hollow brick" shall be classed as structural tile.

Building, Accessory, shall mean a subordinate *detached* building, appurtenant to a main building and located on the same *lot*, the purpose of which is to provide better and more convenient enjoyment of the main building; and shall include among others *private garages* and *private stables*.

Building, Assembly, shall mean a building in which persons congregate for civic, political, educational, religious, social, or recreational purposes; including among others, court houses, schools, colleges, libraries, museums, exhibition buildings, lecture halls, churches, assembly halls, lodge rooms, dance halls, *theatres*, *motion picture theatres*, bath houses, armouries, recreation piers, passenger stations, arenas, gymnasiums.

Building, Commercial and Industrial, shall mean a building occupied for the transaction of business; for the rendering of professional services; for the display, sale, or storage of goods, wares, or merchandise; for the supplying of food, drink, or other bodily needs or comforts; or for the performance of work or labour; including among others, office buildings, stores, markets, *restaurants*, factories, workshops, laboratories.

Building, Institutional, shall mean a building into which persons are admitted to receive care or treatment, or in which persons are held under restraint; including among others, hospitals, asylums, sanatoria, police stations, jails.

Building, Residential, shall mean any building, except an *institutional building*, in which sleeping accommodation is provided; including among others, *one-family dwellings*, *two-family dwellings*, *multiple dwellings*, *hotels*, *lodging houses*, dormitories, convents, studios, club houses, fire stations.

Bulkhead shall mean a *structure* on the roof of a building enclosing a tank, elevator machinery, ventilating apparatus, cooling equipment, evaporators, scientific instruments, or other utilities, appliances, or operating equipment; or a *structure* of walls with or without a roof used to enclose or protect a vertical *shaft* extending through a roof.

C.E.S.A. shall mean Canadian Engineering Standards Association.

Cell, when used with reference to a *hollow masonry unit*, shall mean a hollow space, within the perimeter of the *shells* of such unit, that measures one square inch or more in area and half an inch or more across its least dimension.

Cellar shall mean that portion of a building between two floor levels which is partly or wholly underground and which has more than one-half of its height, from finished floor to finished ceiling, below *grade*.

Cement, when referred to in connection with *reinforced concrete* construction, shall mean Portland Cement, High Early Strength

Cement, or such other *cement* as may be permitted by the *authority having jurisdiction*.

Chimney shall mean an upright shaft of *masonry* or *reinforced concrete* containing and encasing one or more *flues*.

Closure shall be understood to be a general term including doors, windows, or other devices filling openings in walls, *partitions*, floors, or roofs.

Closure, Fire-resistive, shall mean a *closure* capable of functioning satisfactorily under prescribed conditions of exposure to fire.

Column shall mean an upright compression member, the length of which exceeds three times its least lateral dimension.

Column, Composite Reinforced Concrete, shall mean a *column* in which all or part of the longitudinal reinforcement consists of a structural steel or cast iron section.

Column, Ordinary Reinforced Concrete, shall mean a *column* reinforced with longitudinal bars and closely spaced spirals or with longitudinal bars and lateral ties.

Column, Short Reinforced Concrete, shall mean a *reinforced concrete column* in which the ratio of unsupported length to the least lateral dimension is not greater than 12.

Column Capital. See Flat Slab Construction.

Column Strip. See Flat Slab Construction.

Combustible as applied to a material, shall mean any material other than *incombustible* material.

Concrete shall mean a mixture of *cement*, *fine aggregate*, *coarse aggregate*, and water.

Concrete, Cellular, shall mean *concrete* in which the matrix has uniformly distributed pores throughout its mass.

Concrete, Plain, shall mean *concrete* without reinforcement; or *concrete* containing reinforcement, that does not comply with the requirements of this Code for *reinforced concrete*; and shall include *cellular concrete*.

Concrete, Reinforced, shall mean *concrete* containing reinforcement embedded in such a manner that the two materials act together in resisting forces, and complying with the requirements of Section 3.4 of this Code.

Corbel shall mean a horizontal projection on the face of a wall formed by one or more courses of *masonry* each projecting over the course below.

Corbelling. See Corbel.

Consistency is a general term used to designate the relative plasticity of freshly mixed *concrete* or *mortar*.

Court. See **Court, Inner** and **Court, Outer**.

Court, Height of, shall mean the vertical distance from the lowest level of such *court* to the highest point of any bounding wall. Where the *court* bottom is the roof of any lower *storey* of a building, which lower *storey* contains rooms intended for human use, and a skylight or other opening forming the sole lighting or ventilating medium is provided therein for such rooms, the *height of the court* shall be measured from the floor level of the lowest *storey* so receiving light or ventilation from such skylight or opening to the highest point of any bounding wall.

Court, Inner, shall mean an open space, unoccupied from the ground to the sky or from an intermediate floor to the sky except for *structures* specifically authorized by this Code, located on the same *lot* with the building which it serves, and enclosed on all sides by walls, or by walls and the *line or lines* of an adjoining *lot* or *lots*.

Court, Length of, shall mean, in the case of an *outer court*, the mean horizontal distance between the open end and the closed end of the *court*, and, in the case of an *inner court*, the greatest horizontal dimension of such *court*.

Court, Outer, shall mean an open space, unoccupied from the ground to the sky or from an intermediate floor to the sky except for *structures* specifically authorized by this Code, located on the same *lot* as the building which it serves, enclosed on three sides by walls or by walls and the *line* of an adjoining *lot* or *lots* and extending to or opening upon a *street* or *yard*.

Court, Width of, shall mean, in the case of an *outer court*, the least horizontal distance between the sides of such *court*, as distinguished from the open and closed ends of the *court*, and, in the case of an *inner court*, the least horizontal dimension of such *court*.

Curing (of Concrete) shall mean the maintenance of proper temperature and moisture conditions to promote the continued chemical reaction which takes place between the water and the *cement*.

Deformed Bar shall mean a reinforcement bar with closely spaced shoulders, lugs, or projections formed integrally with the bar during rolling so as to engage firmly the surrounding *concrete*.

Detached shall mean, when applied to a building containing a certain occupancy, that the walls and roof of such a building are independent of any other building and provide shelter for only the one class of occupancy indicated.

Diagonal Band. See **Flat Slab Construction**.

Direct Band. See **Flat Slab Construction**.

Door, Fire Resistive. See **Closure, Fire Resistive.**

Dropped Panel or Drop. See **Flat Slab Construction.**

Dwelling, Multiple, shall mean any building or part thereof designed, intended, or used for a residential occupancy consisting of more than two *dwelling units*, and shall include apartment houses, terraces, rows, and group houses.

Dwelling, One-family, shall mean any building or part thereof designed, intended, or used for a residential occupancy consisting only of one *dwelling unit*.

Dwelling, Two-family, shall mean any building or part thereof designed, intended, or used for a residential occupancy consisting only of two *dwelling units*.

Dwelling Unit shall mean a room, or a suite of two or more rooms, designed, or intended for use by an individual or family, in which facilities are provided for cooking or for the installation of cooking equipment.

Existing with reference to a **structure**, shall mean a *structure* already erected, or one for which a legal permit has been issued prior to the adoption of this Code; with reference to an occupancy, it shall mean an occupancy in a building, existing prior to the adoption of this Code.

Exit shall mean a channel or means of egress providing passage from any building, *storey*, or *floor-area* to a *street* or other open space of equal safety.

Exit, Horizontal, shall mean the connection by a bridge, balcony, vestibule, or doorway of two *floor-areas* at substantially the same level; such *floor-areas* being located either in different *structures* or located in the same building and entirely separated from each other by construction having a *fire-resistance rating* of at least 2 hours with all openings therein protected by *fire-resistive closures*.

Fire Escape shall mean one or more flights of stairs and the necessary landings or platforms connecting them, attached to the exterior of a building, providing access to the ground in case of an emergency and not fulfilling the requirements herein specified for an exterior *stairway*.

Fire-resistance Rating shall mean the minimum period of time during which an element of a *structure* may be expected to function satisfactorily whilst subjected to prescribed conditions of heat and load. (These prescribed conditions and the degree of satisfaction required constitute a specification for a fire test.) This term is sometimes abbreviated to "fire-resistance", e.g., a fire resistance of 2 hours; or again, the term may be implied, e.g., 2-hour construction. (See Article 4.7.2.)

Flammable and its derivatives, "*non-flammable*", "*very low flammability*", and "*low flammability*" shall have the meanings defined in C.E.S.A. Specification A54-1940 entitled, "Fire Tests on Building Construction and Materials".

Flat Slab Construction

Flat Slab shall mean a *concrete* slab reinforced in two or more directions, without *beams* or *girders*, except wall or trimmer *beams*, to transfer the loads to supporting *columns*.

Column Capital shall mean an enlargement of the upper end of a *reinforced concrete column* designed and built to act as a unit with the *column*.

Column Strip shall mean a portion of a *flat slab* panel one-half panel in width occupying the two quarter panel areas outside of the *middle strip*, and extending through the panel in the direction in which bending moments are being considered.

Diagonal Band shall mean a group of bars in a *flat slab* placed symmetrically with respect to the diagonal running from corner to corner of the panel.

Direct Band shall mean a group of bars in a *flat slab* placed symmetrically with respect to the centre lines of the supporting *columns*.

Dropped Panel or Drop shall mean the structural portion of a *flat slab* which is thickened throughout an area surrounding the *column capital*.

Middle Strip shall mean a portion of a *flat slab* panel one-half panel in width, symmetrical with respect to the panel centre line and extending through the panel in the direction in which bending moments are being considered.

Panelled Ceiling shall mean the ceiling of a *flat slab* in which approximately that portion of the area enclosed within the intersection of the two *middle strips* is reduced in thickness.

Panel Length shall mean the distance along a panel side from centre to centre of *columns*.

Floor, Laminated, shall mean a floor consisting of scantlings or planks placed on edge and securely nailed together.

Floor-area shall mean an area on any floor, enclosed by exterior walls; or by exterior walls, and interior walls or *partitions* having a *fire-resistance rating* of not less than 2 hours in which all openings are protected by *self-closing* or *automatic fire-resistive closures*.

Floor Panel, or floor panel assembly, shall mean a floor or portion of a floor supported by walls, *columns*, or *beams* other than *joists*; and shall include any *joists*, ribs, or fillers.

Flue shall mean a confined space provided for the conveyance to the outer air of any product of combustion resulting from the operation of any heat producing appliance or equipment employing solid, liquid, or gaseous fuels; and it shall include *chimney flue*, *gas flue*, *smoke pipe*, and *gas vent*.

Flue, Chimney, shall mean a *flue* contained in a *chimney*, leading directly to the outer air, vertical wherever reasonably possible, and in no case inclined at more than 45 degrees to the vertical.

Flue, Gas, shall mean a permanently installed *flue* leading directly to the outer air, vertical wherever reasonably possible, intended to serve any gas appliance excepting a gas-fired incinerator, and having flue gas temperatures not in excess of 550 F. at the outlet of the draft hood when operating at maximum rated input.

Flue Lining shall mean a lining applied to the inside of a *chimney* in order to form a *flue* having smooth, smoke-tight, crack-free walls which will remain unaffected by the degree of heat and corrosion for which such *flue* is designed, as well as unaffected by the weather.

Footing shall mean that part of a *foundation* which is provided to distribute loads to the bearing materials or to piles.

Foundation shall mean that part of a *structure* which is below *grade*, which provides support for the superstructure, and which transmits loads on the superstructure to the bearing materials, and shall include *footings*, *foundation walls*, *foundation piers*, and *piles*.

Garage shall mean any building or portion thereof in which one or more motor vehicles containing flammable liquid in their fuel tanks are stored, repaired, used, displayed, or washed.

Garage, Private, shall mean a *garage* intended only for personal use by an individual or family.

Garage, Public, shall mean any *garage* other than a *private garage*. (See definition of *public* also.)

Gas Cutting shall mean the process of severing ferrous metals by means of oxygen in the presence of high temperature, so as to produce a kerf or cut of uniform width without burning the edges of the kerf or cut.

Girder shall mean a *beam* supporting *columns* or *beams* other than *joists*.

Grade shall mean

- (i) for buildings adjoining one *street* only, the elevation of the sidewalk at the centre of that wall adjoining the *street*;
- (ii) for buildings adjoining more than one *street*, the average of the elevation of the sidewalk at the centres of all walls adjoining the *street*;

- (iii) for buildings having no wall adjoining the *street*, the average level of the ground (finished surface) adjacent to the exterior walls of the building.

All walls approximately parallel to and not more than 15 feet from the *street line* are to be considered as adjoining a *street*.

Hallway shall mean a space in a building, intended to provide a communicating passageway between rooms or suites of rooms, and shall include a corridor.

Height of Building

(a) The **height of a building in feet** shall mean the vertical distance in feet between a horizontal plane through *grade* level and a horizontal plane through,

- (i) the highest point of the roof assembly, in the case of a building with a flat roof or a deck roof;
- (ii) the average level of a one-slope roof provided that such a roof having a slope of less than 20 degrees with the horizontal shall be considered a flat roof;
- (iii) the average level between eaves and ridge in the case of a pitched, gambrel, mansard, or hipped roof.

However, if any main exterior wall which is *combustible* extends above the roof in the form of a false front, facade, or *parapet wall*, its highest point shall be considered the highest point of the building.

(b) The **height of a building in storeys** shall mean the number of *storeys* contained between its roof and the floor of its *first storey*. Balconies or galleries in *places of assembly* shall not be considered as increasing the *height of a building in storeys*. Space under tiers of seats in buildings of the arena type shall not be considered as adding to the *height of a building in storeys* provided such space is employed only for purposes incidental to the major use of the building, i.e., dressing rooms, wash rooms, mechanical equipment rooms, etc. A *mezzanine floor* or floors shall not be considered as increasing the *height of a building in storeys* provided that their aggregate area does not exceed 40 per cent of the area of the room or *storey* in which they are located, provided further that the space beneath the *mezzanine* is not enclosed, and provided finally that the *mezzanine* overhang does not exceed 40 per cent of the least dimension of any room in which it is located.

Height of Room, shall mean the clear vertical distance between the finished floor and the finished ceiling of such room.

Hotel shall mean a building or part thereof wherein accommodation without private cooking facilities is provided for transient lodgers, having a public register in an office where an attendant is present at all times, and having a public dining room or café.

House, Lodging, shall mean a building or part thereof other than a *hotel* wherein lodging without private cooking facilities is provided

for compensation pursuant to previous arrangement and not necessarily to anyone who may apply; but shall not include a single *dwelling unit* within which not more than four sleeping rooms are provided for compensation.

Incombustible. See **Non-combustible**.

Inflammable. See **Flammable**.

Joist shall mean one of a series of floor, roof, or ceiling *beams* spaced not more than 30 inches on centres.

Joist, Ceiling, shall mean one of a number of *beams* supporting a ceiling; there being no finished floor immediately above.

Joist, Floor, shall mean one of a number of *beams* supporting a floor.

Joist, Roof, shall mean one of a number of *beams* supporting a horizontal roof.

Laitance shall mean extremely fine material of little or no hardness which may collect on the surface of freshly deposited *concrete* or *mortar*, resulting from the use of excess mixing water, and usually recognized by its relatively light colour.

Lane shall mean any *passageway* or right-of-way, open from ground to sky, not constituting a *street* but laid down upon a registered plan and dedicated to public use, or legally dedicated as a right-of-way for use in common by adjacent land owners.

Load, Dead, shall mean the weight of all permanent stationary construction entering into and becoming a part of a *structure*.

Load, Live, shall mean all loads except *dead loads* that may be imposed on a *structure*. Wind loads shall be considered as *live loads*.

Lot shall mean the minimum area of land used, or intended to be used, as the site of or appurtenant to any building, as described in the application for a building permit, whether such land is shown on a registered sub-division or described by metes and bounds.

Lot Line shall mean the division line between any two or more *lots* or between any *lot* and a *lane*, and shall include any line bounding a *lot* other than a *street line*.

Masonry shall mean any of the following types of construction:

- (a) Unit *masonry*, when laid up in *mortar*.
- (b) *Plain concrete*.
- (c) Poured or pre-cast gypsum, plain and reinforced.

Masonry, Hollow, shall mean (i) hollow monolithic *masonry*, (ii) hollow *masonry* built of *solid units*, (iii) *masonry* built of *hollow units*, and (iv) *masonry* built of any combination of *hollow* and *solid units*.

Masonry, Solid, shall mean *masonry* composed entirely of *solid units* without enclosed air spaces between such units.

Mezzanine Floor shall mean a substantially level, intermediate floor in any *storey*, overhanging and overlooking a floor beneath.

Modulus of Rupture shall mean the calculated maximum fibre stress at failure of a rectangular *beam*, in which failure is primarily due to excessive flexural stress, on the assumption of a linear variation of stress.

Mortar, when referred to in connection with *masonry* construction, shall mean a plastic material consisting essentially of *cement*, lime, or gypsum, and *aggregate*, used to bond *masonry* units.

Mortar, when referred to in connection with *reinforced concrete* construction, shall mean a mixture of *cement*, fine *aggregate*, and water.

Non-combustible as applied to a material, shall have the meaning defined in C.E.S.A. Specification A54-1940 entitled, "Fire Tests on Building Construction and Materials".

Non-flammable. See **Flammable**.

Opening, Vertical, shall mean an opening in a floor between *storeys* of building, or in a ceiling between a *storey* and an attic space. It shall include openings for stairs, elevators, air wells, and dumb-waiters, but shall not generally include openings for pipes, heating or ventilating ducts, or electrical conduits.

Partition shall mean an interior wall not more than one *storey in height*.

Passageway, Exterior, shall mean a space, open from the ground to the sky, forming part of an *exit* from a building, and having *direct access* to a *street*.

Passageway, Interior, shall mean a substantially horizontal way within a building, kept clear for use as an *exit*, or part of an *exit*, from any *floor-area*.

Penthouse shall mean an enclosed *structure* other than a *bulkhead* on the roof of a building.

Pier shall mean a *masonry column* whether isolated or bonded at its sides to other *masonry*.

Pier, Isolated, shall mean a *pier* not bonded at its sides to other *masonry*.

Pilaster shall mean a *pier* forming part of a wall, partially projecting therefrom, and bonded thereto.

Plumbing System shall mean, severally and individually; the water distribution system; all fixtures and fixture traps; the drainage

system; the house sewer; any private sewage disposal system; all leaders, together with all their devices, appurtenances, and connections.

Private when used with respect to an *accessory room*, or *accessory building*, shall mean that such room or building is an adjunct to or part of one *dwelling unit* only, or of a room or suite of rooms intended only for personal use by an individual or family.

Public when used with respect to a room or other space within a building, shall mean that such room or space is intended to be used in common by the occupants of the building.

Rafter shall mean one of a number of members supporting a sloping roof and running parallel to its slope.

Rating. See **Fire Resistance Rating**.

Reinforcement, Ratio of, shall mean the ratio of the *effective area of the reinforcement* cut by a section of a *beam* or slab to the *effective area* of the *concrete* at that section; the ratio of the area of the longitudinal bars in a *column* to the total area within the protective envelope; the ratio of the volume of spiral reinforcement to the total volume within the outer circumference of the spirals of a *spirally reinforced concrete column*.

Restaurant shall mean any room in which meals are served to the public for a cash consideration.

Roof-area shall mean an area on any roof surrounded by exterior walls either above or below it; or an area delineated by such walls and by interior walls having a required *fire-resistance rating* of 2 or more hours where such interior walls pass through a *combustible* roof or meet an *incombustible* roof; or an area delineated by any of the previous walls together with *masonry* or *reinforced concrete party walls* or *common walls* where the latter walls pass through a *combustible* roof or meet an *incombustible* roof.

Roof Panel, or roof panel assembly, shall mean a roof or portion of a roof supported by walls, *columns*, or *beams* other than *joists*; and shall include any *joists*, ribs, or fillers.

Room, Accessory, shall mean any room other than a *habitable room*, *business* or *work room*, or *assembly room*, and shall include a vestibule, *private hallway*, *private stairway*, water-closet room or bathroom, *private* laundry or recreation room, pantry or storage room, *private* furnace room, *private garage*, or other space that is not used frequently or during extended periods.

Room, Assembly, shall mean any room other than a *habitable room*, *business* or *work room*, used by persons assembling for civic, political, religious, educational, social, recreational, or amusement purposes, and shall include also travellers' waiting rooms.

Room, Business or Work, shall mean any room used by one or more persons for office, clerical, or administrative purposes and any room occupied as a store, salesroom, *restaurant*, market, bakery, factory, workshop, warehouse, machinery room or boiler room, laboratory, *garage* other than a *private garage*, laundry other than one accessory to a *dwelling unit*.

Room, Habitable, shall mean any room, other than a *business* or *work room*, that is used by one or more persons for living, sleeping, eating, or food preparation and shall include a private sitting room, dining room other than a *restaurant*, bedroom, *private* kitchen, hospital ward or sickroom, cell in an *institutional building*; provided that, for purposes of lighting and ventilation, classrooms and study rooms in schools and educational institutions shall be considered as *habitable rooms*.

Room, Height of. See **Height of Room.**

Rubble shall mean *masonry* built of irregularly shaped *stone* units.

Self-closing as applied to a *closure*, shall mean that such a *closure* is normally closed, and will promptly return to the full closed position whenever it is opened and released.

Shaft shall mean a more or less vertical compartment extending through one or more *storeys* of a building or through an attic space, connecting a series of two or more openings in successive floors, or in a floor and a roof, or in a ceiling and a roof; and shall include elevator, dumbwaiter, and conveyor *shafts* but shall not include ducts forming an integral part of a heating or ventilating system.

Sheathing in wood construction shall mean material attached directly to either face of the studs of a stud wall, or to the upper face of *roof joists* or *rafters*.

Shell when used in reference to a *hollow masonry unit*, shall mean an outer wall of the unit.

Siding in wood frame construction shall mean material other than *masonry* used as an exterior wall covering.

Smoke Pipe shall mean a pipe connected to a heat appliance burning solid or liquid fuel conveying products of combustion to a *chimney flue*, or, where no *chimney flue* is required, to the outer air.

Stage shall mean a raised platform in a *place of assembly*, cut off from the audience section by a proscenium wall where the wing space is over 3 feet beyond the proscenium opening on one or both sides or where there is more than 3 feet of space above the proscenium opening.

Stairway shall mean one or more flights of stairs and the necessary landings or platforms connecting them, forming a continuous and uninterrupted path of travel from one *storey* to another; and shall

include an escalator. In the case of an exterior *stairway*, the continuous and uninterrupted path of travel shall be from any *storey* except the *first* to the ground.

Stone shall mean natural *stone*.

Stone, Cast, shall mean solid pre-cast *concrete* units.

Storey shall mean that portion of any building which is situated between the top of any floor and the top of the floor next above it, if there be no floor above it, that portion between the top of such floor and the ceiling above it.

Storey, First, shall mean the *storey* closest to *grade* having its ceiling more than 6 feet above *grade*. (Thus in considering the *height of building in storeys*, a *basement* having a ceiling which is 6 feet or less above *grade* need not be considered.)

Storey, Second, shall mean the *storey* located immediately above the *first storey*.

Straight Slide Escape, Enclosed, shall mean a straight tubular chute attached to the outside of a building for use as an emergency *exit*.

Street shall mean a public or common highway in an urban or suburban district, affording principal means of access to abutting property.

Street Line shall mean the division line between a *lot* and a *street*.

Structural Steel, Unidentified, shall mean structural steel whose classification has not been identified to the satisfaction of the *authority having jurisdiction*.

Structure shall mean a building or construction of any kind.

Theatre shall mean any *place of assembly*, in which movable scenery is employed.

Theatre, Motion Picture, shall mean any *place of assembly* in which moving pictures are shown.

Tile, End Construction, shall mean hollow structural tile or *block* designed to receive its principal stress parallel to the longitudinal axes of the cells.

Tile, Facing, shall mean *solid units* designed to be laid on a backing of other *masonry* and supported solely by a *mortar* joint.

Unit (Masonry), Hollow, shall mean a structural *masonry unit* with a *net area* less than 75 per cent of its *gross area*.

Unit (Masonry), Solid, shall mean any structural *masonry unit* other than a *hollow unit*.

Veneer. See Wall, veneered.

Vent, Gas, shall mean a pipe connecting a gas appliance with a *gas flue*.

Wall, Bearing, shall mean a wall that supports any load other than its own weight.

Wall, Common, shall mean a vertical separation completely dividing a portion of a *structure* from the remainder of the *structure* and creating in effect a building which from its roof to its lowest level is separate and complete unto itself for the purpose for which it is designed, intended, or used, such wall being owned by one party but jointly used by two parties one or both of whom is entitled to such use under the provisions of a lease.

Wall, Curtain, shall mean a *non-bearing wall* between *columns* or *piers* that is not supported at each floor by a *girder* or *beam*.

Wall, Enclosure, shall mean an exterior *non-bearing wall* in skeleton construction anchored to *columns*, *piers*, or floors, but not necessarily built between *columns* or *piers*.

Wall, Faced, shall mean a wall in which the *masonry* facing and backing are so bonded as to exert a common action under load.

Wall, Foundation, shall mean any *bearing wall* situated below the first floor above *grade*, having any part of one or both sides in contact with the soil.

Wall, Non-bearing, shall mean a wall that supports no load other than its own weight.

Wall, Panel, shall mean a *non-bearing wall* in skeleton construction built between *columns* or *piers* and wholly supported at each *storey*.

Wall, Parapet, shall mean that part of any wall which is situated entirely above the highest roof immediately adjacent to it.

Wall, Party, shall mean a wall used jointly by two parties under easement agreement and erected at or upon a line separating two parcels of land held under different ownership.

Wall, Veneered, shall mean a wall having a facing of *masonry* material which is attached but not bonded to the backing.

Water, Surface, shall mean the water carried by the *aggregate* except that held by absorption within the *aggregate* particles themselves.

Weld, Butt, shall mean a weld joining together parts that do not overlap.

Weld, Fillet, shall mean a weld of approximately triangular cross-section joining together parts that overlap or that meet at an angle.

Weld, Plug, shall mean a weld joining two parts by means of a plug of weld metal deposited in a circular hole in one part, fusion being obtained between the weld metal and the parent metal of both parts.

Welding, Fusion, shall mean the process of joining metal parts by means of the metallic arc or gas welding process.

Window, Fire-resistive. See **Closure, Fire-resistive.**

Yard shall mean an open space located on the same *lot* as the building which it serves, unoccupied from the ground to the sky or from an intermediate floor to the sky except for *structures* specifically authorized by this Code, and which extends along the entire length of a *lot line* or a *street line*.

PART 3
OF THE
NATIONAL BUILDING CODE

STRUCTURAL REQUIREMENTS

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N.R.C. NO. 1068 (BOOK 2)

PART 3

STRUCTURAL REQUIREMENTS

For definitions, see Part 2

SECTION 3.1 GENERAL REQUIREMENTS

3.1.1 General.—All *structures* shall be so designed, built, and maintained that under the conditions of *dead* and *live loading* specified herein the stresses permitted in this Code will not be exceeded in any of the materials of construction or in the material on which a *structure* rests.

3.1.2 Design and Supervision.—All work carried out under these regulations shall be designed and supervised by a fully competent architect or engineer or other competent person, and all plans shall be signed by the person responsible for them.

3.1.3 New Materials and Methods of Construction.—Materials and methods of construction not specifically regulated by this Code may be permitted provided their suitability and safe working stresses have been *approved* by the *authority having jurisdiction* on the basis of laboratory tests carried out by a publicly owned or other recognized laboratory.

SECTION 3.2 WOOD CONSTRUCTION

3.2.1 General.—The quality and design of all wood construction, except finish and millwork, used in any building or other *structure* shall conform to the requirements of this Section.

All members shall be so framed, anchored, tied, and braced together as to develop the strength and rigidity necessary for the purpose for which they are used.

When timber construction is used in connection with *masonry* or *reinforced concrete* walls, the walls shall be tied to the interior timber construction at each floor and at the roof at horizontal intervals as required by design loads and stresses.

Where the *joists*, *rafters*, or *beams* are supported by wooden *girders*, such *girders* shall be anchored to the walls so as to furnish resistance as required by the design loads and stresses.

Workmanship in fabrication, preparation, and installation of material shall conform throughout to good engineering practice.

3.2.2 Symbols.—All symbols used in this Section are here collected for convenience of reference.

They are defined as follows:

A = area in square inches of net cross-section of a *column* or strut;

b = breadth of a *beam* in inches;

d = depth of a *beam* in inches; the least cross-sectional dimension of a *column* or strut in inches;

d_1 = depth of a *beam* at a notch in inches;

E = modulus of elasticity in pounds per square inch;

f_c = allowable unit stress in pounds per square inch in compression parallel to the grain for short *columns*;

Note: K is the maximum ratio of unsupported length to least dimension for which the Euler formula may be used (see Item 3.2.6.1).

$$K = 0.64 \sqrt{\frac{E}{f_c}}$$

L = unsupported length of a *column* in inches;

n = allowable unit stress in pounds per square inch, normal to a plane inclined to the grain of a wood member; the safe load, in pounds, on a bolt carrying a load inclined to the grain of a wood member;

P = allowable load in pounds on a compression member;

p = allowable compressive stress, in pounds per square inch, parallel to the grain; the safe load, in pounds, on a bolt carrying a load parallel to the grain of a wood member;

q = allowable compressive stress, in pounds per square inch, perpendicular to the grain; the safe load, in pounds, on a bolt carrying a load perpendicular to the grain of a wood member;

V = shearing force, in pounds;

v = unit shearing stress, in pounds per square inch;

θ = angle between the direction of the load and the direction of the grain.

3.2.3 Quality of Materials

3.2.3.1 Classification of Lumber.—For the purpose of assigning allowable unit stresses to lumber used where its strength is the controlling consideration, two general classes of lumber shall be recognized, namely, "Structural Lumber" and "Yard Lumber".

(a) **Structural Lumber.**—Structural Lumber shall conform to the requirements for the grades given in the C.E.S.A. "Standard Specification for Structural Timbers" A43-1937 as amended in 1940.

(b) **Yard Lumber.**—Yard Lumber shall consist of grades not specifically designated as Structural Lumber and shall comply with Item 3.2.3.1 (a) as to dimensions.

3.2.3.2 Use of Structural Lumber.—Except as otherwise provided herein all framing shall be of Structural Lumber.

3.2.3.3 Use of Yard Lumber.—

(a) **General.**—In addition to the grade requirements presented in the succeeding paragraphs of this Item it is stipulated that no actual piece of lumber of obviously unsuitable quality shall be used in any construction.

(b) Sheathing, Sub-flooring and Plank Wall Construction.—Yard Lumber may be used for wall and roof *sheathing*, sub-flooring and plank wall construction provided that no grade of such lumber shall be below No. 5 Common for White Pine; No. 4 (Quebec 5ths) for Eastern Spruce; No. 1 Cull for Red Pine; No. 3 Common for Douglas Fir, Western Hemlock, Western Red Cedar, and Western Spruce; or equivalent grades of Jack Pine, Eastern Hemlock, Eastern Cedar and other species.

(c) Framing.—Yard Lumber may be used for wall framing, floor and ceiling *joists*, *rafters*, built-up *beams* and studding provided that no grade of such lumber shall be below No. 3 Common for White Pine; No. 3 (Quebec 4ths) for Eastern Spruce; "Merchantable" for Red Pine; No. 2 Common for Douglas Fir, Western Hemlock, Western Red Cedar, and Western Spruce; or equivalent grades of Jack Pine, Eastern Hemlock, Eastern Cedar and other species.

For floor and ceiling *joists*, *rafters*, and lumber used in built-up *beams*, the sizes of which are 2 by 8 inches nominal and up, the next higher grade shall be used, namely, No. 2 Common for White Pine; No. 2 (Quebec 3rds) for Eastern Spruce; "Select Merchantable" for Red Pine; No. 1 Common for Douglas Fir, Western Hemlock, Western Red Cedar, and Western Spruce; or equivalent grades of Jack Pine, Eastern Hemlock, Eastern Cedar and other species.

(d) Designation of Grades.—The grades referred to in the above requirements are those in effect on 30 September, 1940, and prescribed by the White Pine Bureau, Toronto, for White Pine and Red Pine, the Canadian Lumbermen's Association of Ottawa for Eastern Spruce and the B.C. Lumber and Shingle Manufacturers' Association of Vancouver for Douglas Fir, Western Hemlock, Western Red Cedar, and Western Spruce.

3.2.4 Determination of Required Sizes.—In determining the safe load which a member will sustain or in determining the required sizes of a member the following provisions shall govern:

(a) Rough Lumber.—Where rough lumber is used, the full nominal size of the member may be used for the determination of the size required, provided that the actual dimensions are not less than those prescribed in C.E.S.A. Specification A43-1937 as amended in 1940. (See Clauses 29, 44, and 60.)

(b) Surfaced Lumber.—Where surfaced lumber is used, the minimum surfaced (dressed) sizes shall be used in determining the size required in all instances.

3.2.5 Allowable Unit Stresses

3.2.5.1 Basic Unit Stresses.—

(a) Structural Lumber.—Except as provided herein, the allowable stresses for Structural Lumber shall not exceed the values given in Table 1 of this Section. For species and established grades not given in Table I the working stresses used shall be those recommended by the Forest Products Laboratories of Canada, Ottawa.

(b) **Yard Lumber.**—The allowable working stresses permitted for Structural Lumber (C.E.S.A. grade) shall apply when the grades of Yard Lumber permitted in the second paragraph of Item 3.2.3.3 (c) are used. The allowable working stresses for the grades of Yard Lumber permitted in the first paragraph of Item 3.2.3.3. (c) shall be 80 per cent of the above values.

TABLE I (SECTION 3.2)

ALLOWABLE WORKING STRESSES FOR STRUCTURAL TIMBER

SELECT STRUCTURAL GRADE*

Species	Bending lb. per sq. in.			Compression lb. per sq. in.	
	Stress at Extreme Fibre	Modulus of Elas- ticity	Hori- zontal Shear	Perpen- dicular to Grain	Parallel to Grain (Short Columns)
Cedar — Eastern	750	800,000	70	175	600
— Western	900	1,000,000	80	200	800
Douglas Fir — Coast	1600	1,600,000	100	350	1200
— Coast Dense	1750	1,600,000	105	380	1300
— Mountain	1200	1,400,000	90	325	1000
Fir — Amabilis	1100	1,100,000	75	175	800
— Balsam	1100	1,100,000	75	175	800
Hemlock — Eastern	1100	1,100,000	80	300	800
— Western	1300	1,400,000	85	300	1000
Larch — Tamarack	1200	1,300,000	90	325	1000
— Western	1300	1,400,000	90	325	1000
Pine — Jack	1100	1,100,000	75	275	800
— Lodgepole	1100	1,100,000	75	275	800
— Red	1200	1,300,000	85	300	900
— Western White	1000	1,000,000	85	250	800
— " Yellow	1200	1,300,000	85	300	900
— White	1000	1,000,000	85	250	800
Spruce — Eastern	1100	1,200,000	85	250	800
— Sitka	1100	1,200,000	85	250	800
— Engelmann	1100	1,200,000	85	250	800
Beech	1600	1,500,000	120	350	1200
Birch — Yellow	1600	1,600,000	130	350	1200
Elm — White	1300	1,400,000	110	325	900
Maple — Hard	1700	1,600,000	140	500	1200
Oak — Red and White	1400	1,500,000	100	400	1000

*C.E.S.A. Specification A-43-1937 as amended 1940

TABLE I (SECTION 3.2)—*Continued*

STRUCTURAL GRADE*

Species	Bending lb. per sq. in.			Compression lb. per sq. in.	
	Stress at Extreme Fibre	Modulus of Elas- ticity	Hori- zontal Shear	Perpen- dicular to Grain	Parallel to Grain (Short Columbus)
Cedar — Eastern	600	800,000	56	175	480
— Western	720	1,000,000	64	200	640
Douglas Fir — Coast	1280	1,600,000	80	350	960
— Coast Dense	1400	1,600,000	84	380	1040
— Mountain	960	1,400,000	72	325	800
Fir — Amabilis	880	1,100,000	60	175	640
— Balsam	880	1,100,000	60	175	640
Hemlock — Eastern	880	1,100,000	64	300	640
— Western	1040	1,400,000	68	300	800
Larch — Tamarack	960	1,300,000	72	325	800
— Western	1040	1,400,000	72	325	800
Pine — Jack	880	1,100,000	60	275	640
— Lodgepole	880	1,100,000	60	275	640
— Red	960	1,300,000	68	300	720
— Western White	800	1,000,000	68	250	640
— " Yellow	960	1,300,000	68	300	720
— White	800	1,000,000	68	250	640
Spruce — Eastern	880	1,200,000	68	250	640
— Sitka	880	1,200,000	68	250	640
— Engelmann	880	1,200,000	68	250	640
Beech	1280	1,500,000	96	350	960
Birch — Yellow	1200	1,600,000	104	350	960
— White	1040	1,400,000	88	325	720
Maple — Hard	1360	1,600,000	112	500	960
Oak — Red and White	1120	1,500,000	80	400	800

*C.E.S.A. Specification A43-1937 as amended 1940

3.2.5.2 Decrease of Unit Stresses for Various Conditions of Exposure.—In Table I the working stresses apply to timbers when used in continuously dry locations. For the conditions of "occasionally wet and quickly dried" and of "continually wet" the allowable unit stresses given in Table I shall be multiplied by the following reduction factors expressed in percentages:

Function	Occasionally wet and quickly dried	Continually wet
Stress at Extreme Fibre	85	70
Modulus of Elasticity	100	100
Horizontal Shear	100	100
Compression		
Perpendicular to grain	75	60
Parallel to grain	90	80

3.2.5.3 Increase of Unit Stresses for Intermittent Loading.—

When members are designed for an intermittent *live load* or one of infrequent occurrence and having a duration of less than 4 hours under maximum conditions, unit stresses for bending in the extreme fibre, and compression parallel to the grain, may be increased 25 per cent.

3.2.5.4 Increase of Unit Shear Stress in Joints.—The maximum allowable unit stress in horizontal shear may be increased 50 per cent for the purpose of assigning safe allowable unit shearing stress values in designing the details of joints.

3.2.5.5 Increase of Unit Stress in Compression Perpendicular to the Grain.—For *joists* spiked to the studding and supported on a ribbon board gained into the studding (Balloon Frame Construction) the allowable unit stress in compression perpendicular to the grain may be increased 50 per cent, provided that the vertical load shall be considered to be transferred directly to the ribbon. For other bearings located 3 inches or more from the end of a timber, the stress may be increased by the following factor:

Length of Bearing (Inches)	1/2	1	1-1/2	2	3	4	6 (or more)
Factor	1.85	1.60	1.45	1.30	1.15	1.10	1.00

In calculating the bearing area at the ends, or intermediate points, no allowance need be made for the fact that as the *beam* bends the pressure upon the edge or edges of the bearing is greater than at the opposite edge or the edges respectively.

For stress under washers, small plates, or the like, the same factor may be taken as for a bearing, the length of which equals the diameter of the washer or the length of the plate.

3.2.5.6 Compression on Inclined Surfaces.—The unit stress normal to a plane inclined to the grain of a wood member shall not exceed that determined from the formula:

$$n = \frac{p q}{p \sin^2 \theta + q \cos^2 \theta}$$

where

- n is the allowable unit stress on inclined surface, pounds per square inch;
 - p the allowable compressive unit stress parallel to grain (Table I of this Section);
 - q the allowable compressive unit stress perpendicular to grain (Table I of this Section);
- and θ the angle between the direction of the load and the direction of the grain.

3.2.6 Columns and other Compression Members

3.2.6.1 General.—The unit stress in any wood *column* or strut shall not exceed the value given in Table 2 of this Section, which applies to lumber used in continuously dry locations. Where lumber is occasionally wet and quickly dried the values given in Table 2 shall be reduced by 10 per cent and where lumber is continually wet the values shall be reduced by 20 per cent. In no case shall the ratio of unsupported length to least dimension $\frac{L}{d}$ exceed 50.

The unit stresses in Table 2 are based on the following:

(a) **Short Columns.**—Where the ratio of unsupported length to least dimension $\frac{L}{d}$ does not exceed 10:

$$\frac{P}{A} = f_c$$

(b) **Intermediate Columns.**—Where the ratio of unsupported length to least dimension $\frac{L}{d}$ is greater than 10 but where the reduction in allowable stress does not exceed one-third the stress permitted for short *columns*:

$$\frac{P}{A} = f_c \left[1 - \frac{1}{3} \left(\frac{L}{Kd} \right)^4 \right]$$

(c) **Long Columns.**—Where the ratio of unsupported length to least dimension $\frac{L}{d}$ is greater than K :

$$\frac{P}{A} = \frac{\pi^2 E}{36 \left(\frac{L}{d} \right)^2}$$

where

$$K = 0.64 \sqrt{\frac{E}{f_c}}$$

P the total load in pounds;

A the area in square inches of net cross-section;

$\frac{P}{A}$ the working stress or maximum load, in pounds per square inch;

f_c the allowable unit stress in compression parallel to grain for short *columns*, in pounds per square inch (Table 1);

L the unsupported length of *column*, in inches;

d the least dimension of *column*, in inches;

and E the modulus of elasticity, in pounds per square inch.

TABLE 2 (SECTION 3.2)
ALLOWABLE WORKING STRESSES IN POUNDS PER SQUARE INCH, FOR TIMBER COLUMNS
SELECT STRUCTURAL GRADE*

Species	Ratio of length to least dimensions L/d														
	10	12	14	16	18	20	22	24	26	28	30	35	40	45	50
Cedar	600	590	570	560	530	490	440	380	330	280	240	180	140	110	90
	800	780	760	730	690	640	560	480	410	350	310	220	170	140	110
Douglas Fir	1200	1170	1150	1110	1060	990	890	760	650	560	490	360	270	220	180
	1300	1270	1240	1190	1120	1030	900	760	650	560	490	360	270	220	180
	1000	980	960	930	890	810	760	670	570	490	430	310	240	190	150
Fir	800	780	770	750	710	670	610	520	450	390	340	250	190	150	120
Hemlock	800	780	770	750	710	670	610	520	450	390	340	250	190	150	120
	1000	980	960	930	890	840	760	670	570	490	430	310	240	190	150
Larch	1000	980	960	920	880	810	720	620	530	460	400	290	220	180	140
	1000	980	960	930	890	840	760	670	570	490	430	310	240	190	150
Pine	800	780	770	750	710	670	610	520	450	390	340	250	190	150	120
	900	880	870	840	810	760	700	620	530	460	400	290	220	180	140
	800	780	760	730	690	640	560	480	410	350	310	220	170	140	110
Spruce	800	790	770	750	730	690	630	570	490	420	370	270	210	160	130
Beech	1200	1170	1140	1100	1040	960	850	710	610	520	460	340	260	200	160
Birch Maple	1200	1170	1150	1110	1060	990	890	760	650	560	490	360	270	220	180
Elm	900	880	870	850	820	780	730	660	570	490	430	310	240	190	150
Oak	1000	980	970	940	910	860	790	710	610	520	460	340	260	200	160

*C.E.S.: Specification A-43-1937 as amended 1940

STRUCTURAL GRADE*

Species	Ratio of length to least dimension L/d														
	10	12	14	16	18	20	22	24	26	28	30	35	40	45	50
Cedar	480 640	470 630	470 620	460 610	440 590	430 560	400 520	370 470	320 410	280 350	240 300	180 220	140 170	110 140	90 110
Douglas Fir	960 1040 800	950 1020 790	930 1010 780	920 980 770	890 950 750	850 900 720	800 830 680	730 730 630	650 650 560	560 490 430	490 360 310	360 360 310	270 270 240	220 220 190	180 180 150
Fir	640	630	620	610	600	570	540	500	440	380	340	250	190	150	120
Hemlock	640 800	630 790	620 780	610 770	600 750	570 720	540 680	500 630	440 560	380 490	340 430	250 310	190 240	150 190	120 150
Larch	800 800	790 790	780 780	760 770	740 750	700 720	660 680	600 630	530 560	450 490	400 430	290 310	220 240	180 190	140 150
Pine	640	630	620	610	600	570	540	500	440	380	340	250	190	150	120
— Jack — Lodgepole															
— Red	720	710	700	690	670	650	620	580	520	450	400	290	220	180	140
— Western Yellow															
— Western White	640	630	620	610	590	560	520	470	410	350	300	220	170	140	110
— White															
Spruce	640	630	630	620	600	580	560	520	480	420	370	270	210	160	130
— Eastern															
— Sitka															
— Engelmann	960	940	930	910	880	840	780	700	610	520	460	340	260	200	160
Beech															
Birch	960	950	930	920	890	850	800	730	650	560	490	360	270	220	180
Maple															
— Yellow															
— Hard															
Elm	720	710	710	700	680	660	630	600	550	490	430	310	240	190	150
— White															
Oak	800	790	780	770	750	730	690	650	600	520	460	340	260	200	160
— Red and White															

*C.E.S.A. Specification A.43-1937 as amended 1940.

3.2.6.2 Round Columns.—The safe load on a *column* of round cross section shall not exceed that permitted for a square *column* of the same cross-sectional area.

3.2.6.3 Built-up Columns.—The compressive strength of built-up *columns* or compression members, when composed of two or more members spiked or bolted together, either with or without spacing blocks between members, shall be taken as the combined compressive strength of the individual pieces, each considered as an independent *column*; provided, however, that compression members which are fastened together at intervals not exceeding six times the thickness of each piece by bolts or timber connectors or which are laterally braced parallel to the least dimension of the individual members, may be calculated as having 80 per cent of the compressive strength of *columns* having a slenderness ratio $\frac{L}{d}$ based on the least overall dimension of the composite member.

The design of spaced compression members shall be based upon principles acceptable to the *authority having jurisdiction*

3.2.6.4 Detailed Requirements. All wood *columns* and posts shall be framed to true and bearings; shall extend down to supports of such design as to hold securely the *column* or posts in position and to protect its base from deterioration; shall be supported in *basements* or *cellars* by *footings* projecting at least two inches above the finished floor; shall not rest directly or indirectly on floor *beams* except in cases where there is no *column* below

Preservatives shall be applied to *column* ends where necessary to protect against decay.

Untreated wood *columns* in *basements* or *cellars*, when built into masonry *partitions* or walls, shall be exposed on at least two sides.

3.2.7 Beams and Other Flexural Members

3.2.7.1 Horizontal Shear.—The maximum unit stress in horizontal shear in *beams* of rectangular cross-section shall be computed by the use of the following formula:

$$v = 1.5 \frac{V}{bd}$$

where

v is the maximum unit horizontal shear stress in pounds per square inch;

b the breadth of the *beam* in inches;

d the depth of the *beam* in inches;

and V the reaction in pounds.

In determining V the following reductions in loads may be made:

- (1) All uniform loads within a distance of the depth of the *beam* from the nearest support may be neglected.

- (2) All concentrated loads in the vicinity of the support may be reduced in accordance with the factors given in the following table:

Distance of load from the nearest support	1.5d or less	2d	2.5d	3d or more
Factor	0.4	0.6	0.8	1.0

For intermediate positions, factors may be interpolated.

- (3) Distribution of load to adjacent *beams* through flooring or other members shall be considered.

3.2.7.2 Horizontal Shear in Notched Beams.—The maximum unit horizontal shear stress in *beams* of rectangular cross-section notched at the supports, shall be computed by use of the following formula:

$$v = 1.5 \frac{Vd}{bd_1^2}$$

where d_1 is the actual depth of the *beam* at the notch and the other symbols have the same meaning as in Item 3.2.7.1.

3.2.7.3 Cutting and Notching.—*Girders, beams, or joists* may be notched or bored in any part of the section. When such notches or holes occur within three times the depth of the member from either support, they shall not exceed one-fifth the depth of the member except at points of support.

Where *girders, beams, or joists* are notched at points of support, they shall meet the requirements for net section in shear (see Item 3.2.7.2) at the reduced section.

If holes or notches occur more than three times the depth of the member from the nearest support, the net remaining depth shall be used throughout the length of the member in determining the bending strength.

3.2.8 Bolted Joints

3.2.8.1 Safe Loads, Double Shear.—The load on a bolt in double shear in a joint of seasoned lumber, where the side members are one-half the thickness of the main member, shall not exceed the value given in Table 3 or Table 4 of this Section. When the joint is not continuously dry, the reduction prescribed in Item 3.2.8.5 shall apply.

3.2.8.2 Safe Loads, Single Shear.—The load on a bolt in single shear in a two member joint of seasoned lumber shall not exceed one-half the value given in Table 3 or Table 4 for a bolt in a three member joint in which the main member has a thickness equal to twice the thickness of the thinner member in the two member joint. When the joint is not continuously dry, the reduction prescribed in Item 3.2.8.5 shall apply.

TABLE 3 (SECTION 3.2)
ALLOWABLE LOAD ON BOLTS IN THREE-MEMBER JOINTS
(DOUBLE SHEAR) APPLIED PARALLEL TO THE GRAIN

Length of Bolt in Main Member Inches	Diameter of Bolt in Inches						
	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4
	Allowable Load in Pounds						
White Ash, Beech, Yellow Birch, Hard Maple, Red Oak, White Oak							
2	1110	1470	1790	2100	2400		
3	1210	1860	2500	3060	3560		
4	1210	1890	2720	3590	4440		
5	1210	1890	2720	3700	4800	5930	
6	1210	1890	2720	3700	4840	6150	
7		1890	2720	3700	4840	6150	
8		1890	2720	3700	4840	6150	7560
10				3700	4840	6150	7560
12					4840	6150	7560
Douglas Fir, Western Larch, Tamarack							
2	960	1280	1550	1820	2080		
3	1050	1610	2160	2650	3090		
4	1050	1640	2360	3110	3850		
5	1050	1640	2360	3210	4160	5140	
6	1050	1640	2360	3210	4190	5330	
7		1640	2360	3210	4190	5330	
8		1640	2360	3210	4190	5330	6550
10				3210	4190	5330	6550
12					4190	5330	6550
Red and Ponderosa Pine, Western Hemlock							
2	780	1000	1200	1400	1600		
3	910	1360	1750	2090	2400		
4	910	1420	2050	2600	3120		
5	910	1420	2050	2790	3530	4250	
6	910	1420	2050	2790	3640	4570	
7		1420	2050	2790	3640	4630	
8		1420	2050	2790	3640	4630	5700
10				2790	3640	4630	5700
12					3640	4630	5700
Eastern and Western Cedar, Balsam and Amabilis Fir, Eastern Hemlock, Jack and Lodgepole Pine, Eastern and Western White Pine, Spruce							
2	640	800	960	1120	1280		
3	820	1160	1430	1680	1920		
4	820	1290	1790	2180	2550		
5	820	1290	1850	2520	3050	3540	
6	820	1290	1850	2520	3290	4020	
7		1290	1850	2520	3290	4160	
8		1290	1850	2520	3290	4160	5140
10				2520	3290	4160	5140
12					3290	4160	5140

TABLE 4 (SECTION 3.2)
ALLOWABLE LOAD ON BOLTS IN THREE-MEMBER JOINTS
(DOUBLE SHEAR) APPLIED PERPENDICULAR TO THE GRAIN

Length of Bolt in Main Member Inches	Diameter of Bolt in Inches						
	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4
	Allowable Load in Pounds						
White Ash, Beech, Yellow Birch, Hard Maple, Red Oak, White Oak							
2	670	760	850	930	1020		
3	970	1140	1270	1400	1520		
4	1010	1420	1680	1860	2030		
5	930	1430	1910	2280	2540	2770	
6	860	1350	1900	2460	2940	3300	
7		1260	1830	2440	3090	3670	
8		1170	1640	2370	3050	3800	4430
10				2140	2810	3640	4460
12					2590	3340	4220
Douglas Fir, Western Larch, Tamarack							
2	460	520	580	640	700		
3	690	780	870	960	1050		
4	810	1040	1160	1280	1400		
5	780	1150	1430	1600	1750	1900	
6	720	1110	1540	1880	2100	2280	
7		1060	1500	1970	2380	2660	
8		980	1410	1940	2460	2940	3260
10				1800	2350	2960	3600
12					2180	2810	3490
Red and Ponderosa Pine, Western Hemlock							
2	340	380	420	470	510		
3	500	570	630	700	760		
4	650	760	850	930	1020		
5	640	910	1060	1160	1270	1380	
6	610	910	1220	1400	1520	1660	
7		880	1230	1570	1780	1940	
8		860	1180	1590	1950	2210	2380
10				1510	1940	2420	2860
12					1860	2320	2860
Eastern and Western Cedar, Balsam and Amabilis Fir, Eastern Hemlock, Jack and Lodgepole Pine, Eastern and Western White Pine, Spruce							
2	250	290	320	350	380		
3	380	430	480	520	570		
4	500	570	630	700	760		
5	540	710	790	870	950	1040	
6	520	760	950	1050	1140	1250	
7		740	1020	1220	1330	1450	
8		720	970	1310	1520	1660	1790
10				1270	1620	1980	2230
12					1570	1960	2380

3.2.8.3 Loads at Angle to Grain.—When a load is applied to a wood member by means of a bolt and the direction of the load is not parallel to the grain of the member, the safe load shall be determined in accordance with the formula:

$$n = \frac{p q}{p \sin^2 \theta + q \cos^2 \theta}$$

where

- n is the safe load in pounds on bolts;
 p the safe load on bolt parallel to grain as determined from Table 3;
 q the safe load on bolt perpendicular to grain from Table 4;
 and θ the angle between direction of load and direction of the grain of the member.

3.2.8.4 Metal Side Plates.—When metal plates are used on both sides of a wood member, the bolt values parallel to the grain given in Table 3 may be increased 20 per cent.

3.2.8.5 Joints in Wet Locations.—When a joint is to be used in a location that is occasionally wet but quickly dried, the allowable load on the bolt shall be reduced by one-quarter and where used in a location that is continually wet, the allowable load on the bolts shall be reduced by one-third.

3.2.8.6 Bolt Holes.—Bolt holes in wood members shall be made the same diameter as the bolt, unless otherwise specified on plans. When bolt holes are specified to be not more than one-sixteenth of an inch larger than the bolt, allowable loads on the bolts shall be reduced by 10 per cent.

3.2.8.7 Bolt Hole Spacing.—A row of bolts shall mean a number of bolts placed in a line parallel to the direction of load.

Minimum centre-to-centre spacing of bolts in any one row for full design loads shall be four times the bolt diameter. In no case shall the bolt-bearing capacity of any member be exceeded.

Spacing between rows of bolts for loads perpendicular to grain shall not be less than two and one-half times the bolt diameter for $\frac{L}{d}$ ratio of two, and not less than five times the bolt diameter for $\frac{L}{d}$ ratios of six or more, where $\frac{L}{d}$ is the length of the bolt in the main member divided by its diameter. Intermediate values shall be directly interpolated.

Spacing between rows of bolts for loads paralleled to grain shall be such that the net tension area remaining at any section shall not be less than 80 per cent of the total area in bearing under all bolts in the particular timber.

End margin, i.e., the distance from the end of a bolted member to the centre of the bolt nearest the end, shall not be less than 7 times the bolt diameter for a member in tension and shall not be less than twice the bolt diameter or 2 inches, whichever is the lesser, for a member in compression.

Edge margin is defined as the distance from the edge of the timber to the centre of the nearest bolt hole. For members loaded perpendicular to grain, edge margin nearest the edge toward which the load is acting shall be at least 4 times the bolt diameter. For members loaded parallel to grain, edge margin shall be at least one and one-half times the bolt diameter.

3.2.8.8 Washers.—All bolts in direct tension shall be provided with steel plate washers under heads and nuts. The area of these washers must be such that the unit bearing stress on the wood shall not exceed the allowable unit stress. The washer shall be not less in thickness than 1/10 the diameter or 1/10 the length of the longer side of the washer.

Bolts taking shear only shall have standard O.G. malleable iron washers, or equivalent, under heads and nuts.

3.2.9 Timber Connectors.—The load on a toothed-ring or splitting timber connector used with a bolt to transmit stress between structural or load-bearing members shall not exceed the value given in Tables 5 or 6 of this Section, respectively, provided that the *authority having jurisdiction* shall first approve the use of these tables for the particular design of connector being used.

Tables 5 and 6 apply to joints of seasoned lumber; when lumber is used where it is continuously wet, the values given in these tables shall be reduced by 40 per cent.

TABLE 5 (SECTION 3.2)
ALLOWABLE LOADS FOR TWO SYMMETRICALLY LOADED TOOTH-RING
CONNECTORS IN SEASONED TIMBERS

Dia. of Connector (Inches)	Dia. of Bolt (Inches)	Allowable Load in Pounds			
		Parallel with the grain		Perpendicular to the grain	
		Bolt tight in hole	Bolt in over- sized hole	Bolt tight in hole	Bolt in over- sized hole
Beech, Yellow Birch, Hard Maple, Oak, Douglas Fir, Tamarack, Western Larch					
2	1/2	2400	2200	1800	1700
2-5/8	5/8	4200	3600	3200	2700
3-3/8	3/4	5800	5200	4400	3900
4	3/4	6900	6300	5200	4700
Red Pine, Western Hemlock					
2	1/2	2000	1900	1500	1400
2-5/8	5/8	3600	3100	2700	2300
3-3/8	3/4	4900	4400	3700	3300
4	3/4	5900	5400	4400	4000
Basswood, Balsam and Amabilis Fir, Eastern Hemlock, Eastern and Western White Pine, Lodgepole and Jack Pine, Spruce, Western Red Cedar					
2	1/2	1900	1800	1400	1300
2-5/8	5/8	3400	2900	2500	2200
3-3/8	3/4	4600	4200	3500	3100
4	3/4	5500	5000	4200	3800

TABLE 6 (SECTION 3.2)
ALLOWABLE LOADS FOR TWO SYMMETRICALLY LOADED SPLIT-RING
CONNECTORS IN SEASONED TIMBERS

Inside Dia. of Ring (Inches)	Depth of Ring (Inches)	Dia. of Bolt (Inches)	Allowable Load in Pounds	
			Parallel with the grain	Perpendicular to the grain
Beech, Yellow Birch, Hard Maple, Douglas Fir, Oak, Western Larch, Tamarack				
2-1/2	0.75	1/2	5000	3500
4	1.00	3/4	10,500	7400
6	1.25	3/4	15,800	9500
8	1.50	3/4	20,100	10,100
Red Pine, Western Hemlock				
2-1/2	0.75	1/2	3800	2600
4	1.00	3/4	7900	5600
6	1.25	3/4	11,900	7100
8	1.50	3/4	15,100	7600
Basswood, Balsam and Amabilis Fir, Eastern Hemlock, Eastern and Western White Pine, Jack and Lodgepole Pine, Spruce, Western Red Cedar				
2-1/2	0.75	1/2	3300	2300
4	1.00	3/4	6800	4800
6	1.25	3/4	10,300	6200
8	1.50	3/4	13,100	6600

When toothed-ring connectors are used and the direction of the load makes an angle of between 0° and 45° with the grain, the allowable load shall be determined by interpolation from the values given in Table 5 for loads applied parallel to the grain and perpendicular to the grain. When the direction of the load makes an angle of more than 45° with the grain, the value given for loads perpendicular to the grain shall apply.

When split-ring connectors are used and the direction of the load is neither parallel nor perpendicular to the grain, a linear variation of load may be assumed between the values given in Table 6.

Safe loads and design practice for other types of connectors may be determined from published recommendations provided such recommendations are first *approved* by the *authority having jurisdiction*, and provided further that such load values are based on the results of tests of the combined resistance of the connector and its bolt.

3.2.10 Drift Bolts.—The maximum resistance to withdrawal of tightly fitting drift bolts is given in Table 7 of this Section. The values are based on the assumption that the bolts are driven into holes having a

diameter of one-eighth inch less than that of the bolt diameter. No safe working loads are suggested. The character of the work must indicate what factor of safety should be applied to the ultimate values given in Table 7.

TABLE 7 (SECTION 3.2)
HOLDING POWER OF DRIFT BOLTS*

Species	Maximum Withdrawal Load in Pounds per Lineal Inch of Penetration						
	Diameter of Bolt in Inches						
	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4
White Ash, Beech, Yellow Birch, Hard Maple, Red Oak, White Oak	1270	1580	1900	2220	2540	2850	3170
Douglas Fir, Western Larch, Tamarack	750	940	1130	1310	1500	1690	1880
Red and Ponderosa Pine, Western Hemlock	610	760	910	1060	1220	1370	1520
Balsam and Amabilis Fir, Eastern and Western White Pine, Jack and Lodgepole Pine, Spruce, Eastern and Western Cedar, Eastern Hem- lock	480	600	720	840	960	1080	1200

*Factor of safety must be applied in order to determine safe working load (see Article 3.2.10).

3.2.11 Lag Screws

3.2.11.1 Safe Load.—The safe lateral load on a lag screw shall not exceed 40 per cent of the allowable load given in Tables 3 or 4 of this Section for a bolt of the same diameter having a length in the main member of a three member joint equal to three times the thickness of the thinner member joined by the lag screw.

When metal side plates are used, the safe load may be increased by 25 per cent.

3.2.11.2 Penetration.—Lag screws shall penetrate into the farther member not less than one and one-half times the thickness of the side member.

3.2.11.3 Placing.—All lag screws shall be screwed and not driven into place.

In placing lag screws in wood, a hole shall first be bored of the same diameter and depth as the shank, after which the hole shall be continued to a depth equal to the length of the lag screw with a diameter equal to the diameter of the screw at the root of the thread.

3.2.11.4 Holes.—Holes for lag screws in steel plates shall be drilled to a diameter one-thirty-second of an inch larger than the nominal diameter of the lag screw.

3.2.12 Wood Screws

3.2.12.1 Shear Connections.—A wood screw used to fasten a metal plate to a wooden member or a wooden member to a wooden member shall not be subjected to a greater load causing shear and bending than the safe lateral strength of the wood screw as determined from Table 8 of this Section. Screws shall have an embedment into the farther member of at least six-tenths of the length of the screw. The length of the screw shall be not less than seven times its diameter.

TABLE 8 (SECTION 3.2)
SAFE LATERAL RESISTANCE OF WOOD SCREWS IN POUNDS

Species	Nominal Size of Screw*						
	12	14	16	18	20	22	24
White Ash, Beech, Yellow Birch, Hard Maple, White and Red Oak	185	235	285	345	410	485	555
Douglas Fir, Tamarack, Western Larch	155	195	235	285	340	400	455
Red and Ponderosa Pine, Western Hemlock	125	160	195	235	275	325	375
Eastern and Western Cedar, Eastern Hemlock, Balsam and Amabilis Fir, Jack and Lodgepole Pine, Eastern and Western White Pine, Spruce	100	125	150	180	215	255	290

*C.E.S.A. Dimensional Standard B65-1940.

3.2.12.2 Tension Connections.—A wood screw inserted perpendicularly to the grain of the wood shall not be subjected to a greater load tending to cause withdrawal than the safe resistance of the screw to withdrawal as determined from Table 9 of this Section.

A wood screw inserted parallel to the grain of the wood shall not be assumed to resist any computed tensile stresses.

TABLE 9 (SECTION 3.2)

SAFE RESISTANCE TO WITHDRAWAL OF WOOD SCREWS WHEN
INSERTED AT RIGHT ANGLES TO THE GRAIN

Species	Nominal Size of Screw*						
	12	14	16	18	20	22	24
	Safe resistance, pounds per lineal inch of screw						
White Ash, Beech, Yellow Birch, Hard Maple, White and Red Oak	155	175	190	210	230	250	270
Douglas Fir, Tamarack, Western Larch	90	105	115	125	135	150	160
Red and Ponderosa Pine, Western Hemlock	75	85	90	100	110	120	130
Eastern and Western Cedar, Eastern Hemlock, Balsam and Amabilis Fir, Jack and Lodgepole Pine, Eastern and Western White Pine, Spruce	60	65	75	80	85	95	100

*C.E.S.A. Dimensional Standard B65-1940.

3.2.13 Common Wire Nails

3.2.13.1 General.—When the type of construction makes necessary the calculation of the holding power of common wire nails, the requirements of this Article shall be fulfilled.

3.2.13.2 Safe Lateral Strength.—A common wire nail inserted perpendicular to the grain of the wood when used to fasten wood members together shall not be subjected to a greater load causing shear and bending than its safe lateral strength as determined from Table 10 of this Section.

A common wire nail inserted parallel to the grain of the wood shall not be subjected to more than three-fourths of the lateral load allowable when inserted perpendicular to the grain.

TABLE 10 (SECTION 3.2)
SAFE LATERAL STRENGTH OF COMMON WIRE NAILS WHEN
INSERTED AT RIGHT ANGLES TO THE GRAIN

Species	Length of Nail in Inches								
	2	2½	3	3½	4	4½	5	5½	6
	Safe lateral strength, pounds per nail								
White Ash, Beech, Yellow Birch, Hard Maple, White and Red Oak	65	81	97	111	143	160	182	205	229
Douglas Fir, Tamarack, Western Larch	52	65	78	90	116	130	147	166	185
Red and Ponderosa Pine, Western Hemlock	43	53	64	73	95	105	120	136	152
Eastern and Western Cedar, Eastern Hemlock, Balsam and Amabilis Fir, Jack and Lodgepole Pine, Eastern and Western White Pine, Spruce	34	43	51	59	76	85	96	108	121

3.2.13.3 Safe Resistance to Withdrawal.—A common wire nail inserted perpendicular to the grain of the wood shall not be subjected to a greater load, tending to cause withdrawal, than its safe resistance to withdrawal, as determined from Table 11 of this Section.

Nails inserted parallel to the grain of the wood shall not be assumed to resist any computed tensile stresses.

TABLE 11 (SECTION 3.2)
SAFE RESISTANCE TO WITHDRAWAL OF COMMON WIRE NAILS WHEN
INSERTED AT RIGHT ANGLES TO THE GRAIN

Species	Length of Nail in Inches								
	2	2½	3	3½	4	4½	5	5½	6
	Values in pounds per lineal inch of penetration into the main member receiving the point								
White Ash, Beech, Yellow Birch, Hard Maple, White and Red Oak	51	62	70	86	93	103	113	122	134
Douglas Fir, Tamarack, Western Larch	30	37	41	51	55	61	67	72	79
Red and Ponderosa Pine, Western Hemlock	24	30	34	41	45	49	54	59	64
Eastern and Western Cedar, Eastern Hemlock, Balsam and Amabilis Fir, Jack and Lodgepole Pine, Eastern and Western White Pine, Spruce	19	24	26	32	35	39	43	46	51

3.2.13.4 Spacing and Penetration.—Nails shall not be driven closer together than one-half their length unless driven in bored holes, nor closer to the edge of the timber than one-quarter their length. Nails shall be of such length that, when joining one timber to another, the penetration of the nail into the second or farther timber shall not be less than one-half the length of the nail.

3.2.14 Floor Construction

3.2.14.1 Joist Floors.—

(a) **General Requirements.**—All *joists* and *beams* or *girders* shall be adequate to support the loads prescribed in Section 3.6. *Joists* supporting plastered ceilings shall be so proportioned that the calculated deflection due to full *live load* only, will not exceed $1/360$ of the span length.*

(b) **Bridging.**—Cross bridging, on not more than 8-foot centres, shall be placed between all *joists* of which the span is greater than 8 feet.

Under bearing *partitions* that run parallel with supporting *joists*, two or more *joists* as required, shall be used. They shall be well spiked together or separated by solid bridging on not more than 4-foot centres to permit the passage of pipes and heating ducts.

(c) **Detailed Requirements.**—Where *joists* enter stud walls, either exterior or interior, in which the studs are not cut off and capped underneath the *joists*, thus giving bearing support thereto, such *joists* shall be suitably fastened to the studs or may be supported on a wooden ribbon not less than 1 by 4 inches gained into the stud. In the latter case design shall be in accordance with Item 3.2.5.5.

Every wooden *joist*, *rafter*, *beam*, or *girder* entering any *masonry* or *reinforced concrete* wall shall be separated from any wood member entering the opposite side of such wall by at least $4\frac{1}{2}$ inches; it shall have a bearing of at least $3\frac{1}{2}$ inches and the end of the member shall be so cut as to fall freely without disrupting the wall in case of fire.

Header *beams* shall be placed not closer than 18 inches from the front of any fireplace. All spaces between *chimneys* and wood *joists* or *beams* shall be filled with loose *incombustible* materials placed in an *incombustible* support, or a metal collar connected to the *chimney* and fastened to the *joists*, *beams* or flooring to form an effective fire-stop.

All *joists* shall have a minimum bearing of $3\frac{1}{2}$ inches except when supported on a ribbon board, and nailed securely to the adjoining stud; lapped *joists* shall be securely nailed to each other.

Cutting of wood *girders*, *beams*, or *joists* shall be limited to that permitted in Item 3.2.7.3.

(d) **Header and Tail Joists.**—Header *joists* over 6 feet long and tail *joists* over 12 feet long shall be hung in joist or beam hangers, or secured by other devices affording equivalent support.

Trimmers and header *joists* more than 4 feet long shall be doubled.

*Floor joist tables applicable to residential occupancies and other occupancies where the *live load* will not exceed 40 pounds per square foot are given in Table 1 of Appendix B.

(e) **Sub-flooring.**—In wood frame buildings, sub-flooring shall be provided under all floors less than $\frac{3}{4}$ inch in thickness, and under all floors except the top floor in buildings two or more *storeys* in *height*. Sub-flooring shall consist of wood not less than $\frac{3}{4}$ inch thick laid diagonally with all ends bearing on *joists*; alternatively, plywood as specified in Item 3.2.16.2(f) may be used. Such plywood shall be not less than $\frac{5}{8}$ inch thick, provided that $\frac{1}{2}$ inch plywood may be used when the top flooring is not less than $\frac{3}{4}$ inch thick. Wood, other than plywood, shall be nailed to the *joists* with nails which shall be in length at least two and one-half times the nominal thickness of the sub-flooring. The nailing shall have an average spacing of not more than 4 inches along each *joist*. Plywood shall be nailed to the *joists* with $2\frac{1}{2}$ inch common nails, approximately 6 inches apart at all edges and 10 inches apart at interior *joists*, the panels to be laid lengthwise across the *joists*.

3.2.14.2 Plank Floors.—Plank or mill-constructed floors shall consist of splined or tongued-and-grooved plank of not less than 2 inches nominal thickness covered with flooring laid either crosswise or diagonally. Such planks shall not extend closer than $\frac{1}{2}$ inch to walls to allow for swelling in case the floor becomes wet. Such $\frac{1}{2}$ inch space shall be covered by a molding fastened to the wall and so arranged that it will not obstruct the swelling or shrinking movement of the floor.

3.2.14.3 Laminated Floors.—Every member of a solid or *laminated floor* shall be firmly nailed with two nails at each end and one nail at intervals along its length not greater than 18 inches. The nails used shall be of a length equal to two and one-half times the thickness of a single lamination. Devices of equivalent strength may be used in lieu of nails.

In the case of *laminated floors* of more than one span all splices shall be made over supports or close to the quarter points, not less than one-third of such splices being over the supports. No member shall be spliced more than once in a distance equal to a span length. All splices shall be broken so that no two will form a continuous line.

In all single-span *laminated floors* the members forming the floor shall be full-length and free from joints, provided that when a top flooring is used sub-floor members may be jointed, in which case short members shall not be considered in the computation of permissible *live loads*.

At least two laminations at the wall shall be omitted until glazing and roofing have been completed. *Laminated floors* shall not be spiked to the supporting beams.

3.2.14.4 Foundation Ventilation.—The space between the bottom of *floor joists* and the ground of any building (except such space as is occupied by a *basement* or *cellar*) shall be provided with a sufficient number of ventilating openings through *foundation walls* or exterior walls to insure ample ventilation. The minimum total area of ventilating openings shall be proportioned on the basis of 20 square inches for each 25 linear feet or major fraction thereof of exterior wall. Such openings need not be placed in the front of the building.

The minimum clearance between the bottom of *floor joists* and the ground beneath shall be 18 inches.

3.2.15 Roof Construction

3.2.15.1 Ceiling Joists.—Ceiling *joists* shall be capable of supporting a *live load* of 10 pounds per square foot without the stresses prescribed in Article 3.2.5 being exceeded. If a plaster ceiling is used the deflection due to *live load* shall not exceed $1/360$ of the span.*

3.2.15.2 Rafters and Roof Joists.—The span of any *rafter* or roof *joist* shall be such that the allowable fibre stress will not be exceeded when the loads prescribed in Articles 3.6.4 and 3.6.5 are applied. In the case of roof *joists* supporting plaster ceilings the calculated deflection due to full *live load* only shall not exceed $1/360$ of the span.

For dwellings, any *rafter* having a span not exceeding the value given in Table 3 of Appendix B shall be considered to fulfil the requirements of this Item.

Double *rafters* and trimmers shall be used around all dormers and other large roof openings, and hip and valley members shall be increased in size as required to carry the roof load. Adequate collar ties shall be provided.

3.2.15.3 Roof Trusses.—When roof trusses, constructed wholly or partly of wood, are used, the stresses in the various members shall be determined in accordance with established engineering practice for the conditions of loading prescribed in Item 3.6.4.2.

3.2.15.4 Special Types of Roof Construction.—Special types of roof construction, such, for example, as tied arches or rigid frames, may be used provided that the design and calculations are *approved* by the *authority having jurisdiction*.

3.2.16 Stud Wall Construction**

3.2.16.1 Studding.—

(a) **Placing.**—Studs in walls and *partitions* may be placed with the longest cross-sectional dimension parallel with the wall or *partition* provided the studs are considered as *columns* and comply with the requirements of Article 3.2.6. Such walls shall have top and bottom plates except when framed as provided in Item 3.2.14.1 (c).

(b) **Plates.**—In bearing *partitions* the top plate shall be doubled and lapped at each intersection with walls or *partitions*. Joints in the upper and lower members of the top plate shall be staggered not less than 4 feet.

(c) **Bridging.**—All stud *partitions*, or walls over 10 feet in height, shall have block bridging, not less than 2 inches in nominal thickness and of the same width as the stud, fitted snugly and spiked into the studs at mid-height of stud, or other means for giving equal lateral support to the studs. Such bridging may serve as fire-stopping as required in Article 4.19.3.

*For allowable spans of ceiling *joists* computed in accordance with the requirements of this Code, see Table 2 of Appendix B.

**See also Article 3.8.2.

(d) Size and Height.—Exterior stud walls and bearing *partitions* 2 *storeys* or less in height shall consist of not less than 2- by 4-inch studs* on 16-inch centres except in the case of *accessory buildings* not exceeding 500 square feet in *area* in which case studs may be spaced on 24-inch centres; where such walls are 3 *storeys* in height, studding shall be not less than 2 by 4 inches on 12-inch centres, or 3 by 4 inches or 2 by 6 inches on 16-inch centres to the bottom of the *second floor joists*, and 2 by 4 inches at 16-inch centres for the two upper *storeys*. The maximum allowable height between floors of 2- by 4-inch or 3- by 4-inch stud framing shall be 14 feet and of 2- by 6-inch stud framing shall be 20 feet, unless the wall is supported laterally by adequate framing. The above requirements do not necessarily apply if the studs and plates are designed as a system of *columns* and *beams*. Where 3- by 4-inch studding is required two 2- by 4-inch studs nailed together may be used.

(e) Corners.—Angles at corners where stud walls or *partitions* meet shall be framed solid with at least two studs so that no lath can extend from one room to another.

(f) Base Plates.—Stud walls resting on *masonry* shall have base plates or sills. Such sills shall be securely anchored to the *foundation walls*; they shall be not less than the width of the studs nor less than 2 inches nominal thickness. When wood members are embedded in *masonry* below *grade* they shall be of decay-resistive wood or wood treated with preservative.

(g) Pipes and Ducts in Walls.—Stud *partitions* containing plumbing, heating, or other pipes or ducts shall be so framed and the *joists* underneath so spaced as to give proper clearance for the piping and ductwork (see Item 3.2.14.1 (b)). Where plumbing, heating, or other pipes or ducts are placed in or partly in a *partition*, necessitating the cutting of the top or bottom plates, a metal tie not less than one-half inch wide shall be fastened to the plate across and to each side of the opening with not less than four 3½-inch nails. No plate shall be cut in any stud space adjacent to an opening and there shall be at least two stud spaces between any two consecutive openings in such plate.

(h) Chimney Space.—Wood lath, furring, or framing shall be placed not less than 2 inches from any *chimney* and not less than 4 inches from the back of any fireplace.

(i) Headers.—All wall openings involving cutting of a stud, which are 4 feet wide or less shall be provided with double headers not less than 2 inches thick, placed on edge, securely fastened together, and such headers shall have 2-inch solid bearing to the floor or bottom plate. All openings more than 4 feet shall be trussed or provided with lintels which shall have not less than 2-inch solid bearing at each end to the floor or bottom plate.

*Where reference is made to the dimensions of studs the sizes specified are nominal. The dimensions of surfaced lumber shall not be smaller than the nominal size minus 3/8 inch.

3.2.16.2 Sheathing.—

(a) **General.**—*Sheathing* shall be placed on the inside or the outside of the studs in any building provided that it may be omitted in the following circumstances:

- (i) In one-storey buildings where galvanized iron is used as the exterior wall covering, *sheathing* may be omitted, provided the studs are adequately braced.
- (ii) When stucco is used as the exterior wall covering, *sheathing* may be omitted in certain cases (see Item 3.8.5.3 (a)).
- (iii) When wood *siding* of not less than 5/8-inch actual thickness, with lapped or tongued-and-grooved joints, and with not less than two nails to each stud, is used, *sheathing* may be omitted.

(b) **Materials.**—The following materials may be used as *sheathing*:

- (i) Wood *sheathing*.
- (ii) Fibre building board.
- (iii) Gypsum *sheathing* board.
- (iv) Plywood.
- (v) Other materials may be used provided that a test panel shows a racking strength not less than that of a standard panel having horizontal wood *sheathing* 5/8 inch thickness when tested in the manner described in Appendix C. Such materials shall have a high degree of resistance to decay or corrosion from the inside, and shall be protected on their exterior surfaces by water-resistant building paper and *siding* or *masonry* unless they fulfil the following requirements:
 - (1) The *modulus of rupture* determined on wet specimens shall not be reduced by more than 50 per cent as a consequence of 24 hours immersion in water.
 - (2) The *modulus of rupture* shall not be reduced by more than 5 per cent when a sample of the material is immersed in water for 24 hours and subsequently dried to constant weight.
 - (3) The cross-breaking strength per inch width on 12-inch centres shall be not less than 20 pounds.
 - (4) The material shall have a high degree of inherent resistance to weather or shall be effectively protected from water and light by a suitable surface treatment.

(c) **Wood Sheathing.**—

- (i) **Quality.**—Wood *sheathing* shall comply with the requirements of Item 3.2.3.3 (b) as to grade and shall have an actual thickness of not less than 5/8 inch if tongue-and-groove or shiplap is used, and not less than one inch nominal if rough lumber is used.

- (ii) Application.—Wood *sheathing* shall be fastened to the studs with nails at least $2\frac{1}{2}$ inches in length. The nailing shall have an average spacing of not more than 4 inches along each stud.

(d) Fibre Building Board.—

- (i) Quality.—Fibre building board shall comply with the following requirements:

- (1) It shall be manufactured from wood or other vegetable fibre, by a felting or moulding process.
- (2) It shall have been subjected to a temperature of not less than 100C. for not less than one hour in manufacture or to such other treatment as to destroy completely any rot-producing fungi.

- (3) It shall fulfil the following physical requirements:

Thickness (inches) minimum*.....	$\frac{1}{2}$ in.
Transverse strength (<i>modulus of rupture</i> , pounds per square inch) minimum:	
Thickness not more than 0.75 inch.....	290
Thickness more than 0.75 inch.....	250
Deflection of 12-inch span at ultimate load (inches)	
Maximum.....	0.85
Minimum.....	0.25
Water absorption (per cent)	
Maximum.....	7
Linear expansion (per cent)	
Maximum.....	0.5

The above test shall be made in accordance with methods set forth in Appendix D.

- (ii) Application.—The following regulations shall apply to walls sheathed with fibre building board:

- (1) Studs shall be spaced not wider than 16 inches on centres.
- (2) Every sheet shall be erected with the length of the sheet horizontal and with vertical joints staggered so that the joints are not continuous for more than one width of *sheathing*.
- (3) *Sheathing* shall be nailed to each stud with nails not less in length than twice the thickness of the *sheathing* nor less than $1\frac{1}{2}$ inches. Such nails shall be spaced not more than 3 inches apart along all edges and not more than 6 inches apart along all intervening studs and headers.
- (4) Both walls at each corner shall be provided with 1- by 4-inch or larger diagonal braces let into the faces of the studs, such braces extending across not less than three studs and wherever possible extending from the sill to

*Where the fibre board has a transverse strength of not less than 20 pounds when determined by the test procedure given in Appendix D, the minimum thickness specified herein shall not apply.

the plate; sufficient additional braces shall be provided when necessary to give a maximum horizontal distance between any two braces at the sill of 15 feet.

- (5) When openings occur near corners, 1- by 4-inch knee braces let into the faces of the studs shall be installed above and below every such opening at approximately 45 degrees and extending across as many studs as possible.
- (6) The bracing detailed in Items (4) and (5) above shall not be required where fibre building board meeting the following requirements in addition to those set forth in the first paragraph of Item 3.2.16.2 (d) is used:

<i>Modulus of rupture</i> (pounds per square inch)	
minimum.....	350
Cross-breaking strength (per inch width on 12-inch centres) lb. minimum.....	13

- (7) The exterior surface of all fibre building board *sheathing* shall be protected by water-resistant building paper or saturated asphalt felt lapped not less than 4 inches at all joints and around all openings.
- (8) When either the *sheathing* or the building paper is highly resistant to the transmission of water vapour, an effective vapour barrier shall be provided between the interior face of the studs and the exposed interior face of the wall*.
- (9) When such *sheathing* is faced with *masonry* veneer, the ties required for such *masonry* shall be fastened to the studs; when shingles are applied over such *sheathing*, 1- by 2-inch nailing strips, spaced as required, shall be nailed to the studs; wood *siding* shall be nailed to the studs.
- (10) A clear space of not less than one inch shall be provided between any such *sheathing* and any *masonry* veneer.

(e) Gypsum Sheathing Board.—

- (i) Quality.—Gypsum *sheathing* shall be of not less than $\frac{1}{2}$ inch nominal thickness and shall otherwise comply with A.S.T.M. Specification C79-34, Gypsum Sheathing Board.
- (ii) Application.—The following regulations shall apply to walls sheathed with gypsum *sheathing* board:
 - (1) Studs shall be spaced not wider than 16 inches on centres.
 - (2) Sheets shall be erected with the length of the sheet horizontal and with vertical joints staggered so that the joints are not continuous for more than one width of *sheathing*.

*A vapour barrier is desirable whenever the vapour transfer factor of either the *sheathing* or the building paper is less than 2.0. Such vapour barrier should have a transfer factor not greater than 0.5. The vapour transfer factor is expressed in gm. per 24 hours per square metre per mm. vapour pressure difference.

- (3) *Sheathing* shall be nailed to each stud with nails having a length not less than 2 inches and such nails shall be placed not more than 4 inches apart along all studs.
- (4) Both walls at each corner shall be provided with 1- by 4-inch or larger diagonal braces let into the faces of the studs, such braces extending across not less than three studs and wherever possible extending from the sill to the top plate. Sufficient additional braces shall be provided when necessary to give a maximum horizontal distance between any two braces at the sill of 15 feet.
- (5) When openings occur near corners, 1- by 4-inch knee braces let into the faces of the studs shall be installed above and below every opening at approximately 45 degrees extending across as many studs as possible.
- (6) The exterior surface of the *sheathing* board shall be protected by water-resistant building paper or saturated asphalt felt lapped not less than 4 inches at all joints and around all openings.
- (7) When either the *sheathing* or the building paper is highly resistant to the transmission of water vapour an effective vapour barrier shall be provided between interior faces of studs and the exposed interior face of the wall*.
- (8) When gypsum *sheathing* board is faced with *masonry* veneer, the ties required for such *masonry* shall be fastened to the studs; when shingles are applied over such *sheathing*, 1- by 2-inch nailing strips, spaced as required, shall be nailed to the studs; wood *siding* shall be nailed to the studs.
- (9) A clear space of not less than one inch shall be provided between any gypsum *sheathing* board and any *masonry* veneer.
- (10) When gypsum *sheathing* board is faced with stucco, 1- by 2-inch nailing strips, spaced as required, shall be nailed to the studs, unless mesh reinforcement as specified in Item 2.8.5.3 (c) is used. All metal lath or mesh reinforcement shall be nailed to the studs. (For requirements for the use of stucco, see Item 3.8.5.3.)

(f) **Plywood.**—

- (i) **Quality.**—Plywood shall comprise an odd number of wood veneers bonded with a suitable adhesive with the grain of adjacent plies at right angles. The requirements for moisture resistance given in Appendix E (Moisture-resistant Quality) shall be fulfilled.

The minimum thickness of such plywood shall be 5/16 inch.

*A vapour barrier is desirable whenever the vapour transfer factor of either the *sheathing* or the building paper is less than 2.0. Such vapour barrier should have a transfer factor not greater than 0.5. The vapour transfer factor is expressed in gm. per 24 hours per square metre per mm. vapour pressure difference.

(ii) Application.—The following regulations shall apply to walls sheathed with plywood:

- (1) Studs shall be spaced not wider than 16 inches on centres.
- (2) *Sheathing* shall be nailed to each stud with 2-inch nails spaced not more than 6 inches apart along all edges and not more than 12 inches apart along all intervening studs.
- (3) *Sheathing* shall be protected by an exterior wall covering unless it is of "exterior" quality (see Appendix E) and at least 3/8 inch thick.

(g) **Other Materials.**—When other materials fulfilling the requirements of this Item are used as *sheathing*, diagonal and knee braces shall be provided as specified for fibre building board, unless the material is such that a protective covering of water-resistant building paper and *siding* is not required.

When either the *sheathing* or the building paper is highly resistant to the transmission of water vapour, an effective vapour barrier shall be provided between the interior face of the studs and the exposed interior face of the wall*.

3.2.16.3 Exterior Wall Coverings.—

(a) **General.**—Every exterior wall in wood frame construction shall be covered with one or more of the following materials:

- (i) Wood *siding*, bituminous *siding*, or asbestos-cement *siding*.
- (ii) Wood shingles, bituminous shingles, or asbestos-cement shingles.
- (iii) Plywood.
- (iv) Stucco.
- (v) *Masonry* veneer.
- (vi) Galvanized metal.
- (vii) Other material, or combination of the above materials may be used provided they fulfil the following requirements:
 - (1) The exterior wall covering when tested in combination with the *sheathing*, or if no *sheathing* is used, when tested alone, shall have a transverse strength on 12-inch centres of not less than 20 pounds per linear inch.
 - (2) The material shall have a high degree of inherent resistance to weather or shall be effectively protected from water and light by a suitable surface treatment.
 - (3) The *modulus of rupture* shall not be reduced more than 5 per cent when a sample of the material is immersed in water for 24 hours and subsequently dried to constant weight.

*A vapour barrier is desirable whenever the vapour transfer factor of either the *sheathing* or the building paper is less than 2.0. Such vapour barrier should have a transfer factor not greater than 0.5. The vapour transfer factor is expressed in gm. per 24 hours per square metre per mm. vapour pressure difference

All exterior wall covering shall be applied and securely nailed in place in such a way that the *sheathing* and framing beneath is effectively protected from the weather.

(b) **Wood Siding.**—The exposed portion of any piece of wood *siding* shall not be less than 3/16 inch thick at any point.

(c) **Wood Shingles.**—Wood shingles or shakes may be used for the exterior wall covering. They shall be laid with a weather exposure not greater than that given in the following table:

Size of Shingles (when green)	Maximum Exposure	
	Single Coursed	Double Coursed
Length 16 inches, butt thickness not less than 0.33 inch (6 butts to 2 inches)	5½ inches	10 inches
Length 16 inches, butt thickness not less than 0.40 inch (5 butts to 2 inches)	7½ inches	12 inches
Length 18 inches, butt thickness not less than 0.45 inch (5 butts to 2¼ inches)	8½ inches	14 inches
Length 24 inches, butt thickness not less than 0.50 inch (4 butts to 2 inches and thicker)	11½ inches	16 inches

All wood shingles or shakes shall be nailed with copper or hot dipped zinc-coated nails. Each shingle or shake shall be secured with two nails not less than 0.08 inch diameter (No. 14 Imp. wire gauge) nor 1¼ inches long, placed ¾ inch from edge and one inch above exposure line, except in cases where they are applied in double courses when they shall be fastened with two casing nails not less than 0.08 inch diameter (No. 14 Imp. wire gauge) nor 1¾ inches long, placed ¾ inch from edge and 2 inches above the butts.

The coating on hot-dipped zinc-coated nails shall withstand four immersions of one minute when tested by the Preece or copper sulphate test as specified in A.S.T.M. Specification A191-38.

(d) **Plywood.**—Plywood, where used as an exterior wall covering, shall fulfil the requirements for moisture resistance given in Appendix E (Exterior Quality).

The minimum thickness of such plywood shall be 3/8 inch.

(e) **Other Materials.**—For detailed regulations concerning the use of materials other than wood, used as exterior wall coverings on wood stud walls, see Item 3.8.2.4.

3.2.17 Plank Wall Construction

3.2.17.1 Thickness.—Plank walls shall have a thickness of not less than 2 inches in all parts exclusive of *sheathing* if *sheathing* is used, and not less than 3 inches in all parts if *sheathing* is omitted.

3.2.17.2 Framing.—All structural members shall be framed together with dovetailed joints or other joints of equivalent strength so as to provide adequate rigidity in the structure. (For acceptable grades of lumber, see Item 3.2.3.3 (b).)

3.2.17.3 Sheathing.—*Sheathing*, where used, shall comply with the requirements of Item 3.2.16.2 as far as quality and thickness of material is concerned. A layer of water-resistant building paper or saturated asphalt felt shall be placed under the *sheathing* and a similar layer on top.

3.2.17.4 Exterior Wall Covering.—Every exterior wall of plank construction shall have an exterior wall covering meeting the requirements of Item 3.2.16.3.

3.2.17.5 Height.—Plank walls shall not exceed 3 *storeys* or 35 feet in *height*. If such walls exceed 2 *storeys* in *height* the thickness of the planks, exclusive of any *sheathing*, shall be not less than 3 inches.

SECTION 3.3 MASONRY CONSTRUCTION

3.3.1 General.—The quality and design of masonry construction wherever used in any building or *structure* shall conform to the minimum requirements of this Section.

3.3.2 Quality of Materials

3.3.2.1 General.—When specifications of both the American Society for Testing Materials and the Canadian Engineering Standards Association are cited herein, they are to be considered as alternatives; material complying with either will be accepted.

3.3.2.2 Masonry Units.—

(a) Brick

- (i) All *brick*, whether new or used, shall comply with the requirements*, with the exception of that for size prescribed by the specifications, indicated in the following table; in addition, the grade of *brick* used in any location shall be that indicated in the specification as being suitable for such location:

*The various grades of *brick* are indicated in the specification as being suitable for use in the following locations:

(a) Clay or Shale, or Sand-lime Bricks

Grade SW is intended for use where exposed to temperature below freezing in the presence of moisture.

Grade MW is intended for use where exposed to temperature below freezing but unlikely to be saturated with water.

Grade NW is intended for use as back-up or interior *masonry* or if exposed, for use where no frost action occurs; or if frost action occurs, where the average annual precipitation is less than 15 inches.

(b) Concrete Bricks

Grade A is intended for use where exposed to temperature below freezing in the presence of moisture.

Grade B is intended for use as back-up or interior *masonry*.

Type of <i>Brick</i>	C.E.S.A.	Specification A.S.T.M.
Clay or shale	—	C62-40T
Concrete	—	C55-37
Sand-lime	—	C73-39

- (ii) Used *brick* shall be thoroughly cleaned and free from *mortar* and shall comply in all respects with the requirements for new *brick*. Not more than 10 per cent of bats shall be used.

(b) **Tile.**—*Facing tile* to be exposed directly to the weather or soil shall have a maximum absorption of 20 per cent on 5 hours boiling, and a minimum compressive strength as specified for clay or shale *bricks* of Grade NW in Item 3.3.2.2 (a).

For structural tile, see Item 3.3.2.2 (c).

(c) **Blocks.**—

- (i) *Solid blocks* of clay or shale shall comply with the requirements herein prescribed for clay or shale *brick*, with the exception of that for size. (See Item 3.3.2.2 (a).)
- (ii) *Hollow blocks* of clay or shale shall comply with the following requirements:

Load-bearing structural *blocks* other than for use in floor construction shall comply with A.S.T.M. Specification C34-39 for Structural Clay Load-Bearing Wall Tile, provided that tile that will be exposed to the weather shall comply with the requirements of Class LBX in that specification.

Clay *blocks* for use in interior non-load-bearing *masonry*, or in combination tile and concrete ribbed slab construction, shall comply with the requirements of A.S.T.M. Specification C56-39, Structural Clay Non-Load-Bearing Tile.

Clay *blocks* for use in flat or segmental arches, or to be used to resist calculated stresses in combination tile and concrete ribbed slab construction, shall comply with the requirements of A.S.T.M. Specification C57-39, Structural Clay Floor Tile.

- (iii) **Concrete Blocks.**—

Solid concrete blocks shall comply with the requirements of A.S.T.M. Specification C145-40, Solid Load-Bearing Concrete Masonry Units.

Hollow concrete blocks used for load-bearing *masonry* shall comply with the requirements of A.S.T.M. Specification C90-39, Hollow Load-Bearing Concrete Masonry Units.

Blocks of concrete, whether *solid* or *hollow*, for use in interior non-load-bearing *masonry* shall comply with the requirements of A.S.T.M. Specification C129-39, Hollow Non-Load-Bearing Concrete Masonry Units.

Cellular concrete block, whether *solid* or *hollow*, shall be of sound manufacture and shall have a compressive strength based on the *gross area* of not less than 350 pounds per square inch for the average of 5 tests, with a minimum of 300 pounds per square inch in any one test.

Such *blocks* shall be used only for non-load-bearing *masonry*, provided that they may be used for bearing *masonry* if they have been *approved* in accordance with Article 3.1.3 hereof, in respect of the following factors:

- (1) Freedom from deterioration on immersion in water.
- (2) Adequate resistance to impact and concentrated loads.
- (iv) Gypsum *block* shall comply with the requirements of A.S.T.M. Specification C52-33, Gypsum Partition Tile or Block.
- (v) Sand-lime *blocks* shall fulfil the requirements herein specified for *concrete block*.
- (vi) Glass *block*, whether *hollow* or *solid*, shall be subject to approval as provided in Article 3.1.3 in respect of the following factors:
 - (1) Soundness of manufacture.
 - (2) Freedom from spalling or cracking under the temperature conditions to which it will be subjected in use.
 - (3) Adhesion and bonding quality of *mortar* bearing surfaces.

(d) Stone.—All *stone* shall be sound, of proven durability and weather resistance, and shall be free from clay and loose formations. For the purpose of determining allowable working stresses, *stone* shall be sampled in accordance with A.S.T.M. Procedure C101-32T and tested in accordance with A.S.T.M. Procedure C98-30T for determination of compressive strength, and in accordance with A.S.T.M. Procedure C99-36 for determination of *modulus of rupture*. All *stone* shall be tested with the bedding planes lying in the same direction as when erected.

(e) Cast Stone.—*Cast stone* shall fulfil the requirements specified herein for *solid concrete block*, provided that when it is to be used as part of the external architectural treatment of a building (for example, in cornices, lintels, sills, etc., or other locations where more than two faces are exposed to the weather) it shall, in addition, fulfil the following requirements when tested in accordance with A.S.T.M. Procedure C140-39:

Maximum Absorption

Average of 5 tests.....	7 per cent, by weight
Individual test.....	8 per cent, by weight

Minimum Compressive Strength

Average of 5 tests.....	5000 lb./sq. in.
Individual test.....	4000 lb./sq. in.

(f) Other Masonry Units.—See Article 3.1.3.

3.3.2.3 Mortars for Unit Masonry.—

(a) **General.**—All *masonry mortars* shall derive their bonding effect from inorganic cementitious components, provided that bituminous or other organic materials shall be permitted as damp-proofing and caulking compounds.

(b) **Mortar Ingredients.**—Cementing materials and *aggregate* shall comply with the specifications indicated in the following table:

Material	Specification
	A.S.T.M. C.E.S.A.
Quicklime.....	C5-26 —
Hydrated lime.....	C6-31 —
Hydraulic hydrated lime.....	C141-38T —
Portland cement.....	C77-40 A5-1940
Natural cement.....	C10-37 —
Masonry cement.....	C91-40 —
Gypsum plaster.....	C28-40 —
Keene's cement.....	C61-40 —
Aggregate.....	C144-39T —

Quicklime shall be slaked with care to avoid over-heating and shall be stored in the wet condition for not less than 7 days before mixing; hydrated lime shall be stored in the wet condition for not less than 12 hours.

Water for use in mixing *mortar* shall be clean and free from deleterious amounts of acids, alkalis, salts, and organic matter.

(c) **Types of Mortar.**—All *mortars* shall consist of one of the following types:

lime *mortar*
lime-cement *mortar*
cement *mortar*
gypsum *mortar*

or *approved* substitutes, as hereinafter defined.

(d) **Composition of Mortars.**—Portland *cement*, natural *cement*, masonry *cement*, and *aggregate* other than that used in gypsum *mortar* shall be measured by volume, dry, before mixing with water; gypsum and *aggregate* used in gypsum *mortar* shall be proportioned by weight; lime whether delivered as hydrate or quicklime shall be measured by volume in the form of wet putty.

Lime *mortar* shall consist of one part lime putty with not more than 3 parts of *aggregate*.

Mortar consisting of one part hydraulic hydrated lime, one part masonry *cement*, or one part natural *cement*, with not more than 3 parts of *aggregate* may be substituted for lime *mortar*.

Lime-cement *mortar* shall consist of not less than one part lime putty, with one part of portland *cement*, and with not more than 6 parts of *aggregate*.

Mortar consisting of one part of masonry *cement* or natural *cement* with not more than 3 parts of *aggregate* and having a compressive strength at 7 days of not less than 500 pounds per square inch, may be substituted for lime-cement *mortar*.

Cement *mortar* shall consist of one part portland *cement* with not more than 3 parts of *aggregate* with a lime addition of not less than 10 nor more than 25 per cent of the *cement* content.

Cement grout shall consist of one part portland *cement* with not more than 3 parts of *aggregate*.

Gypsum *mortar* shall consist of one part calcined gypsum with not more than 3 parts of *aggregate* by weight.

3.3.2.4 Plain Concrete.—Plain *concrete* shall comply with the requirements for *concrete* given in Section 3.4 of this Code, and shall have a compressive strength of not less than 2000 pounds per square inch, provided that when specifically permitted by the *authority having jurisdiction*, *cellular concrete* of compressive strength not less than 300 pounds per square inch may be used.

3.3.2.5 Gypsum.—Gypsum for use in floor and roof construction shall develop the following minimum ultimate compressive strength in pounds per square inch when dried to constant weight:

1. Gypsum without aggregate.....	1800
2. Gypsum fibre concrete containing not more than 3 per cent by weight of wood chips, shavings, or fibre.....	1000
3. Gypsum fibre concrete containing not more than 12½ per cent by weight of wood chips, shavings, or fibre.....	500

NOTE: Tests for compression shall be made on cylinders 6 inches in diameter and 12 inches in height. Five specimens shall be tested to determine the average compressive strength which shall be not less than the value prescribed above for such mix. Specimens having a compressive strength of less than 75 per cent of such average shall not be considered in determining the compressive strength.

3.3.3 Allowable Working Stresses

3.3.3.1 Unreinforced Unit Masonry.—

(a) **Classification of Solid Units.**—For the purpose of determining allowable compressive stresses, all *solid units* whether of clay, shale, *concrete*, sand-lime, or *ashlar*, shall be grouped in accordance with their minimum compressive strength as follows:

Group	Minimum Compressive Strength lb./sq. in.
A	10,000
B	8,000
C	4,500
D	2,500
E	1,500

The minimum compressive strength of each type of unit shall be determined by the method set forth in the specification applying to such unit. (See Item 3.3.2.2.)

(b) **Allowable Compressive Stress.**—In any unreinforced wall or pier of *unit masonry* the maximum compressive stress in pounds per square inch of *gross area* shall not exceed the values given in Table 1 of this Section.

In *hollow masonry* built of *solid units*, the stresses shall be based upon the effective *net* cross-sectional *area* of the *masonry*.

When *solid masonry* is constructed of *solid units* laid with smooth horizontal joints and completely filled vertical joints, thoroughly inspected, and when the effects of eccentric and concentrated loads and lateral forces are fully considered and allowance made for them, the working stresses in Table 1 may be increased by 50 per cent, subject to written permission from the *authority having jurisdiction*.

When *masonry* is composed of *units* falling in different strength groups, the allowable working stresses shall be those specified for the lowest group of which the *masonry* is composed.

TABLE 1 (SECTION 3.3)
ALLOWABLE COMPRESSIVE STRESSES FOR UNIT MASONRY

Type of <i>Masonry</i>	Nominal Minimum Compressive Strength of Unit lb./sq. in.	<i>Mortar</i>		
		Cement	Lime- Cement	Lime
<i>Solid</i> , composed ⁽¹⁾ ⁽²⁾ of any <i>solid unit</i> except <i>rubble stone</i>	A 10,000	500	350	100
	B 8,000	400	300	100
	C 4,500	250	200	100
	D 2,500	175	140	75
	E 1,500	125	100	50
<i>Hollow</i> , composed ⁽¹⁾ ⁽²⁾ of any <i>solid unit</i> except <i>rubble stone</i>	2,500	125	100	50
<i>Hollow</i> , composed ⁽¹⁾ of any <i>hollow unit</i>	—	80	70	— ⁽³⁾
<i>Rubble stone</i>	—	140	100	70

NOTES: ⁽¹⁾Glass *block* and unreinforced gypsum shall not be used in the construction of *bearing walls*.

⁽²⁾The compressive stress in *masonry* built of *cellular units* as specified in Item 3.3.2.2 shall not exceed 35 pounds per square inch.

⁽³⁾Lime *mortar* shall not be used for *masonry* of *hollow units*.

(c) **Allowable Bearing Pressures.**—The bearing pressure on *unit masonry* under concentrated load shall not exceed the allowable compressive stress given in Table 1 of this Section; provided that the bearing pressure on any one *unit* need not be less than 10 per cent of its ultimate compressive strength.

(d) **Allowable Shear Stress.**—In computing the resistance of buildings to lateral loads, the shearing strength of *masonry* walls shall be assumed to be 15 pounds per square inch of *gross* sectional *area* for walls built of *hollow units* and 25 pounds per square inch of *net* sectional *area* for walls built of *solid units*. For the purpose of resisting horizontal shear the foregoing horizontal shear stress may be increased by one-third of the vertical stress produced by the *dead load* on the *masonry* at the plane under consideration.

3.3.3.2 Flexural Stress in Stone.—The maximum unit stress in bending in sound natural *stone* used in lintels, *foundations*, and elsewhere shall not exceed 1/6 of the average *modulus of rupture* as determined by tests of the type of *stone* used.

3.3.3.3 Concrete.—The maximum stresses in *plain concrete* shall not exceed the following values:

Compression	$0.20f'_c$
Bearing	$0.25f'_c$
Shear (diagonal tension)	$0.02f'_c$

where f'_c is the ultimate compressive strength at 28 days.

3.3.3.4 Reinforced Brick Masonry.—The unit working stresses in reinforced *brick masonry* shall not exceed the values given in Table 2 of this Section.

TABLE 2 (SECTION 3.3)
ALLOWABLE UNIT WORKING STRESSES, IN POUNDS PER SQUARE INCH,
FOR REINFORCED BRICK MASONRY

Type of Stress	Cement-Lime Mortar*	Cement Mortar or Grout
Compression (Extreme fibre stress in bending)	400	500
Direct Compression on <i>Piers</i>	300	400
Shear (no web reinforcement)	25	30
Shear (with web reinforcement taking entire shear)	50	60
Bond: (<i>Deformed bars</i>)		
Vertical bars	60	60
Horizontal bars	80	80
Modulus of Elasticity	1,200,000	1,500,000

*This mortar shall consist of not more than one-half part of lime to one part of Portland Cement and the sand content not exceeding three times the combined content of cement and lime.

3.3.3.5 Gypsum Masonry.—The unit working stresses in gypsum masonry shall not exceed the values given in Table 3 of this Section.

TABLE 3 (SECTION 3.3)
ALLOWABLE UNIT WORKING STRESSES, IN POUNDS PER SQUARE INCH,
FOR GYPSUM MASONRY

Type of Stress	Gypsum without Aggregate	Gypsum Fibre Concrete with not more than 3% of wood chips, shavings, or fibres	Gypsum Fibre Concrete with not more than 12½% of wood chips, shavings, or fibres
Extreme fibre stress in compression in flexure	450	250	125
Direct compression or bearing	360	200	100
Bond between gypsum and reinforcing	40	30	30
Shearing stress	30	25	20
Modulus of Elasticity	1,000,000	600,000	200,000

The wires or cables used as reinforcement shall be cold-drawn steel in which the allowable working stress shall not exceed 20,000 pounds per square inch.

3.3.4 General Design Requirements.—In any masonry structure, provision shall be made for all conditions of stress that may occur, whether specifically mentioned in this Section or not, in accordance with well established principles of mechanics and sound engineering practice.

3.3.5 General Construction Requirements

3.3.5.1 Restrictions on the Use of Materials.—

(a) **Mortars.**—Gypsum mortar shall be used only for non-bearing masonry that is not directly exposed to the weather or soil.

For all unit masonry construction where danger of leakage due to weather is a consideration, lime mortar or lime-cement mortar shall be used, provided that cement mortar may be used if the interior surface of the masonry is thoroughly rendered by trowelling on a substantial coating of lime or lime-cement mortar and provided also that lime mortar shall not be used in any wall the top of which is not protected from the weather.

For all load-bearing hollow masonry and for all masonry exposed to the soil, cement mortar or lime-cement mortar shall be used.

For walls of glass block or of reinforced brick masonry, lime-cement mortar and, when required, cement grout shall be used.

(b) **Unit Masonry and Poured Gypsum.**—Gypsum *masonry* shall be restricted to construction that is not directly exposed to the soil or weather. Unreinforced gypsum *masonry* shall be restricted to furring, fireproofing, and non-bearing *partitions*.

Masonry of hollow units shall not be directly exposed to the soil.

Glass *block* construction shall be limited to non-bearing *partitions*, window openings, and decorative panels.

See also the restrictions on *masonry units* in Item 3.3.2.2.

3.3.5.2. Workmanship.—All *masonry* shall be built true and plumb. All available bearing areas of *masonry units* shall be fully covered with *mortar* spread in an even layer, and all vertical and interior joints shall be filled solidly with *mortar*. This shall not require the filling of a core formed by abutting *hollow units*, but shall require filling between the ends of webs.

Masonry walls and *piers* shall be erected throughout their length to the exact elevations required to support *joists*, *beams*, and *girders* without shimming or blocking. Bond timber shall not be used except at the top of *masonry* walls in frame buildings.

Stone work shall be designed to permit natural *stone* to be used on its quarry bed.

All *brick masonry* shall be laid with the *units* as wet as will permit convenient laying.

3.3.5.3 Joints.—No vertical or horizontal joint shall be less than 3 inches in depth, provided that this shall not apply to facings less than 3 inches in thickness, in which case the joint shall be equal to the full thickness of the facing unit. While uniform joint thickness is desirable, a splay inward from the face not exceeding $\frac{1}{4}$ inch per 3 inches in each joint is permissible in *ashlar* or *rubble masonry*.

3.3.5.4 Use of Wood in Masonry Construction.—No wood or other *combustible* material shall be built into any *masonry* except as provided herein.

Wood *joists* may be supported by *masonry* walls in accordance with the provisions of Item 3.2.14.1 (c). (See also Part 4, Fire Protection.)

Wood plugs may be used in any wall.

Wood brick and wood strips not exceeding 12 inches in length and not less than 32 inches apart on centres horizontally and vertically may be used in the walls of any building.

Continuous wood strips not exceeding $1\frac{3}{4}$ by $\frac{1}{2}$ inch may be used in *masonry* walls not exceeding 3 storeys in height.

Wood nailing blocks, plates, and boarding may be used in and on *parapet walls* for the purpose of attaching metal copings, provided they are securely attached to the wall.

Cambered wood lintels may be left in place in accordance with the provisions of Item 3.3.8.3 (i).

3.3.5.5 Winter Construction.—When there is likelihood of temperature of 32F. or less, adequate equipment shall be provided for heating all materials entering into *masonry* construction. No frozen materials or materials containing ice shall be used.

Masonry shall be protected against freezing until such time as the setting of the *mortar* has advanced far enough to prevent any displacement of the *masonry* on subsequent thawing. (See also Section 3.4 for regulations respecting *concrete*.)

3.3.6 Requirements for Special Types of Construction

3.3.6.1 Reinforced Brick Masonry.—

(a) **Design.**—The formulas and assumptions used in the design of reinforced *brick masonry* shall be the same as required for *reinforced concrete* in Section 3.4 and the requirements of that Section with respect to reinforcing bars shall be fulfilled. All reinforcing bars shall be deformed.

(b) **Construction.**—All joints shall be completely filled with *mortar* and all reinforcing steel shall be entirely embedded in the *mortar*. The clearance between the bar and the *brick* shall be at least one-half the diameter of the bar. Longitudinal vertical wall joints in grouted *brick masonry* shall not be less than $\frac{3}{4}$ inch wide.

Reinforcing steel shall be braced and held in place firmly enough to prevent breaking of the bond while *brick* is being laid.

3.3.6.2 Glass Block Masonry.—Glass block panels in exterior *masonry* walls shall be limited to an area of 144 square feet with a maximum dimension either vertical or horizontal of 13 feet. When used in exterior walls of wood, the same dimensions shall be permitted provided the panels are supported on *masonry*, or steel framing. When they are supported by means of wood framing, their size shall be limited to 5 by 5 feet.

Glass block panels in interior use shall not exceed 20 feet in vertical or horizontal dimension.

All panels shall be securely anchored to the supporting construction, the assembly being designed to resist *wind loads* in accordance with the requirements of Article 3.6.5.

Expansion joints not less than $\frac{1}{2}$ inch thick shall be provided at the top and sides of all panels. These joints shall be kept free of *mortar*. They shall be filled with resilient material and faced with not less than $\frac{1}{2}$ inch of non-hardening waterproofing caulking compound.

All glass block *masonry* shall be reinforced as follows:

Horizontal *mortar* joints shall be reinforced with expanded metal in strips at least 1-7/8 inches wide, 0.04 inch in thickness, weighing not less than 0.1 pound per linear foot or by other *approved* means. Reinforcement shall be lapped at the ends by at least 8 inches when more than one piece is required in any joint. If expanded metal ties are used they shall be so fabricated that each edge is continuous.

Reinforcement shall be spaced at intervals not exceeding 24 inches; provided that where the blocks exceed 8 inches in height reinforcement shall be placed in every horizontal joint.

Specific instructions from the manufacturer of any brand of glass *block* may be substituted for the requirements herein specified, subject to the approval of the *authority having jurisdiction*.

3.3.6.3 Gypsum Masonry.—Gypsum suspension systems shall be not less than 3 inches in thickness, and shall be designed to carry the total *live* and *dead loads*, with a factor of safety of not less than 4. The stress in the suspension wires or cables shall be determined by the formula:

$$T = \frac{wL^2}{8d}$$

where T = Maximum tension in wires or cables in pounds per foot width of slab;
 w = Load in pounds per square foot;
 L = Clear span in feet between supports;
 d = Sag or "dip" of wires or cables in feet at centre of span.

3.3.7 Masonry Footings*

3.3.7.1 General.—*Unit masonry footings* shall be restricted to *rubble stone*; *ashlar*; *brick*; and solid *blocks* of clay, shale, or *concrete*. All *stone* shall have a compressive strength of not less than 2,000 pounds per square inch. All clay, shale, or sand-lime *brick* and *block* shall be of Grade SW as described in the appropriate A.S.T.M. specification for *brick*. All *concrete brick* and *block* shall be of Grade A as described in the appropriate A.S.T.M. specification.

When any course of a *footing* projects beyond a course immediately above, or beyond the face of any wall, *column*, or pedestal immediately above, such course shall have no vertical joint parallel to a vertical face above unless the distance of the joint from such vertical face is at least equal to one and one-half times the projection of the *footing* course.

3.3.7.2 Design.—The area of the base of any *masonry footing* shall be determined from the total wall, *column*, or pedestal load, plus the weight of the *footing* itself, and the permissible load on the *foundation* material.

When flexural calculations are made, *footings* shall be adequate to carry the total *dead* and *live loads* on the assumption that critical sections are at the face of the wall, *column* or pedestal and, in stepped *footings*, also at the face of each step. Any *plain concrete footing* shall be so proportioned that the maximum tensile fibre stress at the critical section will not exceed $0.03f_c$.

When flexural calculations are not made, the ratio of the depth of any *footing* to the total projection beyond any face of the wall, *column*, or pedestal, and the ratio of the depth of any step in a stepped *footing* to its projection shall be not less than the value given in Table 4 of this Section.

*See also Section 3.7, Excavations and Foundations.

TABLE 4 (SECTION 3.3)
MINIMUM RATIO OF DEPTH TO PROJECTION FOR
MASONRY FOOTINGS

Unit Pressure under <i>Footing</i> lb. per sq. ft.	Minimum Ratio of Depth of Projection
2,000	0.8
3,000	1.0
4,000	1.2
5,000	1.3
6,000	1.5
7,000	1.6
8,000	1.7
9,000	1.9
10,000	1.9

3.3.7.3. Masonry Footings for Dwellings and Accessory Buildings.—*Masonry footings* for one- or two-family dwellings or accessory buildings shall be acceptable without computation of the unit pressure under them if they have a minimum projection of 4 inches from all faces of the wall, *column*, or pedestal, and if their depth is at least equal to their projection and never less than 6 inches.

3.3.8 Masonry Walls and Partitions*

3.3.8.1 General Requirements.—

(a) **Support by Combustible Material.**—Except as otherwise provided herein respecting *footings*, no wood or other *combustible* material shall be used to support any *masonry* wall or *partition*.

(b) **Lateral Support.**—Every *masonry* wall or *partition* shall be supported, at right angles to the wall face by means of intersecting walls, *piers*, or by floor or roof constructions; provided that when any wall or *partition* is free standing and has been shown by stress analysis or test to be adequate to withstand, as a cantilever, all lateral forces to which it may be subjected, such lateral support shall not be required. (See also Items 3.3.8.3 (a), 3.3.8.4 (b), and 3.3.8.5.)

Where lateral support is provided by intersecting walls or *piers*, such walls or *piers* shall have sufficient strength and stability to transfer to the ground all the lateral forces that they are assumed to resist. When lateral support is provided by floor or roof construction, such floor or roof construction shall be adequate as a horizontal *beam* or truss to resist the load imposed thereon without causing excessive stress in the supporting walls.

(c) **Anchorage of Walls.**—All *masonry* walls shall be securely bonded at points where they intersect, and anchored at points where they abut or adjoin the frame of a skeleton framed building.

*The requirements of this Article only apply to *masonry partitions* where these are expressly mentioned.

Every *masonry* wall, except a *panel wall*, that is at right angles to the floor members, shall, at each floor above the first floor and at the roof, be anchored to each tier of *joists*, *beams*, *girders*, or floor construction bearing on such wall at maximum intervals of 6 feet 8 inches. Every wall anchor shall be of galvanized steel or wrought iron with minimum thickness of $\frac{3}{16}$ inch and a minimum cross-sectional area of $\frac{9}{32}$ square inch, or an *approved* equivalent. Each wall anchor shall be fastened to the lower part of the *joist*, *beam*, or *girder* to which it is attached and shall extend to within 4 inches of the outside of the wall, where it shall be bent 3 inches into the *masonry*. The abutting ends of all such anchored members shall be strapped, or otherwise fastened together, so as to form a continuous tie from wall to wall.

Every *masonry* wall, except a *panel wall*, that is parallel to the floor members shall be provided with similar anchors at maximum intervals of 6 feet 8 inches, provided that in heavy timber construction such walls shall be anchored by *approved* anchors at the ends of the *beams* supporting the floor and roof construction. In *joist* construction such anchors shall engage the tops of not less than 3 *joists*.

Wherever *joists* are placed in *existing* walls they shall be similarly anchored.

The ends of laminated or mill flooring shall be fastened to sills securely anchored to the walls at intervals not exceeding 6 feet 8 inches.

Every *panel wall* shall be anchored or bonded to the abutting or adjoining framework of the building in an *approved* manner.

(d) **Thickness.**—Where the required thickness of any wall is stated in inches, the width of a *brick* shall be assumed to be 4 inches; for example, a 12-inch wall shall mean a wall having a thickness equal to the width of three *bricks*.

(e) **Furring.**—*Masonry* materials used as furring shall be excluded in calculating the required wall thickness, and such furring shall be considered as without any structural value.

(f) **Corbelling.**—The *corbelling* of walls less than 12 inches thick (except for fire-stopping) is prohibited. For the purposes of this Item, the thickness of a hollow wall built of *solid units* shall be taken as the thickness of the solid portion that it is desired to *corbel*. All *corbelling* shall be done with *solid masonry*. *Corbelling* of walls of *hollow masonry units* shall be supported by at least the equivalent of one full course of the *hollow units* in *solid masonry*. The maximum horizontal projection in any *corbel* shall be one inch for each 2 inches of vertical projection, and in all cases the total projection of the *corbelling* shall be restricted to one-third of the minimum thickness of the wall so *corbelled*.

(g) **Cornices.**—The centre of gravity of all projecting or moulded cornices unless surmounted by *masonry* shall be within the middle third of the wall below, unless satisfactory structural support is provided. In no case shall the centre of gravity of any cornice be outside the face of the supporting wall.

3.3.8.2 Foundation Walls.—See Item 3.7.7.2.**3.3.8.3 Solid Walls and Piers of Unit Masonry.**—

(a) **Lateral Support.**—The distance between lateral supports, as specified in Item 3.3.8.1 (b), shall not exceed 20 times the thickness of the wall.

(b) **Minimum Thickness of Solid Masonry Bearing Walls in Light Occupancy Buildings.**—The thickness of any *solid masonry bearing wall* in any building where the superimposed floor load on floors above the first does not exceed 50 pounds per square foot, shall be such that the unit stresses due to combined *live* and *dead loads* will not exceed those given in Table 1 of this Section (Item 3.3.3.1), provided that the thickness shall in no case be less than the value given in Table 5 of this Section. In addition, the minimum thickness of any such wall shall be 12 inches for the uppermost 70 feet and shall be increased by 4 inches for each successive 45 feet, or fraction thereof, measured downwards from the top of the wall; provided that in buildings not more than three *storeys high* the uppermost 26 feet may be 8 inches in thickness and provided further that 8-inch walls may be used throughout in one- and two-storey *residential buildings* and for the upper three *storeys* in three-storey *residential buildings*.

TABLE 5 (SECTION 3.3)
MINIMUM THICKNESS IN INCHES OF SOLID MASONRY
BEARING WALLS IN LIGHT OCCUPANCY BUILDINGS

Storey	Height of Wall in Storeys							
	8	7	6	5	4	3	2	1
Eighth	12							
Seventh	12	12						
Sixth	12	12	12					
Fifth	12	12	12	12				
Fourth	12	12	12	12	12			
Third	16	12	12	12	12	8		
Second	16	16	12	12	12	8	8	
First	16	16	16	12	12	12*	8	8
Basement or cellar**	16	16	16	16	12	12	12*	12*

*May be 8 inches in *residential buildings*, subject to Item 3.7.7.2.

**The prescribed thicknesses do not apply to walls located more than one *storey* below the *first*.

(c) **Minimum Thickness of Solid Masonry Bearing Walls in Buildings other than Light Occupancy Buildings.**—The thickness of any *solid masonry bearing wall* in any building where the floor load on floors above the first floor exceeds 50 pounds per square foot shall be such that the unit stresses due to combined *live* and *dead loads* will not exceed those given in Table 1 of this Section (Item 3.3.3.1); provided that the thickness shall in no case be less than that given in Table 6 of this Section. In addition, the minimum thickness of any such wall shall be

12 inches for the uppermost 35 feet and shall be increased 4 inches for each successive 35 feet, or fraction thereof, measured downward from the top of the wall.

TABLE 6 (SECTION 3.3.)
MINIMUM THICKNESS IN INCHES OF SOLID MASONRY BEARING
WALLS IN BUILDINGS OTHER THAN LIGHT OCCUPANCY
BUILDINGS

Storey	Height of Wall in Storeys							
	8	7	6	5	4	3	2	1
Eighth	12							
Seventh	12	12						
Sixth	12	12	12					
Fifth	16	12	12	12				
Fourth	16	16	12	12	12			
Third	16	16	16	12	12	12		
Second	20	16	16	16	12	12	12	
First	20	20	16	16	16	12	12	12
Basement or cellar*	20	20	20	16	16	16	12	12

*The prescribed thicknesses do not apply to walls located more than one storey below the first.

(d) **Minimum Thickness of Non-bearing Solid Masonry Walls.**—Except as provided herein for *curtain walls* and *panel walls*, *non-bearing walls* of *solid masonry* shall have a thickness not less than that given in Table 7 of this Section. In addition, the minimum thickness of any such wall shall be 8 inches for the uppermost 15 feet and shall be increased 4 inches for each successive 50 feet, or fraction thereof, measured downward from the top of the wall, provided that in buildings not more than three storeys high the upper 35 feet may be 8 inches thick.

Solid masonry panel walls shall have a thickness of not less than 8 inches unless they are reinforced in which case any such wall or portion thereof not exceeding 25 square feet in area may be constructed of *solid masonry* 4 inches in thickness, provided it is reinforced by 1/16- by 2-inch horizontal iron bands placed not farther apart than 9 inches vertically and extending not less than 9 inches into the adjoining *masonry* on each side or by some other *approved* method. The inner surface of every such 4-inch wall shall be rendered with not less than 1/2 inch of *mortar*.

Curtain walls of *solid masonry* shall have a thickness not less than that given in Table 7 of this Section, provided that in no case need such thickness exceed 12 inches.

TABLE 7 (SECTION 3.3)
MINIMUM THICKNESS IN INCHES OF NON-BEARING SOLID
MASONRY WALLS

Storey	Height of Wall in Storeys							
	8	7	6	5	4	3	2	1
Eighth	8							
Seventh	12	8						
Sixth	12	12	8					
Fifth	12	12	12	8				
Fourth	12	12	12	12	8			
Third	12	12	12	12	12	8		
Second	16	12	12	12	12	8	8	
First	16	16	12	12	12	8	8	8
Basement or cellar*	16	16	12	12	12	12	8	8

*The prescribed thicknesses do not apply to walls located more than one storey below the first.

(e) **Buttressed Walls.**—Where *solid masonry bearing* or *non-bearing walls* are strengthened laterally by *masonry* buttresses, the wall thicknesses specified in parts (b) and (c) and (d) of this Item may be reduced between buttresses by one-half the thickness added by the buttress to the thickness of the wall before reduction, except that no part of such buttressed wall shall be less than 8 inches thick. Buttresses shall be not less in their dimension parallel to the wall than one-eighth the clear distance between them, and the clear distance between them shall not exceed 24 times the reduced wall thickness. Principal *girders* and trusses shall rest on the buttresses.

(f) **Bond.**—In all *solid brick* walls, at least every sixth course on both sides of the wall shall be a header course or there shall be at least one full header in every 80 square inches of each wall surface; in walls more than 12 inches thick the end joints of every header course shall be overlapped with another header course which shall break joints with the course below; provided that in *one- or two-family dwellings* or *accessory buildings* such bond may be reduced to one full header for every 160 square inches of superficial area of the wall if the vertical interval between any two bonding courses does not exceed 24 inches.

Every wall of *rubble stone* shall have bond stone of an area at least equal to 16 per cent of the superficial area of the wall and uniformly distributed throughout the wall. Every bond stone that does not extend through the wall shall be lapped at least 6 inches by another bond stone extending through to the opposite face of the wall.

Ashlar stone walls shall be bonded as prescribed in Item 3.3.8.7.

(g) **Piers.**—The unsupported height of any *isolated pier* shall not exceed 10 times its least dimension.

(h) **Chases and Recesses.**—There shall be no chases in 8-inch walls or within the required area of any *pier*, and no chase in any wall or *pier* shall be deeper than one-third the thickness of the wall or *pier*. No

horizontal chase shall exceed 4 feet in length nor shall the horizontal projection of any diagonal chase exceed 4 feet. No vertical chase shall be closer than 2 feet to any *pilaster*, cross wall, end wall, or other stiffener.

Recesses for *stairways* or elevators may be made in walls but in no case shall the walls at such points be less than the required thickness of walls of the fourth *storey* above the ground floor unless reinforced by additional *piers*, by steel or *reinforced concrete girders* or steel or *reinforced concrete columns* and *girders*, securely anchored to the walls on each side of such recesses. Recesses for alcoves and similar purposes shall have not less than 8 inches of material at the back. Such recesses shall be not more than 8 feet in width and shall be arched over or spanned with lintels.

The aggregate area of recesses and chases in the wall of any one *storey* shall not exceed one-fourth the whole area of the face of the wall in that *storey*.

(i) **Lintels and Arches.**—Every opening in a *masonry* wall shall be bridged by a lintel or an arch of *non-combustible* material. Every such lintel shall have a bearing on *solid masonry* of 4 inches or more at each end.

An arch shall be used only where adequate abutments or tie rods are provided. The strength of any arch shall not be impaired by the introduction of any wood member.

For any opening not more than 4 feet in width in a wall of any building of other than Type 1 construction (Fire Resistive) any cambered wood lintel that is used as centering for a *masonry* arch, may be left in place provided such lintel does not extend more than 2 inches into the wall at either end.

For allowable stresses in *stone* lintels, see Item 3.3.3.2.

(j) **Stone Walls.**—*Stone* walls shall conform to the requirements for *Solid Masonry Walls* and the following additional provision shall also apply:

Rubble stone walls shall be at least 4 inches thicker than the minimum thickness prescribed for *solid masonry* walls and in no case shall they be less than 16 inches thick; provided that in *one-* or *two-family dwellings* such wall may be not less than 12 inches in thickness for a height not exceeding 25 feet above finished *grade* if all *stones* are laid on flat beds.

3.3.8.4 Hollow Walls and Piers of Unit Masonry

(a) **General.**—*Hollow masonry* walls shall include hollow walls built of *solid units*, and walls built of *hollow units*.

In hollow walls of *solid units* the area of the air spaces in any horizontal plane shall not exceed 45 per cent of the *gross cross-sectional area* of the wall.

(b) **Lateral Support.**—The distance between lateral supports shall not exceed 18 times the thickness of the wall.

(c) **Minimum Thickness of Hollow Masonry Walls.**—The thickness of any *hollow masonry* wall shall be such that the unit stresses due to combined *live* and *dead loads* will not exceed those given in Article 3.3.3; provided that the thickness shall in no case be less than that given in Table 8 of this Section. In addition, the minimum thickness of any such wall shall be 12 inches for the uppermost 25 feet and shall be increased by 4 inches for each successive 25 feet, or fraction thereof, measured downward from the top; provided (1) that *basement* walls of *solid units* need not be thicker than any hollow wall immediately above them; (2) that 12-inch walls may be used for the upper three *storeys* in three-storey *residential buildings*; (3) that 12-inch walls may be used for the *basement* or *cellar* of two-storey *residential buildings*; (4) that 8-inch walls may be used for *storeys* above the *basement* or *cellar* in one- or two-storey *residential* and *accessory buildings*.

TABLE 8 (SECTION 3.3)

MINIMUM THICKNESS IN INCHES OF HOLLOW MASONRY WALLS

Storey	Height of Wall in Storeys							
	8	7	6	5	4	3	2	1
Eighth	12							
Seventh	12	12						
Sixth	16	12	12					
Fifth	16	16	12	12				
Fourth	20	16	16	12	12			
Third	20	20	16	16	12	12		
Second	24	20	20	16	16	12	12**	
First	24	24	20	20	16	16*	12**	12**
Basement or cellar***	24	24	20	20	16	16	16*	12

*May be 12 inches in *residential* and *accessory buildings*.

**May be 8 inches in *residential* and *accessory buildings*.

***The prescribed thicknesses do not apply to walls located more than one *storey* below the *first*.

Hollow masonry panel walls shall have a thickness of not less than 8 inches.

(d) **Bond.**—Every unit in any *hollow masonry* wall shall have all contact surfaces solidly embedded in *mortar*.

Where two or more *hollow units* are required in the thickness of any *masonry* wall the inner and outer courses shall be bonded at vertical intervals not exceeding 2 feet by lapping at least $3\frac{3}{4}$ inches over the unit below. The *net* vertical cross-sectional *area* of the bonding units shall be not less than one-sixth the superficial area of the wall. Where the units are such that the *shells* and webs of the bonded units will not align one over the other, the bonding courses shall consist of *solid units*.

Where a hollow wall is constructed of *solid units* it shall have the same *net* cross-sectional *area* of material irrespective of its space within the wall as is required for solid walls; provided that in no place shall the

thickness be less than 4 inches. The inner and outer parts of such wall shall be securely braced and tied together with *approved* bonding units or non-corrodible ties. Where floor and roof systems are carried by such walls provision shall be made for the distribution of these loads to the full cross section of the wall.

(e) Support for Structural Members.—Where a concentrated load is supported by *hollow masonry units*, at least 8 inches of *solid units* shall be provided directly under the bearing for a length that is longer than the bearing by at least twice the required height of the *solid masonry*. For wood *joists*, one inch of *solid masonry* shall be deemed adequate to distribute the *joist* loads.

(f) Change in Wall Thickness.—Where the thickness of any wall, constructed of *hollow masonry units*, is changed at any point, the top 8 inches of the thicker portion of the wall exclusive of any beam-fill shall be constructed of *solid masonry*.

(g) Piers.—*Hollow masonry units* shall not be used for *isolated piers* unless solidly filled with *concrete*. The unsupported height of any such *pier* shall not exceed ten times its least horizontal dimension. Wall sections less than 30 inches in length shall be considered as *isolated piers*.

(h) Chases and Recesses.—Every chase or recess in *hollow masonry* shall be built in as construction proceeds. Chases and recesses in walls and *piers* of *hollow masonry* shall not exceed in extent those permitted for *solid masonry* walls under the same conditions.

(i) Lintels and Arches.—Every opening in a *hollow masonry* wall shall be bridged by an arch or lintel. Arches or lintels shall be in accordance with the requirements of Item 3.3.8.3 (i).

3.3.8.5 Monolithic Concrete Walls.—The provisions of this Item shall apply to monolithic *concrete* walls, either *plain* or containing reinforcement, which do not comply with the requirements of this Code for *reinforced concrete walls*. For regulations concerning *reinforced concrete walls*, see Article 3.4.21.

The distance between lateral supports shall not exceed 20 times the thickness of the wall.

Solid monolithic *concrete* walls shall fulfil all the requirements herein prescribed for *masonry* walls built of *solid units*; provided that the thickness may be reduced by 2 inches, but shall in no case be less than 8 inches.

Hollow monolithic walls of *plain concrete* shall have the same *net* cross-sectional *area* of material, irrespective of the space within the wall, as required for solid walls, provided that in no place shall the *concrete* be less than 4 inches in thickness. The inner and outer parts of such walls shall be securely braced and tied together with non-corrodible ties or other means to bring them into common action. Where floor and roof systems are carried by such walls, provision shall be made for the distribution of these loads to the full cross section of the wall.

3.3.8.6 Veneered Walls*.—

(a) General.—*Veneered walls* shall not exceed 35 feet in height above

*For glass veneer, see Article 3.8.6.

For *masonry* veneer on wood frame construction, see Item 3.8.2.4 (d).

foundation walls. In no case shall the *veneer* be considered a part of the wall in computing the strength of *bearing walls*, nor shall it be considered a part of the required thickness of the wall.

(b) Attachment of Veneer.—Where *masonry* walls are *veneered* with *brick*, *stone*, or other *masonry*, such *veneer* shall be securely tied into the backing either by a header for every 300 square inches of wall surface or by *approved* non-corrodible wall ties spaced not farther apart than one foot vertically and 2 feet horizontally. Headers shall project at least $3\frac{3}{4}$ inches into the backing.

Veneer of facing tile one inch or less in thickness may be secured to the wall without the use of anchors by embedment in *mortar*. No such individual tile shall exceed 144 square inches in superficial area or 16 inches in any one direction. Every tile exceeding 36 square inches shall be corrugated or scored in the back to facilitate bonding.

3.3.8.7 Faced Walls.—

(a) General.—*Faced walls* shall be at least as thick as required for *masonry* walls of the material forming the backing.

When facing is used, it shall not be considered to add to the strength of the wall unless it is at least $3\frac{3}{4}$ inches in thickness.

(b) Bond.—In no case shall the height of a single course in *faced walls* exceed 10 times the thickness of the facing material provided that this shall not apply to *pilaster* and spandrel facing *stone*.

Facings of *brick* or *solid structural units* shall be bonded into the backing with headers, or stretchers at least 4 inches thicker than the facing, the equivalent of one-sixth of the area of the wall.

All *ashlar facing* shall be backed with *brick masonry* unless otherwise *approved*.

All *ashlar facing* that requires anchorage in addition to the bond stone shall be backed by *masonry* not less than 8 inches in thickness.

All *ashlar facing* shall be bonded by means of uniformly distributed bond stones not less than $3\frac{3}{4}$ inches thicker than the facing units and having a superficial area not less than 20 per cent of the superficial area of the facing.

Every stone exceeding one foot in height, other than a bond stone, shall be anchored to the backing by an *approved* metallic anchor or anchors, provided that where each entire alternate course consists of bond stones, having an area not less than one-third the total superficial area of the facing, the anchors may be omitted.

For every anchored stone, there shall be not less than one anchor for each 3 square feet of superficial area, or portion thereof. At least one top anchor shall be provided for every 2 feet in length, or portion thereof, of every such stone, and if such stone exceeds 30 inches in height it shall be provided with an equal number of anchors at or near the bottom.

For *piers* and buttresses, each alternate course of *ashlar facing*, having an area not less than one-third the total superficial area of the facing, shall be bonded not less than $3\frac{3}{4}$ inches into the backing.

Every anchor used for *ashlar facing* shall be at least equal to a 1- by 3/16-inch flat steel anchor for *bearing walls* and at least equal to a 1- by 1/8-inch flat steel anchor for *non-bearing walls*. Every such anchor shall be bent not less than one inch into the facing and into the backing, and shall be completely embedded in *mortar*. All anchors constructed of corrodible metal shall be coated with asphaltum or galvanized after fabrication.

3.3.8.8 Parapet Walls and Walls Projecting Above the Roof of a Building.—All *masonry parapet walls* shall have a thickness equal to that of the wall supporting them.

When the height of any *masonry parapet wall*, or other wall projecting above the roof of a building, exceeds six times its thickness such wall shall be laterally supported.

Masonry parapets shall be effectively coped with *non-combustible* weatherproof material.

Any *masonry wall*, not more than 12 feet in height above the main roof level of any building and enclosing a *penthouse*, elevator shaft, *stairway*, or *bulkhead*, may be constructed of *masonry* 8 inches in thickness provided the unsupported length of such wall between lateral supports does not exceed 20 feet. No such wall shall be deemed either to increase the height of, or require any increase in the thickness of the wall below, provided the allowable working stresses are not exceeded.

3.3.8.9 Use of Existing Walls.—An *existing masonry wall* may be used in the renewal or extension of a building if it complies in all respects with the requirements of this Section, provided that the minimum thickness herein specified shall not apply if structural analysis shows the wall to be adequate for the loads to which it will be subjected.

No *existing wall* shall be used for renewal or extension of a building or increased in height without written permission from the *authority having jurisdiction*.

3.3.8.10 Partitions*.—

(a) **Bearing Partitions.**—All interior *bearing walls*, which do not extend through more than one *storey*, shall be considered as *bearing partitions*.

Solid masonry bearing partitions shall be not less than 8 inches thick and *hollow masonry bearing partitions* shall be not less in thickness than one-eighteenth of the height between floors or floor *beams* but never less than 8 inches.

(b) **Non-bearing Partitions.**—Non-bearing *partitions* whether *solid* or *hollow* shall comply with the requirements of Table 9 of this Section.

Lateral support shall be provided by wedging to the construction above or by anchoring or bonding to adjacent horizontal or vertical construction.

*For plaster *partitions*, see Item 3.8.8.3.

TABLE 9 (SECTION 3.3)
MINIMUM THICKNESS AND MAXIMUM HEIGHT
NON-BEARING PARTITIONS

Thickness Exclusive of Plaster (Inches)	Maximum Unsupported Height (Feet)
2	8*
3	12
4	15
6	20
8	25

*Unsupported length not to exceed 8 feet.

3.3.9 Masonry Floor Construction

3.3.9.1 Design.—When floors of unit *masonry* or of reinforced *brick masonry*, poured-in-place or pre-cast gypsum, or *cellular concrete* are used, they shall be adequate to carry the total *dead* and *live loads* in accordance with the following assumptions:

- (i) that plane sections remain plane after bending
- (ii) that the tensile strength of the *masonry* is negligible
- (iii) that initial stress due to contraction or expansion of the *masonry* is negligible;

provided that for all floors not designed in accordance with accepted engineering formulas, the safe uniformly distributed load shall be taken as one-fifth the total load causing failure in a full-sized test panel with the load applied along two lines parallel to the supports and located one-quarter of the span from the supports.

In unit *masonry* construction adequate provision shall be made for the distribution of impact loads falling on any single unit to those adjacent to it.

3.3.9.2 Basement and Cellar Floors.—Concrete *basement* or *cellar* floors poured on solid rock shall have a thickness of at least 2 inches exclusive of any topping. When placed over soil such floors shall be supported by at least 5 inches of crushed rock, broken *stone* or *brick*, or cinders and shall have a minimum thickness of 3 inches exclusive of any topping.

3.3.10 Masonry Roof Construction.—Roof systems in which *masonry* is used shall comply with the requirements for *masonry* floors prescribed in Article 3.3.9.

SECTION 3.4 REINFORCED CONCRETE CONSTRUCTION

3.4.1 General.—The design and execution of all *reinforced concrete* construction wherever used in any building or *structure* shall conform to the minimum requirements of this Section.

3.4.2 Administrative Requirements

3.4.2.1 Authority Having Jurisdiction.—For the purposes of this Section the *authority having jurisdiction* shall be a fully qualified architect or engineer, or a person acting on the advice of a fully qualified architect or engineer.

3.4.2.2 Material and Loading Tests.—Such tests of materials or of the finished *structure* as may be required by the *authority having jurisdiction* shall be carried out by the architect or engineer or other person in charge. Full records of these shall be taken and reports in ample detail shall be rendered to the *authority having jurisdiction*.

3.4.3. Symbols.—Symbols where used herein shall have the following meanings:

- α = angle between web bars and axis of *beam*; the angle which the sloping face of a *beam* makes with the *beam* axis;
- A = total area of top of pedestal or *footing*;
- A' = loaded area of pedestal, *pier* or *footing* at the *column* base;
- A_c = area of *concrete*, exclusive of area occupied by reinforcement, inside the protective envelope if one is provided, or, for spirally reinforced *columns*, inside the outer periphery of the spiral;
- A_r = cross-sectional area of the metal core in a *composite column*;
- A_s = cross-sectional area of longitudinal bar reinforcement of *columns*;
- A'_s = volume of spiral reinforcement in a *column* divided by the length of the *column*;
- b = breadth of the compression face of a *beam*; width of the stem of a T-*beam* in shear stress calculations;
- c = effective diameter of *column capital* in *flat slab construction*. (See Item 3.4.19.7.)
- d = depth from compression face of a *beam* or slab to the centroid of longitudinal tension reinforcement;
- D = size of a bar, i.e., the diameter of a round bar or the side of a square bar;
- D_1 = size of bar 1;
- F = tensile yield point of pipe material divided by 45,000;
- f_{bc} = permissible unit flexural stress in buckling compression for a *beam*;
- f_c = permissible unit flexural compressive stress in a *beam*; permissible unit bearing stress;
- f'_c = ultimate unit compressive strength of *concrete*, usually at the age of 28 days, when tested according to these regulations;
- f_r = permissible unit compressive stress on a metal core in a *composite column*;
- f'_r = permissible unit compressive stress on a steel pipe in a *pipe column*;
- f_y = specified unit yield point stress of longitudinal bar reinforcement of *columns*;

- f'_y = specified unit yield point stress of the spiral reinforcement of *columns*;
 f_1 = unit stress in the metal core of a *composite column* before the *concrete* has set;
 h = unsupported length of a *column*;
 j = ratio of lever arm of resisting couple to depth d ;
 l = shorter span of a slab supported on four edges; length of embedded anchorage surface;
 L = span of a *beam* or slab; longer span of a slab supported on four edges;
 L_A = the longer span in the case of a continuous slab having two spans;
 L_B = the shorter span in the case of a continuous slab having two spans;
 M = bending moment or moment of resistance in general;
 M_o = sum of positive and negative bending moments at the principal design sections of a panel of a flat slab;
 M' = positive bending moment prescribed for a slab supported on four edges, when such slab forms one of a hypothetical group of equal panels with the span of each panel in such a group being equal to the lesser of two adjacent and unequal spans under consideration;
 m = ratio of shorter span to longer span for a slab supported on four edges;
 n = E_s/E_c = ratio of modulus of elasticity of steel to that of *concrete*;
 Σ_o = sum of perimeters of bars being considered in a bond calculation;
 Σ_{oD} = sum of the products of the perimeter and bar size of all the bars being considered in a bond calculation;
 P = total allowable axial load on a *short column*;
 P' = total allowable axial load on a long *column*;
 r = radius of gyration of the pipe section of a pipe *column*;
 s = distance between points of lateral support of an isolated *beam*;
 t_1 = in *flat slab construction*, thickness of *dropped panel* (or *drop*), or thickness of slab where no *drop* is used;
 t_2 = in *flat slab construction*, thickness of slab, where *drop* is used;
 u = bond stress per unit area of surface of bar;
 u_1 = bond stress per unit area of surface of bar 1;
 v = unit shear stress on the composite area of a *reinforced concrete beam*;
 V = total transverse shear;
 w = uniformly distributed *dead* and *live load* per unit of length of *beam* or slab;
 w' = uniformly distributed *dead* and *live load* per unit of area of a floor or roof;
 W = total *dead* and *live load* uniformly distributed over a single panel.

3.4.4. Materials

3.4.4.1 Cement.—

(a) **General.**—All *cement* used shall be Portland Cement or High Early Strength Cement, provided that special *cements* may be used with the permission of the *authority having jurisdiction*.

(b) **Portland Cement.**—Portland Cement shall comply with the requirements of C.E.S.A. Specification A5-1940.

(c) **High Early Strength Cement.**—High Early Strength Cement shall comply with the requirements of C.E.S.A. Specification A57-1940.

3.4.4.2 Aggregates.—

(a) **General.**—*Concrete aggregates* shall comply with the requirements of C.E.S.A. Specification A23-1941. Materials that do not conform to the above specifications may be used, subject to the approval of the *authority having jurisdiction*, provided that they have been shown by test or actual service to produce *concrete* of the required strength having adequate durability and water tightness.

(b) **Aggregates for Light-weight Concrete.**—*Aggregates* for light-weight *concrete* shall comply with the requirements of C.E.S.A. Specification A23-1941 or A.S.T.M. Specification C130-39.

(c) **Maximum Size of Aggregate.**—The maximum size of *aggregate* shall be not larger than one-fifth of the narrowest dimension between the forms of the member for which the *concrete* is to be used, nor larger than two-thirds of the minimum clear spacing between reinforcing bars.

(d) **Aggregates in Concrete Used for Fire Protection.**—For classification of *aggregates* in *concrete* used for fire protection, see Part 4.

3.4.4.3 Water.—Water for *concrete* shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.

3.4.4.4 Admixtures.—Admixtures may be used only in *concrete* with the approval of the *authority having jurisdiction* based upon evidence that the compressive strength of the *concrete* will not be reduced more than 10 per cent by the use of such admixtures.

3.4.4.5 Reinforcement.—All steel used as reinforcement shall comply with the requirements of one of the following classes, provided that other types of reinforcement may be used if *approved* by the *authority having jurisdiction*:

(a) Billet-steel concrete reinforcing bars shall comply with C.E.S.A. Specification G30-1938.

(b) Rail-steel concrete reinforcing bars shall comply with C.E.S.A. Specification G31-1938.

(c) Cold-drawn steel wire for concrete reinforcement shall comply with C.E.S.A. Specification G32-1938.

(d) Fabricated steel bar or rod mats for concrete reinforcement shall comply with C.E.S.A. Specification G45-1938.

(e) Welded steel wire fabric for concrete reinforcement shall comply with C.E.S.A. Specification G46-1938.

Hard grade billet steel or rail steel shall not be used for stirrups, column or beam ties or spirals.

3.4.4.6 Storage of Materials.—Cement and aggregates shall be stored at the work in such a manner as to prevent deterioration, or intrusion of foreign matter. Any material which has deteriorated or which has been damaged shall not be used for concrete.

3.4.5 Proportioning of the Mix

3.4.5.1 General.—All concrete shall be classified as "controlled concrete" or "ordinary concrete". The requirements for these grades of concrete are prescribed in Items 3.4.5.2 to 3.4.5.5.

3.4.5.2 Water Content.—

(a) **Controlled Concrete.**—In controlled concrete, the water content shall be determined from the results of tests of the materials proposed for use in the structure, carried out in advance of construction, using the consistencies suitable for the work and in accordance with the procedure described in C.E.S.A. Specification A23-1941, Appendix VI "Standard Method of Making Compression Tests of Concrete". A curve representing the relation between the water content and the average 28-day compressive strength or earlier strength at which the concrete is to receive its full working load, shall be established for a range of values including compressive strengths 20 per cent greater than will be required in practice. The curve shall be established by at least four points, each point representing the average values from at least four test specimens. The water content used in the concrete for the structure shall be such that the strength as determined from the preliminary tests will be related to the specified strength in the manner shown in Table I of this Section.

TABLE 1 (SECTION 3.4)
RELATION BETWEEN SPECIFIED COMPRESSIVE STRENGTH OF
CONCRETE AND STRENGTH REQUIRED IN PRELIMINARY TESTS

Specified Compressive Strength of Field Concrete lb./sq. in.	Strength Required in Preliminary Tests lb./sq. in.
2000	2400
2500	3000
3000	3500
4000	4600

No substitutions shall be made in the materials used on the work without additional tests in accordance herewith to show that the quality of the concrete is satisfactory.

(b) **Ordinary Concrete.**—In ordinary *concrete* the water content per sack of *cement* shall not exceed the value given in Table 2 of this Section.

TABLE 2 (SECTION 3.4)
PERMISSIBLE AMOUNT OF WATER ON ORDINARY CONCRETE

Specified Compressive Strength lb./sq. in.	Water Content Imp. Gallons per 87½ lb. Sack of <i>Cement</i>
2000	5.75
2500	5.10
3000	4.50
3500	4.05
4000	3.70

Allowance shall be made for *surface water* present in the *aggregate* when computing the water content. In the absence of a more exact determination, the amount of *surface water* may be estimated from the values given in Table 3 of this Section.

TABLE 3 (SECTION 3.4)
APPROXIMATE QUANTITY OF SURFACE WATER CARRIED BY
AVERAGE AGGREGATE

<i>Aggregate</i>	Approximate Quantity of <i>Surface Water</i>
Very wet sand	¾ gal. per cu. ft.
Moderately wet sand	½ gal. per cu. ft.
Moist sand	¼ gal. per cu. ft.
Moist gravel or crushed rock	1/8 to ¼ gal. per cu. ft.*

*The coarser the *aggregate*, the less water will it carry.

3.4.5.3 Consistency and Aggregate Content.—In all *concrete*, the proportions of *fine* and *coarse aggregate* and *cement* shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcement with the method of placing employed on the work, but without permitting the material to segregate or excess free water to collect on the surface. The volume of *coarse aggregate* shall be not less than the volume of *fine aggregate* and not more than twice the volume of *fine aggregate*. These proportions do not necessarily apply to light-weight *aggregates*.

3.4.5.4 Tests.—

(a) **Controlled Concrete.**—When controlled *concrete* is used, compression tests shall be made during the progress of the work. Not

less than the number of specimens shown in Table 4 of this Section shall be made and not less than 3 specimens for each strength of *concrete* for any one day's operation.

TABLE 4 (SECTION 3.4)
MINIMUM NUMBER OF TEST SPECIMENS REQUIRED
WHEN CONTROLLED CONCRETE IS USED

Total Cubic Yards of <i>Concrete</i>	Minimum Number of Test Specimens
less than 100	one for each 50 cu. yd. or fraction thereof
100-1000	one for each 125 cu. yd. or fraction thereof
1000-2000	one for each 175 cu. yd. or fraction thereof
more than 2000	one for each 250 cu. yd. or fraction thereof

(b) **Ordinary Concrete.**—When ordinary *concrete* is used, compression tests shall be made during the progress of the work, when required by the *authority having jurisdiction*.

(c) **Methods of Test and Interpretation of Results.**—Tests shall be carried out in accordance with C.E.S.A. Specification A23-1941, Appendix VII, "Method of Making and Storing Specimens of Concrete in the Field". The standard age of test shall be 28 days, but 7-day tests may be used provided the relation between the 7 and 28 day strength of the *concrete* is established by test for the materials and proportions used.

In all cases where the average strength of the test specimens falls below the required strength, the *authority having jurisdiction* shall have the right to order a change in the mix for the remaining portion of the *structure*. Where conditions are such as to leave reasonable doubt as to the adequacy of the *concrete* for the purpose for which it is intended the *authority having jurisdiction* shall have the right to order load tests to be made on the portions of the *structure* so affected.

3.4.5.5 Supervision when Controlled Concrete is Used. When controlled *concrete* is used, the work shall be carried out under the direction of a responsible supervisor or inspector, competent and qualified for the execution of *reinforced concrete* construction.

3.4.6 Mixing and Placing

3.4.6.1 Mixing.—

(a) **General.**—The mixing of *concrete*, unless otherwise authorized by the *authority having jurisdiction*, shall be done in a mechanical batch mixer. The mixer shall be equipped with a suitable charging hopper, water storage and water measuring device. It shall be cleaned at frequent intervals when in use and maintained in such a condition that the mixing action will be unimpaired.

(b) **Machine Mixing at the Site.**—The mixing of each batch shall continue until there is a uniform distribution of material and the mass is

uniform in colour and *consistency*. In no case shall the mixing time be less than one minute after all the materials are put into the mixer.

(c) **Ready Mixed Concrete.**—Ready mixed *concrete* shall be proportioned, mixed, and delivered in accordance with the requirements of A.S.T.M. Specification C94-38 "Specification for Ready Mixed Concrete".

(d) **Hand Mixing.**—When hand mixing is permitted by the *authority having jurisdiction*, 10 per cent extra *cement* shall be used. Hand mixing shall be carried out on a water-tight platform and great care shall be taken to ensure that mixing is continued until the mass is uniform in colour and *consistency*.

3.4.6.2 Placing.—

(a) **Conveying.**—*Concrete* shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of materials.

Equipment for chuting, pumping, and pneumatically conveying *concrete* shall be of such size and design as to ensure a practically continuous flow of *concrete* at the delivery end without separation of materials. Conveying equipment shall be thoroughly flushed with water before and after each run; the water used for this purpose shall be discharged outside the forms.

(b) **Depositing.**—*Concrete* shall be deposited as nearly as possible in its final position to avoid rehandling. Concreting shall be carried on as a continuous operation until the panel, section or other unit of operation is complete. The top surface shall be generally level. When construction joints are necessary they shall be made in accordance with Item 3.4.10.3 or 3.4.10.4.

Concrete shall only be deposited in water with the written permission of the *authority having jurisdiction*, and special precautions shall be taken to prevent segregation of the mix and washing out of the *cement*. In no case shall such *concrete* be considered as "controlled" *concrete*.

Care shall be taken to prevent the contamination of *concrete* by corrosive waters or soils.

3.4.6.3 **Compacting.**—All *concrete* shall be properly compacted by suitable means during the operation of placing and shall be thoroughly worked around reinforcement, around embedded fixtures, and into the corners of the forms.

3.4.6.4 **Re-tempering of Concrete.**—The re-tempering of *concrete* or *mortar* that has partially hardened, that is, remixing with or without additional *cement*, *aggregate* or water, will not be permitted.

3.4.7 Curing of Concrete

3.4.7.1 **General.**—After *concrete* has set sufficiently, its exposed surfaces shall be kept continuously wet. This shall continue for a period of at least 7 days after the *concrete* was deposited.

3.4.7.2 Warm Weather Requirements.—In warm weather, particular care shall be taken to prevent drying out of the *concrete* at any time during the *curing* period.

3.4.7.3 Cold Weather Requirements.—Adequate equipment shall be provided for heating the *concrete* materials and protecting the *concrete* during freezing or near-freezing weather. No frozen materials, or materials containing ice, shall be used.

Concrete mixed and deposited when the temperature of the surrounding atmosphere is 40 F. or lower shall have a temperature of not less than 50 F. nor more than 100 F. Effective means shall be provided for maintaining the temperature of the *concrete* at not less than 50 F. nor more than 80 F. for at least 72 hours after placing. Whenever the atmospheric temperature is less than 50 F. a continuous record of atmospheric temperatures in the vicinity of the *concrete* shall be kept.

No dependence shall be placed on salt or other chemicals for the prevention of freezing.

3.4.8 Forms

3.4.8.1 General.—Forms shall be of such strength and rigidity and so supported as to prevent excessive deflection under the weight or pressure of the *wet concrete*. They shall be sufficiently tight to prevent leakage of *mortar*.

3.4.8.2 Design.—Forms constructed of wood shall be such that the unit stresses will not exceed twice the values prescribed in Tables 1 and 2 of Article 3.2.5. In calculating the deflection of any form the modulus of elasticity prescribed in Tables 1 and 2 of Article 3.2.5 shall apply. When plywood is used for forms, only the plies in which the grain is parallel to the span shall be considered to resist stress.

Shores supporting forms for slabs, *beams*, *girders*, or arches, shall be set on wedges or other effective supports in order that they may be removed without producing undue strains or shock in the superstructure.

If adequate foundations for shores cannot be secured, forms shall be supported on trusses.

Shores supporting successive *storeys* shall be placed directly above those below, or so designed that the load will be transmitted directly to those below.

3.4.8.3 Construction.—

(a) **Warping of Forms.**—Care shall be taken to ensure that forms do not become dried and warped before *concrete* is deposited.

(b) **Cleaning and Inspection.**—Immediately before *concrete* is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly clean, properly treated, and free from snow, ice, or other foreign materials.

Temporary openings shall be provided at the base of *column* and wall forms, and other places where necessary, to facilitate cleaning and inspection. These openings shall be so placed that water for removing debris shall have a clear run to the outside of the forms.

3.4.8.4 Removal.—The removal of forms shall be carried out in such a manner as to ensure the complete safety of the *structure*. Shoring shall not be removed until the member has acquired sufficient strength to support safely its weight and the load on it. Members subjected to additional loads during construction shall be adequately shored to support safely both their own weight and the additional loads. This shoring shall not be removed until the member has acquired sufficient strength to support safely its own weight and the load on it.

3.4.9 Waterproofing and Protective Treatment

3.4.9.1 Waterproofing.—While by paying careful attention to the quality and proportioning of ingredients and the manipulation of the mixture prior to and during placing, *concrete* can be produced that for all practical purposes is watertight, special attention must be paid to the construction of joints as set forth in Item 3.4.10.4*.

3.4.9.2 Concrete in Alkali Soils and Water.—Where *concrete* will be exposed to corrosive soils or ground waters, provision shall be made by the use of a rich mix, special *cement*, protective coverings or other means acceptable to the *authority having jurisdiction* to ensure adequate durability.*

3.4.10 Details of Construction

3.4.10.1 Reinforcement.—

(a) **Cleaning.**—Reinforcement before being placed shall be clean and free from coatings, including ice, that would tend to reduce the bond. Where there is delay in depositing *concrete*, reinforcement shall be re-inspected and cleaned when necessary.

(b) **Fabrication.**—Reinforcement shall be accurately formed to the dimensions indicated on the drawings. Stirrups, *column* ties, and *beam* ties, under 3/4 inch size, shall be bent around a pin having a diameter not less than twice the size of the bar for bends up to 90 degrees, nor less than three times the size of the bar for bends between 90 and 180 degrees. For stirrups, *column* ties, and *beam* ties, 3/4 inch size and over, the corresponding minimum pin diameters shall be three times and four times the bar size, respectively. Except in standard hooks, other bars of structural or intermediate grade shall be bent around a pin having a diameter not less than 12 times the size of the bar. Bars of hard grade or rail steel shall be bent around a pin having a diameter not less than 12 times the size of the bar.

*Concrete exposed to the action of any material having possible physical or chemical action on the *concrete* requires special investigation.

*The destructive action of alkali waters on *concrete* is progressive. The rate of deterioration varies with the 'Alkali-resisting' property of the *cement* used, decreases as the *concrete* is made stronger and more impermeable and increases as the sulphate content of the water increases. Where *structures* are only partially immersed or are in contact with alkali soils or waters on one side only, evaporation may cause serious concentrations of sulphate salts with subsequent deterioration, even where the original sulphate content of the soil or water is not high.

At sites where alkali concentrations are, or may become, very high, Portland Cement *concrete* cannot be recommended, and if used, the ground water should be lowered by drainage so that it will not come into direct contact with the *concrete*.

Additional protection may be obtained by the use of membrane waterproofing or tile surfacing.

Reinforcement shall not be straightened or rebent in a manner that will injure the material. Bars with kinks, or bends not shown in the drawings, shall not be used. Heating of the reinforcement will be permitted only when the entire operation is *approved* by the *authority having jurisdiction*.

(c) Placing Reinforcement.—

- (i) Reinforcement shall be accurately placed and secured against displacement by using annealed iron wire ties or suitable clips at intersections, and shall be supported by *concrete* or metal supports, spacers, or metal hangers.
- (ii) The minimum centre-to-centre distance between parallel bars shall be two and one-half times the diameter of round or three times the side dimensions for square bars, but in no case shall the clear spacing between the bars be less than one and one-half times the maximum size of the large *aggregate* nor less than one inch in *beams* and *girders* or less than $1\frac{1}{2}$ inches in *columns*.

The spacing of the principal reinforcement in slabs shall be not greater than two and one-half times the effective depth where the reinforcement runs in one direction only, nor three times the effective depth where the reinforcement runs in two or more directions.

- (iii) At a tension splice, the minimum spacing described in Item 3.4.10.1 (c) (ii) shall be maintained. Splices in adjacent bars carrying tension shall be staggered.

At a compression splice, each pair of lapped bars may be in contact but the minimum clear spacing between the splice and the adjacent splice shall be that specified for adjacent single bars.

When it is necessary to splice reinforcement at points other than shown on the drawings, the character of the splice shall be *approved* by the *authority having jurisdiction*.

(d) Future Bonding.—Exposed reinforcement intended for bonding with future extensions shall be effectively protected from corrosion.

3.4.10.2 Concrete Protection for Reinforcement.—All reinforcement shall be placed so that its distance from the nearest face of the *concrete* shall not be less than that prescribed in Table 5.

TABLE 5 (SECTION 3.4)
MINIMUM PROTECTION REQUIRED FOR REINFORCING BARS
IN INTERIOR MEMBERS

Location of Bars	Minimum Protection Required
Slabs: reinforcement not over ½ inch in size	¾ inch
reinforcement more than ½ inch in size	1 inch
All other members except spirally reinforced <i>columns</i>	1 inch or 1 bar diameter whichever is the greater
Spirally reinforced <i>columns</i>	1½ inch

At those surfaces of *footings* and other principal structural members in which the *concrete*, not placed in forms, is to be in direct contact with soil, reinforcement shall have a minimum covering of 3 inches of *concrete*. At surfaces where *concrete*, placed in forms, is to be in direct contact with soil, or may be exposed to alternate freezing and thawing, reinforcement shall have a minimum covering of 2 inches of *concrete*. In water-retaining *structures* not subject to alternate freezing and thawing, reinforcement shall have a minimum covering of at least 1¼ inches of *concrete*.

Reinforcement in fire-resistive construction shall be protected as required in Part 4.

3.4.10.3 Construction Joints.

(a) Location and Design.—

- (i) Construction joints shall be so located and designed as least to impair the strength and appearance of the *structure*. The reinforcement, if any, shall continue through the joint. Shearing strength at the joint shall be provided, where necessary, by mortises or keys formed in the *concrete*, by inclined reinforcement, or by other means satisfactory to the *authority having jurisdiction*. The locations and details of construction joints not indicated on the plans shall be subject to the approval of the *authority having jurisdiction*.
- (ii) Construction joints in *columns* shall be located at the under-side of the floor members. Haunches and *column capitals* shall be considered as part of and continuous with the floor or roof. At least two hours shall elapse after depositing *concrete* in *columns* or walls before depositing *concrete* in the floor system. If an *approved* system of vibration is used in pouring the *column* or wall this period may be reduced.

- (iii) Construction joints in the floor system shall be located at or near the middle of the span in slabs, *beams*, or *girders*, unless a *beam* intersects a *girder* at this point, in which case the joint in the *girder* shall be offset a distance equal to twice the width of the *beam*.
- (iv) Where a construction joint is required in a section of a building more than 100 feet long, or more than 100 feet between expansion joints, special reinforcement shall be placed at right angles to the joint and extending on each side of it a distance sufficient to develop the permissible tensile stress in the reinforcement by bond. This reinforcement shall be placed near the face of the member remote from the main tensile reinforcement, and its cross-sectional area shall not be less than 0.5 per cent of the section of the members cut by the joint.

(b) Bonding of New Concrete to Old.—

- (i) On recommencing placing of *concrete* on work which was completed not more than 3 hours before, the forms shall be tightened if necessary, and the surface of the previous work shall be roughened and thoroughly cleaned of foreign matter and *laitance*. The new *concrete* shall be placed in such a manner as will ensure an excess of *mortar* over the entire surface of the joint.
- (ii) On recommencing placing of *concrete* on work which was completed more than 3 hours before, the requirements of the preceding paragraph shall apply, and in addition the surface of the hardened *concrete*, after being saturated with water, shall be sprinkled with dry *cement* which shall then be thoroughly worked up into a paste with a stiff brush, or alternatively the wetted surface shall be covered with a thin layer of neat *cement* paste which shall then be thoroughly brushed into the surface. In either case the neat *cement* coating shall not be allowed to dry out, and the placing of the new *concrete* shall proceed immediately. Special care shall be taken in compacting the new *concrete* at the joint.

3.4.10.4 Watertight Construction.—At a horizontal construction joint in watertight construction, the surface to which succeeding *concrete* is to be bonded shall be finished with a depth of at least 6 inches of *concrete* of a *consistency* such that it can be placed with a minimum of puddling and with no free water showing. The surface shall be protected from loss of moisture and from mechanical injury.

Vertical construction joints shall not be made in watertight construction unless shown on the plans or authorized by the *authority having jurisdiction*.

3.4.10.5 Expansion Joints.—

(a) Expansion joints shall be so detailed that the necessary movement may occur with a minimum of resistance at the joint. The *structure* adjacent to the joint shall preferably be supported on separated *columns* or walls. Reinforcement shall not extend across an expansion joint; the break between the two sections shall be complete.

(b) Unless otherwise specified, *reinforced concrete structures* exceeding 200 feet in length and of width less than about one-half the length shall be divided by means of expansion joints not more than 200 feet apart. *Structures* in which marked changes in plan dimensions take place abruptly shall be provided with expansion joints at the sections where such changes occur.

3.4.11 Permissible Stresses

3.4.11.1 Permissible Stresses in Concrete.—The unit stresses for *concrete* shall not exceed the values given in Table 6 of this Section where f'_c is the minimum ultimate compressive 28-day strength, or earlier strength, at which the *concrete* is to receive its full working load.

TABLE 6 (SECTION 3.4)
PERMISSIBLE STRESSES IN CONCRETE

Kind of Stress	Permissible Unit Stress
Flexure	
Extreme fibre stress in compression	$0.40f_c$
Extreme fibre stress accompanied by buckling	See Item 3.4.14.4
Extreme fibre stress in tension in <i>plain concrete</i>	$0.03f_c$
Shear	
(a) Provided that the unit shear stress does not exceed $0.06f_c$, the shear value of the <i>concrete</i> shall be taken as follows:	
<i>Beams</i> , with or without web reinforcement, when the anchorage provided fulfils the minimum requirements prescribed in Item 3.4.14.9 (b) (i)	$0.02f_c$
<i>Beams</i> , with or without web reinforcement, when the anchorage provided is 50 per cent more than the minimum requirements prescribed in Item 3.4.14.9 (b) (i)	$0.03f_c$
<i>Slabs and footings</i>	$0.03f_c$
(b) When the unit shear stress on the composite section exceeds $0.06f_c$, the shear value of the <i>concrete</i> shall be neglected. The web reinforcement shall be capable of resisting the entire shear and the anchorage of the longitudinal steel shall be 50 per cent more than the minimum requirements prescribed in Item 3.4.14.9 (b) (i).	
(c) In no case shall the shear stress on the composite section exceed $0.12f_c$.	
(d) Punching shear based on the gross depth of the member	$0.10f_c$
Bond	
(a) Anchorage bond stress considered uniformly distributed over the embedded anchorage surface. Plain straight bars and plain bent bars other than those having standard hooks. l/D not over 25 On the embedded surface of a standard hook 125 per cent of the value permitted for straight bars. When l/D exceeds 25, the anchorage bond stress on such excess length shall be 2/3 of the foregoing, except that, if the bar is provided with a standard hook, this reduction shall not apply.	Anchorage bond stress $= 200 - \frac{240,000}{f_c}$
(b) Bond stress resulting from shearing force on <i>beams</i> , <i>slabs</i> , and one-way <i>footings</i> . Plain bars	$u = 400 - \frac{480,000}{f_c}$
(c) On <i>deformed bars</i> 125 per cent of the values permitted for plain bars may be used.	
(d) On two-way <i>footings</i> 75 per cent of the values given in (a), (b), or (c) shall be used.	
Bearing	
On full area	$0.25f_c$
On part of area	See Item 3.4.22.5
Pedestals	See Article 3.4.23

3.4.11.2 Permissible Stresses in Reinforcement.—The unit stresses in reinforcement shall not exceed the values given in Table 7 of this Section.

TABLE 7 (SECTION 3.4)
PERMISSIBLE TENSILE STRESSES IN REINFORCEMENT

Material	Specified Minimum Yield Point lb./sq. in.	Permissible Stress lb./sq. in.
Structural grade steel bars	33,000	18,000
Structural steel shapes	33,000	18,000
Intermediate grade bars	40,000	20,000
Hard grade billet-steel bars and rail-steel bars	50,000	20,000
Cold-drawn steel wire	56,000	25,000
Web reinforcement, hangers, or other direct tension members of any grade of steel		16,000
Other steel reinforcement		0.50 of yield point stress but not over 20,000

3.4.12 Tests of Structures or Structural Elements.—When a load test is required by the *authority having jurisdiction*, the member or portion of the *structure* under consideration shall be subjected to a superimposed load equal to one and one-half times the *live load*. This load shall be left in position for a period of 24 hours before removal. If, during the test, or upon removal of the load, the member or portion of the member shows signs of weakness or faulty construction, it shall be reconstructed or strengthened in accordance with the requirements of this Section.

If, within 24 hours after the removal of the load, the slabs or *beams* do not show a recovery of at least 75 per cent of the maximum deflection shown during the 24 hours under load, the test loading shall be repeated. The *structure* shall be considered to have failed to pass the test if, within 24 hours, the recovery after the second test is not at least 75 per cent of the maximum deflection shown during the second test.

3.4.13 General Design Requirements

3.4.13.1 General.—In any *reinforced concrete structure*, provision shall be made for all conditions of stress that may occur, whether specifically mentioned in Articles 3.4.13 to 3.4.24 or not, in accordance with well established principles of mechanics and sound engineering practice. In particular, adequate consideration shall be given to the effects of continuity due to monolithic construction on the distribution of bending moments and shears.

3.4.13.2 Resistance to Wind Loads.—In buildings or in portions of buildings where the *masonry* walls and permanent *partitions* are not capable in accordance with Article 3.3.3. of withstanding the total wind load, the structural frame alone shall be adequate to resist this load.

3.4.13.3 Calculation of Bending Stresses.—The calculation of bending stresses in *reinforced concrete* members shall be based on the following assumptions:

- (a) that for stresses due to bending, a transverse section plane before bending remains plane after bending;
- (b) that the moduli of elasticity of steel, and of *concrete* of a given strength are constant;
- (c) that the tensile strength of the *concrete* is negligible;
- (d) that initial stress due to contraction or expansion of the *concrete* is neglected;
- (e) that the modular ratio has the value

$$n = \frac{30,000}{f'_c}$$

but in no case less than 7.5; or alternatively the modular ratio may be assumed to have the value given in Table 8 of this Section.

TABLE 8 (SECTION 3.4)

MODULAR RATIO TO BE ASSUMED IN FLEXURAL CALCULATIONS

f'_c lb per sq. in.	n
2000—2400	15
2500—2900	12
3000—3900	10
4000 and over	8

The above values are for *concrete* made from normal weight *aggregates*; for light weight *concrete* the modular ratio shall be assumed to be twice as great.

3.4.13.4 Estimating the Stiffness of a Member.—For the purpose of estimating the stiffness of a flexural member the moment of inertia shall be assumed as that of its gross section neglecting the reinforcement. In the case of a *T-beam* or an *L-beam* the effective flange width shall be assumed as not more than 50 per cent of that defined in Item 3.4.14.7. For *columns* or other compression members the transformed area of the reinforcement shall be included.

3.4.14. Beams, and Slabs Reinforced in one Direction

3.4.14.1 Effective Span.—The effective span of a freely supported *beam* or slab having a single span shall be either the distance between centres of supports or the clear span plus the depth of the *beam* or slab, whichever is the lesser.

The effective span of a continuous *beam* or slab considered as freely supported shall be the distance between centres of supports.

The effective span of a *beam* or slab considered to act integrally with supports shall be the clear distance between the faces of the supports.

For *beams* having brackets built to act integrally with both *beam* and support, and of a width not less than the width of the *beam*, and making an angle of 45 degrees or more with the *beam*, the span shall be measured from the section where the combined depth of the *beam* and bracket is at least one-third more than the depth of the *beam*.

3.4.14.2 Minimum Thickness of Slabs.—In ordinary *beam* and slab construction the minimum thickness of slabs shall be 3 inches.

3.4.14.3 Bending Moments and Shearing Forces.—*Beams* and slabs constructed monolithically with the supporting *beams* or *girders* shall be considered as freely supported continuous *beams*.

Beams and slabs constructed monolithically with the supporting *columns* shall be considered as part of a monolithic framework.

For monolithic construction the moments computed at the face of the supports shall be used to proportion the members at those sections.

Except as provided in the subsequent paragraphs of this Item, every cross section of a *beam* or slab shall be adequate to resist the maximum positive and negative bending moments due to the following conditions of loading:

- (a) *Dead load* on all spans plus *live load* on alternate spans. Not more than three consecutive spans need be considered.
- (b) *Dead load* on all spans plus *live load* on adjacent spans.

Provided that the maximum positive moments so obtained in any two adjacent spans are increased by an amount not exceeding 15 per cent of the mean of the negative moments at the faces of the intermediate support, these latter may each be reduced by the same amount and the bending moment curves adjusted accordingly.

The negative bending moment near the centre of the span of a *beam* or slab due to loads applied to neighbouring spans may be reduced by one-third in the case of a *beam*, and one-half in the case of a slab, on account of the torsional resistance of supporting *beams* or the bending resistance of *columns*.

In the absence of more exact estimates, the total bending moments and shearing forces due to uniformly distributed loads applied to a number

of approximately equal spans may be assumed to have the following values:

Positive moment near the middle of an end span.....	$\frac{wL^2}{10}$
Positive moment near the middle of an interior span.....	$\frac{wL^2}{12}$
Negative moment at end supports—not less than.....	$\frac{wL^2}{24}$
Negative moment at the first interior support:	$\left\{ \begin{array}{l} \text{two spans.....} \quad \frac{wL^2}{8} \\ \text{more than two spans.....} \quad \frac{wL^2}{10} \end{array} \right.$
Negative moment at interior support other than the first.....	$\frac{wL^2}{12}$

Shearing force at the outer edge of the first interior support $0.60 wL$
 Shearing force at interior supports other than the first $0.50 wL$
 where L is the clear span for positive moments, and the average of the two adjacent clear spans for negative moments, and shearing forces.

For the purposes of this Item “approximately” shall mean that the longer of two adjacent spans shall not exceed the shorter by more than 25 per cent.

3.4.14.4 Lateral Support.—Where the distance, s , between points of lateral support of an isolated *beam* exceeds 15 times the width, b , of the compression face, the permissible flexural stress in the *concrete* shall not exceed

$$f_{bc} = f_c \left(1.5 - \frac{s}{30b} \right) \dots \dots \dots (1)$$

where f_c is the permissible flexural stress in *beams* continuously supported laterally. In no case shall the ratio s/b exceed 30. *Beams* subject to such reduction of stress shall be reinforced at the compression face. Such reinforcement shall not be less than 0.0025 of the effective area of the *beam*.

3.4.14.5 Minimum Reinforcement in Slabs.—

(a) **Shrinkage and Temperature Reinforcement.**—Reinforcement for shrinkage and temperature stresses normal to the principal reinforcement shall be provided in floor and roof slabs where the principal reinforcement extends in one direction only. Such reinforcement shall provide for the following minimum ratios of reinforcement area to *concrete* area (bd), but in no case shall such reinforcing bars be placed farther apart than five times the slab thickness nor more than 24 inches:

Floor slabs where plain bars are used	0.0025
Floor slabs where <i>deformed bars</i> are used	0.002
Floor slabs where wire fabric is used, having welded inter- sections not farther apart in the direction of stress than 12 inches	0.0018
Roof slabs where plain bars are used	0.003
Roof slabs where <i>deformed bars</i> are used	0.0025
Roof slabs where wire fabric is used, having welded inter- sections not farther apart in the direction of stress than 12 inches	0.0022

(b) **Main Reinforcement.**—The amount of reinforcement provided to resist bending stresses shall not be less than that required for shrinkage and temperature stresses.

3.4.14.6 Reinforcement in Beams.—

(a) **General.**—In any *beam* at least one-quarter of the positive reinforcement shall be extended beyond the face of the support so as to provide an embedment sufficient to develop one-third of the allowable stress in the bar.

(b) **Compression Steel.**—Where steel is used to resist compression in *beams* it shall be thoroughly secured against buckling by means of ties or stirrups not less than 1/4 inch diameter which shall be spaced not more than 8 inches apart.

(c) **Shear Reinforcement.**—Unit shear stress on the composite section shall be determined by the following formulas:

$$\text{For members of constant depth} \quad v = \frac{V}{bjd} \dots \dots \dots (2)$$

$$\text{For members of varying depth} \quad v = \frac{V \pm \frac{M}{jd} \tan \alpha}{bjd} \dots \dots \dots (3)$$

The negative sign applies where the bending moment, M , increases numerically in the same direction as the depth, d , increases, and the positive sign where the moment decreases numerically in this direction. The angle α is the angle which a sloping face makes with the axis of the *beam*.

The shear value of a *beam* section shall be the sum of the shear value of the *concrete* as prescribed in Item 3.4.11.1 and the shear value of the reinforcement.

Any stirrup shall pass round the tensile reinforcement or be otherwise secured thereto and shall be effectively anchored in the compression zone of the *beam* by passing round the compression reinforcement or by the use of a hook.

Any bent-up bar, if not continued to form negative reinforcement, shall be anchored by an embedment sufficient to develop by bond the tensile stress in the bar due to diagonal tension, this embedment being measured from the neutral axis of the *beam*.

The spacing of shear reinforcement, measured along the neutral axis of the *beam*, shall in no case exceed jd and when the unit shear stress exceeds $0.06f'_c$ the spacing shall not exceed $0.6d$. This limitation shall not apply where the unit shear stress for *plain concrete* is not exceeded. The maximum distance between the face of the support and the first web reinforcement bar, measured along the neutral axis, shall not exceed one-half the spacing required in the neighbourhood of the supports nor $0.50jd$.

3.4.14.7 Requirements for T-beams and L-beams.—

(a) **Effective Flange Width.**—In *T-beam* construction the slab and *beam* shall be built integrally or otherwise effectively bonded together. The effective flange width to be used in the design of symmetrical *T-beams* shall not exceed one-fourth of the span length of the *beam*, and its overhanging width on either side of the web shall not exceed 8 times the thickness of the slab nor one-half the clear distance to the next *beam*, where the *beams* involved are of equal size.

For *beams* having a flange on one side only (*L-beam*), the effective overhanging flange width shall not exceed $1/12$ of the span length of the *beam*, nor 6 times the thickness of the slab, nor one-half the clear distance to the next *beam*.

(b) **Reinforcement.**—Where the principal reinforcement in a slab which is considered as the flange of a *T-beam* (not a rib in ribbed floors) is parallel to the *beam*, transverse reinforcement shall be provided in the top of the slab. Such reinforcement shall not be less than 0.3 per cent of the cross-sectional area of the slab (bd). The spacing of the bars shall not exceed 5 times the depth of the slab, nor in any case 18 inches, and their length measured from the face of the *beam* stem shall be sufficient to develop the permissible stress in the bar at the prescribed anchorage bond stress.

The area of the steel in compression at any cross section adjacent to a support shall not exceed 2 per cent of the cross-sectional area of the stem of the *beam* in that section.

(c) **Shear Resistance.**—In computing the shear and diagonal tension resistance of *T-beams* and *L-beams* only the stem shall be considered as effective.

(d) **Isolated Beams.**—Isolated *beams* in which the T-form is used only for the purposes of providing additional compression area, shall have a flange thickness not less than one-half the width of the web and a total effective flange width not more than 4 times the web thickness.

3.4.14.8 Calculation of Bond Stress Due to Shearing Force.—

The bond stress resulting from shearing force shall be determined by the following formulas:

For members of constant depth
$$u = \frac{V}{jd\Sigma o} \dots\dots\dots (4)$$

$$\text{For members of varying depth} \quad u = \frac{V \pm \frac{M}{jd} \tan \alpha}{jd \Sigma o} \dots \dots \dots (5)$$

The negative sign applies where the bending moment, M , increases numerically in the same direction as the depth, d , increases, and the positive sign where the moment decreases numerically in this direction.

In applying formula (4) or (5) to any section of a *beam* in which the reinforcement includes bent bars, those bars which are within a distance of one-third of the effective depth of the *beam* from the main longitudinal reinforcement may be counted as contributing to bond resistance.

Where a group of bars of different sizes exists at a cross section, the bond stress on any particular bar shall be determined by the following formula and shall not exceed the permissible bond stress:

$$u_1 = u D_1 \frac{\Sigma o}{\Sigma o D} \dots \dots \dots (6)$$

where u_1 is the unit bond stress on bar 1;

D_1 the size of bar 1;

Σo the sum of the perimeters of all the bars;

$\Sigma o D$ the sum of the products of the perimeter and bar size of all the bars.

3.4.14.9 Anchorage.—

(a) **General.**—Every reinforcing bar in a flexural member shall be anchored by embedment, with or without a standard hook, in *concrete* not subjected to appreciable tensile stress, except that bars may be spliced in accordance with the provisions of Item 3.4.14.10. Any mechanical device capable of developing the strength of the bar without damage to the *concrete* may be used in place of a hook. Test results must be presented to show the adequacy of such devices.

The anchorage required for reinforcement other than shear reinforcement shall be determined on the basis of the calculated bond stress at sections of the bar where the calculated direct stress approaches zero or where there is an abrupt change in such stress. (For anchorage requirements for shear reinforcement see Item 3.4.14.6 (c).)

In calculating the length of embedment required for the anchorage of a bar the stress prescribed in Item 3.4.11.1 for anchorage bond stress shall apply.

A standard hook shall consist of a semi-circular bend having an inside diameter of not less than 5 nor more than 8 times the size of the bar, with an extension of 4 times the size of the bar or 2 inches whichever is the lesser. Hooks shall not be used unless precautions are taken to ensure that the encasing *concrete* is safe against splitting.

(b) Relation of Required Anchorage to Calculated Bond Stress.

- (i) When the calculated bond stress as determined by equation (4), (5), or (6) does not exceed the value given by

$$u = 200 - \frac{240,000}{f'_c} \text{ lb./sq. in.} \dots\dots\dots (7)$$

anchorage shall consist of an embedment sufficient to develop the tensile stress in the bar at the section for which the bond is calculated or sufficient to develop a stress equal to 20 per cent of the permissible stress in the bar, whichever is the greater.

- (ii) When the calculated bond stress as determined by formula (4), (5), or (6) exceeds the value given by formula (7), anchorage shall consist of an embedment sufficient to develop the tensile stress in the bar at the section for which the bond is calculated, or sufficient to develop a stress equal to 20 per cent of the permissible stress in the bar multiplied by the ratio of the calculated bond stress to the value given by formula (7), whichever is the greater.
- (iii) In no case shall the calculated bond stress exceed twice that given by formula (7).

(c) Compression Reinforcement.—For bars in compression, anchorage shall consist of a straight embedment sufficient to develop the stress in the bar at the section for which the bond is calculated but not more than 25 times the size of the bar.

3.4.14.10 Splicing of Tensile Reinforcement.—When it is necessary to splice a bar carrying a tension by lapping, the length of the lap shall be sufficient to transfer the permissible stress in the bar at the bond stress prescribed in Item 3.4.11.1 for anchorage. In such cases the minimum spacing of the spliced bars shall be as prescribed for parallel bars in Item 3.4.10.1 (c).

3.4.15 Slabs Reinforced in Two Directions

3.4.15.1 General.—The provisions of this Item shall, where the long span does not exceed three times the short span, apply to slabs supported on four edges by *beams* or walls and reinforced in two directions, and also to two-way ribbed floor construction as specified in Item 3.4.18.4 and shall apply only to slabs or ribbed floors built monolithically with the supports.

3.4.15.2 Bending Moments.—

(a) For isolated slabs and for a group of approximately equal panels the maximum bending moments may be assumed to be those given in Table 9 of this Section. These coefficients are also shown diagrammatically in Figure 1. Panels shall be considered to be approximately equal when the longer of two adjacent spans does not exceed the shorter by more than 25 per cent.

(b) For slabs, other than in two-way ribbed floor construction, the minimum thickness shall be $3\frac{1}{2}$ inches, and the effective depths shall be the actual distances from the compression face of the slab to the centroids of the steel in each direction.

(c) When the slab is not effectively held down to the supporting *beams* at an exterior corner, reinforcement shall be introduced in each direction for a length equal to one-fifth of the longer span of the slab. This reinforcement shall be in the form of a mesh at both the top and the bottom of the slab and the effective amount in the direction parallel to the diagonal at the top of the slab and perpendicular to the diagonal at the bottom shall be equal in quantity per unit width of slab to the reinforcement provided for maximum positive moment in the short span. Slab steel otherwise required for this location may be considered as part of this corner reinforcement.

TABLE 9 (SECTION 3.4)
COEFFICIENTS OF MAXIMUM BENDING MOMENTS IN RECTANGULAR
SLABS REINFORCED IN TWO DIRECTIONS

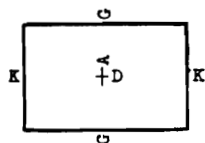
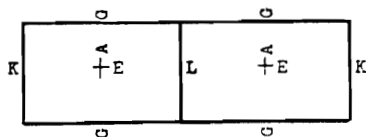
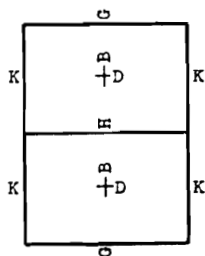
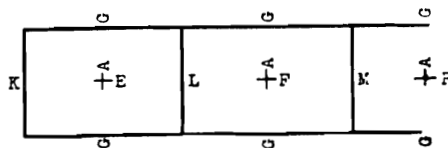
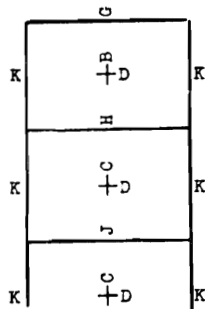
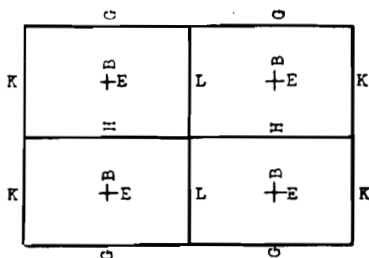
	Coefficient of $w'l^2$	
	Short Span	Long Span
Positive Moments		
(a) Near the centre of single spans	$0.13 - 0.09m$	0.04
(b) Near the centre of the end span of two or more spans	$0.115 - 0.08m$	0.035
(c) Near the centre of interior spans	$0.095 - 0.065m$	0.03
Negative Moments		
(a) At the exterior supports of a slab	$0.05 - 0.03m$	0.02
(b) At the interior support of two spans and at the first interior support of more than two spans	$0.13 - 0.085m$	$0.085 - 0.04m$
(c) At interior supports other than the first	$0.103 - 0.066m$	$0.077 - 0.04m$

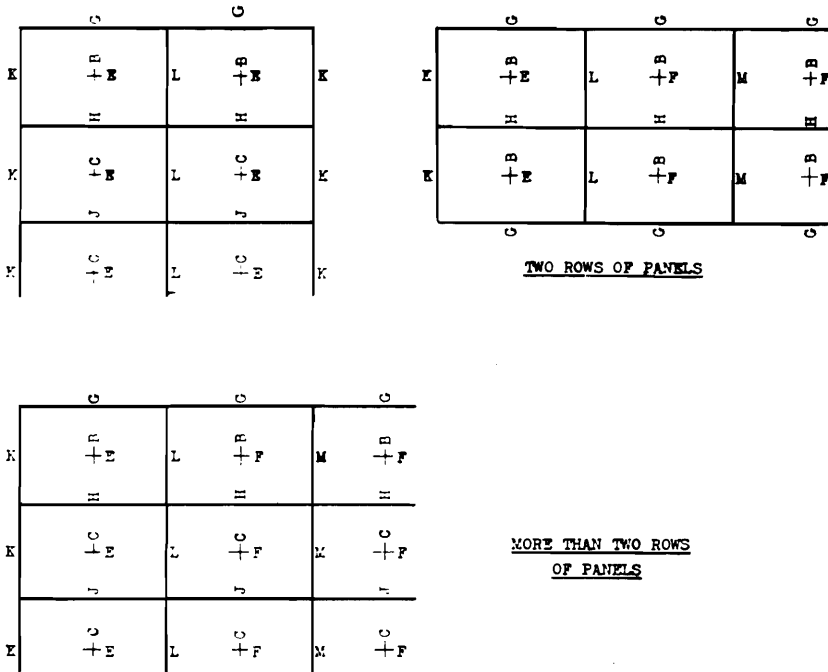
Symbols have the following meanings:

w' = load per square unit

l = shorter span

$m = \frac{\text{shorter span}}{\text{longer span}}$

SINGLE PANELTWO PANELSSINGLE ROW OF PANELSFOUR PANELS

LIST OF COEFFICIENTS

Positive Moments		Negative Moments	
Symbol	Coefficient of $w'l^2$	Symbol	Coefficient of $w'l^2$
A	0.13 - 0.09m	G	0.05 - 0.03m
B	0.115 - 0.08m	H	0.13 - 0.085m
C	0.095 - 0.065m	J	0.103 - 0.066m
D	0.04	K	0.02
E	0.035	L	0.085 - 0.04m
F	0.03	M	0.077 - 0.04m

w' = load per unit of area

l = shorter span

m = $\frac{\text{shorter span}}{\text{longer span}}$

COEFFICIENTS OF MAXIMUM BENDING MOMENTS
IN RECTANGULAR SLABS REINFORCED IN
TWO DIRECTIONS

FIGURE 1.

(d) Unless more exact methods are used to determine the distribution of bending moments in a group of unequal panels, the following maximum bending moments shall be provided for, considering two adjacent and unequal spans:

- (i) The positive moments in the longer span and the negative moments at the support shall be assumed to be equal to those that would be present if both spans were equal to the longer one.
- (ii) The positive moments near the centre of the shorter span shall be assumed to be given by the following formulas:
when the shorter span is an interior span,

$$M = M'(2 - 0.8 \frac{L_A}{L_B}) \dots \dots \dots (8)$$

when the shorter span is an end span

$$M = M'(1.3 - 0.25 \frac{L_A}{L_B}) \dots \dots \dots (9)$$

where M' is the moment that would be present if both spans were equal to the smaller one

L_A is the larger span,

and L_B the smaller span.

3.4.15.3 Arrangement of Reinforcement.—The positive moment reinforcement may be reduced by one-half for a distance not exceeding one-quarter of the shorter span measured from the edges of the slab.

In no case shall the amount of reinforcement provided to resist bending stresses be less than that specified in Item 3.4.14.5 (a) for temperature and shrinkage reinforcement.

3.4.15.4 Load on the Supporting Beams.—The pressure exerted by uniformly loaded rectangular two-way slabs on the supporting *beams* or walls may be assumed to be uniformly distributed and of an intensity w pounds per linear foot,

$$\text{where } w = \left(1 + \frac{1}{m}\right) \frac{w' l}{8} \dots \dots \dots (10)$$

and $m = \frac{\text{shorter span}}{\text{longer span}};$

w' = unit load on slab in pounds per square foot;

l = shorter span.

3.4.16 One-way Ribbed Floor Construction

3.4.16.1 General.—One-way ribbed floor construction shall consist of *concrete* ribs and slabs placed monolithically, with or without burned clay, *concrete* tile or gypsum tile fillers. The ribs shall not be farther apart than 30 inches face to face. The ribs shall be straight, not less than 4 inches wide, nor of a depth more than three times the width.

3.4.16.2 Allowance for the Strength of Fillers.—When burned clay or *concrete* tile fillers, of material having a unit compressive strength at least equal to that of the ribs are used, and the fillers are so placed that the joints in alternate rows are staggered, the *shells* of the fillers in contact with the ribs may be included in the calculations involving shear or negative bending moment. No other portion of the fillers may be included in the design calculations.

3.4.16.3 Concrete Slab.—

(a) The thickness of the *concrete* slab shall not be less than $1/12$ of the clear distance between the ribs nor less than $1\frac{1}{2}$ inches when the fillers complying with Item 3.4.16.2 are used; nor less than 2 inches when removable forms, or fillers not complying with Item 3.4.16.2 are used.

(b) The slab shall be so reinforced that the stresses in the *concrete* and the reinforcement will not exceed those permitted in Article 3.4.11, and the reinforcement at right angles to the ribs shall not be less than that prescribed for temperature and shrinkage in Item 3.4.14.5 (a) nor less than $1/4$ inch diameter rods at 12-inch centres or equivalent. Reinforcement of the slab parallel to the ribs shall not be required.

(c) When the finish used as a wearing surface is placed monolithically with the structural slab in buildings of the warehouse or industrial class, the thickness of the slab shall be $1/2$ inch greater than the thickness used for design purposes.

(d) Where the slab contains conduits or pipes, the thickness shall not be less than one inch plus the total over-all depth of such conduits or pipes at any point. Such conduits or pipes shall be so located as not to impair the strength of the construction.

3.4.16.4 Bridging.—When removable forms are used, bridging shall be provided as follows: one row of *concrete* bridging shall be placed in clear spans of 12 feet to 24 feet; two rows of bridging shall be placed in all clear spans greater than 24 feet. Bridging shall be reinforced top and bottom with not less than 1 2-inch rods or the equivalent area in other shapes. Such bridging shall be the full depth and width of the rib.

3.4.17 Pre-cast Concrete Joists

3.4.17.1 General.—Pre-cast *concrete joists* shall not be used in floors for which the prescribed *live load* is in excess of 100 pounds per square foot.

The depth of pre-cast *concrete joists* shall be not more than 4 times the width of the top or bottom flanges nor less than $1/24$ of the span length.

The thickness of the top slab shall be not less than $1/12$ of the clear distance between the *joists* nor less than 2 inches, and not less than $1\frac{1}{2}$ inches over the *joists*. Every slab shall be reinforced and such reinforcement shall fulfil the requirements of Item 3.4.16.3 (b).

A method of bonding between the *joist* and the slab shall be provided which, to the satisfaction of the *authority having jurisdiction*, will ensure complete T-beam action.

3.4.17.2 Bridging.—Pre-cast *joists* shall be bridged in accordance with the requirements of Item 3.4.16.4.

3.4.18 Two-way Ribbed Floor Construction

3.4.18.1 General.—Two-way ribbed floor construction shall consist of *concrete* ribs running in two directions at right angles to one another, with or without burned clay, *concrete* tile or gypsum tile fillers, and with *concrete* top slabs placed monolithically with the ribs.

3.4.18.2 Allowance for Strength of Fillers.—When burned clay or *concrete* fillers of material having a compressive strength at least equal to the minimum required for the *concrete* in the ribs are used, the *shells* in contact with the concrete ribs may be included in calculating the resistance to shear and bending moment, and the top and bottom *shells* may be included in calculating the resistance to bending moment.

3.4.18.3 Concrete Slab.—

(a) The thickness of the *concrete* slab shall not be less than 1/12 of the clear distance between the ribs, nor less than 1½ inches when fillers complying with Item 3.4.18.2 are used; nor less than 2 inches when removable forms or fillers not complying with Item 3.4.18.2 are used.

(b) The slab shall be so reinforced that the stresses in the *concrete* and the reinforcement will not exceed those permitted in Article 3.4.11, and the reinforcement in each direction shall not be less than that prescribed for temperature and shrinkage in Item 3.4.14.5 (a) nor less than 1/4 inch diameter rods at 12-inch centres or equivalent.

3.4.18.4 Method of Calculation.—

(a) Two-way ribbed floor construction having burnt clay or *concrete* fillers of material having a unit compressive strength at least equal to that of the rib and having top and bottom *shells* shall be assumed to act as solid slabs and the provision of Article 3.4.15 shall apply.

(b) For two-way ribbed floor construction having removable forms, or fillers not complying with the requirements of Item 3.4.18.2 and paragraph (a) hereof, the load shall be distributed between the ribs spanning the long and the short way by dividing the panel into two series of strips parallel to its sides and equating the central deflections of the mid-span strips. Due allowance must be made for the effect of restraint at the edges.

3.4.19 Flat Slab Construction

3.4.19.1 General Limitations.—

(a) *Flat slab construction* as herein considered shall mean a *concrete* slab reinforced in two or more directions, without *beams* or *girders*, except wall or trimmer *beams*, to transfer the loads to supporting *columns*. Slabs with *dropped panels (drops)* or *panelled ceilings* shall be considered as *flat slabs* provided that they meet the requirements herein given for such construction.

(b) The moment coefficients and slab thicknesses specified herein are for a series of rectangular slabs of approximately uniform size arranged in three or more rows of panels in each direction, and in which the ratio of length to width of panel does not exceed 1.33.

(c) For *structures* having a width of less than three rows of panels, or in which irregular panels are used, a special analysis of bending moments shall be made.

3.4.19.2 Slab and Drop Thicknesses.—

(a) The effective depth of the slab, including the *drop* where used, shall be such that the stresses in the *concrete* and the steel due to the bending moments and shears herein specified, calculated by the methods used for rectangular *beams*, shall not exceed the permissible stresses given in Article 3.4.11.

(b) For slabs with *drops* the width of the section resisting negative bending moment shall be taken as the width of the *drop*; the full width of the *column strip* shall be assumed for all positive bending moments and for all bending moments in slabs without *drops*.

(c) The total thickness of the slab, excluding the *drop* where used, for *concrete* having a strength of 2500 pounds per square inch, shall in no case be less than $L/32$ for end panels without *drops*; $L/36$ for interior panels fully continuous without *drops* and for end panels with *drops*; $L/40$ for interior panels fully continuous with *drops*.

For *concrete* having a strength (f'_c) other than 2500 pounds per square inch these limitations shall be modified by multiplying the coefficients by

$$\sqrt[3]{\frac{2500}{f'_c}}$$

3.4.19.3 Minimum Size of Columns.—The diameter of round *columns* supporting floors carrying a total load of 200 pounds per square foot or less shall be not less than 1/18 of the average span nor less than 12 inches. If the total load exceeds 200 pounds per square foot the diameter of the *columns* shall be not less than 1/15 of the average span nor less than 16 inches. If a *column* other than a round *column* is used, its moment of inertia shall be, at least, as great as the moment of inertia of the minimum permissible size of round *columns*.

3.4.19.4 Minimum Size of Drop.—The *drop* shall have a length or diameter in each direction of not less than one-third of the *panel length* in that direction and its thickness shall be not less than 25 per cent, nor more than 50 per cent, greater than the thickness of the slab.

3.4.19.5 Division of Panels.—A *flat slab* panel shall be considered as consisting of strips in each direction as follows (see Figure 2):

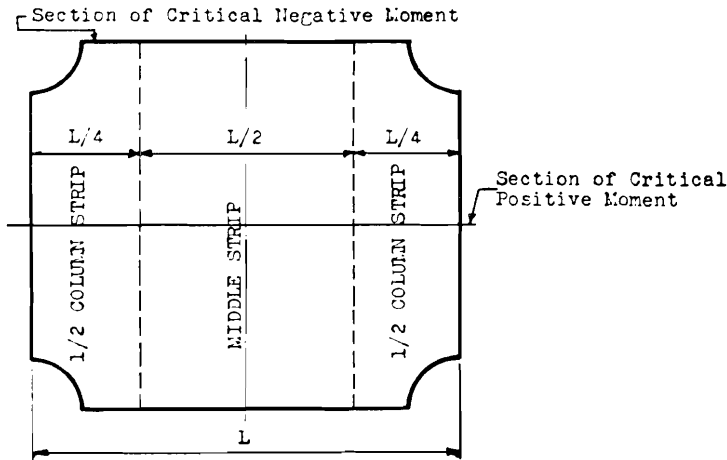


FIG. 2. SECTION 3.4 SUBDIVISION OF PANEL

A *middle strip*, one-half panel in width, symmetrical about the panel centre line and extending throughout the entire *length* of the *panel* in the direction in which moments are being considered.

A *column strip* one-half panel in width, occupying the two areas outside the *middle strip*.

3.4.19.6 Critical Sections for Moment Calculations.—The critical sections for which moment coefficients are given in Item 3.4.19.5 are located as follows:

Positive Moment Sections —Along the centre lines of the panel.

Negative Moment Sections—Along the edges of the panel, on lines joining the *column* centres, except that they follow the perimeter of the *column capital* instead of passing through it.

3.4.19.7 Moments at the Critical Sections.—The moments to be provided for in fully continuous interior panels at the sections referred to in Item 3.4.19.6 shall be not less than those given in Table 10 of this Section.

TABLE 10 (SECTION 3.4)

MOMENTS TO BE ASSUMED IN THE DESIGN OF INTERIOR PANELS
OF FLAT SLABS ASSUMED TO CARRY UNIFORMLY
DISTRIBUTED LOADS

Strip	Flat Slabs without Drops		Flat Slabs with Drops	
	Negative	Positive	Negative	Positive
Column Middle	Slabs with 2-Way Reinforcement			
	0.46 M_o	0.22 M_o	0.50 M_o	0.20 M_o
	0.16 M_o	0.16 M_o	0.15 M_o	0.15 M_o
Column Middle	Slabs with 4-Way Reinforcement			
	0.50 M_o	0.20 M_o	0.54 M_o	0.19 M_o
	0.10 M_o	0.20 M_o	0.08 M_o	0.19 M_o

where $M_o = 0.09 WL \left[1 - \frac{2c}{3L} \right]^2$ (11)

W = the total *dead* and *live load* uniformly distributed over a single panel area;

L = the distance from centre to centre of the *columns* in the direction in which moments are considered;

and c = base diameter of the largest right circular cone, which lies entirely within the average *column* (including the *capital*) for the four corners of the panel, the vertex angle of which is 90 degrees and the base of which is $1\frac{1}{2}$ inches below the bottom of the slab or the bottom of the *drop* (see Figure 3). When a square, or other symmetrically shaped *capital* is used, c is the diameter of the circle the area of which is equal to the area of the base of the largest 90-degree pyramid that can be included within the outlines of the *column capital*. For wall *columns* with *capitals* or brackets, the value of c perpendicular to the wall may be taken as twice the distance from the centre of the *column* to a point where the sloping face of the *capital* or bracket is $1\frac{1}{2}$ inches vertically below the underside of the slab or *drop*, provided the face of the *capital* or bracket makes an angle with the vertical not over 45 degrees. In the direction of the wall, c may be taken as the width of the *column* plus twice the depth from the bottom of the slab or the *drop*, if one is provided, to the bottom of the marginal *beam*.

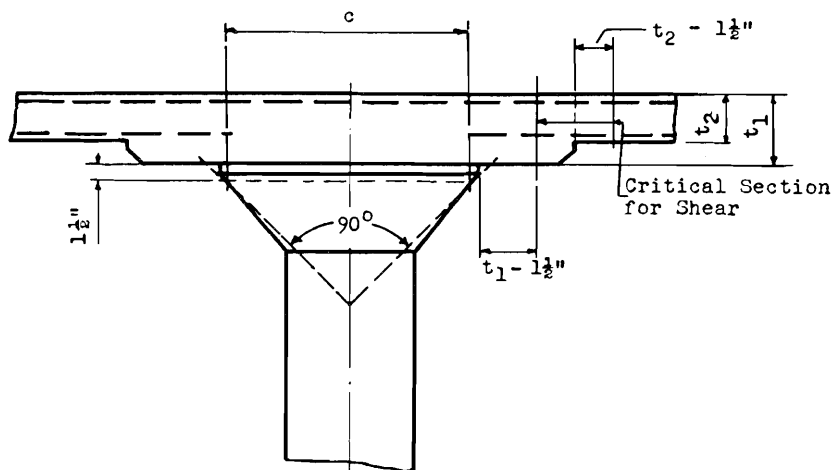


FIG. 3. PARTICULARS OF COLUMN HEAD

The moment coefficients given in Table 10 may be varied by not more than 6 per cent, provided the numerical sum of the positive and negative moments at the principle design sections is not reduced.

3.4.19.8 Reinforcement—General Requirements.—Each strip shall be capable of resisting the specified moments without the use of steel in compression, except in side and end panels, and where openings in panels necessitate rearrangement of reinforcement. Structural steel embedded in the slab or *dropped panel* may be regarded as contributing to resistance in bending and shear subject to the provisions of this Section respecting design and stresses.

The ratio of reinforcement to effective area of *concrete* at any section of any strip shall be not less than 0.0025.

Bends in continuous bars and the ends of all bars shall be staggered within a zone having a width of $0.067L$. Mere sagging of the bars shall not be accepted as the equivalent of positive bending.

3.4.19.9 Arrangement of Reinforcement—Two-way System.—

(a) In *column strips* at least one-half of the reinforcement for positive moment shall be of such length and so placed as also to reinforce the negative moment sections at the two adjacent *column* heads also. This reinforcement and all other reinforcement for negative moment shall extend into the adjacent panel to points averaging $0.25L$ for slabs without *drops* and $0.33L$ for slabs with *drops* beyond the line joining *column* centres.

Not less than one-quarter of the reinforcement for positive moment shall extend within the *drop* at least 20 diameters of the bar, but not less than 12 inches, or when no *drop* is used, to within $0.125L$ of the line joining *column* centres. The remainder of the reinforcement for positive moment shall extend to points averaging $0.33L$ on either side of the centre line of panel.

(b) In *middle strips* one-half of the reinforcement for positive moment shall be of such length and so placed as to reinforce the adjacent negative moment sections, and shall extend into the adjacent panels to points averaging $0.25L$ beyond the line joining *column* centres. The remaining half of the reinforcement for positive moment shall extend in the bottom face of the slab to points averaging $0.33L$ on either side of the centre line of panel.

3.4.19.10 Reinforcement—Four-way System.—

(a) **Reinforcement Required.**—In the four-way system of reinforcement the steel shall be arranged in *direct bands* and *diagonal bands*. The *direct bands* shall have the same location as the *column strips* but shall have a width of 0.4 times the panel width. The *diagonal bands* shall have a width of one-half the *panel-length*, or in the case of rectangular panels, one-half the mean *panel length*. The *effective area of reinforcement* in a *diagonal band* shall be the value obtained by multiplying the normal cross-sectional area of the reinforcement by the cosine of the angle that the band makes with the direction for which its effectiveness is desired.

The moments shall be assumed to be resisted in the following manner:

- (i) The reinforcement in the *direct band* shall resist the entire positive moment in the *column strip*.
- (ii) The reinforcement in the *diagonal bands* shall resist the entire positive moment in the *middle strip*.
- (iii) The area of the reinforcement in the *direct band*, plus the *effective area of the reinforcement* in the *diagonal bands*, shall be sufficient to resist the negative moment in the *column strip*.
- (iv) Additional reinforcement shall be provided to resist the negative moment in the *middle strip*.

(b) Arrangement of Reinforcement.—

- (i) For *direct bands* the provisions respecting two-way systems shall apply.
- (ii) In the *diagonal bands* one-half of the reinforcement for positive moment shall be of such length and so placed as to reinforce the negative moment sections at the two diagonally opposite *column* heads. This reinforcement and all other *diagonal band* reinforcement for negative moment shall extend into the adjacent panels to points averaging $0.35L$ for slabs without *drops* and $0.45L$ for slabs with *drops* beyond lines drawn through the *column* centres at right angles to the direction of the band.

One-half of the reinforcement for positive moment shall extend in the bottom face of the slab to within a distance of $0.2L$ from a line drawn through the *column* centre at right angles to the direction of the band.

- (iii) The additional reinforcement required to take the negative moment in the *middle strip* shall extend for a distance averaging $0.25L$ for slabs without *drops* and $0.33L$ for slabs with *drops* on either side of the line joining the *column* centres.

3.4.19.11 Wall and Other Irregular Panels.—In the *column strip* of wall panels and other panels in which the slab is non-continuous on one edge, the negative moment at the first interior *column* line and the positive moment at the centre of the end panel shall be increased 15 per cent over the moments given for interior panels. For the *middle strip* the corresponding moments shall be increased 30 per cent.

At the wall or discontinuous edge the negative moment perpendicular thereto in the *column strip* shall be taken as not less than 90 per cent and in the *middle strip* not less than 70 per cent of the corresponding moments for a normal interior panel as given in Table 10 of this Section.

The positive moment reinforcement perpendicular to the discontinuous edge shall extend to within 2 inches of this edge and have an embedment of at least 6 inches in spandrel *beams* or *columns*. All negative moment reinforcement shall be bent or hooked at spandrel *beams* or *columns* to provide adequate bond resistance.

If a marginal *beam* has a depth greater than one and one-half times the slab thickness, each *column strip* adjacent and parallel to the *beam* shall be capable of resisting a moment at least one-quarter as great as that specified in Table 10 for a *column strip*.

If the marginal *beam* has a depth equal to or less than one and one-half times the slab thickness, the *column strip* adjacent and parallel to the *beam* shall be capable of resisting a moment one-half as great as that specified in Table 10 for a *column strip*.

3.4.19.12 Marginal Beams.—In panels having a *beam* on one discontinuous edge, or on each of two intersecting discontinuous edges, each *beam* shall be capable of carrying the load superimposed directly upon it together with one-quarter of the total *dead* and *live load* supported by the adjacent panel.

Beams on opposite discontinuous edges of a panel and the slab between them shall be capable of carrying the entire load and the slab shall be considered as a simple span.

3.4.19.13 Flat Slabs on Bearing Walls.—Where there is a *beam* or a *bearing wall* on the centre line of *columns* in the interior portion of a continuous *flat slab*, the negative moment at the *beam* or wall line in the *middle strip* perpendicular to the *beam* or wall shall be taken as 30 per cent greater than the moment specified in Table 10 for a *middle strip*. The two half *column strips* adjacent and parallel to the *beam* or wall shall together be designed to resist a moment at least one-half of that specified in Table 10 for a *column strip*.

3.4.19.14 Moments in Wall Columns.—Each exterior *column* shall, through the combined resistance of the *storey* of the *column* below the floor and, where existing, that above the floor, be capable of resisting a moment amounting to 35 per cent of the total moment in the panel M_o as given by formula (11).

3.4.19.15 Shearing Stress in Flat Slabs.—The unit shearing stress on a vertical section which lies at a distance ($t_1 - 1\frac{1}{2}$ inches) beyond the edge of the *column capital* shall not exceed $0.03f'_c$ where t_1 is the thickness of a *flat slab* without *drops*, or the thickness of a *flat slab* including *drops* where such are used.

Where a *drop* is used, the unit shearing stress on a vertical section which lies at a distance ($t_2 - 1\frac{1}{2}$ inches) beyond the edge of the *drop* and parallel with it, shall not exceed $0.03f'_c$ where t_2 is the thickness of the slab at points outside the *drop*.

3.4.19.16 Openings in Flat Slabs.—Unframed openings may be used in *flat slabs*, provided that the total positive and negative resisting moments be maintained as required in Item 3.4.19.7 and that these total positive and total negative moments be redistributed between the remaining principal design sections to meet the new conditions, and subject to the following restrictions as to size:

- (a) In the area common to two *middle strips*, unframed openings may be of any size.
- (b) In the area common to two *column strips* the aggregate width of unframed openings, measured at right angles to either *column strip*, shall not exceed $0.05L$.
- (c) In the area common to one *middle strip* and one *column strip*, openings shall not interfere with the normal placing of more than one-quarter of the bars in either strip.

Openings which do not comply with the foregoing requirements shall be completely framed on all sides with *beams* to carry the load to the *columns*.

3.4.20 Columns

3.4.20.1 Effective Area.—In determining the resistance of a *column* to axial loads, no allowance shall be made for the strength of the cover provided for fire protection. (For fire protection requirements, see Part 4; for minimum cover, see Item 3.4.10.2.). The effective area of a *column* having spiral reinforcement shall be the area within the outer periphery of the spiral.

For a combination of axial and bending stresses the *gross area* of the *column* may be considered as effective, provided that in no case shall the axial load permitted on a *column* subjected to bending be more than if no bending were present.

When estimates of stiffness or of the slenderness ratio are being made, the *gross area* of the *column* may be considered to be effective.

3.4.20.2 Unsupported Length.—The unsupported length of a *column* shall be taken as:

- (a) In *flat slab construction*, the clear distance between the floor and the lowest part of the *capital*.

(b) In *beam* and slab construction, the clear distance between the floor and the under side of the deeper *beam* (or slab in the absence of a *beam*) framing into the *column* at the next higher floor level in the direction of bending under consideration.

(c) In a *column* supported laterally by struts or *beams* only, the clear distance between consecutive struts or *beams* in each vertical plane, provided that to be considered an adequate support two such struts or *beams* shall meet the *column* at approximately the same level and the angle between vertical planes through the struts or *beams* shall not vary more than 30 degrees from a right angle.

(d) When brackets are used at the junction of *beams* or struts with *columns*, the clear distance between supports may be considered as reduced by the depth of the bracket, provided that the bracket width equals that of the *beam* or strut and is at least half that of the *column* and that it makes an angle of 45 degrees with the face of the *column*.

(e) For all *columns*, the length considered shall be that which produces the greatest ratio of length to lateral dimension.

3.4.20.3 Minimum Dimensions.—Principal *columns* in buildings shall have a minimum lateral dimension of 8 inches. Minor *columns* and struts shall have a minimum lateral dimension of 6 inches.

3.4.20.4 Longitudinal Reinforcement for Ordinary Columns. The cross-sectional area of longitudinal reinforcement shall be not less than one per cent of the effective area of the *column*. The maximum area shall not exceed 8 per cent of the effective area of the *column* for *columns* having spiral reinforcement, nor 4 per cent for tied *columns*. Bars shall have a minimum diameter of 1/2 inch, and not less than 4 shall be used in a tied *column*, or 6 in a *column* having spiral reinforcement. (For minimum spacing of bars, see Item 3.4.10.1 (c).)

In a *column* that has a larger cross-sectional area than is required to support the load, the minimum percentage of steel may be based upon the area of *concrete* required to resist stress and not the actual area, provided that in no case shall such reduced effective area be less than one-half the actual effective area.

At all joints in longitudinal reinforcement the bars shall be overlapped for a length sufficient to develop the stress in the bar by bond, but not more than 25 times the size of the upper bar, unless they are otherwise efficiently jointed by welding, screwing, or other means in such a manner as to develop the full force in the bar.

Where changes in the cross-section of a *column* occur, the longitudinal bars shall be offset in a region where lateral support is afforded by a *concrete capital*, floor slab, or by metal ties or reinforcing spirals. Where bars are offset, the slope of the inclined portion from the axis of the *column* shall not exceed 1 in 6 and the bars above and below the offset shall be parallel to the axis of the *columns*.

3.4.20.5 Columns with Lateral Ties.—

(a) **Permissible Load.**—The permissible load on a *column* reinforced with longitudinal bars and lateral ties, and subjected to centric axial loading only, in which the ratio of the unsupported length to least lateral dimension is not greater than 12, shall be determined from the following formula:

$$P = 0.25f'_c A_c + 0.30f_y A_s \dots \dots \dots (12)$$

where P is the permissible load;

A_c the effective area of the *concrete*;

f_y the specified yield stress of the longitudinal reinforcement (see Item 3.4.11.2);

A_s the cross-sectional area of the longitudinal reinforcement.

(b) **Lateral Ties.**—Lateral ties shall be at least $\frac{1}{4}$ inch diameter and shall be spaced apart not more than 16 bar diameters, 48 tie diameters, or the least dimension of the *column*. When there are more than four vertical bars, additional ties shall be provided so that every longitudinal bar is held firmly in position and has lateral support equivalent to that provided by a 90 degree corner tie.

3.4.20.6 Columns with Spiral Reinforcement.—

(a) **Permissible Load.**—The permissible load in a *column* reinforced with longitudinal bars and a continuous spiral, and subjected to centric axial loading only, in which the ratio of unsupported length to least lateral dimension is not greater than 12, shall be determined from the following formula:

$$P = 0.25f'_c A_c + 0.30f_y A_s + 0.60f'_y A'_s \dots \dots \dots (13)$$

where f'_y is the yield stress of the spiral reinforcement (see Item 3.4.11.2);

A'_s is the volume of the spiral reinforcement divided by the length of the column;

and the other symbols have the same meanings as in Item 3.4.20.5.

(b) **Spiral Reinforcement.**—The volume of spiral reinforcement shall not be less than 0.5 per cent nor more than 2 per cent of the volume of *concrete* enclosed within the outer periphery of such reinforcement.

Anchorage of spiral reinforcement shall be provided by $1\frac{1}{2}$ extra turns of spiral rod or wire at each end of the spiral unit. Splices, when necessary, shall be made in the spiral rod or wire by welding or by a lap of $1\frac{1}{2}$ turns. The pitch of the spirals shall not be more than 3 inches or $\frac{1}{6}$ of the diameter of the core, whichever is the lesser. The minimum pitch shall be such that the requirements of Item 3.4.10.1 (c) (minimum distance between reinforcing bars) are fulfilled.

The spiral shall be continuous and evenly spaced, and shall extend from the floor level in any *storey* to the level of the lowest horizontal reinforcement in the floor above. In a *column* with a *capital* it shall extend to the plane at which the sectional area of the *capital* is twice that of the *column*.

3.4.20.7 Long Columns.—The permissible load on a *column* in which the ratio of unsupported length to least lateral dimension exceeds 12 shall be that given by formula (14).

$$P' = P(1.33 - 0.0275 \frac{h}{d}) \dots \dots \dots (14)$$

where P' is the permissible load;

P the permissible load on a short column;

h the unsupported length;

and d the least lateral dimension.

3.4.20.8 Bending Moments in Columns.—Bending moments in *columns* supporting a symmetrical arrangement of *beams* of approximately equal span may be neglected. Bending moments in other *columns* shall be investigated and the stresses resulting from them shall be adequately provided for. In the absence of more exact estimates, bending moments in *columns* at any panel point may be determined by distributing the unbalanced fixed end moment together with the moment due to vertical shear between the column lengths above and below the panel point and the *beams* framing into the *column* at the panel point, in proportion to their stiffnesses.

3.4.20.9 Permissible Stresses Due to Axial Loading and Bending.—The compressive fibre stress in an eccentrically loaded *column*, determined by the usual methods of elastic analysis, shall not exceed $0.40f'_c$.

The tensile stress in the longitudinal reinforcement may equal that specified for flexural members, provided, however, that splices in the tensile steel at or near the section of maximum *column* moment are capable of developing the stress in the reinforcement.

3.4.20.10 Composite Columns.—

(a) **General.**—A *composite column* shall mean a *column* having an unpainted structural steel or cast iron core solidly encased in *concrete* having a strength of not less than 2000 pounds per square inch, with or without longitudinal reinforcement. Spiral reinforcement not less than 0.5 per cent and not more than 2 per cent of the area of the *concrete* within the outer periphery of the spiral shall be provided. A clearance of at least 2 inches shall be maintained between the spiral and a round metal core and at least one inch between the spiral and the corners of a non-circular section. The other details of the spiral shall conform to Item 3.4.20.6 (b).

(b) **Allowable Load.**—On a *composite column* the unsupported length of which is not greater than 12 times its least lateral dimension, the allowable axial load, in addition to the initial load carried by the structural steel or cast iron core, shall be determined by the following formula:

$$P = 0.25f_c A_c + 0.30f_s A_s + 0.60f_r A_r + (f_r - f_s) A_r \dots \dots \dots (15)$$

where f_r is 0.48 times the specified yield stress of a structural steel core, or 10,000 pounds per square inch for a cast iron core;

f_s the stress in the *column* due to loads applied before the *concrete* has set;

A_r the cross-sectional area of the metal core, and the other symbols have the same meaning as in Item 3.4.20.6 (a).

The metal core shall be capable of supporting all loads that may be placed upon it before the *concrete* has set, in accordance with the provisions of Section 3.5 (Steel and Iron Construction). Except as provided herein, transfer of loads to the metal core shall be provided by the use of bearing members such as brackets or other positive connections; these shall be provided at the top of the metal core and at intermediate floor levels where required. If such metal brackets or connections are omitted, it shall be assumed that the metal core carries no part of the vertical reaction of the *beams* in the *storey* immediately below such *beams*.

The provisions of Items 3.4.20.7, 3.4.20.8, and 3.4.20.9 shall apply to *composite columns*.

3.4.20.11 Pipe Columns.—The safe load on a *column* consisting of a steel pipe filled with *concrete* and provided with steel or cast-iron caps and bases shall be determined from the following formula:

$$P = 0.25f_c A_c + f_s A_r \dots \dots \dots (16)$$

$$\text{where } f'_r = \left[18,000 - \frac{70h}{r} \right] F$$

h = the unsupported length;

r = the radius of gyration of the pipe section;

and $F = \frac{\text{tensile yield point of pipe material}}{45,000}$

If the yield point is not known the factor F shall be taken as 0.5.

Pipe *columns* shall only be used when the loads are axial and bending moments are negligible.

Steel pipe used in *concrete*-filled pipe *columns* shall fulfil the requirements of A.S.T.M. Specification A53-36, Welded and Seamless Steel Pipe, provided that the thickness shall be not less than 0.12 inch.

3.4.21 Walls and Partitions

3.4.21.1 Loading.—All *reinforced concrete* walls and *partitions* shall be capable of resisting any lateral or other pressures to which they may be subjected. Adequate provision shall be made to resist bending moments due to eccentric loading, and for stresses arising from the deflection of floors, *beams*, or *girders*.

3.4.21.2 Minimum Thickness.—*Bearing walls* and all exterior walls of *reinforced concrete* shall have a thickness of not less than 4 inches and not less than $1/30$ the distance between the supporting or enclosing members.

Non-bearing walls other than exterior walls, and *partitions* shall have a thickness of not less than 2 inches and not less than $1/60$ the distance between the supporting or enclosing members.

3.4.21.3 Permissible Loads.—The working stresses in *reinforced concrete bearing walls* with minimum reinforcement, as required by Item 3.4.21.4, shall be $0.2f'_c$ for walls in which the ratio of height to thickness is not greater than 12, and shall be reduced in accordance with formula (14) for long columns, where the ratio of height to thickness exceeds 12.

Where the reinforcement in *bearing walls* is properly anchored by lateral ties, the allowable loads may be determined by the formulas given for *reinforced concrete columns*. In the case of concentrated loads, the length of the wall to be considered as effective for each shall not exceed the centre-to-centre distance between loads, nor shall it exceed the width of the bearing plus four times the wall thickness.

3.4.21.4 Reinforcement.—*Reinforced concrete* walls shall be reinforced with an area of steel in each direction, both vertical and horizontal, at least equal to 0.0025 times the cross-sectional area of the wall, if of bars, and 0.0018 times the area if of welded steel wire fabric. The wire of the welded fabric shall have a diameter of not less than 0.135 inch. Walls more than 8 inches in thickness shall have the reinforcement for each direction placed in two layers parallel with the faces of the wall. One layer, consisting of not less than $1/2$ and not more than $2/3$ the total required, shall be placed not less than 2 inches nor more than $1/3$ the thickness of the wall from the exterior surface. The other layer, comprising the balance of the required reinforcement, shall be placed not less than $3/4$ inch and not more than $1/3$ the thickness of the wall from the interior surface. Bars, if used, shall not be less than $3/8$ inch round, nor shall they be spaced more than 18 inches on centres.

3.4.22 Footings

3.4.22.1 Load.—The area of *footings* shall be proportioned for the soil loadings permitted under Section 3.7. For computation of moments and shears, the upward re-action per unit area or per pile shall be the total *column* load (not including the weight of the *footing* itself) divided by the area or by the number of piles. Provision shall be made for possible flexure and uplift in *columns*.

3.4.22.2 Sloped or Stepped Footings.—*Footings* may be sloped or stepped, provided that the shearing and flexural stresses at no section exceed the allowable values, and provided further that the thickness of the *footing* above the reinforcement at the edge shall be not less than 6 inches for *footings* on soil, nor less than 12 inches for *footings* on piles. Sloped or stepped *footings* shall be cast as a unit or in separate layers.

If poured in separate layers, the projection of any unreinforced layer beyond the face of the construction above it shall not exceed $\frac{1}{2}$ the depth of that layer and the method of bonding the new *concrete* to old shall be that prescribed in Item 3.4.10.3 (b).

3.4.22.3 Bending Moments in Footings.—

(a) The critical section for bending moment in a *concrete footing* which supports a *concrete column*, pedestal, or wall, shall be considered to be at the face of the *column*, pedestal, or wall. For *footings* under walls of *solid masonry*, the critical section shall be at the face of the wall. For *footings* under *masonry* walls built of *hollow units*, the critical section shall be half-way between the middle and the edge of the wall. For *footings* under metallic bases which have efficient distributing ribs, the critical section shall be at the edge of the base. For *footings* under metallic slab bases, the critical section shall be half-way between the face of the *column* or pedestal and the edge of the metallic slab.

(b) The bending moment at the critical section in a square *footing*, or in a rectangular *footing* having its side not greater than one and one-half times its width, shall be computed from the load on trapezoids bounded by the line of the critical section for moment, the corresponding outside edge of the *footing* and the portions of the two diagonals.

(c) For a round or octagonal *concrete column* or pedestal, the face of the *column* shall be taken as the side of a square of an area equal to the area enclosed within the perimeter of the *column* or pedestal.

3.4.22.4 Shearing and Bond Stress.—

(a) The critical section for diagonal tension in *footings* on soil shall be assumed as a vertical section at a distance from the face of the *column* or pedestal supported by the *footing* equal to the effective depth, d , of the *footing* at the face of the *column* or pedestal.

In *footings* on piles the critical section shall be assumed at a distance $\frac{d}{2}$ from the face of the *column* or pedestal, and any piles whose centres are at or outside the section shall be included in computing shear.

(b) The shear stress in a *footing* with sloping top surface shall be computed as for a *beam* wedge shaped in profile (see Item 3.4.14.6 (c)).

(c) The critical section for bond shall be assumed at the face of the *column* or pedestal. Bond shall also be investigated at vertical planes where changes of section or of reinforcement occur.

3.4.22.5 Transfer of Stress from Column to Pedestal.—

(a) The compressive stress in longitudinal reinforcement in *columns* or pedestals shall be transferred to the *footing* by distributing bases or dowels. Where dowels are used, there shall be at least one for each bar and their total sectional area shall be not less than the area of the longitudinal reinforcement in the *column* or pedestal. The dowels shall project into the *column* or pedestal and into the *footing* a distance sufficient to develop the working stress in the dowels by bond.

(b) The permissible compressive unit stress on top of the pedestal or *footing* directly under the *column* due to the total *column* load less the load transferred to the *footing* by the dowels shall not be greater than that determined by the following formula:

$$f_c = 0.25f'_c \sqrt[3]{\frac{A}{A'}} \dots\dots\dots (17)$$

where A is the total area at top of pedestal or *footing*;
and A' the loaded area at *column* base or pedestal.

In sloped or stepped *footings*, A may be taken as the area of the uppermost horizontal surface of the *footing* or as the area of the lower base of the longest frustum of a pyramid or cone contained wholly within the *footing* and having for its upper base the loaded area A' and having side slopes of 1 horizontal to 2 vertical.

3.4.23 Pedestals.—The height of a pedestal shall not exceed three times its least lateral dimension. Where this height is exceeded the member shall be designed as a *reinforced concrete column*.

The allowable compressive unit stress on the *gross area* of a concentrically loaded pedestal without reinforcement shall not exceed $0.25f'_c$. Where this stress is exceeded, reinforcement shall be provided and the member designed as a *reinforced concrete column*.

3.4.24 Pedestal Footings.—A pedestal *footing* shall mean a *column footing* projecting a distance of less than one-half its depth from the faces of the *column* on all sides and having a depth not more than three times its least width.

A pedestal *footing* supported directly on piles shall have a mat of reinforcing bars having a cross-sectional area of not less than 0.2 square inch per foot in each direction, placed 3 inches above the top of the piles.

SECTION 3.5 STEEL AND IRON CONSTRUCTION

3.5.1 General.—The regulations contained in this Section shall apply to steel and iron *structures* for buildings and such other steel and iron *structures* as grandstands, canopies, and signs.

3.5.2 Symbols.—Symbols where used herein shall have the following meanings:

- b = breadth of compression flange of a *beam*;
- D = depth of member assumed to resist shear (see Item 3.5.10.5);
- E = modulus of elasticity (29×10^6 pounds per square inch);
- f_a = axial unit stress;
- F_a = allowable axial unit stress;
- f_b = maximum unit stress due to bending;
- F_b = allowable unit stress due to bending;

- f_e = Eulerian values of stress = $\frac{\pi^2 E}{(l/r)^2}$;
- f'_c = ultimate compressive strength of *concrete*; usually at the age of 28 days, when tested according to the regulations prescribed in Section 3.4;
- f_y = specified yield point, in pounds per square inch;
- l = unbraced length of a compression member, measured between the neutral axes of the members providing lateral support, except that, when either end of a *column* is considered to be laterally supported, the unbraced length shall be measured between such end and the neutral axis of the nearest member providing lateral support; the laterally unsupported length of the compression flange of a *beam*;
- m = greater projection of a *column* base plate over a *column*, in inches;
- n = lesser projection of a *column* base plate over a *column*, in inches; the size of a *fillet weld*, in sixteenths of an inch;
- p = allowable unit stress in axial compression; allowable unit stress in axial tension; pressure on the underside of a *column* base plate, in pounds per square inch;
- r = critical radius of gyration of a member, in inches;
- t = thickness;
- V = total vertical shear;
- v = unit shearing stress;
- y = distance from neutral axis to extreme fibre in compression, in plane of bending moment.

3.5.3 Materials

3.5.3.1 Structural Members.—The quality of all steel used for structural members shall be governed by the following requirements:

(a) Medium Structural Steel shall conform to C.E.S.A. Specification S40-1935.

(b) Mild Structural Steel shall conform to C.E.S.A. Specification S39-1935.

(c) Special Steel shall conform to any specification *approved* by the *authority having jurisdiction*.

(d) *Unidentified Steel* shall be tested by an *approved* testing laboratory in accordance with A.S.T.M. Standard E8-40T, Methods of Tension Testing of Metallic Materials, as a result of which tests the *authority having jurisdiction* may approve or prohibit the use of such material; the results of such tests shall form the basis for the determination of the working stresses as herein prescribed.

3.5.3.2 Rivets and Bolts.—All rivets and bolts shall be made of Structural Rivet Steel conforming to C.E.S.A. Specification S42-1935, or other specification *approved* by the *authority having jurisdiction*.

3.5.3.3 Pins.—All pins shall be made of steel conforming to C.E.S.A. Specification S40-1935, or other specification *approved* by the *authority having jurisdiction*.

The strength of steel for pins shall be at least equal to that prescribed for Medium Structural Steel.

3.5.3.4 Castings.—

(a) **Steel Castings.**—Steel castings shall conform to C.E.S.A. Specification G28-1929.

(b) **Iron Castings.**—Iron castings shall conform to C.E.S.A. Specification S16-1940.

3.5.3.5 Used Materials.—Used material that is to be re-used shall be subject to the approval of the *authority having jurisdiction*.

3.5.4 Unit Working Stresses

3.5.4.1 General.—Except as herein provided, all parts of a *structure* shall be such that the unit stresses in pounds per square inch, calculated in accordance with the provisions of Articles 3.5.5 to 3.5.15 will not exceed the values given in Items 3.5.4.2 to 3.5.4.5.

3.5.4.2 Increase of Unit Stresses in Wind-bracing Connections.—The stresses in rivets herein permitted may be increased by 70 per cent in tension and 20 per cent in shear when determining the resistance to end moment of a wind-bracing connection, provided that full allowance is made for the end moments due to the vertical loads.

3.5.4.3 Unit Stresses for Medium Structural Steel, Steel and Iron Castings, Structural Rivet Steel, and Steel for Bolts and Pins

	Pounds per square inch
(a) Tension	
Medium structural steel in axial tension, net section . . .	20,000
Rivets having two full heads, and bolts	10,000
(b) Compression	
Medium structural steel in axial compression—as prescribed in Item 3.5.8.5, but in no case more than . . .	18,000
Plate girder stiffeners, axial compression on gross section	20,000
Webs of rolled sections at toe of fillet	24,000
Direct compression on cast steel bases	14,000
Direct compression on cast iron bases	10,000
Axial compression on cast iron <i>columns</i>	$9000 - \frac{40l}{r}$

(c) Bending

Tension on extreme fibres of rolled sections, plate girders, and built-up members, net section; provided that rivet-filled holes up to 10 per cent of the gross area of the tension flange may be neglected	20,000
Compression on extreme fibres—as prescribed in Item 3.5.10.4, but in no case more than	20,000
Tension or compression on extreme fibres of pins	27,000
Tension or compression on steel castings	12,000
Tension on iron castings	3,000
Compression on iron castings	10,000

(d) Shearing

Gross section of webs and gussets	13,000
Pins and power-driven shop rivets	15,000
Power-driven field rivets and tightly fitting turned bolts in drilled or reamed holes	13,500
Sledge-driven rivets and unfinished bolts	10,000

(e) Bearing

Outstanding legs of stiffener angles and other steel parts in contact	27,000	
	Single	Double
	Shear	Shear
Pins and power-driven shop rivets	24,000	30,000
Power-driven field rivets and tightly fitting turned bolts in drilled or reamed holes	21,600	27,000
Sledge-driven rivets and unfinished bolts	16,000	20,000

NOTE:—The foregoing stresses for shearing and bearing shall be reduced 25 per cent when rivets or bolts are countersunk.

3.5.4.4 Unit Stresses for Other Structural Steels.—Except as otherwise provided in Items 3.5.8.5 and 3.5.10.4, the unit working stresses permitted in Mild Structural Steel shall be 90 per cent of those permitted herein for Medium Structural Steel. The unit working stresses permitted in Special Steel shall be as determined by the *authority having jurisdiction* based on the results of tests made by a publicly owned or other recognized laboratory.

3.5.4.5 Unit Stresses for Unidentified Structural Steel.—The unit working stresses permitted in *unidentified structural steel* shall not exceed 6/10 of the yield point stress determined in accordance with A.S.T.M. Specification E8-40T, provided that in no case shall the stresses in *unidentified structural steel* exceed those permitted for Mild Structural Steel.

3.5.5 General Design Requirements

3.5.5.1 General.—In any steel *structure*, member, or connection, provision shall be made for all conditions of stress that may occur, whether specifically mentioned in this Section or not, in accordance with well established principles of mechanics and sound engineering practice.

3.5.5.2 Resistance to Wind Loads.—In buildings or in portions of buildings where the *masonry* walls are not capable in accordance with Article 3.3.3 of withstanding the total wind load, the structural frame alone shall be adequate to resist this load. *Partitions* shall only be considered as resisting wind loads when they are permanent.

3.5.5.3 Use of Rivets, Bolts, and Welding.—The component parts of the steel framework shall be jointed together by the use of rivets, bolts, or *fusion welding*. The use of unfinished bolts shall be limited as prescribed in Item 3.5.14.1.

3.5.5.4 Expansion and Contraction.—Where necessary, adequate provision shall be made for expansion and contraction in steel *structures*.

3.5.5.5 Eccentricity.—At any joint where the gravity axes of the joined members do not meet at a point, provision shall be made for the stresses resulting from eccentricity.

Where the centre of gravity of a group of rivets or bolts transmitting stress to the end of a member does not coincide with the gravity axis of the member, provision shall be made for the stresses resulting from eccentricity.

3.5.6. Minimum Thickness of Material

3.5.6.1 General Requirements.—The steel used for members exposed to the weather shall not be less than $\frac{1}{4}$ inch thick, and, for members not exposed to weather, not less than $\frac{3}{16}$ inch thick. This provision shall not apply to secondary members or light members such as those in sign structures, suspended ceilings, skylights, greenhouses, or *fire-escapes*, or to the webs of rolled sections, or to fillers.

3.5.6.2 Gusset Plates.—A gusset plate that will receive a stress of 35,000 pounds, or more, from any one member, shall not be less than $\frac{3}{8}$ inch in thickness.

3.5.6.3 Members in Compression.—The thickness of an outstanding leg of any member in compression, except where reinforced by a plate, shall not be less than $\frac{1}{16}$ the unsupported length of the outstanding leg.

No material used in compression shall have an unsupported width of more than 60 times its thickness, and not more than 40 times the thickness of the unsupported material shall be considered as effective section. *Column* web-plates whose thickness is less than $\frac{1}{40}$ of the unsupported width shall be stiffened by pairs of horizontal angles at intervals not greater than twice the gross width of the web-plates.

3.5.6.4 Corrosion.—Adequate provision shall be made against the action of any corrosive agent that may come in contact with any steel member.

3.5.7 Tension Members

3.5.7.1 Net Section.—In computing the net area of any tension member the diameter of any rivet hole or bolt hole shall be assumed to be $\frac{1}{8}$ inch greater than the nominal diameter of the rivet or bolt; and deduction shall be made for as many rivet holes as it contains gauge lines unless the distance centre to centre of rivet holes, measured on the diagonal, is at least 40 per cent greater than the distance between the gauge lines.

3.5.7.2 Tie Plates.—Where intermediate tie plates, instead of latticing, are used with tension members, such plates shall be spaced not farther apart in the clear than 15 times the width of the flange to which they are attached; and each tie plate shall be connected to the member by not fewer than two rivets on each side.

3.5.8 Compression Members

3.5.8.1 Effective Area.—In computing the effective area of a compression member no deduction need be made for holes filled by rivets.

3.5.8.2 Splices.—Where compression members are faced for complete bearing, they shall be spliced sufficiently to hold the connected members accurately in place and to resist any tension produced by bending. Where such members are not faced for complete bearing, they shall be so spliced that all stress will be transmitted through the splice material.

3.5.8.3 Slenderness Ratio.—The ratio l/r , unbraced length to critical radius of gyration, shall not exceed the following values:

- (a) For all *columns* in buildings. 150
- (b) For other compression members. 200

3.5.8.4 Bending Moments.—Bending moments in *columns* supporting a symmetrical arrangement of *beams* of approximately equal span may be neglected. Bending moments in other *columns* shall be investigated and the stresses resulting from them shall be provided for.

An acceptable method of calculating such moments is given as Appendix F.

3.5.8.5 Axial Stress in Compression Members.—The axial stress in a structural steel compression member shall not exceed the value given by the following formula:

$$p = 0.546 \left[\frac{f_y + (1 + .0015 \, l/r) f_e}{2} - \sqrt{\left(\frac{f_y + (1 + .0015 \, l/r) f_e}{2} \right)^2 - f_y f_e} \right]$$

where p = allowable unit stress, in pounds per square inch;

f_y = specified yield point, in pounds per square inch, of steel used;

l = unbraced length, in inches;

r = critical radius of gyration, in inches;

and $f_e = \frac{\pi^2 E}{(l/r)^2} = \frac{2.86 \times 10^8}{(l/r)^2}$ pounds per square inch.

Values of p , calculated using the above formula, are given in Table 1 of this Section.

TABLE I (SECTION 3.5)
ALLOWABLE STRESSES FOR COLUMNS SUPPORTING
AXIAL LOADS ONLY

l/r	Allowable Stress in Pounds per Square Inch	
	Mild Structural Steel	Medium Structural Steel
0	16,300	18,000
10	16,100	17,800
20	15,900	17,500
30	15,600	17,100
40	15,300	16,800
50	14,900	16,300
60	14,400	15,800
70	13,800	15,000
80	13,000	14,000
90	12,000	12,800
100	10,900	11,500
110	9,800	10,100
120	8,700	8,900
130	7,700	7,800
140	6,800	6,900
150	6,100	6,100
.....		
160	5,400	5,400
170	4,900	4,900
180	4,400	4,400
190	4,000	4,000
200	3,600	3,600

3.5.8.6 Latticed and Battened Members.—

(a) **Resistance to Shear.**—The lattice bars or batten plates of any compression member shall be adequate to resist a transverse shear equal to at least 2 per cent of the axial stress in the member, which shear shall be considered as distributed to all lattice systems in parallel planes, according to their relative capacities. For *columns* carrying calculated bending stress, lattice rather than batten plate systems shall be used, and these shall be proportioned to resist the shear involved in the bending moments in addition to the above defined 2 per cent.

(b) **Lattice Bars.**—All lattice bars shall be so spaced that the ratio l/r of the segment of the main member between consecutive connections of the lattice bars shall be not over $\frac{3}{4}$ of that of the member as a whole.

In determining the section of a lattice bar the *column* formula given in Item 3.5.8.5 shall be used, l being taken as the unbraced length of the bar in the case of single latticing, and $7/10$ of this length in the case of double latticing.

The thickness of a lattice bar shall be not less than $1/40$ of its unbraced length in the case of single latticing, and $1/60$ of this distance for double latticing.

All lattice bars shall have rolled edges and their minimum width shall be not less than:

- 2 $\frac{3}{4}$ inches for 1 inch rivets
- 2 $\frac{1}{2}$ inches for $\frac{7}{8}$ inch rivets
- 2 $\frac{1}{4}$ inches for $\frac{3}{4}$ inch rivets
- 2 inches for $\frac{5}{8}$ inch rivets.

All lattice bars shall be inclined at an angle of approximately 60 degrees to the axis of the member when single latticing is used, and at an angle of approximately 45 degrees when double latticing is used.

All double latticing bars shall be riveted at their intersections.

(c) **Batten or Tie Plates.**—Batten or tie plates shall be provided at the ends of the lattice systems and at points where the system is interrupted and shall be connected to each segment by not less than three rivets. End tie plates shall have a length of not less than the perpendicular distance between the lines of rivets connecting them to the flanges, and intermediate ones of not less than one-half this distance. The thickness of tie plates shall be not less than $1/50$ of the distance between connecting lines of rivets.

Where batten or tie plates are used instead of latticing, each plate shall be equal to an end tie plate as specified above, and such plates shall be so spaced that the ratio l/r of the segment of the main member between the plates will not be over $\frac{3}{4}$ of that of the member as a whole. Adequate provision shall also be made for bending stresses in the main member induced by such batten plates.

3.5.9 Members Subject to Direct Stress Combined with Bending.—Members subject to both axial and bending stresses shall be so proportioned that the quantity $\frac{f_a}{F_a} + \frac{f_b}{F_b}$ does not exceed unity,

where f_a = axial unit stress;

F_a = allowable axial unit stress;

f_b = maximum unit stress due to bending;

and F_b = allowable unit stress due to bending.

3.5.10 Beams and Girders

3.5.10.1 Effective Span Length.—For the purpose of computing resistance to bending, the effective span of a member shall be considered to be the distance between the centres of its bearings.

3.5.10.2 Allowance for End Restraint.—Where a *beam* is restrained at either end, due allowance may be made for such restraint. An acceptable method of calculating restraining moments in certain cases is given in Appendix G.

3.5.10.3 Deflection.—The calculated deflection of *beams* (except those in roofs not carrying plaster) shall not exceed $1/360$ of the span determined as follows:

- (a) for the total load on *beams* supporting *masonry* walls,
- (b) for the *live load* on all others.

3.5.10.4 Compression Flanges.—

(a) **Medium Structural Steel.**—When the ratio l/b of unsupported length to breadth of compression flange exceeds 15, the compressive stress in pounds per square inch shall not exceed $(25,000 - 333\ l/b)$ except as follows:

- (i) The allowable stress may be taken as $6/10$ of the critical stress at which elastic instability may occur provided such critical stress is not greater than the specified yield point*.
- (ii) For isolated members solidly encased in *concrete* the breadth b may be taken as the width of the compression flange of the *beam* plus the least *concrete* cover beyond the edge of the flange on one side only, such additional allowance being limited to 4 inches.

(b) **Other Grades of Structural Steel.**—For grades of steel other than Medium Structural Steel the allowable stresses in compression flanges prescribed for Medium Structural Steel shall apply; provided that in no case shall any such stress exceed $6/10$ of the yield point stress of the material.

3.5.10.5 Unit Shearing Stress.—The unit shearing stress, v , on the web of a *beam* shall be determined from the formula

$$v = \frac{V}{Dt}$$

where V is the total vertical shear;

D the depth of the *beam* in the case of a rolled *beam*, or the depth of the web plate in the case of a plate girder;

and t the thickness of the web.

3.5.10.6 Flange Plates.—Where flange plates are used on plate girders or rolled *beams*, they shall extend not less than 18 inches beyond the point where any portion of their section is needed to make up the required flange area, and shall be limited in width so as not to extend more than 12 times the thickness of the thinnest plate, or a maximum of 6 inches, beyond the outer row of rivets connecting them to the angles.

3.5.10.7 Splices.—Web and flange splices shall be arranged so that sufficient rivets and material are provided to develop the full value of the stress in the spliced members and distribute it symmetrically to the component parts.

*An acceptable method of calculating the critical stress in certain cases is given by Timoshenko. Trans. Am. Soc. C.E. 1924, pp. 1247-1262.

3.5.10.8 Buckling of Web.—Where webs are thin and shears are heavy, adequate provision shall be made for resistance to buckling.

3.5.10.9 Stiffeners.—Where rolled *beams* or plate girders are seated on their lower flanges, the capacity of the web shall be investigated and end stiffeners added if necessary. Such end stiffeners shall be proportioned to take the end reaction.

Intermediate stiffener angles shall be provided on plate girders at points of concentrated loading; and at intervals along all plate girders where the clear distance between flange angles is more than 80 times the thickness of the web; provided that such stiffeners may be omitted if

the shearing stress in the web does not exceed $\left[\frac{8000}{h/t} \right]^2$ pounds per square

inch. The spacing of such stiffeners shall be not greater than one and one-half times the clear distance between the flange angles.

End stiffeners shall always be in pairs, and intermediate stiffeners generally so. The outstanding legs of stiffeners shall not be less than 2 inches plus 1/30 of the depth of the girder. End stiffeners and stiffeners at points of concentrated loading shall be fitted to the loaded flange of the *beam* or girder.

3.5.10.10 Riveting.—Rivets connecting the flanges to the webs of plate girders between stiffeners shall be proportioned to carry the resultant of the longitudinal and vertical shears on such rivets.

3.5.10.11 Allowance for Concrete Encasement.—

(a) **General.**—Allowance may be made, in accordance with the provisions of this Item, for the strengthening effect of *concrete* encasement or of a *concrete* slab on a *beam*, if the *concrete* has a minimum strength of 2000 pounds per square inch and the steel is not painted.

(b) **Initial Stress.**—Allowance may be made only for the portion of the load that is supported by the *beam* after the *concrete* has set. If the *concrete* or any other loading causes stress in the steel before the *concrete* has set, such loads shall be assumed to be supported by the steel only.

(c) **Method of Calculation.**—Allowance may be made for the strengthening effect of the *concrete* by assuming that the steel and the *concrete* act together elastically, in which case the stress in the steel shall not exceed that permitted in Article 3.5.4. If the horizontal shear stress on the upper surface of the steel *beam* exceeds $.025f'_c$, special provision shall be made to increase the bond between the steel and the *concrete*. Such provision shall be adequate to resist all horizontal shear stress on the upper surface of the steel *beam* in excess of $.025f'_c$ and may take the form of anchorage plates or angles rigidly attached to the top of the flange of the steel *beam*.

3.5.11 Steel Trusses, including Open Web Steel Joists

3.5.11.1 General.—Steel trusses spaced at greater than 30 inches on centres shall comply with the general requirements of this Section; floor and roof construction involving trusses spaced at not more than 30 inches on centres shall be considered as open web steel *joist* construction and shall comply with the requirements of Item 3.5.11.2 hereof.

3.5.11.2 Open Web Steel Joist Construction.—

(a) General Requirements.—Open web steel *joists* shall be considered as secondary members of the steel frame and shall not be assumed to contribute to its rigidity, except that, where they are rigidly attached to the upper flange of a *beam* as provided in paragraph (e) hereof, they may be assumed to provide lateral support to the *beam*.

An open web steel *joist* shall be capable of supporting all loads to which it may be subjected, and it shall be such that a concentrated load of 800 pounds at any panel point will nowhere produce stress in excess of that permitted in this Code, such *joist* being simply supported and otherwise unloaded. For the purpose of determining the stress in any portion, an open web *joist* shall be considered as a pin-connected truss.

(b) Maximum Span.—The span of an open web *joist* shall not be greater than 24 times its depth.

(c) Spacing.—The spacing of open web *joists* shall not be greater than 30 inches.

(d) Concrete Slabs.—The minimum thickness of any *concrete* slab over open web steel *joists* used in any floor shall be 2 inches for *joist* spacings up to and including 24 inches, and 2½ inches for *joist* spacings up to and including 30 inches. The minimum thickness of *concrete* slabs over open web steel *joists* used in roofs shall be 2 inches for *joist* spacings up to and including 30 inches. The *concrete* shall have a minimum strength of 2000 pounds per square inch.

Every slab shall be so reinforced that the stresses in the *concrete* and the reinforcement will not exceed those permitted in Section 3.4 of this Code and in no case shall the reinforcement at right angles to, and parallel to, the *joists* be less than ¼ inch diameter rods at 12-inch centres or equivalent, except that the reinforcement parallel to the *joists* may be omitted where wood finish floors are used.

All slab reinforcement shall be in the form of rods, or mesh, or ribs of lath of equivalent sectional area.

(e) Bearing and Anchorage.—Every open web steel *joist* shall have a bearing at each end of at least 4 inches on either *masonry* or *reinforced concrete*, or at least 2½ inches on steel.

Where open web steel *joists* are supported on *masonry* walls, every third *joist* shall be anchored to the *masonry* in an adequate manner.

Where open web steel *joists* are supported on steel *beams*, *girders*, or trusses, each end of each *joist* shall be fastened to the supporting steel by a form of anchorage that will effectively anchor the *joist* and tie the floor system through as a whole. Where a *joist* is considered as providing full lateral support to the compression flange or chord of the supporting steel member, the *joist* shall be bolted or welded to such flange or chord.

(f) **Bridging.**—Every open web steel *joist* shall be securely bridged at intervals not exceeding 7 feet or $40b$ whichever is the lesser, where b is the breadth of the top chord of the *joist*. Such bridging shall securely support the top chord of the *joist* against lateral displacement and shall be adequate to distribute any concentrated load, such as a *partition* load that may be placed on the *joists*. The bridging shall be considered adequate for the latter purpose if its moment of resistance in inch-pounds is not less than 250 times the maximum spacing of the *joists* in inches.

(g) **Top Chord.**—Adequate lateral support shall be provided for the top chord during construction.

A *concrete* slab may be considered to prevent bending stresses in the top chord of a *joist* where the distance between panel points is not greater than 12 times the thickness of the slab. When the distance between panel points exceeds 12 times the thickness of the slab or when no slab is provided, the bending stress in the top chord of a *joist* shall be calculated assuming the load to be uniformly distributed between panel points, and the adequacy of the section shall be verified by the method given in Article 3.5.9.

(h) **Connections.**—All joints and connections shall be capable of withstanding a stress at least three times as great as that due to the working load and shall be capable of withstanding all stresses incidental to reasonable handling.

3.5.12 Column Bases

3.5.12.1 General Requirements.—Adequate provision shall be made for transferring the *column* loads, and moments, if any, to the *footings* and *foundations*.

3.5.12.2 Steel Base Plates.—For rectangular base plates of Medium Steel which distribute the load uniformly, the minimum thickness in inches shall not be less than that given by the following formula:

$$t = \sqrt{.00015p \left[m^2 - \frac{n^2}{4} \right]}$$

where t is the plate thickness, in inches;

p is the pressure on the base, in pounds per square inch;

m is the greater projection of plate over *column*, in inches;

and n is the lesser projection of plate over *column*, in inches.

When other grades of steel are used, the thickness shall be that determined from the above formula multiplied by $\sqrt{\frac{f_v}{33}}$ where f_v is the specified yield point in kips per square inch for the grade of steel being used.

3.5.12.3 Grillage Beams.—Where grillage *beams* are encased in *concrete* that fills all interstices and extends in all directions at least 4 inches beyond the outer edges of all such *beams*, and that has a compressive strength of at least 2000 pounds per square inch, the working stresses prescribed in Article 3.5.4 may be increased by one-third, and the webs may be considered as braced against buckling, provided that all *beams* in the same tier are spaced at least 3 inches apart.

3.5.13 Rivets and Riveted Connections

3.5.13.1 Effective Diameter.—The nominal diameter of a rivet shall be considered as its effective diameter.

3.5.13.2 Minimum Number of Rivets.—All connections except those of minor members such as girts, lattice bars, and hand rails shall have not less than two rivets or bolts.

3.5.13.3 Long Rivets.—Where rivets carry stress and pass through fillers, their number shall be increased by one per cent for each 1/16 inch of filler, and the additional rivets when practicable shall be outside of the connection.

Rivets subject to calculated stress, whose grip exceed $4\frac{1}{2}$ diameters, shall be increased in number at least one per cent for each additional 1/16 inch of the grip. If the grip exceeds 6 times the diameter of the rivet, specially designed rivets shall be used.

3.5.13.4 Minimum Spacing and Maximum Spacing.—The minimum distance between centres of rivet holes shall be 3 diameters of the rivet; but where possible this distance shall be not less than:

4-1/2 inches	for 1-1/4 inch rivets
4 inches	for 1-1/8 inch rivets
3-1/2 inches	for 1 inch rivets
3 inches	for 7/8 inch rivets
2-1/2 inches	for 3/4 inch rivets
2 inches	for 5/8 inch rivets
1-3/4 inches	for 1/2 inch rivets.

Except where otherwise specified, the pitch of rivet holes in any one group shall not exceed:

9 inches	for 1-1/4 inch rivets
8 inches	for 1-1/8 inch rivets
7 inches	for 1 inch rivets
6 inches	for 7/8 inch rivets
5 inches	for 3/4 inch rivets
4 inches	for 5/8 inch rivets
3 inches	for 1/2 inch rivets.

3.5.13.5 Minimum Edge Distance.—The minimum distance from the centre of any rivet hole to a sheared edge shall be:

2-1/4 inches	for 1-1/4 inch rivets
2 inches	for 1-1/8 inch rivets
1-3/4 inches	for 1 inch rivets
1-1/2 inches	for 7/8 inch rivets
1-1/4 inches	for 3/4 inch rivets
1-1/8 inches	for 5/8 inch rivets
1 inch	for 1/2 inch rivets.

and to a rolled edge (except in lattice bars) shall be:

2 inches	for 1-1/4 inch rivets
1-3/4 inches	for 1-1/8 inch rivets
1-1/2 inches	for 1 inch rivets
1-1/4 inches	for 7/8 inch rivets
1-1/8 inches	for 3/4 inch rivets
1 inch	for 5/8 inch rivets
7/8 inch	for 1/2 inch rivets.

The distance between the centre of any rivet under computed stress, and that end or other boundary of the connected member toward which the pressure of the rivet is directed, shall be not less than the shearing area of the rivet shank (single or double shear respectively) divided by the thickness of the member. Such end distance may, however, be decreased in such proportion as the stress per rivet is less than that permitted under Article 3.5.4; and the requirement may be disregarded in case the rivet in question is one of three or more in a line parallel to the direction of stress.

3.5.13.6 Rivets in Built-up Members.—If two or more web plates are used in contact, stitch rivets shall be provided to make them act as one.

The maximum pitch in the line of stress of compression members composed of plates and shapes shall not exceed 16 times the thickness of the thinnest outside plate or shape, nor 20 times the thinnest enclosed plate or shape with a maximum of 12 inches, and at right angles to the direction of stress the distance between lines of rivets shall not exceed 30 times the thickness of the thinnest plate or shape. For angles in built sections with two gauge lines, with rivets staggered, the maximum pitch in the line of stress in each gauge line shall not exceed 24 times the thickness of the thinnest plate or shape with a maximum of 18 inches.

At the ends of built-up compression members, the pitch of rivets connecting the component parts shall not exceed 4 times the diameter of the rivets for a distance, from the ends, of $1\frac{1}{2}$ times the maximum width of the member; except that in angles having two lines of rivets staggered, the pitch on each gauge line may be twice this limit, but not more than that allowed for the body of the member.

In tension members the pitch of stitch rivets in any direction shall be not more than 30 times the thickness of the thinnest plate connected.

In tension members composed of two angles a pitch of 3 feet 6 inches will be allowed, and in compression members 2 feet, but the ratio l/r for each angle between rivets shall be not more than $3/4$ of that for the whole member.

3.5.14 Bolted Connections

3.5.14.1 Use of Unfinished Bolts.—Field Connections may be made with unfinished bolts except the following, which shall be made by rivets, welds, turned bolts, or *approved* special design of bolts:

(a) *Column* splices and connections of *beams* and *girders* to *columns* where the structural framework is assumed to resist wind or other lateral loads.

(b) Roof-truss splices and connections of trusses to *columns*, *column* splices, *column* bracing, and crane supports in all *structures* carrying power-driven travelling cranes, or carrying jib cranes of over one ton capacity.

(c) Connections for supports of running machinery and of other *live loads* that produce impact or reversal of stress.

3.5.14.2 Length of Bolts.—The shank of any finished bolt shall be long enough to provide full bearing, to permit the use of a washer under the nut, and to ensure full engagement for the thread of the nut.

3.5.14.3 Spacing of Bolts.—The minimum requirements for spacing and edge distance of bolts shall be those prescribed for rivets in Items 3.5.13.4 and 3.5.13.5.

3.5.15 Welded Connections

3.5.15.1 Filler Metal.—All electrodes for use in metallic arc process shall conform to C.E.S.A. Specification S48T-1938.

All rods for use in gas welding shall conform to the requirements for Grade 10 or better material as prescribed in A.S.T.M. Specification A205-37T.

3.5.15.2 Qualification of Welders.—All metallic arc welding shall be performed by shops and operators qualified under C.E.S.A. Specification S47T-1938.

All gas welding shall be performed by shops and welders qualified to the satisfaction of the *authority having jurisdiction*.

3.5.15.3 Parent Metal.—The parent metal to be welded shall be Medium or Mild Structural Steel, provided that the *authority having jurisdiction* may permit the welding of other grades of structural steel on the basis of it being established that their weldability is at least equal to that of Medium Structural Steel.

3.5.15.4 Types of Weld.—For the purposes of this Code, all welds shall be classified as *butt*, *fillet*, or *plug welds*.

Butt welds shall be continuous for the full length of the joint. *Fillet welds* may be either continuous or intermittent.

3.5.15.5 Size of Weld.—The size of a *butt weld* shall be defined as the thickness of the plates connected.

The size of a *fillet weld* between two flat surfaces shall be defined as the length of the shorter side in contact with the parent metal as seen in the normal cross section of the weld. The thickness through the throat of the weld shall not be less than 7/10 of the size of the weld.

When either one of the surfaces being connected by a *fillet weld* is curved, the size and shape of the weld shall be determined by the *authority having jurisdiction*.

3.5.15.6 Use of Welds.—*Butt welds* may be used to transmit direct stress, shearing stress, or a combination of these two, with or without bending moment, at an allowable stress not exceeding that specified under Item 3.5.15.9, except that non-reinforced single-V *butt welds* shall be limited as specified under Item 3.5.15.13, and shall not be subjected to bending stresses.

Fillet welds may be used to transmit direct stress, longitudinal or transverse shear, or a combination of these, with or without bending moment, except that single *fillet welds* shall not be subjected to bending about the longitudinal axis of the weld. (For method of calculating combined stresses, see Item 3.5.15.15.)

Plug welds shall only be used for the purpose of carrying calculated stress when expressly permitted by the *authority having jurisdiction*.

3.5.15.7 Effective Lengths.—The "effective length" of a *fillet weld* shall be defined as its nominal or designated length, less twice its size.

No *fillet weld* shall be considered as carrying stress unless its effective length is at least 4 times its size. Where a *fillet weld* is carried over the edge or end of the plate or section merely for sealing purposes, such extra length shall be disregarded in computing the effective length.

3.5.15.8 Type of Electrodes.—All *butt welds* made by the metallic arc process shall be made with covered electrodes. *Fillet welds* made by the metallic arc process shall also be made with covered electrodes, except when the use of bare or lightly coated electrodes is authorized by the *authority having jurisdiction*.

Any process which provides equivalent protection for the arc and molten metal and which produces deposited weld metal, meeting the requirements of the C.E.S.A. Specification S48T-1938, for general-purpose covered electrodes, shall be accepted as equivalent to the use of covered electrodes.

3.5.15.9 Working Stresses.—The value of a *butt weld* shall be considered as equal to the full value of the connected metal when in compression, and to 85 per cent of that value when in tension or shear, except as provided in Item 3.5.15.13.

When covered electrodes are used, the unit stress in *fillet welds* shall be 600 n pounds per lineal inch, where n is the size of the weld in sixteenths of an inch, provided that the tensile strength of the deposited metal of *butt welded* specimens made with the electrode in question and tested as required in C.E.S.A. Specification S48-T, is not less than 60,000 pounds per square inch, and provided the tensile strength of *fillet weld* specimens tested in accordance with C.E.S.A. Specification S47-T is not less than 54,000 pounds per square inch. Otherwise the unit stress in *fillet welds* made with covered electrodes shall be 500 n pounds per lineal inch.

Where *plug welds* are used by permission from the *authority having jurisdiction* for carrying calculated stress, the permissible unit stress shall be 7,500 pounds per square inch if made with bare or lightly covered electrodes, and 9,000 pounds per square inch if made with covered electrodes.

When gas welding is used, the stresses prescribed for bare or lightly covered electrodes shall apply when welds are made with filler metal of grades 2, 4, 10, or 15, and the stresses prescribed for covered electrodes shall apply when welds are made with filler metal of grades 20, 30, or 40. The grades referred to are those described in A.S.T.M. Specification A205-37T.

3.5.15.10 Details of Design.—Every welded *structure* shall be designed so as to give the maximum possible accessibility to the welded joints during fabrication, and to minimize distortion of the members.

Overhead welding shall be kept to a minimum, particularly in field work.

As far as practicable, *fillet welds* connecting the various parts of a single frame shall be kept to a uniform size.

The size of every *fillet weld* used to connect material up to one inch thick shall be not less than one-third of the thickest section connected. Every *fillet weld* used to connect material over one inch in thickness shall be not less than 3/8 inch in size.

Every welded joint shall be so designed that the centroid of the effective values of the component welds in the joint shall coincide with the neutral axis of the member connected, unless due allowance is made for eccentricity in the proportioning of the welds and the member. Furthermore, each component part of a built-up member shall be adequately connected for its own proportion of the transmitted stress.

In intermittent *fillet welding*, the maximum clear distance between any two consecutive welds in one line shall be 4 times the effective length of the shorter weld and shall not be more than 12 inches. When staggered intermittent welds lie on parallel lines which are not more than 6 inches apart, the spacing on each line may be double that above specified.

3.5.15.11 Stitch Welding.—Stitch welding shall conform in principle with the requirements for stitch riveting set forth in Item 3.5.13.6.

3.5.15.12 Edge Preparation for Butt Welding.—The edges of all plates or shapes to be *butt welded* shall be prepared in such a manner that satisfactory welded joints can be obtained. *Butt welds* shall be of any one of the following types:

- (a) Square
- (b) Single-V
- (c) Single-U
- (d) Double-V
- (e) Double-U.

The adoption of any other type of *butt weld* shall be subject to the approval of the *authority having jurisdiction*.

For material 1/4 inch and under in thickness, where it is possible to weld from both sides, a square *butt weld* may be used, and preparation normally dispensed with.

For material over 1/4 inch in thickness, where it is possible to weld from both sides, either single-V, single-U, double-V, or double-U *butt welds* shall be used. The method of edge preparation and the welding technique shall be subject to the approval of the *authority having jurisdiction*.

For material of all thicknesses, where it is practicable to weld from one side only, either a single-V or a square open joint shall be used and, where possible, a backing-bar shall be introduced.

If the thickness of the two sections to be *butt welded* varies by 1/4 inch or more, the end of the thicker section shall be bevelled off to meet the thinner, at a slope of not more than 1 in 5.

3.5.15.13 Reinforcing of Butt Welds.—All *butt welds* shall be built up so that the thickness through the centre line of the joint shall be at least 1/16 inch, or 10 per cent greater than that of the parent metal adjacent to the joint. Where a flush finish is required, this reinforcing shall first be deposited and then ground off.

Where conditions make it impossible to weld from both sides and no suitable backing-bar is provided, the allowable stress in the weld shall be only 50 per cent of that specified above under Working Stresses. (See Item 3.5.15.9.)

Where *butt welds* which can only be made from one side are backed up by a suitable bar, and where the joint is so designed and the welding technique so applied that adequate fusion of the weld into the backing material is obtained, the full unit stress specified above under Working Stresses shall be permitted.

The ends of *butt welds* shall be reinforced with cross-runs of weld metal deposited at right angles to the centre line of the joint, and these runs shall be of a length not less than twice the width of the weld at its widest point.

3.5.15.14 Fillet Welds in Slots.—Every slot provided for fillet welding shall have rounded ends and the *fillet welds* shall extend completely around the periphery of such slot.

3.5.15.15 Combined Stresses.—Welded connections subjected to combined bending and shear, such as those connecting *beams* to *columns*, shall be such that the principal stresses and the maximum shear stress do not exceed the values given in Item 3.5.15.9.

3.5.15.16 Combined Riveted or Bolted and Welded Connections.—On new work, welds and rivets or bolts combined in one connection shall not be considered as sharing the stress, and welds shall be provided to carry the entire stress for which the connection is designed.

3.5.15.17 Workmanship.—

(a) **Condition of Metal Surfaces.**—All metal surfaces which are to be welded shall be dry, clean, and free from loose scale, paint, and grease.

(b) **Peening and Stress-relieving.**—Peening and stress-relieving may be used when suggested by the nature of the work. These operations shall, however, only be carried out with the permission of the *authority having jurisdiction*, and the procedure employed shall be submitted for his approval.

(c) **Distortion.**—Every welding process shall be carried out in such a way as to control and minimize distortion. Tack welds, temporary stiffeners, tie bars, supports, etc., may be used for this purpose and shall be used when required by the *authority having jurisdiction*.

(d) **Temperature.**—No welding shall be done when the temperature of the metal or the surrounding atmosphere is below 32F., unless special precautions are taken and the procedure *approved* by the *authority having jurisdiction*.

(e) **Pre-heating.**—Every massive assembly, where the individual parts are short, thick, or highly restrained against distortion, shall be pre-heated to approximately 150F, and maintained at this heat during the welding process.

3.5.16 Fabrication

3.5.16.1 Practice.—The workmanship and finish shall conform to accepted good commercial practice. Materials shall have clean surfaces before being worked.

3.5.16.2 Straightening.—When straightening or flattening of rolled material is necessary it shall be done by methods that will not injure the material. Sharp kinks or bends will be cause for rejection.

3.5.16.3 Finish.—Finished members shall be true to line and free from twists, bends, and open joints.

Compression joints in built-up members depending upon contact bearing shall have the bearing surfaces truly faced after the member has been assembled and riveted up.

Cast bases shall be planed on the surfaces to be in contact with steel, and the bottom surfaces, resting on dressed *masonry*, shall be rough machined.

Shearing, chipping, and burning shall be accurately done.

All stiffener angles at end bearings or at points of concentrated loading, on *beams* and plate girders, shall be given a driving fit against the flanges.

3.5.16.4 Rivet Holes.—Except as otherwise specified herein, rivet holes in material up to and including $\frac{3}{4}$ inch in thickness may be punched full size. Thicker material shall be drilled from the solid unless punching or sub-punching is specially permitted by the *authority having jurisdiction*. In built-up members, aggregating 3 inches or more in thickness, the holes in all constituent parts shall be sub-punched or sub-drilled sufficiently small to permit them to be reamed true without enlarging the diameter beyond that specified. Outside burrs shall be removed from drilled holes.

3.5.16.5 Punched Holes.—The diameter of the die shall be not more than $\frac{1}{8}$ inch greater than the nominal diameter of the rivet, and the relative sizes of punch and die shall be such as will not produce depression on the surface of the plate adjacent to the hole.

Drifting to enlarge unfair holes will not be allowed, but if holes must be enlarged to admit rivets, they shall be reamed. Poor matching of holes will be cause for rejection.

3.5.16.6 Size of Rivets.—Size of a rivet shall mean its nominal diameter before heating.

3.5.16.7 Rivet Heads.—Rivet heads, when not countersunk, or flattened, shall be of *approved* shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

3.5.16.8 Riveting.—Hot-driven rivets shall be heated uniformly to a light cherry red and driven while hot. Such rivets, when heated and ready for driving, shall be free from slag, scale, and carbon deposit. Cold-driven rivets may be used, subject to the approval of the *authority having jurisdiction*. All rivets, when driven, shall completely fill the holes. Loose, burned, or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal;

and, if necessary, they shall be drilled out. Caulking or re-cupping shall not be permitted.

Rivets shall be driven by pressure riveters where practicable. The riveters shall retain the pressure after the upsetting is completed.

3.5.16.9 Turned Bolts.—Where turned bolts are used, the holes shall be reamed parallel and the bolts shall make a tight fit, with the threads entirely outside of the holes. A washer not less than 1/4 inch thick shall be used under each nut.

3.5.16.10 Annealing.—Excepting minor details, steel which has been partially heated shall be properly annealed.

3.5.16.11 Gas Cutting.—*Gas cutting* shall not be performed on a member while under stress, provided that detail cutting to correct minor fabrication errors may be done if the removal of metal does not reduce the strength below design requirements.

Gas-cut edges shall be smooth and regular in contour.

Stresses shall not be transmitted into metal through a gas-cut surface.

3.5.16.12 Shop Painting.—

(a) **Paint.**—All metal surfaces, other than machine finished surfaces, and surfaces that are to be encased in *concrete*, shall be given one shop coat of anti-corrosive priming paint.

(b) **Surfaces in Contact.**—Surfaces coming in contact shall be cleaned by effective means before assembly but shall not be painted.

(c) **Cleaning in Shop.**—Before painting, all metal surfaces shall be thoroughly scraped and cleaned of rust, scale, and dust, either with sand-blast, steel scrapers, or stiff wire brushes; finally the surfaces shall be dusted off with stiff bristle brushes. All oil, paraffin, or grease shall be removed from such surfaces.

(d) **Inaccessible Surfaces.**—All surfaces that may be inaccessible after erection shall be given two shop coats.

(e) **Machine Finished Surfaces.**—Machine finished surfaces (except abutting joints and base plates) shall be covered with a protective coating.

(f) **Conditions for Painting.**—Painting shall not be done in damp or freezing weather, except under cover; and the steel shall be free from

moisture or frost when the paint is applied. Material painted in damp or freezing weather shall be kept under cover, and at a temperature above freezing, until the paint is dry.

(g) Application.—The paint shall be of the proper working consistency and each coat shall be applied by brushing or spraying in such a manner as to ensure complete coverage and then allowed to dry thoroughly before application of the next coat.

The paint shall be carefully worked into all joints. The shop coat must be dry before handling.

3.5.17 Erection

3.5.17.1 General Requirements.—The frame of all steel skeleton buildings shall be carried up true and plumb, and temporary bracing shall be introduced, wherever necessary, to take care of all loads to which the *structure* may be subjected, including those due to erection equipment and the operation thereof. During erection the work shall be securely bolted up to provide safely for all erection stresses and conditions, and no riveting shall be done until proper alignment has been secured.

3.5.17.2 Riveting.—Rivets driven in the field shall be heated and driven with the same care as shop rivets and shall be power driven unless otherwise authorized by the *authority having jurisdiction*.

3.5.17.3 Bolts.—The threads of all bolts shall be burred or otherwise checked to prevent the nuts from becoming loose.

3.5.17.4 Cleaning Steel.—After erection, steel-work shall be cleaned of all dirt, rust, and loose or broken paint.

3.5.17.5 Painting after Erection.—All rivet and bolt heads, and bare or scratched spots shall be given one coat of anti-corrosive priming paint before the field coat is applied.

All metal surfaces, except such as are to be encased in *concrete*, shall be given one field coat of an *approved* paint.

Surfaces which are to be protected by *concrete* casing shall not be painted, and all such surfaces shall be left in a perfectly clean condition, free from all dirt, rust, grease, or paint spots.

No field painting shall be done in damp or foggy weather, or at any time when the temperature of the steel-work is below 40F. No paint shall be applied to surfaces which are not absolutely clean and dry.

SECTION 3.6 LIVE LOADS

3.6.1 General Requirements.—The *live loads* prescribed herein are minimum requirements and, where greater loads are liable to be imposed, such greater loads shall be assumed in place of the *live loads* prescribed.

3.6.2 Floor Loads.—

3.6.2.1 Minimum Floor Loads—The following minimum floor loads shall be assumed for the occupancies given below. For occupancies not specifically mentioned or about which there is any uncertainty, the *authority having jurisdiction* shall decide on the loads to be assumed.

	Load in Pounds per Square Foot
Rooms used for sleeping or domestic purposes.....	40
Rooms used for office purposes*.....	50
Corridors in <i>hotels</i> and hospitals.....	50
Classrooms in schools.....	50
Corridors and entrance halls in schools.....	75
Dining rooms and restaurants.....	75
Assembly halls having fixed seats.....	60
Bowling alleys, pool rooms, billiard rooms, and similar areas.....	75
Rooms, corridors, and public spaces which may become densely crowded	100
Grandstands.....	100
<i>Stairways</i> and <i>fire escapes</i>	100
Dance halls and gymnasiums.....	100
Retail shops and stores.....	100
Wholesale shops and storage buildings.....	125
Factories.....	125
Sidewalks.....	250
<i>Garages</i> for passenger cars and all other vehicles not exceeding 6000 pounds gross weight, stables.....	75 (4000)
<i>Garages</i> for trucks and buses not exceeding 20,000 pounds gross weight.	150 (8000)
Driveways.....	250 (12,000)

Notes:

1. Floors in office buildings and in other buildings carrying *partitions* that may be shifted, shall be capable of supporting in addition to other loads a single *partition* of the type used in the building placed in any position; or alternatively the floor load shall be increased by 20 pounds per square foot over the entire area.
2. If any floor area is intended for such use that concentrated loads due to safes or other equipment may be expected, adequate provision shall be made for them.
3. Unless otherwise specified corridors shall be assumed to carry a *live load* not less than that of the heaviest loaded floor to which they give access.
4. The figures in parentheses are alternative concentrated loads. Provision shall be made for either the uniformly distributed load or the concentrated load whichever produces the greater stress.
5. Concentrated loads may be assumed to be distributed over an area 2 feet 6 inches square.
6. Floor loads for *garages* to be used by trucks exceeding 20,000 pounds gross weight shall be *approved* by the *authority having jurisdiction*.

*Attention is directed to the fact that ground floor space intended for office purposes may subsequently be occupied as "Retail shops and stores" or "Rooms which may become densely crowded".

3.6.2.2 Reduction of Live Loads on Floors.—The following reductions in the *live loads* specified on floors shall be permitted in the consideration of certain *columns*, *piers*, walls, *foundations*, trusses, *girders*, and *beams*.

- (i) For *Beams*, *Girders*, and Trusses.—A reduction of 15 per cent when the floor area carried is 200 square feet or more.

This reduction shall not apply to roof loads or to buildings to be used as warehouses or for storage purposes.

No reduction shall be allowed for slabs or *joists*.

- (ii) For *Columns*, *Piers*, Walls, and *Foundations*.—All *columns*, *piers*, walls, and *foundations* shall be assumed to carry the *live loads* indicated in Table 1 of this Section. (The reduction permitted for *beams* shall not be superimposed upon the reduction permitted for *columns*, *piers*, walls, and *foundations*.)

TABLE 1 (SECTION 3.6)

PERCENTAGE OF TOTAL LIVE LOAD ON FLOORS AND ROOFS
TO BE ASSUMED IN THE CONSIDERATION OF COLUMNS,
PIERS, WALLS, AND FOUNDATIONS

Load Carried	Percentage of Total <i>Live Load</i>		
	Warehouses and storage buildings	Manufacturing buildings, stores, <i>garages</i>	All other buildings
Roof	100	100	100
1 floor and the roof	100	90	85
2 " " " "	95	85	80
3 " " " "	90	80	75
4 " " " "	85	75	70
5 " " " "	80	70	65
6 " " " "	80	70	60
7 " " " "	80	70	55
8 or more floors and the roof	80	70	50

- (iii) For Stresses Resulting from a Combination of Wind and Other Loads.—When considering the stresses in a *structure* and the pressure on the *foundation* bearing materials resulting from a combination of wind and other loads, it shall be permissible to reduce the assumed *live load* on floors, as prescribed herein, by one-half, provided that in no case shall such stresses or bearing pressures be assumed to be less than those resulting from a combination of *dead loads* and *live loads* other than wind.

3.6.3 Ceiling Loads.—Ceiling *joists* shall be capable of supporting a *live load* of 10 pounds per square foot.

3.6.4 Roof Loads

3.6.4.1 Snow.—Roofs having a slope of 20 degrees or less shall be capable of supporting a vertical *live load* of from 20 to 40 pounds per square foot of roof surface, the value to be assumed depending upon the probable snowfall and rainfall in the locality in which the building is to be erected*.

For roofs having a slope of more than 20 degrees and no parapets the loading may be reduced to that given by the following formula:

$$L_1 = L \left[1 - 0.0233 (\alpha - 20) \right]$$

where L_1 is the snow load for a sloping roof;

L the snow load for a flat roof;

and α the slope of the roof in degrees.

In portions of roofs where an unusual depth of snow may accumulate, adequate provision shall be made to support the snow load likely to occur.

3.6.4.2 Combinations of Wind and Snow Loads.—Roofs shall be capable of resisting wind loads as specified herein in addition to vertical loads. Pitched roofs shall be capable of resisting the snow load acting on the whole roof, or on a part of it, with or without the wind load applied simultaneously.

3.6.4.3 Minimum Total Load.—Roof members supporting roofs having a slope of not more than 20 degrees and carrying less than 500 square feet of roof, shall be capable of supporting a total load including *dead load* but excluding wind, of not less than 50 pounds per square foot.

*As a guide to the selection of the *live load* to be assumed the following formula shall be used:

$$L = S + R$$

where S is the sum of the average snowfalls in January, February, and March, in inches, over a number of years;

R the sum of the average rainfalls in January, February, and March, in inches, over a number of years;

and L is related to *live load* by the following table:

L	<i>Live Load</i>
Less than 20	20 pounds per square foot
20—30	30 pounds per square foot
More than 30	40 pounds per square foot

3.6.5 Wind Loads

3.6.5.1 Wind on Vertical Surfaces.—

- (i) The wind force on the vertical faces of a building shall be assumed to have the following values:
 - (1) for the first 300 feet above ground, 20 pounds per square foot
 - (2) for any part of a building more than 300 feet above ground, the wind force shall be assumed to increase by 0.025 pounds per square foot for each foot of height in excess of 300.
- (ii) Two-thirds of the assumed wind force shall be considered to be a normal pressure applied to the windward wall and one-third shall be considered to be a normal suction applied to the leeward.

3.6.5.2 Wind on Plane Sloping Roof Surfaces.—The external wind force on the slopes of plane pitched roofs, that is roofs which slope both ways from a ridge or crown, shall be assumed to be as follows:

On the leeward slope a suction normal to the plane of the roof of 9 pounds per square foot.

On the windward slope a pressure normal to the plane of the roof varying with the angle of slope with the horizontal, α , as given in Table 2 of this Section, positive quantities indicating pressure and negative quantities indicating suction.

TABLE 2 (SECTION 3.6)
PLANE PITCHED ROOFS—WIND FORCE ON WINDWARD SLOPE

Slope α	Pounds per Square Foot
20° or less	-12
20° to 30°	(1.2 α - 36)
30° to 60°	(0.3 α - 9)
Over 60°	9

3.6.5.3 Wind on Curved Pitched Roofs.—The external wind force normal to the surface of a curved or generally rounded pitched roof, where r is the ratio of the rise of the arc to its span, shall be assumed to be as given in Table 3 of this Section, positive quantities indicating pressure and negative quantities indicating suction.

TABLE 3 (SECTION 3.6)
WIND FORCE ON CURVED PITCHED ROOFS

Rise Ratio r	Wind Force, Pounds per Square Foot		
	Windward Quarter of Roof Arc	Central Half of Roof Arc	Leeward Quarter of Roof Arc
(a) When the side walls are vertical			
Zero to 0.20	-12	$(-15r-11)$	-9
0.20 to 0.35	$(80r-28)$	$(-15r-11)$	-9
or, alternatively, for 0.20 or over	$(30r-6)$		
(b) When the arc of the roof starts from ground level			
All positive values	$19r$	-11	-9

3.6.5.4 Allowance for Internal Suction or Pressure.—In normally closed buildings in which the percentage of possible wall opening is n , the following internal forces shall be assumed to occur simultaneously with the external wind force specified in Items 3.6.5.1, 3.6.5.2, and 3.6.5.3:

- (i) a normal suction $(4.5 + 0.15n)$, or 9, pounds per square foot, whichever is the lesser
- (ii) a normal pressure of $(4.5 + 0.25n)$, or 12, pounds per square foot, whichever is the lesser.

For *structures* having open sides, such, for example, as grandstands, the wind force on exterior surfaces shall be assumed to be as specified in Items 3.6.5.1, 3.6.5.2, and 3.6.5.3, and the wind force on interior surfaces shall be assumed to be as follows:

Open side facing the wind: a pressure of 12 pounds per square foot.

Closed side facing the wind: a suction of 9 pounds per square foot.

Examples showing the distribution of wind loads on various types of buildings and other *structures* are given in Figures 1 and 2 of this Section.

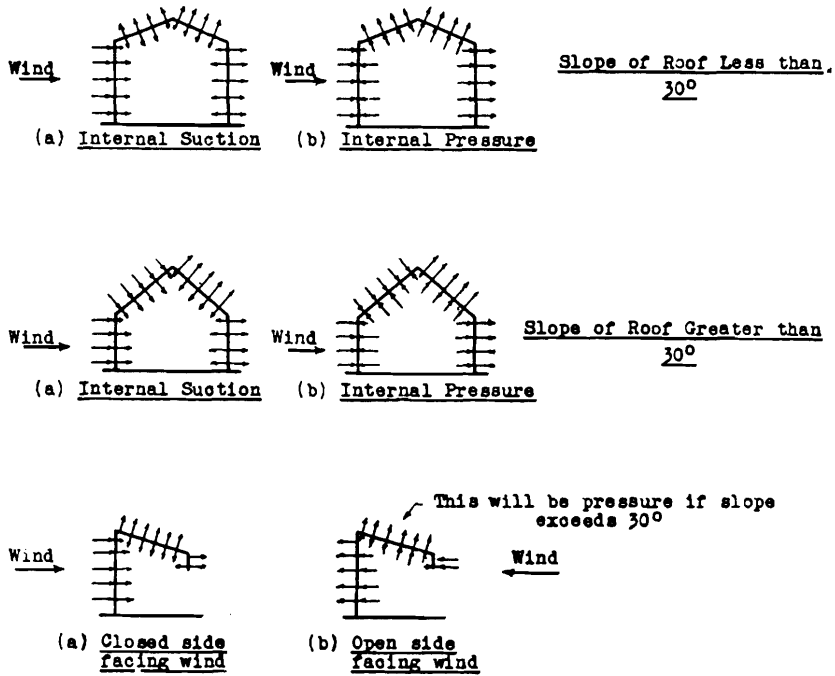


FIG. 1. SECTION 3.6 DISTRIBUTION OF WIND PRESSURE ON PLANE SURFACES

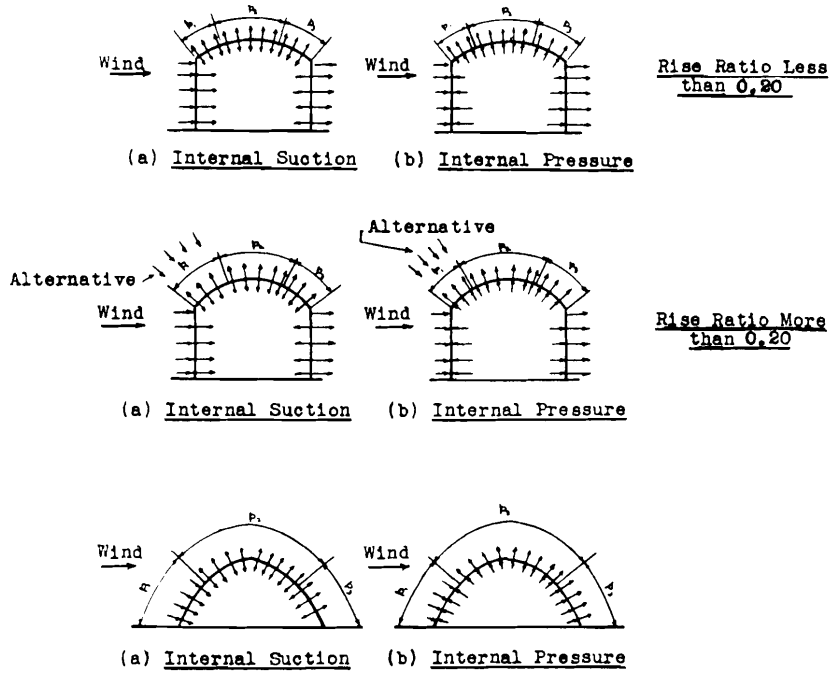


FIG. 2. SECTION 3.6 DISTRIBUTION OF WIND PRESSURE ON CURVED ROOFS

3.6.5.5 Special Cases.—For buildings having irregular or unusual shapes or locations, the wind loads to be assumed shall be *approved* by the *authority having jurisdiction*.

3.6.5.6 Wind Pressure on Signs, Tank Towers, Stacks, and Other Exposed Structures.—Ground signs shall be capable of withstanding a wind pressure of 20 pounds per square foot applied to the net exposed area of the sign and its supports. Roof signs, tank towers, stacks, and other exposed *structures* shall be capable of withstanding a wind pressure of 30 pounds per square foot applied to the net exposed area of the *structure* projected on a plane normal to the direction of the wind. The wind pressure on circular tanks, towers, and stacks shall be assumed to act on two-thirds of the projected area.

3.6.5.7 Stability.—Unless the *structure* is securely anchored to the *foundation*, the overturning moment due to wind pressure shall not exceed two-thirds of the moment of stability of the *structure* as determined by the *dead load*, nor shall the calculated uplift on any *column* without anchorage be in excess of two-thirds of the *dead load* in that *column*. Anchors shall be capable of resisting the excess overturning moment.

3.6.6 Other Loads.—

3.6.6.1 Pressure Due to Earth or Water.—Adequate provision shall be made for loads due to earth or water that may be applied to a *structure*, such as earth pressure on *basement* walls or upward pressure of water on floors.

3.6.6.2 Construction Loads.—Adequate provision shall be made for loadings which may occur during the erection of a *structure*.

3.6.6.3 Impact and Vibration.—The *live loads* prescribed in this Section include allowances for impact arising from normal usage. Adequate provision shall be made for stresses due to abnormal vibration and impact.

3.6.6.4 Lateral Load on Balcony Railings.—Every balcony railing shall be capable of resisting a horizontal force of 40 pounds per lineal foot acting normal to its length.

3.6.6.5 Lateral Forces Due to Earthquakes.—In regions where destructive earthquakes are probable*, every *structure* and portion of a *structure* shall be capable of resisting the horizontal forces induced thereby. An acceptable method of calculating such forces is given in Appendix H.

3.6.7 Posting of Live Loads.—When *live loads* permitted by this Code for a floor or part thereof, other than a *garage* floor, exceed 100 pounds per square foot, notices shall be posted and maintained by the

*Major earthquake shocks have occurred in the St. Lawrence Basin and elsewhere in Canada. (See "Seismology in Canada" Canada Year Book, 1938, pp. 27-29.)

owner in that part of each floor to which they apply, stating the maximum permissible *live load* as determined by the *authority having jurisdiction*.

In *public garages* notices shall be posted by the owner stating the maximum weight of vehicle, as determined by the *authority having jurisdiction*, permitted to use each floor or portion thereof.

In each *assembly room*, auditorium, or room used for similar purposes, where fixed seats are not installed, notices shall be posted by the owner stating the maximum number of persons, as determined by the *authority having jurisdiction*, permitted to use the room.

3.6.8 Occupancy Permits.—Plans for *commercial and industrial buildings*, filed with the *authority having jurisdiction*, shall show on each drawing the *live loads* per square foot of area covered, for which the building is designed, and occupancy permits for buildings hereafter erected shall not be issued until the floor load signs, required by Article 3.6.7, have been installed. No changes in the occupancy of an *existing* building or a new building shall be made until an occupancy permit has been issued by the *authority having jurisdiction*. Such occupancy permit shall certify that the floors are suitable for the loads characteristic of the proposed occupancy.

SECTION 3.7 EXCAVATIONS AND FOUNDATIONS*

3.7.1 Excavations

3.7.1.1 General Requirements.—Until provision for permanent support has been made, excavations shall be properly guarded and protected by the persons causing them to be made so as to prevent such excavation from becoming dangerous to life or limb. Where necessary, excavations shall be sheet-piled, braced or shored, and permanent excavations shall be protected by retaining walls or other permanent *structures* to prevent movement or caving of the adjoining soil.

3.7.1.2 Excavation for Pile Foundations.—The excavation for *pile foundations*, wherever practicable, shall be completed to pile cut-off grade, or lower, before piles are driven. In no case shall piles be driven through more than 3 feet of unexcavated material above pile cut-off grade.

3.7.2 Foundations—General Requirements

3.7.2.1 General.—*Foundations* shall be adequate to distribute to the supporting material all vertical, horizontal, and inclined loads, as specified in Item 3.7.2.2, without exceeding the allowable stresses specified elsewhere in this Code. *Concrete* in *foundations* shall comply with the requirements of Section 3.4 of the Code and shall have an ultimate strength of at least 2000 pounds per square inch.

*When buildings do not exceed three *storeys in height* and are constructed on bearing materials other than clay, silt, or loose sand or gravel, it will not usually be necessary to refer to Articles 3.7.5, 3.7.6, and 3.7.8 to 3.7.16.

3.7.2.2 Foundation Loads.—

(a) The loads to be used in computing the maximum pressure upon bearing materials under *foundations* shall be *dead* and *live loads* as specified in Section 3.6 including the weight of the *foundations*, but excluding loads from overlying soil. (For permitted reductions of *live loads*, see Item 3.6.2.2.)

(b) Eccentricity of loading in *foundations* shall be fully investigated and the maximum pressure shall not exceed the allowable bearing values.

3.7.3 Depth of Foundations

3.7.3.1 General Requirements.—

(a) Except as provided in (e) herein, all *foundations* shall rest upon bedrock or upon well compacted and stable deposits of soil that neither contain nor overlie an appreciable amount of organic or other foreign matter.

(b) Due consideration shall be given to the effect on the supporting value of the bearing material, of any differences in levels of neighbouring *foundations*.

(c) Except as provided in (e) herein, all *foundations*, except those resting on bedrock shall be carried down below the level of possible damage from frost.

(d) Except as provided in (e) herein, no *foundation* shall be placed on frozen soil nor shall any *foundation* be placed during freezing weather unless adequately protected against frost action.

(e) Paragraphs (a), (c), and (d) hereof do not apply to the *foundations* of *detached garages* or similar *accessory buildings*, of not more than one *storey in height*.

3.7.4 Borings and Test Pits

(a) Before issuing a permit for erection or *alteration* of a permanent *structure*, the *authority having jurisdiction*, in the absence of satisfactory data, may require the owner to dig pits or to make borings at such locations and carried to such depths as will disclose the character of the materials underlying the site of the proposed *structure*. When it is proposed to support a *structure* directly on bedrock, loading the rock to more than 10 tons per square foot, the *authority having jurisdiction* may require such drill holes or core borings as may be necessary to prove that sound bedrock has actually been reached.

(b) Where borings and pits are made, copies, in duplicate, of the test reports, together with samples properly protected from evaporation representing the various classes of soil as nearly as possible in their natural state in the ground*, including samples of the material selected

*The use of air-tight containers for the protection of samples is recommended.

for the support of the *foundation*, may be required by the *authority having jurisdiction* for his information and classification. "Wash" or bucket samples will not be accepted.

3.7.5 Classification of Foundation Bearing Materials.—The terms used in the following classification shall be interpreted in accordance with generally accepted geological and engineering nomenclature. Certain terms shall, for the purposes of this Section, have more specific interpretations, as follows:

(a) Rocks.—

Shale:—A laminated, fine-textured, soft rock composed of consolidated clay or silt that cannot be molded without the addition of water, but that can be reduced to a plastic condition by moderate grinding and mixing with water.

Slate:—A dense, very fine-textured, soft rock that is readily split along cleavage planes into thin sheets and that cannot be reduced to a plastic condition by moderate grinding and mixing with water.

Schist:—A fine-textured, laminated rock with a more or less wavy cleavage, containing mica or other flaky minerals.

(b) Non-cohesive Soil.—

Gravel:—An uncemented mixture of mineral grains $\frac{1}{4}$ inch or more in diameter.

Sand:—A type of soil possessing practically no cohesion when dry, and consisting of mineral grains smaller than $\frac{1}{4}$ inch in diameter.

Coarse Sand:—A sand consisting chiefly of grains that will be retained on a 50 mesh sieve.

Fine Sand:—A sand consisting chiefly of grains that will pass a 50 mesh sieve, and be retained on a 200 mesh sieve.

Compact Gravel, Compact Sand:—Deposits requiring picking for removal and offering high resistance to penetration by excavating tools.

Loose Gravel, Loose Sand:—Deposits readily removable by shovelling only.

(c) Cohesive Soil.—

Boulder Clay or Glacial Till:—A thoroughly compact mixture of clay, sand, gravel, and boulders; or a cemented mixture of sand, or of sand and gravel, with or without boulders.

Clay:—A fine-grained, inorganic soil possessing sufficient cohesion when dry to form hard lumps that cannot readily be pulverized by the fingers.

Hard Clay:—A clay requiring picking for removal, a fresh sample of which cannot be molded in the fingers, or can be molded only with the greatest difficulty.

Medium Clay:—A clay that can be removed by spading, a fresh sample of which can be molded by a substantial pressure of the finger.

Soft Clay:—A clay that, when freshly sampled, can be molded under relatively slight pressure of the fingers.

Inorganic Silt:—A fine-grained inorganic soil consisting chiefly of grains which will pass a 200 mesh sieve, and possessing sufficient cohesion when dry to form lumps that can readily be pulverized with the fingers.

3.7.6 Allowable Loads on Foundation Bearing Materials

3.7.6.1 Allowable Bearing Values.—

(a) The allowable bearing values given in this Article are to be used only in the absence of positive tests, well established local experience and practice, or professional advice.

(b) For the purposes of this Item, bearing materials are divided into three general types as follows:

Type I Consolidated and cemented material including rock.

Type II Unconsolidated, non-cohesive material.

Type III Unconsolidated, cohesive material.

(c) For Type I bearing materials the maximum pressure under *foundations* shall not exceed the allowable values set forth in Table 1 of this Section, except when determined in accordance with the provisions of Article 3.7.15 and, in any case, subject to the modifications of subsequent paragraphs of this Item.

TABLE 1 (SECTION 3.7)
MAXIMUM ALLOWABLE BEARING PRESSURE
ON TYPE I MATERIALS

Material	Allowable Bearing Pressure Tons per sq. ft.
Massive bedrock, without laminations, such as granite, diorite, and other granitic rocks; and also gneiss, trap rock, and felsite, all in sound condition	100
Sandstone, limestone, and laminated rocks such as slate and schist, in sound condition	35
Hard shale in beds	20
Residual deposits of shattered or broken bedrock of any kind except shale	10
Boulder clay or glacial till	10

(d) For Type II bearing materials in a compact state* the maximum pressure under *foundations* shall not exceed the allowable values set forth in Table 2 of this Section, except when determined in accordance with the provisions of Article 3.7.15 and, in any case, subject to the modification of subsequent paragraphs of this Item.

TABLE 2 (SECTION 3.7)
MAXIMUM ALLOWABLE BEARING PRESSURE
ON TYPE II MATERIALS (COMPACT)

Material	Allowable Bearing Pressure Tons per sq. ft.
Gravel, sand-gravel mixture	$3.50 + .15 D \dagger$
Coarse sand	$3.00 + .10 D$
Fine sand	$2.50 + .05 D$

$\dagger D$ is the depth in feet of the *foundation* below *grade*

When Type II bearing materials are in a region of permanent ground water, the allowable bearing pressure shall in all cases be reduced to two-thirds of the values given in Table 2.

TABLE 3 (SECTION 3.7)
MAXIMUM ALLOWABLE BEARING PRESSURES
ON TYPE III MATERIALS

Material	Allowable Bearing Value Tons per Square Foot	
	$B \dagger$ not more than 10 ft.	B more than 10 ft.
Hard clay	$\frac{10}{\sqrt{B}}$	3
Medium clay	$\frac{7}{\sqrt{B}}$	2
Soft clay	$\frac{1.5}{\sqrt{B}}$	0.5
Inorganic silt	As determined by the <i>authority having jurisdiction</i>	

$\dagger B$ is the least horizontal dimension in feet of the *foundation* or *footing*

*In lieu of tests to determine the degree of compaction, the driving of a 2- by 2-inch wooden post, having a sharp point, will indicate if the "loose state" is to be suspected. If driving be easy the loose state exists and bearing tests should be carried out.

(e) For Type II bearing materials in the "loose state", the maximum allowable pressure under *foundations* shall be determined from the results of tests carried out in accordance with Article 3.7.15.

(f) For Type III bearing materials, the maximum pressure under *foundations* shall not exceed the allowable values set forth in Table 3 of this Section*. In the case of important *structures*, if the moisture content of any stratum at a depth below the bottom of the *footing* of less than 1.5 times the smallest horizontal dimension of the proposed *structure* exceeds 20 per cent of the dry weight, the allowable bearing pressure shall be determined from the results of tests carried out in accordance with Article 3.7.15.

(g) Where the bearing materials directly under a *foundation* overlie a stratum having smaller allowable bearing values, these smaller values shall not be exceeded at the level of such stratum. Computation of the vertical pressure in the bearing materials at any depth below a *foundation* shall be made on the assumption that the load is spread uniformly at an angle of 60 degrees with the horizontal; but the area considered as supporting the load shall not extend beyond the lines of adjacent property nor beyond the intersection of 60 degree planes of adjacent *foundations* on the same property.

(h) Where the bearing material is of varying compressibility under different parts of the same *structure*, such variations shall be investigated by tests as prescribed in Article 3.7.15 and, if necessary, provision shall be made to prevent dangerous differential settlements.

(i) Wherever, in an excavation, an inward or upward flow of water develops in an otherwise satisfactory bearing material, special methods, satisfactory to the *authority having jurisdiction*, shall be immediately adopted to stop or control the flow in such a way as to prevent disturbance of the bearing material.

3.7.7 Footings, Foundation Walls and Foundation Piers

3.7.7.1 Footings.—

(a) **General.**—*Footings* shall be constructed of *masonry, reinforced concrete, footing stones, or steel grillages embedded in concrete*; except that wood *footings* may be used under *structures* of Type 4 (Wood Frame) or Type 5 (Unprotected Metal or Fire-retardant Treated Wood) construction, provided that the wood *footing* shall be creosoted under pressure unless it is entirely below the permanent ground-water level as determined by the *authority having jurisdiction*. (For classification of types of construction, see Article 4.3.2.) The method of creosoting shall be such as to ensure a minimum net absorption of 6 pounds per cubic foot. Creosote shall conform to Specification No. 11-GP-1 of the Canadian Government Purchasing Standards Committee.

(b) **Masonry Footings.**—*Masonry footings* shall conform to the requirements of Article 3.3.7.

*Appreciable settlements should always be anticipated with Type III bearing materials.

(c) **Reinforced Concrete Footings.**—*Reinforced concrete footings* shall conform to the requirements of Article 3.4.22.

(d) **Footing Stones.**—Footing stones shall be at least 10 inches in thickness and shall be fully bedded. They may be laid dry for buildings not exceeding three *storeys in height*; for higher buildings they shall be laid in cement *mortar* or cement-lime *mortar* and shall conform to the requirements for *masonry footings* given in Article 3.3.7. Stresses in footing stones shall not exceed the maximum specified in Item 3.3.3.2.

(e) **Structural Steel Grillages.**—Structural steel grillages shall conform to the requirements of Section 3.5 (Steel and Iron Construction). There shall be at least 6 inches of *concrete* below all the steel and it shall be entirely embedded in and surrounded by *concrete* at least 4 inches thick. (See also Item 3.5.12.3.)

(f) **Wood Footings.**—Wood *footings* shall conform to the requirements of Section 3.2 (Wood Construction).

3.7.7.2 Foundation Walls.—

(a) **General.**—All *foundation walls* supporting *masonry* construction shall be built of *masonry* or of *reinforced concrete*. Wood frame construction, shall be supported on walls or *piers* of *masonry* or *reinforced concrete* provided that wood posts may be used if they are creosoted under pressure by a method ensuring a minimum net absorption of 6 pounds per cubic foot.

For restrictions on the use of *masonry* materials in contact with the soil, see Item 3.3.5.1.

(b) **Thickness.**—In no case shall the thickness of any *masonry foundation wall* be less than that of the wall above it.

Every *foundation wall* supporting *masonry* construction shall have a thickness not less than that prescribed in Section 3.3 for the *basement* or *cellar storey* of such *masonry* wall. (See Tables 5, 6, 7, or 8 of Section 3.3, also requirements for lateral support, Items 3.3.8.3 (a), 3.3.8.3 (e), 3.3.8.4 (b), and 3.3.8.5.)

Every *foundation wall* supporting wood frame construction shall not be less than 8 inches thick if of *solid masonry*, or 10 inches thick if of *hollow masonry*, provided that any wall supporting *masonry* veneer shall have a minimum thickness of 10 inches.

(c) **Water-proofing.**—Where there is a danger of structural damage from leakage of ground water, adequate provision shall be made for the water-proofing of *foundation walls*. Such water-proofing shall be provided by means of *concrete* of adequate impermeability or by effective surface treatment.

For requirements governing the damp-proofing of *basement* or *cellar* walls, see Articles 5.6.2 and 5.6.3.

3.7.7.3 Foundation Piers.—*Foundation piers* may be constructed of either *plain* or *reinforced concrete*, provided that whenever the centre line of a *foundation pier* deviates from the centre of its load more than 1/16 of its height, or more than 1/10 its diameter, it shall be reinforced.

Foundation piers constructed of *plain concrete* shall conform to the requirements of Section 3.3, Masonry Construction. When the height of the shaft exceeds 6 times its least dimension the maximum working stress shall not exceed

$$f = 0.20f'_c \left(1.3 - \frac{H}{20D} \right)$$

where f'_c is the ultimate compressive strength of the *concrete*;

H the length of the shaft measured from the top of the bell to the cut-off;

and D the least diameter of the shaft.

In no case shall the height of a *plain concrete foundation pier* exceed 12 times its least diameter.

Foundation piers constructed of *reinforced concrete* shall comply with the requirements for *reinforced concrete columns* given in Article 3.4.20, except that the limitation of the ratio of height to least dimension contained therein shall not apply. When the height of the shaft exceeds 18 times its least dimension, the maximum load shall not exceed

$$P' = P \left(1.5 - \frac{H}{36D} \right)$$

where P' is the permissible load;

P the permissible load on a short *foundation pier*;

H the length of the shaft measured from the top of the bell to the cut-off;

and D the least diameter of the shaft.

Whenever the base of any *foundation pier* is belled out to a greater area than the shaft, it shall have a depth of not less than 12 inches at the edge of the base.

In the absence of lateral support, the load on a *foundation pier* shall not exceed that on a *column* of the same material.

Either a curb shall be constructed around the excavation at least one foot in height or the shell of the *foundation pier* shall be maintained to a height of at least one foot below the top of the curb or shell.

3.7.8 Piles — General Requirements

3.7.8.1 Timber Piles.—

(a) Timber piles shall comply with the requirements of C.E.S.A. Specification A56-41, Specification for Wood Piling.

When creosoted piles are used, the creosote shall conform to Specification No. 11-GP-1 of the Canadian Government Purchasing Standards Committee and the method of treatment shall be such as to ensure a minimum net absorption of 8 pounds per cubic foot.

(b) That portion of the ends of wood piles affected by driving shall be cut off before capping is placed. The cut-off grade shall be below the permanent ground water level, as determined by the *authority having jurisdiction*, unless the piles are creosoted, in which case the cut-off ends shall be swabbed three times, at intervals, with hot creosote oil, and subsequently protected with suitable capping.

3.7.8.2 Pre-cast Concrete Piles.—

(a) *Pre-cast concrete* piles shall be made of *concrete* having a compressive strength of at least 3000 pounds per square inch reinforced with vertical rods having a cross-section of at least one per cent of the cross-section of the pile. The vertical rods shall be stayed laterally with steel ties or spirals having a volume of at least one per cent of the pile for a length of 4 feet from each end of the pile and of at least 0.4 per cent of the pile for the remaining length. Material for ties shall have a diameter of at least 3/16 inch and not less than one-quarter the diameter of the longitudinal rods.

(b) *Pre-cast concrete* piles shall be of sufficient strength to withstand all stresses resulting from reasonable handling and driving.

(c) When pre-cast *concrete* piles are driven to or into Type I bearing materials, or through materials containing boulders, they shall have metal tips of *approved* design. The driving equipment shall be such as to avoid injury to the piles.

3.7.8.3 Cast-in-place Concrete Piles.—Cast-in-place *concrete* piles shall be so made and placed as to insure the exclusion of all foreign matter and to secure a well-formed unit of full cross-section. In forming such piles, the *concrete* shall not be placed in water.

3.7.8.4 Concrete-filled Cylindrical Steel Piles.—Piles consisting of *concrete*-filled steel cylindrical shells filled after driving, in which the steel shell is considered as having a bearing value, shall have an inside diameter not less than 10 inches and a shell thickness of at least 3/8 inch, except that 10-inch and 12-inch piles may have a shell thickness of 5/16 inch. Splices of shells shall be of such material and design as to insure alignment of shells and transmission of the load. The ends of each section of the shell shall be perpendicular to its axis, and all bearing surfaces shall be smooth and true. The outside diameter of the pile shall be at least 1/40 of its length.

After driving, the inside of the shell shall be carefully cleaned to the bottom and its direction and cross-section verified. The cross-sectional area shall not vary more than 10 per cent from its original cross-section. Shells shall be filled with *concrete* having an ultimate strength of at least 2000 pounds per square inch. *Concrete* shall not be placed in water except with written approval of the *authority having jurisdiction* after submission of detailed specifications for procedure.

3.7.8.5 Steel Piles.—Rolled structural steel piles shall comply with the requirements for structural steel as specified in Section 3.5 (Steel and Iron Construction). The minimum thickness of metal shall be $\frac{3}{8}$ inch.

3.7.8.6 Composite Piles.—Composite piles shall consist of a combination of any two of the types of piles provided for in this Section. The minimum dimensions of each part shall be those specified for piles of its type. The joint between the two types shall be constructed so as to prevent their separation, maintain alignment, and support the load. The design of composite piles, method of driving, and the details of the joint shall be subject to the approval of the *authority having jurisdiction*.

3.7.9 Minimum Number of Piles Required

(a) A detached *column* or *pier* supported by piles shall rest upon not less than three piles, but a *column* or *pier* connected to permanent construction, providing adequate lateral support to the top of the piles, may rest upon a single pile, or upon two piles.

(b) In a building not more than one *storey* nor more than 20 feet *high*, the *foundation wall*, if supported laterally by *masonry*, *reinforced concrete*, or steel construction at intervals not exceeding 20 feet, may be supported by a single row of piles. If the distance between such lateral supports exceeds 10 feet, the capping shall be continuous, and shall consist of a structural steel grillage or *reinforced concrete* cap, at least 2 feet wide, in which the number of square inches of longitudinal steel reinforcement near each vertical face is at least $\frac{1}{8}$ of the length in feet between lateral supports. Other *foundation walls* supported upon piles shall rest upon at least two rows of piles. The outer rows shall be at least 2 feet apart on centres under buildings up to 30 feet *in height* and at least 3 feet apart under buildings higher than 30 feet.

3.7.10 Minimum Spacing of Piles

3.7.10.1 Timber Piles.—The centre-to-centre spacing of timber piles shall be not less than 30 inches nor less than $2\frac{1}{2}$ times the butt diameter.

3.7.10.2 Pre-cast Concrete Piles.—The minimum spacing centre to centre of pre-cast *concrete* piles shall be 30 inches, and the minimum clear distance between adjacent piles shall be 16 inches.

3.7.10.3 Cast-in-place Concrete Piles.—The spacing of cast-in-place *concrete* piles shall be sufficient to insure the preservation of the full cross-section. The spacing centre to centre shall be not less than twice the average diameter of the embedded portion of the pile, nor less than 30 inches. When the centre-to-centre spacing is less than $2\frac{1}{4}$ times the average diameter of the embedded portion of the pile, or less than 36 inches, no pile shall be filled with *concrete* until all adjacent piles within a radius of $4\frac{1}{2}$ average pile diameters, and not less than 5 feet, have been driven to the required resistance.

3.7.10.4 Concrete-filled Cylindrical Steel Piles.—The centre-to-centre spacing of *concrete*-filled steel piles, when driven open-ended, shall be not less than the diameter of the shell plus 10 inches, and not less than 2 feet. When driven with closed ends, the spacing shall be as provided in Item 3.7.10.3 for cast-in-place *concrete* piles.

3.7.10.5 Steel Piles.—The minimum spacing centre to centre of rolled structural steel piles shall be 24 inches, and the minimum clear distance between adjacent piles shall be 16 inches.

3.7.10.6 Composite Piles.—The centre-to-centre spacing of composite piles consisting of a wood pile and a cast-in-place *concrete* pile shall be limited by the requirements for cast-in-place *concrete* piles.

3.7.11 Method of Driving Piles

(a) The method of driving shall be such as not to impair the strength of the pile and shall meet with the approval of the *authority having jurisdiction*. A steel or iron follower may be used subject to his approval. It shall be equipped with a suitable socket encasing the pile head sufficiently to prevent damage while driving. Shattered, broomed, or otherwise damaged pile heads shall be cut back to sound material before driving with the follower. If a wooden driving block is used, it shall, while used for measuring the penetration, be of sound hard wood equal to oak, not more than 12 inches in height, with the grain parallel to the axis of the pile, and shall be enclosed in a steel casing of adequate strength to resist lateral distension.

The weight of the hammer used in driving a *reinforced concrete* pile shall be not less than 30 times the weight of one lineal foot of the pile.*

(b) Piles shall not be jetted except with specific approval of the *authority having jurisdiction*. The jet shall not be continued in operation after the point of the pile has reached a depth of 80 per cent of the anticipated full depth of penetration. In any case, the last 6 feet of penetration of the pile shall be performed by driving without the assistance of the jet.

(c) No broken or damaged pile shall be used to sustain any load.

(d) Types of pile construction not specifically provided for in this Section shall meet such additional requirements as may be prescribed by the *authority having jurisdiction*.

3.7.12 Inspection During Pile Driving and Filing of Records.—The *authority having jurisdiction* shall require a competent inspector qualified by experience and training, and satisfactory to him, to be on the work at all times while piles are being driven. The inspector shall make an accurate record of the material and the principal dimensions

*The most favourable conditions of driving represented by the value of the factor:

$$\frac{\text{set}}{\text{maximum stress in head of pile}}$$

occur when a heavy hammer is used for a comparatively small drop, the head of the pile being protected by sacking or other soft material.

of each pile, of the weight and fall of the hammer, if a single-acting steam hammer or drop hammer; and the size and make, number of blows per minute, and energy per blow, if a double-acting steam hammer; together with the average penetration of each tenth pile, beginning with the first, for at least the last five blows, and the grades at tip and cut-off. A copy of these records shall be filed and kept in the office of the *authority having jurisdiction*. Where piles are driven through soft soil to hard bearing material, providing high point resistance, the grades of all piles or pile shells previously driven shall be measured to detect uplift; and if uplift occurs in any pile or pile shell while other piles are being driven, such pile or pile shells shall be driven again to the required resistance.

3.7.13 Allowable Load on Piles

3.7.13.1 Pressure on Bearing Materials.—The allowable pile loading shall be limited by the provision that the vertical pressures in the bearing materials at or below the points of the piles produced by the loads on all piles in a *foundation* shall not exceed the allowable bearing values of such materials, as specified in Article 3.7.6, or as determined by *foundation* load tests. Piles or pile groups shall be assumed to transfer their loads to the bearing materials by spreading the load uniformly in all directions at an angle of 60 degrees with the horizontal, starting at a polygon circumscribing the piles at the top of the bearing stratum in which they are embedded, but the area considered as supporting the load shall not extend beyond the intersection of the 60 degree planes of adjacent piles or pile groups.

The allowable load on each pile shall be further limited by the requirement that such load shall not cause excessive movement of the pile relative to the soil. Satisfactory proof of this load for all soil conditions and all types of piles can be obtained from load tests conducted in accordance with Article 3.7.16.

3.7.13.2 Pile-driving Formula.—

(a) **Hiley Formula.**—In the absence of proof of the supporting capacity of a pile obtained by means of loading tests, the load on any pile shall not exceed the allowable value determined from the Hiley pile-driving formula*:

$$R = \frac{4nWh}{s + c/2}$$

where R is the allowable load on the pile, in pounds;

n the efficiency of the blow as prescribed in paragraph (b) hereof;

W the weight of the striking part of the hammer, in pounds;

h the height of the free fall of the hammer in feet as prescribed in paragraph (c) hereof;

*The pile-driving formula will not give a reliable indication of the supporting capacity of a pile driven into materials such as fine grained silt or soft clay. If the penetration per blow after a period of rest of at least 24 hours differs appreciably from that immediately after driving, such materials may be assumed to exist and load tests should be carried out.

- s the average penetration per blow in inches for the last five blows; s shall be measured during the driving and not upon redriving when a pile has been allowed to stand more than one hour after having been driven. In the case of wood piles, broomed heads shall be cut out to sound wood before making penetration measurements.
- c the sum of the temporary elastic compressions of the pile, the driving head, and the ground.
The value of (c) may be determined experimentally or may be estimated from the values given in paragraph (d) hereof.

(b) **Estimation of the Efficiency of the Blow.**—Where the pile is driven into penetrable ground, the efficiency of the blow shall be assumed to be given by

$$n = \frac{W + e^2 P}{W + P}$$

For the special case where a pile point meets with refusal on impenetrable rock, the efficiency of the blow shall be assumed to be

$$n = \frac{W + 0.5e^2 P}{W + 0.5P}$$

where P is the weight of the pile which includes helmet or driving cap or anvil;

- e is the coefficient of restitution of the hammer on the pile.
This shall be assumed to have the following values:

- 0.5 for steel ram of double-acting hammer striking on steel anvil and driving steel sheet-piles or *reinforced concrete* piles,
- 0.4 for steel ram of double-acting hammer striking on steel anvil and driving timber piles,
- 0.4 for cast iron ram of single-acting or drop hammer striking directly on head of *reinforced concrete* pile not fitted with a helmet,
- 0.33 for ram of single-acting hammer striking on a 1-inch thick plate on the top of a helmet containing a wood cap fitted to a 16- by 3/4-inch steel piling tube,
- 0.25 for cast iron ram of single-acting or drop hammer striking on well conditioned wood cap of helmet in driving *reinforced concrete* piles, or directly on head of timber pile,
- 0.25 for steel piling tubes driven by a mandrel,
- 0.0 for a deteriorated condition of head of timber pile or of the wood cap and for excess of packing in helmet.

(c) **Estimation of the Height of Fall (h).**—The values of h shall be taken as:

- H for drop hammers released by a monkey trigger,
- $0.9H$ for single-acting steam hammers,
- $0.8H$ for drop hammers actuated by a wire rope from friction winch,

where H is the actual stroke of the hammer or ram in feet.

For double-acting hammers:

$$h = \frac{H(W + AM)}{W}$$

where A is the area of the piston in square inches acted on by the steam;

M is the mean effective steam pressure, in pounds per square inch.

Alternatively, Wh may be determined by means of an *approved* device attached to the hammer measuring the actual energy in foot pounds per blow delivered.

Where single-acting hammers or drop hammers work in leader guides inclined at an angle θ from the vertical, a further allowance must be made for the frictional resistance of the guides and for the reduced component of gravity acting along the direction of the guides. This shall be done by substituting for h ,

$$h_1 = h (\cos \theta - \mu \sin \theta)$$

where μ is the coefficient of friction (usually 0.1).

(d) Estimation of the Total Temporary Compression (c).—

The total temporary compression in inches (c), occurring at each blow of the hammer, shall be determined by measurement during the driving of the pile, or alternatively may be estimated approximately by calculation using the following formula:

$$c = \frac{3R}{A} \left[\frac{L}{E} + .0001 \right]$$

R may be the allowable pile load in pounds assumed in the design unless the allowable load computed from the penetration varies more than 20 per cent from such assumed load;

A is the area of cross-section of the pile, or in the case of a pile driven by a mandrel or a tube, the area of cross-section of the mandrel or tube, in square inches;

L is the length of the pile, tube, or mandrel, in inches;

E is the modulus of elasticity of the material of the pile, tube, or mandrel, in pounds per square inch.

(d) Penetration for an Allowable Load.—The penetration (s) for an allowable load may be determined from the Hiley formula as given in the preceding paragraphs of this Item. A negative value of s indicates that a heavier hammer must be used.

3.7.13.3 Maximum Load on Piles.—

(a) Timber Piles.—The load on a timber pile shall be such that the unit stress, calculated on the cross-sectional area at mid-length of the pile, is not greater than the value given for Structural Grade in Table 1 of Section 3.2 (Compression parallel to the grain, short columns).

(b) Pre-cast Concrete Piles.—The load on a pre-cast *concrete* pile shall not exceed $0.3A$ tons, where A is the area of cross-section of the pile in square inches.

(c) **Cast-in-place Concrete Piles.**—The load on a cast-in-place *concrete* pile shall not exceed 30 tons for a conical pile having an 8-inch tip and an average diameter of 11 inches, nor for an uncased cylindrical pile having a diameter of 15 inches. The load on a cased cylindrical pile 15 inches in diameter shall not exceed 40 tons. The allowable loads may be increased for larger piles in proportion to the increase in pile area.

(d) **Concrete-filled Cylindrical Steel Piles.**—

- (i) The load on a *concrete*-filled steel pile shall not exceed the safe load on the *concrete* at 500 pounds per square inch plus that on the steel shell at 6000 pounds per square inch, after deducting 1/8 inch in thickness from the outside of the tube; nor shall the load carried by the steel exceed one-half of the total load on the pile. If a pile as actually driven is longer than 40 diameters, the limit of load specified in this paragraph shall be reduced by a percentage equal to the excess length divided by the diameter. If splices below the upper section are closer than 20 feet, the safe load on the pile shall be reduced 5 per cent for each splice in excess of the number required for 20-foot spacing.
- (ii) When a single *concrete*-filled steel pile supports a detached *column pier*, as provided in Article 3.7.9 the load shall not exceed two-thirds the capacity of the pile determined as provided in paragraph (i) of this Item.

(e) **Steel Piles.**—The load on a rolled structural steel pile shall not exceed:

40 tons for an	8-inch section
50 tons for a	10-inch section
60 tons for a	12-inch section
65 tons for a	14-inch section

and in no case shall the unit stress exceed 8500 pounds per square inch.

(f) **Composite Piles.**—The load on a composite pile shall be limited by the strength of the weaker portion.

3.7.14 Foundation Load Tests.—Whenever the supporting capacity of a bearing material or of a pile is in doubt, the *authority having jurisdiction* may require tests to be made to enable him to determine the load to be permitted thereon. The load so determined shall be taken as the allowable load.

3.7.15 Tests of Bearing Materials

(a) When a soil test is required, a test pit, with vertical sides, shall be excavated to the level of the proposed *footing* and the test load shall be applied over an area of at least one square foot.* This load shall be of the same intensity as it is proposed to use in service, provided that

*Allowance should be made for the fact that on certain types of soil the unit bearing value under large footings is less than that under small footings.

in filled ground it shall be $1\frac{1}{2}$ times as great. It shall be left undisturbed for 24 hours after settlement has ceased. This load shall then be doubled by the successive application, at intervals of at least 4 hours, of at least 4 equal increments. The total load shall be left undisturbed until 24 hours after settlement has ceased. The soil so tested shall be deemed adequate for the proposed intensity of loading, if the settlement under the intensity of loading proposed for use in service is less than $\frac{3}{8}$ inch and if the total settlement throughout the test does not exceed $\frac{3}{4}$ inch.

(b) Measurements of settlement shall be made every hour for 6 hours after each application of load and at least every 12 hours thereafter.

3.7.16 Pile Loading Tests.—In testing a pile in place, it shall be loaded to twice its proposed working load, by additions, at not less than 4 hour intervals, of loads of not more than 5 tons. Measurement of settlement shall be made and recorded immediately before and after the addition of each load. Such measurements shall be adjusted to compensate for the elastic compression of the pile. The pile shall be considered adequate to support the proposed working load if the total settlement so measured does not exceed $\frac{1}{2}$ inch and if no further settlement occurs after a lapse of 48 hours.

SECTION 3.8 WALLS AND PARTITIONS

3.8.1 General.—The construction of all walls and *partitions* wherever used in any building or *structure* shall conform to the minimum requirements of this Section.

3.8.2 Wood Stud Walls and Plank Walls

3.8.2.1 Studding.—For detailed requirements for studding, see Item 3.2.16.1 .

3.8.2.2 Plank Walls.—For detailed requirements for plank walls, see Article 3.2.17.

3.8.2.3 Sheathing.—For detailed requirements for *sheathing*, see Item 3.2.16.2.

3.8.2.4 Exterior Wall Coverings.—

(a) **General.**—For general requirements for exterior wall coverings on wood stud walls, and for detailed requirements for wood *siding*, wood shingles, and ply-wood used as wall coverings, see Item 3.2.16.3.

(b) **Bituminous Siding and Shingles.** — Bituminous *siding*, whether backed with insulating or reinforcing material or not, shall consist of felt of net weight not less than 0.1 pound per square foot, having not less than 175 per cent of saturation, with a continuous covering of crushed siliceous aggregate or other equally inert material.

When used as continuous sheets, such *siding*, exclusive of any backing which may be incorporated with it, shall weigh not less than 75 pounds per 100 square feet when in place, and when used as lapped *siding* (shingle

fashion), exclusive of any backing, such *siding* shall weigh not less than 180 pounds per 100 square feet when in place.

Exterior walls of which such *siding* forms a part shall comply with the requirements of paragraph (vii) (1) of Item 3.2.16.3 (a).

Siding of continuous sheets shall be nailed over each stud with not less than one 1½-inch nail for each 6 inches, and shall also be nailed to *sheathing* or other required backing with not less than 5 nails to each square foot of wall surface; shingle-type *siding* shall be nailed with not less than 2 nails under the lap for each *shingle* unit and, in addition, all lapped edges within 6 feet of the ground shall be nailed so as to prevent malicious damage. Nails used shall be copper, zinc-coated, or other equally non-corrodible type. Subject to permission from the *authority having jurisdiction*, nailing instructions from the manufacturer of such *siding* may be substituted for the requirements herein specified for nailing.

When such *siding* incorporates fibre board backing, it shall be so installed that it overlaps any *foundation wall* and shall not be within 2 feet of the soil in any location.

(c) **Asbestos-cement Siding and Shingles.**—Asbestos-cement *siding* and shingles shall fulfil the following requirements:

- (i) Minimum thickness when in place.....5/32 inch
- (ii) *Modulus of rupture* when dry.....3000 pounds
per square inch
- (iii) *Modulus of rupture* following 24 hours im- 1250 pounds
mersion in water.....per square inch
- (iv) Maximum absorption after 24 hours im-
mersion in water.....17½ per cent

(d) **Masonry Veneer.**—Veneer on wood frame construction may consist of *solid masonry units* not less than 3¾ inches thick, or *stone* not less than 6 inches thick. *Sheathing* shall be covered with water-resistant building paper or asphalt-saturated felt lapped 4 inches at joints and around all openings. Veneer shall be secured to the studs with non-corrodible metal ties spaced not more than 16 inches apart in either direction.

When either the *sheathing* or the building paper is highly resistant to the transmission of water vapour an effective vapour barrier shall be provided between the interior face of the studs and the exposed interior face of the wall.*

(e) **Galvanized Metal.**—Galvanized metal where used as an exterior wall covering shall weigh not less than 12.5 ounces per square foot (28 gauge). When *sheathing* is omitted, nailing strips shall be placed between the studs in such a manner as to permit the metal to be nailed at vertical intervals of not more than 4 feet.

*A vapour barrier is desirable whenever the vapour transfer factor of either the *sheathing* or the building paper is less than 2.0. Such vapour barrier should have a transfer factor not greater than 0.5. The vapour transfer factor is expressed in gm. per 24 hours per square metre per mm. vapour pressure difference.

(f) **Stucco.**—For requirements for stucco walls, see Article 3.8.5.

(g) **Glass Veneer.**—For requirements for glass veneer, see Article 3.8.6.

3.8.3 Masonry Walls.—For requirements for *masonry* walls, see Article 3.3.8.

3.8.4 Reinforced Concrete Walls.—For requirements for *reinforced concrete* walls, see Article 3.4.21.

3.8.5 Stucco Walls

3.8.5.1 General Requirements.—Stucco shall fulfil the requirements prescribed for cement *mortar* or for lime-cement *mortar* (see Item 3.3.2.3), and shall be applied in three coats, unless it is pneumatically placed, or is applied to a *masonry* base, in which case two coats shall be considered sufficient.

The minimum thickness of the stucco from the face of the base shall be not less than $\frac{3}{4}$ inch at every point, provided that where stucco is applied to monolithic *concrete* or *unit masonry*, the minimum thickness shall be $\frac{1}{4}$ inch or $\frac{1}{2}$ inch respectively.

Non-corrodible flashing or other expedients that will prevent penetration of moisture behind the stucco shall be used where necessary.

3.8.5.2 Application.—The application of stucco shall be in accordance with accepted good commercial practice.

3.8.5.3 Stucco on Wood Frame Construction.—

(a) **Back Plastering.**—Except as provided herein, back plastering shall be required where *sheathing* is omitted. It shall be of sufficient thickness to extend back between the studs a distance of not less than $\frac{1}{4}$ inch. Back plastering may be omitted where stucco fulfilling the following conditions is used:

- (i) The stucco is backed with a water-proof paper.
- (ii) A test panel shows a racking strength not less than that of a standard panel having horizontal wood *sheathing* of $\frac{5}{8}$ inch thickness, when tested in the manner described in Appendix C.

(b) **Building Paper.**—In all cases, except in back plastered construction, asphalt-saturated felt weighing not less than 14 pounds per 100 square feet, or any substantial water-resistant building paper which passes a 60-pound Mullen test, shall be applied directly over the studs or *sheathing*. Felt or paper shall be lapped 4 inches at all joints and around all openings.

(c) **Reinforcement.**—Stucco, when backed by *sheathing*, shall be reinforced with metal lath weighing not less than 1.8 pounds per square yard and having openings the least dimension of which is not less than $\frac{3}{4}$ inch and the maximum area of which does not exceed 4 square inches; provided that reinforcement weighing not less than 1.1 pounds per

square yard and having openings not more than 2 inches square (No. 16 gauge wire) may be used. Where *sheathing* is omitted, the weight of such metal lath shall be not less than 3.0 pounds per square yard.

Metal lath shall be galvanized or otherwise effectively protected against corrosion, and may consist of expanded metal lath, wire lath, or wire fabric. It shall be furred away from *sheathing* or building paper at least $\frac{3}{8}$ inch at all points by the use of special furring nails or devices or by suitable metal strips, unless self-furring metal lath is used.

3.8.6 Glass Veneer

3.8.6.1 Restrictions on the Use of Glass Veneer.—Glass veneer shall be not less than $\frac{5}{16}$ inch thick. The area of a single section of glass veneer shall not exceed 10 square feet when installed at a height of not more than 15 feet above ground level, and shall not exceed 6 square feet when installed at a height of more than 15 feet above ground level. The length of a single section of glass veneer shall not exceed 4 feet.

3.8.6.2 Backing.—Glass veneer shall be placed against a dry, rigid, secure, plane wall surface of *masonry*, *reinforced concrete*, or cement plaster on expanded metal lath, or other *approved incombustible* material. Cement plaster on metal lath shall be not less than $\frac{3}{4}$ inch thick with studding spaced at not more than 12 inches on centre.

All loose paint and other existing surface coatings, that will not permanently adhere, shall be removed from the backing.

3.8.6.3 Application.—The base for any glass veneer shall be thoroughly dry and shall be covered by a bond coat of *approved* primer.

The bond coat and the mastic cement shall be of such composition as to ensure proper adhesion between the two materials.

Approved mastic cement shall be applied for a width of 3 inches around the perimeter of the area covered with glass veneer and around all openings within the glass area. Elsewhere, mastic cement shall cover at least 60 per cent of the back of the glass and shall be not less than $\frac{1}{4}$ inch nor more than $\frac{1}{2}$ inch in thickness.

3.8.6.4 Support for Glass.—Where glass veneer is applied more than 4 feet above *grade*, the mastic cement shall be supplemented by the use of metal shelf angles of non-corrodible metal not less than 0.04 inch thick. Such angles shall have vertical legs not less than 3 inches long, and horizontal legs long enough to extend to within $\frac{1}{8}$ inch of the exterior surface of the glass veneer; the angles shall be 3 inches long.

The horizontal spacing of shelf angles shall be such that one angle supports not more than 10 square feet of glass, but in any event, sheets of 24 inches to 48 inches shall be supported by an angle at each lower corner. Angles shall be located in every horizontal joint; provided that if two or more horizontal courses total less than 24 inches, the angles may be set at vertical intervals not exceeding 36 inches.

Where glass veneer is applied on a vertical surface more than 18 feet above ground level, not less than two fastenings shall be provided on

each horizontal or vertical edge of each section of veneer. Such fastenings shall be so designed as to furnish support for each section of glass and also to hold it in a vertical plane independently of the mastic cement.

Shelf angles and other fastenings shall be secured to the backing with expansion bolts, toggle bolts, or by other means satisfactory to the *authority having jurisdiction*.

3.8.6.5 Joints.—All horizontal joints in glass veneer construction shall be cushioned with pads of adhesive cork or other *approved* pads that shall extend from the rear surface of the glass to within 1/8 inch from the front surface. Where the veneer extends to a side-walk, each unit shall be supported at its base with at least two *approved* cushions not less than 1/4 inch in thickness. No glass unit shall touch any other glass unit.

All joints shall be filled solidly with an *approved* joint cement to ensure completely water-tight construction.

Where glass veneer abuts non-resilient materials at the sides or top, 1/4 inch expansion joints shall be provided.

3.8.6.6 Protection.—All exposed edges of glass veneer shall be protected from the weather by over-lapping non-corrodible metallic flashing, and shall be made watertight. Any uncompleted exterior construction of glass veneer shall be made watertight before being left unattended.

3.8.7 Metal Veneer.—Metal veneer, including metal backed by *concrete*, shall be anchored according to specific instructions from the manufacturer, subject to the approval of the *authority having jurisdiction*. (For galvanized metal, see Item 3.8.2.4 (e).)

3.8.8 Partitions

3.8.8.1 Wood Stud Partitions.—For requirements for wood stud *partitions*, see Item 3.2.16.1.

3.8.8.2 Masonry Partitions.—For requirements for *masonry partitions*, see Item 3.3.8.10.

3.8.8.3 Plaster Partitions.—Solid *incombustible* non-bearing *partitions* of reinforced plaster shall have a thickness of not less than 1/16 of the unsupported height, but never less than 2 inches. The shell thickness of hollow *incombustible* non-bearing *partitions* of reinforced plaster shall be not less than 3/4 inch. Lath and metal studs in plaster *partitions* shall be in accordance with the requirements of Specification A42.1-1938 of the American Standards Association, "Standard Specification for Gypsum Plastering".

SECTION 3.9 FLOOR AND ROOF CONSTRUCTION

3.9.1 General.—All floors and roofs shall be constructed in accordance with the requirements of this Section.

3.9.2 Wood Floor Construction.—For requirements governing the construction of wood floors including *joist* floors, plank floors, and *laminated floors*, see Article 3.2.14.

3.9.3 Wood Roof Construction.—For requirements governing the construction of wood roofs, see Article 3.2.15.

3.9.4 Masonry Floor Construction.—For requirements governing the construction of *masonry* floors, see Article 3.3.9.

3.9.5 Masonry Roof Construction.—For requirements governing the construction of *masonry* roofs, see Article 3.3.10.

3.9.6 Reinforced Concrete Floor and Roof Construction.—For requirements governing the construction of *reinforced concrete* floors and roofs, see Articles 3.4.14 to 3.4.19.

3.9.7 Open Web Steel Joist Construction.—For requirements governing the construction of open web steel *joist* floors and roofs, see Item 3.5.11.2.

3.9.8 Special Types of Floor or Roof Construction.—Types of floor or roof construction not specifically regulated in Articles 3.9.2 to 3.9.7 may be used if *approved* by the *authority having jurisdiction* in accordance with the requirements of Article 3.1.3.

SECTION 3.10 ROOF COVERINGS

3.10.1 General.—Every roof shall be covered with one or more of the following materials, provided that other materials may be used if *approved* by the *authority having jurisdiction* in accordance with the requirements of Article 3.1.3:

1. Bituminous Composition Roof Coverings
 - (a) Built-up roof coverings
 - (b) Prepared roof coverings
 - (c) Shingles
2. Asbestos-cement Roof Coverings
 - (a) Sheets (flat or corrugated)
 - (b) Shingles
3. *Plain or Reinforced Concrete* Slabs
4. Metal Roof Coverings
 - (a) Sheets (flat or corrugated)
 - (b) Shingles
5. Slate
6. Clay Roof Tile
7. Wood Shingles
8. Canvas

3.10.2 Restrictions on the Use of Certain Roof Coverings*.—Bituminous composition roof coverings, when applied on roof decks having a slope of more than 4 inches to the foot, shall be nailed to the deck. Gravel, crushed stone, or crushed slag shall not be used as a surfacing on bituminous composition roof coverings when the slope of the deck exceeds 3 inches to the foot. No shingles, whether bituminous, asbestos-cement, wood, or metal, and no slate or tile shall be used when the slope of the deck is less than 3 inches to the foot.

3.10.3 Bituminous Composition Roof Coverings

3.10.3.1 Built-up Roof Coverings.—

(a) Materials.—Bituminous composition built-up roof coverings shall be constructed from the following materials:

- (i) Saturated Asphalt Felt, consisting of a bituminous-saturated asbestos felt conforming to A.S.T.M. Specification D250-27, Asphalt Saturated Asbestos Felt for Use in Constructing Built-up Roofs, except that Section 7 shall be changed to read as follows:

“7. The fabricated bituminized felt shall conform to the following requirements:

Width of Roll.—Either 36 or 32 in., as may be specified. 1/4 in.

Area per Roll.— Minimum 324 sq. ft.

Weight of Material per 100 sq. ft. Exclusive of Packing and Wrapping.—Minimum, 14 lb.

Loss on Heating at 105 C. (221 F.) for 5 hr.—

Maximum, 5 per cent.

Pliability at 77 F. (25 C.).—At least 8 out of 10 strips shall not crack when bent 90 deg. at a uniform speed over a rounded corner of 1/2-in. radius.”

- (ii) Asbestos Felt Sheet, consisting of a sheet of one or more plies of “Saturated Asbestos Felt” coated on one or both sides with a bituminous coating.
- (iii) Saturated Rag Felt, consisting of felt of vegetable and/or animal fibres uniformly saturated with asphalt or coal tar. It shall conform to A.S.T.M. Specification D226-41T, Asphalt Saturated Roofing Felt for Use in Waterproofing and Constructing Built-up Roofs; or D227-41, Coal-tar Saturated Roofing Felt for Use in Waterproofing and Constructing Built-up Roofs.
- (iv) Rag Felt Sheet, consisting of “Saturated Rag Felt” containing not less than 1.6 times the weight of the dry felt in asphalt or coal tar saturant, and coated on one or both sides with a bituminous coating.

*See also the requirements for Roof Coverings given in Section 4.11. Fire-retardant Roof Covering.

(v) **Coating Materials:**

Asphalt cement used for coating layers in built-up roof coverings shall conform to A.S.T.M. Specification D312-41, Asphalt for Use in Constructing Built-up Roof Coverings.

Coal tar pitch used for coating layers in built-up roof coverings shall conform to A.S.T.M. Specification D450-41, Coal Tar Pitch for Roofing, Damp-proofing, and Water-proofing.

Gravel, crushed stone, or crushed slag for roof coatings shall be 1/4 inch to 5/8 inch in particle size and shall be dry and free from dirt.

(b) **Construction.**—Built-up roof coverings shall consist of two or more layers of saturated felt or saturated felt sheets, such layers being thoroughly mopped with a hot bituminous cement so that no layer is in direct contact with a layer above. When the top layer is without a weather-proof coating, it shall be thoroughly and completely covered with hot bituminous material, with or without the addition of gravel.

Every built-up roof covering shall contain at least 42 pounds of saturated felt for each 100 square feet of roof. Such felt may be saturated only; or it may be coated to form sheets as previously described in (a) of this Item but no allowance shall be made for the weight of the coating except in respect of total weight of the roof covering. In addition, the total weight per 100 square feet of any built-up roof including felts, sheets, and moppings shall not be less than 120 pounds.

3.10.3.2 Prepared Roof Coverings.—

(a) **Rag felt sheets** shall consist of Saturated Rag Felt containing not less than 1.6 times the weight of the dry felt in asphalt or coal tar saturant, shall be coated on one or two sides with hot bitumen compounded with fine mineral matter, and shall weigh not less than 34 pounds for smooth mineral surfaced sheets and 74 pounds for granular surfaced sheets per 100 square feet of finished roof area.

(b) **Asbestos felt sheets** shall consist of Saturated Asbestos Felt coated on one or both sides with hot bitumen compounded with fine mineral matter weighing not less than 37 pounds per 100 square feet of finished roof area.

3.10.3.3 Bituminous Shingles.—

(a) **Asbestos felt shingles** shall consist of Saturated Asbestos Felt containing not less than 0.5 times the weight of the dry felt in asphalt or coal tar saturant, coated on one or two sides with hot bitumen compounded with fine mineral matter, and surfaced on the weather side with embedded granular fire-retardant mineral material.

(b) **Rag felt shingles** shall consist of Saturated Rag Felt containing not less than 1.75 times the weight of the dry felt in asphalt or coal tar saturant, coated on one or two sides with hot bitumen compounded with fine mineral matter, and surfaced on the weather side with embedded granular fire-resistant mineral material.

(c) **Minimum Weight.**—All bituminous shingles shall be so laid that there are not less than two thicknesses at any point. The total weight of shingles per 100 square feet of finished roof area shall be not less than 180 pounds.

3.10.4 Asbestos-cement Roof Coverings.—Asbestos-cement roof coverings whether in the form of sheets or shingles shall fulfil the following requirements:

Minimum thickness.....	5/32 inch
<i>Modulus of rupture</i> when dry.....	3000 lb./sq. in.
<i>Modulus of rupture</i> following 24 hours immersion in water.....	1250 lb./sq. in.
Maximum absorption after 24 hours immersion in water.....	17½ per cent.

3.10.5 Concrete Slabs.—*Plain concrete* slabs fulfilling the requirements of Section 3.3 may be used for roofs without a protective covering.

Reinforced concrete slabs, whether pre-cast or cast-in-place, fulfilling the requirements of Section 3.4 may be used for roofs without a protective covering.

3.10.6 Metal Roof Coverings

3.10.6.1 Iron or Steel.—Iron or steel roof coverings of the corrugated, flat, or shingle type shall be not less than 0.018 inch thick. Galvanized sheets or shingles shall weigh not less than 14 ounces per square foot of metal. Iron and steel sheets shall be protected by non-corrodible metal coatings or by paint or by some other effective means.

3.10.6.2 Copper.—Copper roofing shall weigh not less than 14 ounces per square foot.

3.10.7 Slate.—All slate shall have a minimum thickness of approximately 3/16 inch and shall be of reasonably smooth cleavage and free from knots or knurls that would lessen the durability or weather tightness of the finished work.

All slate shall have a *modulus of rupture* of not less than 9000 pounds per square inch, and shall not absorb more than 0.45 per cent by weight of water after immersion for 48 hours.

Every slate shall be securely fastened to the supporting roof construction with copper nails or with the copper nails and copper wire.

3.10.8 Clay Roof Tile.—Clay roof tile shall be securely fastened with copper nails or copper wire; provided that for roofs not exceeding a rise of 8 inches in 12 inches, galvanized iron nails may be used, and provided further that tile with projecting lugs need not be nailed or wired in place. Wire shall be not smaller than No. 14 B. & S. gauge. Nails shall penetrate the supporting roof construction not less than 3/4 inch.

Roofing tile other than flat pan tile with or without flanges, or flat shingle tile, or flat decorative tile, shall satisfy the following strength requirements:

Breaking load, average of five specimens. 400 pounds

Breaking load, individual test. 350 pounds

The load shall be applied at the centre of the tile, the tile being supported on the turned down edges at points 6 inches each side of the centre of the tile, giving four points of support and a span of 12 inches.

Roof tile, shall not absorb more than 15 per cent of the dry weight of the tile during a 48-hour immersion test.

3.10.9 Wood Shingles.—Wood shingles shall have a butt thickness of not less than 0.40 inch, provided that shingles having a butt thickness of not less than 0.33 inch may be used if they are edge grained, clear, and free from sap. They shall be laid with a weather exposure not greater than that given in Table 1 of this Section.

TABLE 1 (SECTION 3.10)
MAXIMUM EXPOSURE FOR WOOD SHINGLES

Size of Shingles (when green)	Maximum Exposure
Length 16 inches, butt thickness not less than 0.33 inch (6 butts to 2 inches)	4-1 1/2 inches
Length 16 inches, butt thickness not less than 0.40 inch (5 butts to 2 inches)	5 inches
Length 18 inches, butt thickness not less than 0.45 inch (5 butts to 2 1/4 inches)	5-1/2 inches
Length 24 inches, butt thickness not less than 0.50 inch (4 butts to 2 inches and thicker)	7-1 1/2 inches

All wood shingles shall be nailed firmly with copper or hot dipped zinc-coated nails not less than 0.08 inch diameter (No. 14 Imp. Wire Gauge) nor 1 1/4 inches long, placed 3/4 inch from edge and one inch above the exposure line. Each shingle shall be nailed with two nails placed one inch above the exposure line and 3/4 inch from each edge driven substantially into the supporting roof construction.

3.10.10 Canvas Roofing.—Canvas roofing shall be stretched tightly and secured to the roof surfaces with closely spaced copper or galvanized nails. All canvas roofing shall be painted so as to ensure a durable and waterproof surface.

PART 4
OF THE
NATIONAL BUILDING CODE

FIRE PROTECTION

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N.R.C. NO. 1068 (BOOK 3)

PART 4 FIRE PROTECTION

SECTION 4.1 GENERAL REQUIREMENTS

4.1.1 Application.—No building or *structure* which comes within the scope of this Code shall be constructed, erected, enlarged, altered, raised, or moved, except in accordance with the regulations prescribed in this Part of this Code. In addition, all regulations shall be complied with governing the quality, design, and erection of engineering materials as set forth in Part 3 of this Code.

4.1.2 Support of Fire-resistive Constructions.—Every structural member and structural assembly, including any wall, *partition*, floor, or roof, which is required by this Code to have a certain minimum *fire-resistance rating* shall, unless specifically excepted, be supported from the ground up by construction having in no case a lesser *fire-resistance rating* than the member or assembly supported.

SECTION 4.2 REQUIREMENTS PERTAINING TO THE CLASSIFICATION, SEPARATION, AND LOCATION OF OCCUPANCIES, AND TO CHANGES THEREIN

4.2.1 Classification of Occupancies.—When necessary for the purposes of this Code, every building or other *structure* or part thereof, whether *existing* or hereafter erected, shall be classified on the basis of its occupancy and use, in accordance with the system of classification which follows in this Article; and any occupancy not mentioned specifically or about which there is any uncertainty shall be classified by the *authority having jurisdiction* who shall include it in that group and division which it most nearly resembles, such classification being based on considerations of the existing or proposed internal fire hazard and the safety of persons in and about the occupancy.

GROUP A OCCUPANCIES (ASSEMBLY BUILDINGS)

DIVISION 1

Theatres

Motion Picture Theatres

DIVISION 2

Arenas

Libraries

Armouries

Lodge Rooms

Auditoriums

Museums

Bath Houses

Non-residential Clubs

Churches

Non-residential Colleges

Community Halls

Non-residential Schools

Court Rooms

Passenger Stations

Dance Halls

Recreation Piers

Exhibition Buildings

Rinks

Gymnasiums

GROUP B OCCUPANCIES (INSTITUTIONAL BUILDINGS)

DIVISION 1

Asylums	Prisons
Jails	Reformatories
Police Stations	

DIVISION 2

Children's Shelters	Old People's Homes
Hospitals	Orphanages
Infirmaries	Sanatoria

GROUP C OCCUPANCIES (COMMERCIAL AND INDUSTRIAL BUILDINGS)

DIVISION 1

Dry-cleaning plants employing flammable or explosive solvents or cleaners.

DIVISION 2

Aircraft Hangers	<i>Public Garages</i>
Box Factories	Storage Buildings for paint,
Flour Mills	petroleum products, hay,
Gasoline Service Stations	waste paper, or other
Grain Elevators	highly flammable or
Mattress Factories	explosive materials
Paint Shops or Factories	Sub-stations (electrical)
Planing Mills	Woodworking Factories

DIVISION 3

Laboratories	Retail Stores
Office Buildings	Undertaking Premises
Printing Plants	Wholesale Stores
<i>Restaurants</i>	

Factories	} for the use or storage of <i>combustible</i> goods; such occupancies being not elsewhere classified
Loft Buildings	
Salesrooms	
Storage Rooms	
Workshops	

Dry-cleaning plants employing no flammable or explosive solvents or cleaners

DIVISION 4

Cold-storage Plants	Pumping Plants
Creameries	Telephone Exchanges
Ice Plants	
Power Plants (excluding sub-stations)	

Factories	using <i>incombustible</i> and
Workshops	non-explosive materials

Salesrooms	for <i>incombustible</i> and
Storage Rooms	non-explosive materials

GROUP D OCCUPANCIES (RESIDENTIAL BUILDINGS)

	DIVISION 1	
Convents		Residential Clubs
Dormitories		Residential Colleges
Monasteries		Residential Schools
	DIVISION 2	
Apartment Houses		<i>Lodging Houses</i>
Fire Stations		<i>Multiple Dwellings</i>
<i>Hotels</i>		
	DIVISION 3	
<i>One-family Dwellings</i>		<i>Two-family Dwellings</i>

GROUP E OCCUPANCIES (ACCESSORY BUILDINGS AND OTHER STRUCTURES)

	DIVISION 1	
Open Sheds		<i>Detached, one-storey, non-business buildings used only to house not more than 10 non-commercial motor vehicles or 2 such vehicles and 3 commercial vehicles</i>
<i>Private Barns</i>		
<i>Private Garages</i>		
<i>Private Stables</i>		
	DIVISION 2	
Towers		Water Tanks
	DIVISION 3	
Reviewing Stands		Stadiums
Amusement Park <i>Structures</i> , not elsewhere classified.		

4.2.2 Change in Occupancy.—No change shall be made in the use or occupancy of any building or other *structure* until an Occupancy Permit therefor has been obtained from the *authority having jurisdiction*, as required in Item 1.4.2.2 of this Code.

4.2.3 Mixed Occupancies within One Building

4.2.3.1 Separate Buildings in Continuous Structures.—For the purposes of this Article, a portion of a *structure* may be considered a separate building when it is completely separated from the remainder of the *structure* by one or more unpierced walls having a *fire-resistance rating* of at least 4 hours (see Section 4.9), provided that the following requirements are fulfilled:

- (a) Such wall or walls shall extend from ground to or through the roof as hereinafter required;
- (b) Such wall or walls shall be continuous in buildings employing *combustible* floor assemblies, but in other buildings may be supported at intermediate levels by *beams*, *girders*, or floors having in each case a *fire-resistance rating* of at least 4 hours;
- (c) Such wall or walls shall pass through any *combustible* roof assembly and shall extend above it in the form of a parapet except as otherwise provided in Article 4.9.5; and shall either pass through a *non-combustible* roof, or make a well bonded and anchored joint with it.

4.2.3.2 Interpretation of Code Requirements for Buildings Containing more than One Occupancy.—

(a) **General.**—Where a building contains more than one major occupancy or is used for more than one major purpose, and where any requirement or restriction in this Code is based on the building or a part thereof being classified as belonging to a certain occupancy, then the most restricted occupancy in the building shall govern in all matters pertaining to the building as a whole, e.g., matters such as permissible type of construction, maximum *height* and *area*, location and proximity to *lot lines*, heating appliances serving the whole building, etc.; whereas when any such requirement or restriction is clearly limited to that portion of the building devoted to a specific use, then only that portion need be so governed, e.g., requirements respecting the number and width of *exits*, requirements respecting heat producing appliances contained within and serving only one occupancy, sprinklers required on account of occupancy, requirements respecting the protection of exterior openings and the protection of *vertical openings*, etc. In the latter case, however, when any requirement affects adjoining occupancies, such as a *vertical opening* between two occupancies, the more restrictive requirement shall govern.

(b) **Exceptions.**—When a comparatively small portion of a building is used for any minor purpose incidental to a major occupancy, and when, in the opinion of the *authority having jurisdiction*, such minor occupancy does not involve any material increase in hazard to the remainder of the building, it shall be classed as part of the major occupancy*; however, occupancies in Group C, Divisions 1 and 2 shall not be classed as a portion of other occupancies unless specifically permitted by the *authority having jurisdiction*.

4.2.3.3 Separation of Mixed Occupancies.—

(a) **General.**—In any building, each part that comprises a distinct occupancy division shall be separated from all other occupancy divisions in accordance with Table 1 of this Section. For the purposes of this Item, the exception given under Sub-item 4.2.3.2. (b) shall apply. In no case, however, need the separation be more fire-resistive than the exterior walls of the building unless such walls have a *fire-resistance rating* of less than one hour.

(b) **Forms of Occupancy Separations.**—Occupancy separations may be vertical or horizontal or of any other form found necessary to afford a complete separation between the occupancies concerned.

*For example, such occupancies as first-aid rooms in factories, stores, or *assembly rooms* shall be classed as factories, stores, or *assembly rooms*, respectively; libraries attached to offices shall be classed as offices; rooms that are part of a retail store and are used for repairing or manufacturing goods incidental thereto shall be classed as stores; school rooms, *assembly rooms*, and storage rooms, incidental to factories, offices, *hotels*, or other occupancies, and minor retail store or sales rooms in *hotels*, apartments, clubs, etc., shall be classed as a portion of such major occupancy.

TABLE 1 (SECTION 4.2)
FIRE SEPARATIONS REQUIRED FOR MIXED OCCUPANCIES

Abbreviations
A — Absolute Separation
S — Special Separation
O — Ordinary Separation
N — No Occupancy Separation Required (See Sub-item 4.2.3.3 (c) (iv).)

Occupancy Group	Division	Nature of Occupancy	Type of Separation Required Between Occupancies														
			Group A			Group B		Group C				Group D			Group E		
			1	2 & 3		1	2	1	2	3	4	1	2	3	1	2	3
			(a)	(b)	(a) (b)												
A	1	(a) Theatres, motion picture theatres; with seating capacity of more than 300 in any one room	N	N	N	S	S	A	A	S	S	S	S	O	A	N	N
		(b) Theatres, motion picture theatres; with seating capacity of 300 or less in any one room	N	N	N	O	O	A	A	O	O	O	O	O	A	N	N
	2	(a) Auditoriums, community halls, court rooms, dance halls, libraries, lodge rooms, non-residential clubs, non-residential colleges, non-residential schools; Arenas, armouries, bath-houses, churches, exhibition buildings, gymnasiums, museums, passenger stations, recreation piers, rinks; with seating capacity of more than 750 in any one room	N	N	N	S	S	A	A	S	S	O	O	O	A	N	N
B		(b) Same as (a) immediate above except with seating capacity of 750 or less in any one room	N	N	N	O	O	A	A	O	O	N	N	N	A	N	N
	1	Asylums, jails, police stations, prisons, reformatories	S	O	S	O	O	A	A	S	S	O	O	O	S	N	N
	2	Children's shelters, hospitals, infirmaries, old people's homes, orphanages, sanatoria	S	O	S	O	O	A	A	O	O	O	O	O	S	N	N
C	1	Dry cleaning plants employing flammable or explosive solvents	A	A	A	A	A	A	A	S	S	A	A	A	S	O	S
	2	High hazard industrial occupancies	A	A	A	A	A	A	A	S	S	O	A	A	S	O	S
	3	Medium hazard industrial and commercial occupancies	S	O	S	O	S	O	S	O	O	O	O	O	O	N	O
D	4	Low hazard industrial occupancies	S	O	S	O	S	O	S	O	O	O	O	O	N	N	N
	1	Convents, dormitories, hostels, monasteries, residential clubs, residential colleges, residential schools	S	O	O	N	O	A	A	O	O	O	O	O	O	N	N
	2	Apartment houses, fire stations, hotels, lodging houses, multiple dwellings	S	O	O	N	O	O	A	O	O	O	O	O	O	N	O
E	3	Dwellings (One- and two-family)	O	O	O	N	O	O	S	O	N	N	N	N	O	N	O
	1	Private barns, private garages, private stables	A	A	A	S	S	S	O	O	N	O	O	O	N	N	O
	2	Sheds, towers, water tanks	N	N	N	N	N	O	N	N	N	N	N	N	N	N	N
	3	Reviewing stands, stadiums, amusement park structures, not elsewhere classified	N	N	N	N	N	S	S	O	N	O	O	O	O	N	N

Notes:

- (1) In Type 1A or 1B Construction, or Type 1C with incombustible floor assemblies, (see Section 4.3) no separation shall be required between occupancies of Group D, Divisions 2 and 3, and office buildings, printing plants, restaurants, retail stores, undertaking premises, wholesale stores.
- (2) Provided that:
 - (a) protection for the roof members of the garage equivalent to a 1-hour fire-resistance rating shall be provided, or alternatively, the roof may be of heavy timber construction, viz., 2½ inch tongued and grooved, or splined, or 3 inch laminated;
 - (b) openings from a dwelling into a private garage shall be restricted to a single doorway not over 36 inches wide with the door sill at least 12 inches above the garage floor;
 - (c) such opening may be protected by a snug-fitting, self-closing door having a fire resistance not less than that of a wood-slab flush-type door at least 1½ inches thick in all parts;
 - (d) the garage floor shall be of incombustible material.

(c) **Types of Occupancy Separations*.**—Occupancy separations shall be classed as **Absolute**, **Special**, and **Ordinary**.

- (i) An **Absolute Occupancy Separation** shall have no openings in it and shall be so constructed as to have a *fire-resistance rating* of not less than 4 hours. Any such separation meeting a *combustible* roof shall pass through it and extend above it as a parapet, except as otherwise provided in Article 4.9.5.
- (ii) A **Special Occupancy Separation** shall be so constructed as to have a *fire-resistance rating* of not less than 3 hours. Any such separation meeting a *combustible* roof shall pass through it and extend above it as a parapet, except as otherwise provided in Article 4.9.5.

All openings in walls forming such separation shall be protected on each side thereof by *fire-resistive closures* meeting the requirements of Section 4.12 and such closures shall normally be kept closed. One of these closures shall be *self-closing* and the other shall be either *self-closing* or *automatic*.

All openings in floors forming such separation shall be protected by enclosures in the *storeys* immediately above and below. The walls of such enclosures shall be of not less than 2-hour fire-resistive construction. All openings in such enclosures shall be protected with *self-closing fire-resistive closures* meeting the requirements of Section 4.12, and such doors shall normally be kept closed.

- (iii) An **Ordinary Occupancy Separation** shall be so constructed as to have a *fire-resistance rating* of not less than one hour. All openings in any such separation shall be protected with *self-closing fire-resistive closures* meeting the requirements of Section 4.12, and such closures shall normally be kept closed.
- (iv) The symbol 'N' is used in Table 1 of this Section to indicate that neither an **Absolute**, nor a **Special**, nor an **Ordinary Occupancy Separation** is required between certain adjoining but different occupancies occurring within any one building. The requirements of Table 1 are based only upon considerations of mixed occupancies within a building; and they shall be subject to any more restrictive regulations respecting *fire-resistance ratings* for walls, *partitions*, floors, and roofs, which may be given in Section 4.3 (Requirements Pertaining to Types of Construction), Section 4.5 (Heights and Areas), and elsewhere in this Code.

*See Sections 4.7 to 4.10 for information respecting *fire-resistance ratings* of various structural elements and structural assemblies. For information regarding *fire-resistive closures*, see Section 4.12.

4.2.4 Requirements pertaining to the Exposure of Exterior Walls

4.2.4.1 General.—

(a) The specific requirements of this Part of this Code respecting the construction of exterior walls and the protection of openings therein with reference to adjacent *lot lines*, shall apply to adjacent buildings belonging to the same owner, but with reference to a line or lines separating the sites of the buildings, every such line being located by the owner and described in his application for a building permit, provided, however, that an *accessory building* may be considered to be located on the same site or *lot* as the building to which it is accessory. Every such line serving to separate two building sites shall be treated as a *lot line* and, considering this treatment, no such line shall be so located as to bring about in any *existing structure* any non-conformity with the Code which did not previously exist.

Wherever the construction of verandahs, porches, balconies, canopies, and similar *structures* is regulated on the basis of distance from a *lot line*, the requirements of this Item with respect to buildings on the same property shall apply.

(b) For the purposes of the requirements pertaining to the exposure of exterior walls, in considering the location of a *structure* on a *lot* bounded by a registered *lane*, such a *lot* shall be assumed to extend to the centre line of the *lane*.

(c) When distance from a *lot line* is a criterion for requirements as to fire-resistive qualities of exterior walls and openings therein, such requirements shall apply to all walls and parts thereof within the criterion distance regardless of the angle they may form with a *lot line*, excepting walls of *inner courts*, air wells, or *outer courts* facing on a *street* and bounded on three sides by walls of the one building under consideration.

(d) The distance from any *lot line* to any exterior wall shall be measured at right angles to the vertical plane containing the *lot line*.

(e) For information pertaining to the method of determining *fire-resistance ratings*, see Section 4.7; for information pertaining to fire-resistive walls, see Section 4.9; and for information pertaining to the protection of openings in exterior walls and to the maximum aggregate areas of openings in exterior walls, see Section 4.12.

(f) In addition to the requirements of this Article, all restrictions on the location of any *structure* with reference to the fire zone in which the property is located shall be observed. See Articles 4.4.3 and 4.4.4.

4.2.4.2 Group A, Assembly Buildings.—

(a) The main entrance of any *assembly building* shall front directly upon a *street* having a width of at least 30 feet provided that an *assembly building* intended for the use of more than 300 persons shall front directly upon a *street* having a width of at least 50 feet.

(b) No exterior wall or part thereof having a *fire-resistance rating* of less than 4 hours shall be located within 3 feet of any *lot line*.

(c) No exterior wall or part thereof having a *fire-resistance rating* of less than 3 hours shall be located within 5 feet of any *lot line*.

(d) No exterior wall or part thereof having a *fire-resistance rating* of less than 2 hours shall be located within 10 feet of any *lot line*.

(e) Every opening in any exterior wall or part thereof which is within 12 feet of a *lot line* shall be protected by a *fire-resistive closure*. A reduction in this requirement may be made in accordance with Item 4.2.4.8.

4.2.4.3 Group B, Institutional Buildings.—

(a) No exterior wall or part thereof having a *fire-resistance rating* of less than 3 hours shall be located within 5 feet of any *lot line*.

(b) Every opening in an exterior wall or part thereof which is within 12 feet of any *lot line* shall be protected by a *fire-resistive closure*. A reduction in this requirement may be made in accordance with Item 4.2.4.8.

4.2.4.4 Group C, Commercial and Industrial Buildings, Divisions 1 and 2.—

(a) No exterior wall or part thereof having a *fire-resistance rating* of less than 3 hours shall be located within 10 feet of any *lot line*.

(b) Every opening in any exterior wall within 15 feet of any *lot line* shall be protected by a *fire-resistive closure*. A reduction in this requirement may be made in accordance with Item 4.2.4.8.

4.2.4.5 Group C, Commercial and Industrial Buildings, Divisions 3 and 4.—

(a) No exterior wall or part thereof having a *fire-resistance rating* of less than 3 hours shall be located within 4 feet of any *lot line*.

(b) Every opening in any exterior wall or part thereof which is within 9 feet of any *lot line* shall be protected by a *fire-resistive closure*.— A reduction in this requirement may be made in accordance with Item 4.2.4.8.

4.2.4.6 Group D, Residential Buildings.—

(a) No exterior wall or part thereof having a *fire-resistance rating* of less than 2 hours shall be located within 3 feet of any *lot line*; provided, however, that any wall having a *fire-resistance rating* of one hour of a *detached one- or two-family dwellings* may be located not closer than one foot from a *lot line*.

(b) In occupancies belonging to Division 1 or 2 of Group D, every opening in any exterior wall or part thereof which is within 6 feet of any *lot line* shall be protected by a *fire-resistive closure*. A reduction in this requirement may be made in accordance with Item 4.2.4.8.

4.2.4.7 Group E, Accessory Buildings and Other Structures.—

(a) No exterior wall or part thereof of any *accessory building* other than a *private garage* not exceeding 500 square feet in area, located within 3 feet of any *lot line*, shall be constructed of any material other than *masonry* or *reinforced concrete*, except that an exterior wall of a building of Type 5 Construction (Unprotected Metal or Fire-retardant Treated Wood) may be located within one foot of any *lot line*, subject to all restrictions resulting from its location in a particular fire zone (see Articles 4.4.3 and 4.4.4).

(b) When any portion of a reviewing stand or stadium constructed of Masonry and Frame, or Wood Frame, is within 10 feet of a *lot line*, such portion shall have exterior walls extending upwards for the full height of the *structure* and having a *fire-resistance rating* of at least 2 hours, and all openings therein shall be protected by *fire-resistive closures*. A reduction in this last requirement may be made in accordance with Item 4.2.4.8.

(c) No *accessory building* shall be located within 3 feet of the building to which it is accessory.

4.2.4.8 Reduced Requirements for Openings in One-storey Buildings.—The distance from a *lot line*, within which *fire-resistive closures* are required for various occupancies by Items 4.2.4.2 to 4.2.4.7 inclusive, may be reduced by one-third when the building exceeds neither one *storey* nor 35 feet in *height*.

4.2.4.9 Protection of Openings in the Vicinity of Absolute or Special Separations.—

(a) When any required absolute or special separation, whether it be an occupancy or an area separation (see Sub-item 4.2.3.3 (c) and Item 4.5.3.1), meets an exterior wall facing on a *street*, *yard*, *court*, or air well, any opening in the exterior wall adjacent to such separation shall be protected by a *fire-resistive closure* as follows:

- (i) When the separation is horizontal, openings above and below it which face in the same direction and are within 4 feet of being in the same vertical plane, shall be protected by *fire-resistive closures* if the distance between such openings, on a vertical projection, is less than the distance from a *lot line* at which unprotected openings are permitted in exterior walls for the most restricted occupancy on either side of the separation.
- (ii) Any exterior opening within 3 feet of the junction of a vertical separation with an exterior wall shall be protected by a *fire-resistive closure*.

- (iii) When the openings face in different directions and the separation is either vertical or horizontal, any opening within twice the distance from a *lot line* in which unprotected openings are permitted in exterior walls for the most restricted occupancy on either side of the separation, shall be protected by a *fire-resistive closure*, all distances being measured in a straight line or lines in any direction outside the confines of the building.
 - (iv) No protection shall be required in any building not exceeding two *storeys* or 35 feet in *height* and in any building not exceeding three *storeys* or 45 feet in *height* of Group D (Residential) Occupancy.
 - (v) No protection shall be required in the case of show windows on a *street front*.
- (b) When an opening in any exterior wall is situated above and within 35 feet of a *combustible* roof abutting the exterior wall at a height in excess of 15 feet above the ground, each such opening shall be protected by a *fire-resistive closure*; provided that such openings in a residential occupancy shall be excepted.
- (c) In occupancies classified as belonging to Group C, Division 1, 2, or 3, excepting office buildings, window openings, situated vertically above each other and not required to be protected against fire, shall be separated by a distance of at least 3 feet measured vertically.
- (d) See Article 4.14.13 for special minimum requirements with respect to exterior openings in boiler rooms or rooms containing central heating equipment.

SECTION 4.3 REQUIREMENTS PERTAINING TO TYPES OF CONSTRUCTION

4.3.1 General.—The requirements of this Section are the minimum requirements for the various types of construction. A building may be classed as being of a specific type of construction only when all the requirements for that type of construction are complied with.

The classification of types of construction as given in Article 4.3.2 is based on the ability of various materials and structural assemblies to resist fire and protect life. Where specific materials, methods of construction, or fire-resistive qualities are required, such requirements shall be the minimum requirements; but any materials, methods of construction, or fire-resistive qualities which will afford equal or greater fire resistance and protection to life may be used in lieu thereof.

The *fire-resistance ratings* for certain specific materials and combinations of materials as given in Sections 4.8, 4.9, and 4.10 shall be acceptable. *Ratings* for materials and combinations of materials not specifically mentioned therein shall be established on the basis of tests made in accordance with Section 4.7.

4.3.2 Classification of Types of Construction.—For the purposes of this Code, types of construction are classified as follows:

- Type 1A Fire-resistive Construction
- Type 1B Fire-resistive Construction
- Type 1C Fire-resistive Construction
- Type 2 Heavy Timber Construction
- Type 3 Masonry and Frame Construction
- Type 4 Wood Frame Construction
- Type 5 Unprotected Metal or Fire-retardant Treated Wood Construction

and other types of construction as classified by the *authority having jurisdiction*.

When two or more types of construction occur in the same building and are not separated by an unpierced wall having a *fire-resistance rating* of 4 or more hours as described in Item 4.2.3.1, the entire building shall be subject to the most restrictive requirements for any of the types of construction concerned.

Any building which, on account of its structural nature and details, cannot be definitely classified as belonging to a particular type of construction as set forth in this Section, shall for the purposes of this Code be assigned to the least fire-resistive and most restricted type of the types to which it most nearly conforms.

4.3.3 Type 1, Fire-resistive Construction

4.3.3.1 Fire Resistance.—In order that any *existing* or proposed building may be classed as belonging to Type 1A, 1B, or 1C Construction, its components, structural members and structural assemblies shall have *fire-resistance ratings* not less than those set forth in Table 1 of this Section; provided that within any Group C (Commercial and Industrial) Occupancy, non-bearing *partitions* of metal, wood, or glass, or of a combination of these materials, may be erected within a compartment of not more than 5000 square feet in floor area if such compartment is enclosed within walls or *partitions* having a *fire-resistance rating* of at least one hour.

4.3.3.2 Use of Combustible Materials in Types 1A, 1B, and 1C Construction.—

(a) **General.**—No *combustible* material shall be used in any Type 1A, 1B, or 1C Construction, except as permitted in this Item.

TABLE 1 (SECTION 4.3)
REQUIRED MINIMUM FIRE-RESISTANCE RATINGS IN HOURS FOR
TYPE 1 CONSTRUCTION

Name and Description of Building Component	Required Fire-resistance Ratings (hours)		
	Type 1A	Type 1B	Type 1C
Walls (Other than <i>partitions</i>)			
Exterior walls including <i>court</i> walls but excluding air-well walls; <i>party walls</i> and <i>common walls</i>	4	4	3
<i>Bearing walls</i> of all kinds not elsewhere mentioned	4	3	2
Interior <i>non-bearing walls</i> , <i>enclosure walls</i> for air wells.....	2	2	2
<i>Penthouse</i> and <i>bulkhead</i> walls other than those over main exterior walls (see Section 4.17).....	3	2	2
Partitions			
<i>Bearing partitions</i>	3	2	2
<i>Non-bearing partitions</i> enclosing <i>exits</i> or <i>shafts</i>	2	2	- (a)
<i>Non-bearing partitions</i> other than those enclosing <i>exits</i> or <i>shafts</i> (see Item 4.3.3.1).....	1	1	1
Columns			
<i>Columns</i> supporting walls and/or bearing <i>partitions</i>	4	3	2
<i>Columns</i> supporting neither walls nor bearing <i>partitions</i>	4	3	1 (b)
Trusses			
Roof trusses.....	4	2	1
Trusses other than roof trusses.....	4	3	1 (b) (e)
Piers			
All <i>piers</i>	4	3	2
Girders			
<i>Girders</i> supporting walls and/or bearing <i>partitions</i> ..	4	3	2
<i>Girders</i> supporting neither walls nor bearing <i>partitions</i>	4	3	1 (b)
Beams (c)			
<i>Beams</i> supporting walls and/or bearing <i>partitions</i> ..	4	3	2
<i>Beams</i> supporting neither walls nor bearing <i>partitions</i> , such as floor <i>beams</i> , roof <i>beams</i> , etc.....	3	2	1 (b)
Floors and Roofs (d)			
Floor slabs; <i>floor panel</i> assemblies including <i>joists</i> ; roof slabs; <i>roof panel</i> assemblies including <i>joists</i> and purlins.....	3	2	1 (b) (f)

- (a) The requirements of Article 4.6.7 with respect to the enclosure of *exits* shall be fulfilled. The requirements of Section 4.16 and more specifically Item 4.16.2.1 with respect to the protection of *vertical openings* shall be fulfilled.
- (b) When used as part of or in association with any *exit*, the more restrictive requirements of Article 4.6.7 shall be complied with.
- (c) The required protection may be omitted on lintels spanning masonry-wall openings not over 6 feet wide in the case of *bearing walls*, and not over 10 feet wide in the case of *non-bearing walls*, on lintels where adequate *masonry* arches are provided above them, and on lintels supported from protected members above.
- (d) In certain buildings under certain conditions, the required *ratings* may be obtained by the association of a ceiling with a floor or roof. For further details, see Item 4.3.3.4.
- (e) Any truss supporting walls, *columns*, or bearing *partitions*, shall have a *fire-resistance rating* of at least 2 hours.
- (f) See Sub-items 4.3.3.2 (c), 4.3.3.2 (d), and Item 4.3.3.3.

(b) **Millwork, Floor and Wall Finishes.**—*Combustible* materials may be used in the construction of:

- (i) show window frames, backing, and aprons in the *first storey*, provided that, where the first floor is cut away to light a *basement*, the vertical opening so formed shall be enclosed within the *first storey* by construction having a *fire-resistance rating* equal to that required for the first floor;
- (ii) show cases and similar appurtenances;
- (iii) interior trim, false beams, picture moulds, base boards, hand rails, wainscoting;
- (iv) floor finishes including wood flooring with or without sleepers, provided that any space between such flooring and a floor slab shall be fire-stopped into areas not exceeding 100 square feet, and shall be filled with *incombustible* material under any permanent *partition*;
- (v) decorative and acoustical wall or ceiling treatments applied without concealed spaces, provided that all such treatments in any room or space serving as a *place of assembly* shall have been so treated as to render them *non-flammable* or of *very low flammability*;
- (vi) ordinary doors and windows including frames, in either interior or exterior openings which are not required by reason of exposure, or for exit or separation purposes, to be of special fire-resistive construction, except that doors and windows including frames in the exterior walls of buildings of Type 1A or 1B Construction exceeding six *storeys* in *height* shall be of *incombustible* materials or of the 'kalamein' type;

(c) **Type 1B Construction.**—In buildings of Type 1B Construction, *combustible* materials may be used for the following:

- (i) non-bearing *partitions*, provided they have a *fire-resistance rating* of not less than one hour;
- (ii) roofs of buildings not exceeding 75 feet in *height* may be sheathed with tongued and grooved wood planks not less than 2½ inches nominal* thickness, provided that such *sheathing* is wholly separated from the *storeys* below by construction having the *rating* required in Table 1 for roofs. Such separation may be provided by a ceiling serving as required protection for roof members as permitted in Item 4.3.3.4.

(d) **Type 1C Construction.**—In buildings of Type 1C Construction, *combustible* materials may be used for the following:

- (i) non-bearing *partitions*, provided they have a *fire-resistance rating* of not less than one hour;

*In this Section the meaning of the term "nominal" as applied to the dimensions of wood members shall conform to the usage defined in Specification A43-1937 of the C.E.S.A., as amended in April, 1940.

- (ii) joisted *floor and roof panel* assemblies, provided that such assemblies have a *fire-resistance rating* of not less than one hour and provided also that the *fire-resistance rating* of all *piers, columns, beams, girders*, and trusses other than roof trusses is not less than 2 hours. (See Sub-item 4.3.3.4 (b) for further regulations.)
- (iii) roofs of buildings not exceeding 75 feet in *height* may be sheathed with tongued and grooved wood plank not less than 2½ inches nominal* thickness;
- (iv) roof trusses and other roof members of wood may be used without protection, provided that no member is less than 4 by 6 inches in nominal dimension;
- (v) roof trusses and other roof members of wood may be used without limitation as to size where every part of the framework of the roof is not less than 18 feet above any floor or balcony, and where a ceiling equivalent to a one-hour *rating* (see Table 2, Section 4.8) is suspended not less than 6 inches distant from any such framework;
- (vi) roof trusses and other roof members of wood treated with fire-retardant chemicals in accordance with the requirements of A.S.T.M. Specification C132-40T may be used without limitation as to size if protected by a ceiling in accordance with the provisions of Item 4.3.3.4.
- (vii) roof trusses and other roof members of wood treated with fire-retardant chemicals in accordance with the requirements of A.S.T.M. Specification C132-40T may be used without limitation as to size, if every part of the framework of the roof is not less than 25 feet above any floor or balcony, provided such framing carries no loads other than normal roof loads, access walks, and ventilating equipment. In an *Assembly Building* the above limiting distance shall not apply in the case of an inclined or stepped balcony with fixed seats, or a level balcony not more than 5 feet wide, provided that such a balcony is constructed of *incombustible* materials. If such balcony is constructed of *combustible* materials, the limiting distance shall be 10 feet.

4.3.3.3 Use of Unprotected Metal in Types 1A, 1B, and 1C Construction.—

(a) **General.**—In buildings of Type 1A, 1B, or 1C Construction, unprotected metal may be used for elevator guides or brackets, or for *beams* acting only as elevator guide supports, or for framework around elevator shaft doorways.

(b) **Type 1A Construction.**—Roof framing may be of unprotected metal when every part of such framing is not less than 25 feet, above any floor or balcony, provided such framing carries no loads other than normal roof loads, access walks, and ventilating equipment. In

*In this Section the meaning of the term "nominal" as applied to the dimensions of wood members shall conform to the usage defined in Specification A43-1937 of the C.E.S.A., as amended in April, 1940.

an *Assembly Building* the above limiting distance shall not apply in the case of an inclined or stepped balcony with fixed seats, or a level balcony not more than 5 feet wide.

(c) Type 1B Construction.—

- (i) Roof framing may be of unprotected metal, and formed steel sheets without protection may be used to cover in a roof, when every part of such framing is not less than 25 feet above any floor or balcony, provided such framing carries no loads other than normal roof loads, access walks, and ventilating equipment. In an *Assembly Building* the above limiting distance shall not apply in the case of an inclined or stepped balcony with fixed seats, or a level balcony not more than 5 feet wide.
- (ii) Formed steel sheets may be used to cover in the roof in any Type 1B building, provided that such sheets shall be separated from the *storeys* below by construction having the *rating* required by Table 1 for roofs of Type 1B buildings. Such separations may be provided by a ceiling.

(d) Type 1C Construction.—Roof framing may be of unprotected metal, and formed steel sheets without protection may be used to cover in a roof when every part of such framing is not less than 25 feet above any floor or balcony, provided such framing carries no loads other than normal roof loads, access walks, and ventilating equipment. In an *Assembly Building* the above limiting distance shall not apply in the case of an inclined or stepped balcony with fixed seats, or a level balcony not more than 5 feet wide, provided that such balcony is constructed of *incombustible* materials. If such balcony is constructed of *combustible* materials, the limiting distance shall be 10 feet.

4.3.3.4 Use of Ceilings for Fire Protection Purposes.—

(a) Roof Members.—All roof members, including roof trusses, may be protected by a flat or curved ceiling as specified in Item 4.8.2.4 provided:

- (i) that such members and trusses support no loads other than the usual roof loads, the ceiling, access facilities, and ventilation equipment including its enclosures;
- (ii) that the space between the ceiling and the roof is completely enclosed and fire-stopped, such space being used for no purpose whatsoever except as noted in (iii) hereof; and access to such space being restricted to *self-closing* doors or hatches having a *fire-resistance rating* of at least one hour;
- (iii) that ventilating equipment and similar minor mechanical equipment may be housed in the space above the ceiling, if it is enclosed on all sides by *incombustible* construction having a *fire-resistance rating* equal to that required for the roof framing up to a maximum of 2 hours, access to such enclosures being through *self-closing fire-resistive closures*;

- (iv) all *shafts* or *stairways* passing upwards through the space above the ceiling shall be enclosed therefrom by construction having such *ratings* as may elsewhere be required, but in no case less than the *rating* required for the roof framing;
- (v) where a roof member or roof truss projects below the general level of the ceiling, the projecting portion shall be protected in accordance with Table 1 of Section 4.8.

In buildings of Type 1A Construction, where every part of the framework of the roof is not less than 18 feet above any floor or balcony, the ceiling protection for roof members need only be equivalent to a 2-hour *rating* (see Table 2, Section 4.8), provided such ceiling is not less than 6 inches distant from any part of the roof construction. In an *Assembly Building* the above limiting distance shall not apply in the case of an inclined or stepped balcony with fixed seats, or a level balcony not more than 5 feet wide.

In buildings of Type 1B Construction, where every part of the framework of the roof is not less than 18 feet above any floor or balcony, the ceiling protection for roof members including roof planks or formed steel sheets if used (see Sub-item 4.3.3.2 (c) and Item 4.3.3.3), need only be equivalent to a one-hour *rating* (see Table 2, Section 4.8), provided such ceiling is not less than 6 inches distant from any part of the roof construction. In an *Assembly Building* the above limiting distance shall not apply in the case of an inclined or stepped balcony with fixed seats, or a level balcony not more than 5 feet wide.

(b) Floor Beams and Girders.—In buildings of Type 1B Construction, all floor members shall be individually encased in fire-resistive materials, except that floor members carrying floor areas not exceeding 600 square feet and which support no walls other than non-bearing *partitions*, may be protected by a flat or curved ceiling. Such a ceiling shall be equivalent to 2-hour protection in accordance with Table 2 of Section 4.8, provided that where there is a *solid masonry* or *reinforced concrete* slab at least 2 inches thick in the floor assembly located above the top of the floor members, the ceiling thickness may be reduced to one inch, no further allowance being made for suspending the ceiling. The space immediately above such a ceiling shall be effectively divided by vertical fire-stops into areas not exceeding 600 square feet. Where *beams* or *girders* extend below the general ceiling level, their soffits and sides below the ceiling level shall be protected by materials having a *rating* of two hours.

In buildings of Type 1C Construction having *incombustible* floor assemblies, *beams* and *girders* may be protected by a flat or curved ceiling, provided that *beams* or *girders* supporting walls other than non-bearing *partitions* or supporting *columns*, shall be individually protected, and provided that the space immediately above such a ceiling shall be effectively divided by vertical fire-stops into areas not exceeding 600 square feet. Where *beams* or *girders* extend below the general ceiling level, their soffits and sides below the ceiling level shall be protected by materials having a *rating* of one hour.

In buildings of Type 1C Construction having *combustible*, joisted, floor assemblies, a ceiling shall be attached directly to the underside of each *joist*, or may be suspended from the *joists* if all parts of the ceiling and hangers are *incombustible*, provided the space immediately above such ceiling is effectively divided by vertical fire-stops into areas not exceeding 600 square feet, and provided further that the floor assembly as a whole shall have a *fire-resistance rating* of at least one hour. Where wood *joists* are supported by steel *beams* or *girders*, each steel member shall have its soffit and sides individually protected for its full depth with materials having a 2-hour *rating*, provided that wood *joists* may project into these protective materials, and any space between the top flange of a steel member and a floor shall be fire-stopped with *incombustible* material.

4.3.4. Type 2, Heavy Timber Construction

4.3.4.1 General Description (Fire Resistance).—

(a) Buildings of Type 2 Construction shall have walls of *masonry* or *reinforced concrete* and an interior framing of wood, with plank or *laminated wood floors* and roofs; provided that in lieu of wood, the interior framing may be partly or entirely of protected steel or *concrete* and the floors and roofs may be constructed in whole or in part of *incombustible* material. In any case, wood, where used, shall be arranged in heavy solid masses and smooth flat surfaces avoiding thin sections, sharp projections and concealed or inaccessible spaces. Structural members and structural assemblies shall have the minimum nominal* dimensions or the minimum *fire-resistance ratings* shown in Table 2 of this Section. (For restrictions on the use of *combustible* materials in *Exits*, see Item 4.6.6.1.)

(b) In Type 2 Construction, built-up members shall not be used unless the individual pieces of wood of which such members are composed comply with the requirements for minimum dimensions given in Table 2. Where wood structural members are supported on *masonry* or *reinforced concrete* walls, there shall be at least 4 inches of *masonry* between the ends of the members and the face of the wall remote from the member.

4.3.4.2 Use of Ceilings for Fire Protection Purposes.—Where the roof framework of a building of Type 2 Construction is composed of structural steel, the required protection may be provided by a ceiling in accordance with Item 4.8.2.4.

*In this Section the meaning of the term "nominal" as applied to the dimensions of wood members shall conform to the usage defined in Specification A43-1937 of the C.E.S.A., as amended in April, 1940.

TABLE 2 (SECTION 4.3)
MINIMUM REQUIREMENTS FOR FIRE RESISTANCE IN
HEAVY TIMBER CONSTRUCTION

Name and Description of Building Component	Minimum Nominal Size of Wood Member (in inches)	Minimum <i>Fire-resis-</i> <i>tance Rating</i> Required when no Wood Size is given, or as an alter- native to a given Wood Size (hours)
Walls (Other than <i>Partitions</i>)		
Exterior walls including <i>court</i> walls but excluding air-well walls; <i>party walls</i> and <i>common walls</i>		3 (<i>Incombustible</i>)
<i>Bearing walls</i> of all kinds not else- where mentioned		2 (<i>Incombustible</i>)
Interior <i>non-bearing walls</i> , <i>en-</i> <i>closure walls</i> for air-wells		2 (<i>Incombustible</i>)
Walls of <i>penthouses</i> or <i>bulkheads</i> other than those over main ex- terior walls, subject to Item 4.17.2.4.		1
<i>Partitions</i>		
<i>Bearing partitions</i>		2
<i>Non-bearing partitions</i> enclosing <i>exits</i> or <i>shafts</i>		- (g)
<i>Non-bearing partitions</i> other than those enclosing <i>exits</i> or <i>shafts</i>		1 (d)
<i>Columns</i>		
All <i>columns</i> (a)	8 x 8	2
<i>Trusses</i>		
All <i>trusses</i> (a) (e)	4 x 6	1 (b)
<i>Piers</i>		
All <i>piers</i>		2 (<i>Incombustible</i>)
<i>Girders and Beams</i>		
All <i>girders and beams</i> (a)	6 x 10	2 (c)
Floors (e)	3-inch tongued and grooved, or splined (f); or 4-inch laminated.	1 (<i>Incombustible</i>)
Roofs (e)	2½-inch tongued and grooved, or splined; or 3-inch laminated.	1 (<i>Incombustible</i>)

- (a) No wood or other *combustible* material shall be used to support any *masonry* wall.
- (b) Any truss supporting walls, *columns*, or *bearing partitions*, shall have a *fire-resistance rating* of at least two hours.
- (c) The required protection may be omitted on lintels spanning *masonry* wall openings not over 6 feet wide in the case of *bearing walls*, and not over 10 feet wide in the case of *non-bearing walls* on lintels where adequate *masonry* arches are provided above them, and on lintels supported from protected members above.
- (d) Within any business occupancy (Group C) located in a building of Type 2 Construction, *non-bearing partitions* of metal, wood, or glass, or of a combination of these materials, may be erected within a compartment of not more than 5000 square feet in floor area; provided that such compartment is enclosed within walls or *partitions* which have a *fire-resistance rating* of at least one hour with all openings therein protected by *self-closing fire-resistive closures* meeting the requirements of Section 4.12.
- (e) When used as part of or in association with any *exit*, the more restrictive requirements of Article 4.6.7 shall be complied with.
- (f) Alternatively, the floor may consist of 2-inch tongued and grooved, or splined planks, covered by a continuous layer of asbestos paper weighing at least 14 pounds per 100 square feet, on which is laid tongued and grooved flooring having a finished thickness of at least 3/4 inch.
- (g) The requirements of Article 4.6.7 with respect to the enclosure of *exits* shall be fulfilled. The requirements of Section 4.16, and more specifically Item 4.16.2.1, with respect to the protection of *vertical opening* shall be fulfilled.

4.3.5 Type 3, Masonry and Frame Construction

4.3.5.1 General Description.—Every building of Type 3, Masonry and Frame Construction, shall have exterior walls, *party walls*, and *common walls of masonry or reinforced concrete*, and the interior framing may be constructed in whole or in part of *reinforced concrete*, wood, or unprotected iron or steel. (This type does not include wood frame construction having an *incombustible* veneer.) The term exterior walls as used herein shall include all *court walls* and *air-well walls*.

4.3.5.2 Special Requirements in Type 3 Construction.—

(a) **Exits.**—The regulations regarding the use of *combustible* materials in the construction of *exits* as given in Item 4.6.6.1 shall be complied with. The regulations regarding required *fire-resistance ratings* for *exit* enclosures and portions thereof as given in Article 4.6.7 shall be complied with.

(b) **Height of Wood-stud Walls.**—No wood-stud wall shall exceed three *storeys* in *height*.

(c) **Walls and Partitions Generally.**—Walls and *partitions* separating *dwelling units* or apartments from one another or from public *hallways*, and all walls and *partitions* in Group B, *Institutional Buildings*, shall have a *fire-resistance rating* of at least one hour. (See also Sub-item 4.12.4.1 (c) and Article 4.1.2.)

(d) **Protection of Structural Members.**—In addition to all requirements pertaining to *exits* (see Sub-item (a) hereof), all members carrying *masonry* in buildings over one *storey* in *height* shall have a *fire-resistance rating* of at least one hour. Bottom flanges of exterior lintels need not be protected. (See also Article 4.1.2.)

(e) **Ceilings.**—Every building of Type 3 Construction having a *height* of two or more *storeys* which is classified as belonging to Group A, *Assembly Buildings*, or to Group B, *Institutional Buildings*, or to Group D, *Residential Buildings*, excepting *one-family dwellings* and such *two-family* and *multiple dwellings* as contain no *dwelling unit* above another *dwelling unit*, shall have all floor assemblies, including the ground floor when there is any usable space beneath it, protected by ceilings or other constructions of such materials and thicknesses as to ensure a *fire-resistance rating* of at least one hour for the floor construction as a whole.

Similar protection shall be provided for the ground floor of all buildings classified as belonging to Divisions 1, 2, or 3, Group C, *Commercial and Industrial Buildings*, and having a *height* of two *storeys* or more, when such buildings are of Type 3 Construction and have a usable space beneath such floors. Such protection shall also be provided for the floors of *dwelling units* situated above a Commercial and Industrial Occupancy. (See also Article 4.1.2.)

An *approved* sprinkler system may replace any ceiling required by this Sub-item for the protection of floor assemblies.

4.3.6 Type 4, Wood Frame Construction

4.3.6.1 General Description.—Type 4, Wood Frame Construction, is that in which the structural parts and materials are of wood, or are dependent upon wood for support, and shall include wood frame construction having an *incombustible* veneer.

4.3.6.2 Special Requirements in Type 4 Construction.—

(a) Notwithstanding the allowable maximum areas of Article 4.5.1, in any wood frame *structure* divided by a series of two or more *common walls* or *party walls*, at least every alternate *common wall* or *party wall* shall be of *masonry* or *reinforced concrete*, and shall be carried through the roof to form a parapet as and when required by Article 4.9.5.

(b) No *combustible party wall* or *common wall* shall extend below the first *storey*; and every such *combustible wall* shall extend to the underside of the roof *sheathing*, and shall have a *fire-resistance rating* in all parts of not less than one hour. There shall be no openings in *common walls* or *party walls* unless they can be shown to be necessary, and any such openings shall be protected by a *self-closing door* not less fire-resistive than a wood-slab door 1³/₄ inches thick in all parts.

(c) In *two-family* or *multiple dwellings*, all walls or *partitions* separating *dwelling units* from one another and from public *hallways*, shall have a *fire-resistance rating* of at least one hour. (See also Sub-item 4.12.4.1 (c).)

4.3.7 Type 5, Unprotected Metal or Fire-retardant Treated Wood Construction.—Type 5, Unprotected Metal or Fire-retardant Treated Wood Construction, shall be that in which the structural frame of a building including bracing is of unprotected metal or of wood treated with fire-retardant chemicals in accordance with the requirements of A.S.T.M Specification C132-40T, the exterior walls and roofs are of sheet metal or other *incombustible* material, and the floors, excepting finished wearing surfaces, are of *incombustible* materials. With the exception of fire-retardant treated wood, the use of *combustible* materials in Type 5 Construction shall be limited to that permitted in Type 1A Construction except as otherwise specifically allowed by footnote (c) of Table 2 of Section 4.5.

SECTION 4.4 LOCATION OF FIRE ZONES AND RESTRICTIONS THEREIN

4.4.1 Location of Fire Zones*.—For fire protection purposes, the municipality is hereby divided into three classes of districts termed, Fire Zone No. 1, Fire Zone No. 2, and Fire Zone No. 3. The boundaries of these districts are set forth in the "Description of Fire Zones" which is annexed hereto and which is hereby declared to form part of this Code. Fire Zone No. 1 is the most restricted area, and Fire Zone No. 3 is the least restricted area.

4.4.2 General Restrictions in Fire Zones

4.4.2.1 Buildings Located in More than One Fire Zone.—Any building or *structure*, located partly in one fire zone and partly in another, shall be considered to be in the more highly restricted fire zone.

4.4.2.2 Buildings Moved.—Any building or *structure* moved within or into any fire zone shall comply with all the requirements for new buildings in such fire zone.

4.4.2.3 Existing Buildings.—

(a) **Increases in Height.**—The number of *storeys* in any *existing* building shall not be increased unless the building and all *existing* or proposed additions and *alterations* comply with the requirements of this Code for the fire zone in which the building is located.

(b) **Increases in Area.**—No building shall be increased in *area* unless the additions comply with the requirements of this Code for the fire zone in which it is located. When the *existing* building does not comply with all the requirements of this Part of this Code for a new building in such zone, any addition exceeding 50 per cent of the *area* of the *existing* building shall be separated from it by construction not less fire resistive than a 'special occupancy separation'. (See Item 4.2.3.3.)

(c) **Maximum Dimensions.**—No building located in any fire zone shall be increased in *height* or *area* to an extent such that the enlarged building would exceed the dimensions permitted for such building in such fire zone. Where no restriction based on location in a fire zone is indicated in Articles 4.4.3 or 4.4.4, maximum allowable *heights* and *areas* shall be determined from Section 4.5.

*Whilst the delineation of fire zones for any particular municipality is something that must be done after full consideration of local conditions, it may be useful to indicate the general characteristics of the various fire zones.

Fire Zone No. 1 is a district composed of closely built *commercial and industrial buildings* including particularly buildings of considerable height and buildings in which large quantities of flammable goods are stored. Fire Zone No. 2 is a district composed of *business and commercial buildings* of less height and more widely spaced than those in Fire Zone No. 1, together with apartment houses, *hotels* and *multiple dwellings* generally. Fire Zone No. 2 separates Fire Zone No. 1 from Fire Zone No. 3. In Fire Zone No. 3, the occupancies are predominantly *one- and two-family dwellings* with occasional retail stores, gasoline service stations and the like.

In many municipalities there will be no necessity for Fire Zone No. 1, in which Fire Zone No. 2 will be the more restricted zone.

Municipalities are strongly recommended to obtain competent professional advice when fixing boundaries of fire zones. Such boundaries should be reviewed from time to time and adjusted if necessary.

4.4.2.4 Temporary Structures.—Temporary buildings such as reviewing stands and other miscellaneous *structures* conforming to the requirements of Part 3 and Part 5 of this Code, and sheds, canopies, or fences used to protect the safety and assure the welfare of those in and around the site of construction work, may be erected in any fire zone by special permit from the *authority having jurisdiction*, and used for a limited period of time. Such *structures* shall be completely removed upon the expiration of the time limit stated in the permit.

4.4.3 Restrictions in Fire Zone No. 1

4.4.3.1 Type 5 Construction (Unprotected Metal or Fire-retardant Treated Wood).—No building or *structure* of Type 5 Construction having an *area* greater than 500 square feet shall be constructed in or moved into Fire Zone No. 1, unless designed or intended exclusively for an occupancy belonging to Group A, Division 2, in which case its exterior walls shall have a *fire-resistance rating* of at least one hour.

4.4.3.2 Type 4 Construction (Wood Frame).—No building or *structure* of Type 4 Construction (Wood Frame) shall be constructed in or moved into Fire Zone No. 1, except that:

(a) One *private garage* not exceeding 250 square feet in *area* and 12 feet in *height* may be erected upon any one *lot*.

(b) Wood frame verandahs, porches, or balconies which do not exceed 10 feet in depth, and no part of which extends more than 3 feet above the floor of the *second storey* may be erected on *one- and two-family dwellings*, provided that no part of any such verandah, porch, or balcony is closer than 3 feet to any *lot line*. (See Item 4.2.4.1 for regulations pertaining to buildings on the same property and other details.)

(c) Wood cornices supported by wood lookouts or brackets may be erected over store fronts or upon buildings not exceeding 45 feet in *height*.

(d) Facades of wood frame not exceeding 12 feet in height may be erected on otherwise open parking lots or open markets.

4.4.3.3 Restriction of Commercial and Industrial Occupancies.—No occupancy belonging to Division 1 or 2 of Group C (*Commercial and Industrial Buildings*) shall be permitted in Fire Zone No. 1, with the exception of *public garages* and motor service stations.

4.4.3.4 Roof Coverings.—Roofs of buildings in Fire Zone No. 1 shall be covered only with fire-retardant roofing as specified in Section 4.11, provided that canvas roof coverings may be used on verandahs and similar projections from the building which have substantially horizontal surfaces and no part of which is less than 3 feet from any *lot line*. (See Item 4.2.4.1 for regulations pertaining to buildings on the same property and other details.)

4.4.4 Restrictions in Fire Zone No. 2

4.4.4.1 Type 4 Construction (Wood Frame) and Type 5 Construction (Unprotected Metal or Fire-retardant Treated Wood).—

(a) In Fire Zone No. 2, every building of Type 4 Construction exceeding 250 square feet in *area*, and every building of Type 5 Construction exceeding 500 square feet in *area* shall have all exterior walls so constructed as to afford a *fire-resistance rating* of at least one hour.

(b) No verandah or gallery of Type 4 Construction shall be permitted above the third *storey* of any building. Any verandah or gallery, or portion thereof, which is enclosed to form a sunroom exceeding 100 square feet in *area*, shall be considered a part of the building to which it is appurtenant, and the building shall then be subject to any and all regulations and restrictions resulting from the type of construction employed in such sunroom. No verandah or gallery of Type 4 Construction shall be closer than 3 feet to any *lot line* (see Item 4.2.4.1 for regulations pertaining to buildings on the same property and other details).

4.4.4.2 Restriction of Commercial and Industrial Occupancies.—No occupancy belonging to Division 1 or 2 of Group C (*Commercial and Industrial Buildings*) shall be permitted in Fire Zone No. 2, with the exception of *public garages* and motor service stations. (See Article 4.2.1, Classification of Occupancies.)

4.4.4.3 Roof Coverings.—In Fire Zone No. 2, any roof covering conforming to the requirements of Section 3.10 may be used, except as follows:

(a) When the exterior walls of any building are less than 3 feet from any *lot line* (see Item 4.2.4.1 for regulations pertaining to buildings on the same property and other details), the roof covering of such building shall be “fire-retardant” as specified in Section 4.11.

(b) When Fire Zone No. 2 is the most restricted fire zone, (i.e., when no part of the municipality is designated as Fire Zone No. 1) roof coverings on buildings of Type 1A, 1B, 1C, or Type 2 Construction exceeding 10,000 square feet in *area*, or 4 *storeys* or 55 feet in *height*, whichever is the more restrictive, shall be “fire-retardant” as specified in Section 4.11.

4.4.5 Restrictions in Fire Zone No. 3.—Any building complying with the requirements of this Code may be constructed or moved into or within Fire Zone No. 3. Any roof covering conforming to the requirements of Section 3.10 may be used.

SECTION 4.5 HEIGHTS AND AREAS

4.5.1 Permissible Heights and Areas.—Except as permitted herein, the *heights* and *areas* of buildings shall not exceed the figures given in Tables 1 and 2 of this Section.

TABLE 1 (SECTION 4.5)

MAXIMUM PERMISSIBLE HEIGHTS OF BUILDINGS FOR A GIVEN OCCUPANCY CLASSIFICATION

Note: The more restrictive requirement, either *height* in feet or in *storeys*, shall govern.

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Occupancy Group	Occupancy Group (See Art. 4.2.1 for full details)	Types of Construction						
		1A Fire Resistive	1B Fire Resistive	1C Fire Resistive	2 Heavy Timber	3 Masonry and Frame	4 Wood Frame	5 Unprotected Metal or Fire- retardant treated Wood
A	1 <i>Theatres and motion picture theatres</i> ^(a)	Unlimited	75 ft. ^(a)	45 ft. ^(a) 3 storeys	45 ft. 3 storeys	35 ft. 2 storeys	35 ft. 1 storey	35 ft. 1 storey
	2 Auditoriums, community halls, etc., including non-resi- dential colleges and schools ^(c)	Unlimited	75 ft. ^(a)	55 ft. ^(a) 4 storeys	55 ft. 4 storeys ^(b)	45 ft. 3 storeys	35 ft. 1 storey	1 storey
B	1 Asylums, jails, etc.	Unlimited	75 ft.	---	---	Not permitted	---	---
	2 Children's shelters, hospitals, etc.	Unlimited	75 ft.	45 ft. 3 storeys	45 ft. 3 storeys	35 ft. 2 storeys	35 ft. 1 storey	1 storey
C	1 Dry-cleaning plants employing flammable or explosive solvents	1 storey	1 storey	---	---	Not permitted	---	---
	2 High hazard industrial occupancies	75 ft. ^(e)	75 ft.	45 ft. 3 storeys	45 ft. 3 storeys	35 ft. 2 storeys	25 ft. 1 storey	1 storey
	3 Medium hazard industrial and commercial occupancies ex- cluding office buildings	Unlimited	75 ft.	75 ft. ^(e)	55 ft. 4 storeys	45 ft. 3 storeys	35 ft. 2 storeys	1 storey
	Office buildings	Unlimited	Unlimited	75 ft.	75 ft.	55 ft. 4 storeys	35 ft. 2 storeys	1 storey
D	4 Low hazard industrial occupancies	Unlimited	Unlimited	75 ft.	75 ft.	55 ft. 4 storeys	35 ft. 2 storeys	1 storey
	1 Convents, dormitories, etc.	Unlimited	Unlimited	55 ft. 4 storeys	55 ft. ^(b) 4 storeys	45 ft. ^(b) 3 storeys	35 ft. 1 storey	1 storey
	2 Apartment houses, <i>hotels</i> , etc.	Unlimited	Unlimited	75 ft. ^(e) 6 storeys	55 ft. 4 storeys	45 ft. 3 storeys	35 ft. ^(b) 2 storeys	1 storey
	3 <i>One- and two-family dwellings</i>	Unlimited	Unlimited	55 ft. 4 storeys	55 ft. 4 storeys	45 ft. 3 storeys	40 ft. 3 storeys	1 storey
E	1 Open sheds, <i>private</i> barns, <i>garages</i> , etc.	Unlimited	Unlimited	55 ft.	55 ft.	45 ft.	20 ft.	45 ft.
	2 Towers, water tanks	Unlimited	Unlimited	---	---	Unlimited	---	---
	3 Stands and stadiums, etc.	Unlimited	Unlimited	55 ft.	55 ft.	45 ft.	35 ft. ^(f)	45 ft.

(a) The *height* in feet of one-storey buildings shall not be limited when such buildings are of *incombustible* construction throughout; also, in one-storey buildings of Type 1C Construction in which *combustible* construction is limited to wood roof *sheathing*, trusses, or purlins, (see Sub-item 4.3.3.2 (d)), the allowable *height* in feet may be increased to a maximum of 75 feet.

(b) Schools and colleges including university buildings shall not exceed two storeys in *height*, and convents or monasteries other than those accommodating only adults shall be considered schools.

(c) When the height exceeds 55 feet or 4 storeys, whichever is the more restrictive, all floors shall be constructed of *incombustible* materials; floors immediately above the *basement* or *cellar* shall have a *fire-resistance rating* of at least two hours, with all openings in such separations protected by *self-closing* or *automatic fire-resistance doors*.

(d) The main floor of every *theatre* or *motion picture theatre* located in any building of other than Type 1A or 1B Construction shall be located at or near *grade level* when its seating capacity including any balcony or galleries exceeds 300.

(e) The floor level of any room and the exhibition ring of any arena, designed or intended as a *place of assembly* for more than 500 persons, shall be located at or near *grade level* when the building in which it is located is of other than Type 1A or 1B Construction.

(f) In the case of a stand or stadium having a roof, the *height* may be measured from the top of *incombustible* construction where such construction is used for the support of seats.

(g) The *height* of grain elevators and flour mills in Type 1A Construction shall not be limited.

(h) The *height* of buildings of D2 occupancy in Type 4 construction may be 3 storeys, but not more than 35 feet if plank walls having a thickness of not less than 3 inches exclusive of any *sheathing* are used. (See Article 3.2.17).

MAXIMUM PERMISSIBLE AREAS (SQ. FT.) OF BUILDINGS FOR A GIVEN OCCUPANCY CLASSIFICATION(a) pays

Note: Where seats are installed or moved into an *assembly building*, their number in any one room shall be limited as indicated in this table.

Occupancy Group	Division of	Types of Construction						
		4	3	2	1C	3	4	5
	Occupancy Group (See Art. 4.2.1 for full details)	1A Fire Resistive	1B Fire Resistive	1C Fire Resistive	2 Heavy Timber	3 Masonry and Frame	4 Wood Frame	5 Unprotected Metal or Fire- retardant treated Wood
A	1 Theatres and motion picture theatres	Unlimited	10,000 ^(b) 1000 seats	10,000 ^(b) 750 seats	7,500 500 seats	5,000 500 seats	3,000 300 seats	5,000 500 seats
	2 Auditoriums, community halls, etc., including non-residential schools, and colleges	Unlimited	20,000 ^(b) 1500 seats	10,000 ^(b) 1000 seats	10,000 750 seats	5,000 500 seats	3,000 300 seats	Unlimited ^(c)
	1 Asylums, jails, etc.	Unlimited	25,000			Not permitted		
B	2 Children's shelters, hospitals, etc.	Unlimited	25,000	10,000	10,000	5,000	3,000	Unlimited
	1 Dry-cleaning plants employing flammable or explosive solvents or cleaners	Unlimited	25,000			Not permitted		
C	2 High hazard industrial occupancies	Unlimited	25,000	10,000	10,000	5,000	5,000 ^(d)	5,000 ^(d)
	3 Medium hazard industrial and commercial occupancies, excluding office buildings	Unlimited	25,000	10,000	10,000	5,000	5,000	Unlimited
		Unlimited	Unlimited	25,000	15,000	7,500	5,000	Unlimited
D	4 Low hazard industrial occupancies	Unlimited	Unlimited	25,000	15,000	7,500	5,000	Unlimited ^(e)
	1 Convents, dormitories, etc.	Unlimited	Unlimited	20,000	12,000	5,000	5,000	Unlimited
	2 Apartment houses, hotels, etc.	Unlimited	Unlimited	25,000	15,000	5,000	5,000	Unlimited
E	3 One- and two-family dwellings	Unlimited	Unlimited	25,000	15,000	5,000	5,000	Unlimited
	1 Private barns and garages, etc.	Unlimited	Unlimited	25,000	10,000	5,000	5,000 ^(e)	Unlimited
	2 Towers, water tanks	Unlimited	Unlimited	25,000	10,000	5,000	1,000	Unlimited ^(e)
	3 Stands and stadiums, etc.	Unlimited	Unlimited	25,000	15,000	7,500	3,000	Unlimited ^(e)

(a) The maximum permissible areas set forth in this table may be increased in accordance with Article 4.5.3.

(a) The maximum permissible area set forth in this section shall be increased in accordance with Article 22-303.

(b) The area and number of seats in a one-storey building shall not be limited when the conditions for unlimited *height* as given in footnote (a) of Table 1 of this Section are fulfilled; provided that the building is unsubdivided except for minor *partitions*, ticket booths, and necessary rooms for sanitary facilities and administrative purposes.

(c) If the building is located in Fire Zone No. 2 or Fire Zone No. 3, and if the area is limited to 20,000 sq. feet, untreated wood may be used:

- (i) For roof beams or purlins having a minimum nominal size of 6 by 10 inches provided that no part of any such member is closer than 14 feet to any floor or balcony; provided, however, that proximity within the 14-foot limiting distance of an inclined or stepped balcony or tier with fixed seats, or of a level mezzanine or balcony not more than 5 feet wide, shall be permitted.

- (ii) For roof *sheathing* having a minimum nominal thickness of 2 inches, provided all such *sheathing* is not less than 14 feet above any floor or balcony.
- (iii) For girts having a minimum nominal size of 3 by 6 inches.

(d) In Fire Zone No.3 aircraft hangers may be of unlimited area if draft stops are provided so as to divide the roof area into sections not exceeding 3500 square feet. Such draft stops shall extend to the bottom chords of roof trusses.

(e) The area shall be limited to 1,000 square feet in the case of a *garage* other than a *private garage*.
(f) The area shall be limited to 600 square feet in the case of gasoline service stations, paint shops or factories, public *garages* and storage buildings for paint or petroleum products.

4.5.2 Modifications to Maximum Permissible Heights

4.5.2.1 Roof Structures.—The limitations upon the *heights* of buildings as given in this Section shall not be held to limit the height of steeples, towers, cupolas, parapets, cornices, statuary, balustrades, railings, flag poles, weathervanes, *chimneys*, vent pipes, skylights, ventilators, steam exhausts, or signs, erected on and above the roof of a building. (For regulations concerning roof structure, see Section 4.17).

4.5.2.2 Chimneys and Other Isolated Structures.—This Code shall not be construed to limit the height of *chimneys*, smokestacks, gas storage tanks, water storage tanks not on a building, water cooling-towers not on a building, wireless masts, flag poles, or ventilator stacks.

4.5.3 Modifications of Maximum Permissible Areas

4.5.3.1 Area Separations.—No building shall be limited in *area* if it is subdivided by walls into sections none of which exceeds the limiting areas given in Table 2 of this Section. Such walls shall form a "special separation" as described in Item 4.2.3.3, and shall extend from the ground to, or through, the roof as required by Item 4.2.3.3. Such walls shall be continuous in buildings employing *combustible* floor assemblies, but in other buildings may be supported at intermediate levels by *beams*, *girders*, or floors having in each case a *fire-resistance rating* of at least 3 hours.

TABLE 3 (SECTION 4.5)

ALLOWABLE FACTORS FOR INCREASING THE MAXIMUM AREAS
OF BUILDINGS GIVEN IN TABLE 2

Conditions of Location or Construction Under which <i>Area</i> may be Increased	Buildings Belonging to Occupancy Groups A (Assembly), B (Institutional), D (Residential)	Buildings Belonging to Occupancy Groups C (Commercial and Industrial) or E (Accessory)
(i) Buildings fronting on two <i>streets</i>	1.3	1.5
(ii) Buildings fronting on three <i>streets</i>	1.5	2.0
(iii) Buildings having <i>approved</i> automatic sprinkler systems installed throughout all usable space*	2.0	2.0
(iv) Buildings not exceeding one <i>storey</i> or 35 feet in <i>height</i> , provided that any such building is not limited by Table 1 of this Section to a <i>height</i> of one <i>storey</i>	1.5	1.5

*In any building of mixed occupancy, a governing occupancy may have its allowable *area* increased, as indicated in Table 3 above, by the installation of *approved* sprinklers throughout that occupancy only.

4.5.3.2 Increase of Maximum Permissible Areas under certain Conditions.—The maximum permissible *areas* of buildings for various occupancies and types of construction as set forth in Table 2 of this Section, may be increased under the conditions set forth in Table 3 of this Section by multiplying them by the appropriate factor or factors given in Table 3. These factors are cumulative; i.e., where two factors are applicable to a building, they may be multiplied together and the resulting product shall be the allowable factor by which the *area* of the building may be increased.

SECTION 4.6 EXITS

4.6.1 General Requirements.—*Exits*, complying with the requirements of this Section, shall be provided for every building and for every *floor-area*, balcony, gallery, and tier; excepting that *exits* in *detached one- and two-family dwellings*, and *exits* wholly contained within and serving only one *dwelling unit*, shall not be regulated by the requirements of this Section. In addition, every room shall have access to one or more *exits* as prescribed in Item 4.6.5.2 (a); and all stairs located in any path of *exit* travel shall meet the requirements of Item 4.6.6.2, except as permitted for *fire escapes*.

For the purposes of this Section, any roof designed or intended for *public* use shall be considered to be a *floor-area*.

Where *exits* are provided in addition to those required by this Section, they shall comply with the minimum requirements herein specified in respect of dimensions and construction.

No *exit* shall diminish in width as it approaches a *street*; neither shall it diminish in security and safety except as specifically permitted in Item 4.6.4.1 and Article 4.6.7.

Where the term *street* is used as indicating the ultimate goal of an *exit*, it shall be interpreted as including any space open from ground to sky which is sufficiently large to constitute a place of safe refuge.

4.6.2 Types of Exits.—*Exits* shall consist of the following, used either singly or in association to provide the necessary passage:

- Exterior passageways*
- Exterior stairways*
- Exterior ramps*
- Fire escapes*
- Enclosed straight slide escapes*
- Doorways*
- Interior passageways*
- Horizontal exits*
- Interior stairways*
- Interior ramps*
- Elevators.*

Hallways and corridors are not, in general, considered to be *exits*, but are regarded as providing access to the *exits* from the *storey* or *floor-area* in which they are located. However, a *hallway* or corridor may form part of an *exit*, e.g., a corridor connecting a *stairway* to the exterior of a building; and such a *hallway* or corridor is considered an *interior passageway* and must comply with the requirements described herein for an *interior passageway*. space

4.6.3 Restrictions on the Use of certain Types of Exits.—

Exits consisting in whole or in part of an exterior *stairway* or an exterior ramp more than 15 feet high shall not constitute more than one-half of the required number of *exits* from any *floor-area*. x

Fire escapes and *enclosed straight slide escapes* shall not be permitted to serve any Group B (Institutional) Occupancy or any Group A (Assembly) Occupancy excepting the back-stage areas, provided that *enclosed straight slide escapes* may be used to correct a deficiency in *exits* in buildings of Group B, Division 2, Occupancy not more than 45 feet in height. admission

Exits consisting in whole or in part of *fire escapes* or *enclosed straight slide escapes* shall not constitute more than one-half of the required number of *exits* from any building or *floor-area*, and shall not be constructed on any building more than three *storeys* or 45 feet in height; except that where an existing occupancy is deficient in *exits*, the authority having jurisdiction may require the deficiency to be corrected, in which case *fire escapes* may be erected on buildings not exceeding 6 *storeys* or 70 feet in height. x
obtain

Horizontal exits shall not constitute more than one-half of the required number of *exits* from any *floor-area*. x

An elevator shall not serve as part of a required *exit* except in Group D, *Residential Buildings*, and in office buildings where such buildings are of Type 1A or 1B Construction, or 1C with *incombustible* floors. In any *floor-area* of such a building, a bank of two or more passenger elevators may serve as part of not more than one of two or more required *exits*. }

Every *floor-area* shall have at least one *exit* independent of elevators, *fire escapes*, *enclosed straight slide escapes*, and *horizontal exits*.

4.6.4 Outlets from Exits

4.6.4.1 Continuity of Exits.—

(a) In no building shall any *exit* pass through any room or space used for purposes other than as an *exit* or entrance, except in the case of:

- (i) A *horizontal exit*;
- (ii) *Exits* in Office or *Residential Buildings* to the extent that the path of not more than one-half of the required *exits* may lead through a *hallway* or lobby having stores, *restaurants*, or other business occupancies opening thereon; provided that the lobby floor is not more than 15 feet above x

the *street* level at the entrance thereto, and provided further that such business occupancies of a *combustible* nature shall be protected by an *approved* automatic sprinkler system, and provided that in no case shall the path of travel across a lobby or *hallway* from a *stairway*, ramp, or elevator, to a door opening on a *street* or *exterior passageway* exceed 50 feet;

- (iii) An *Institutional Building*, where one of two or more *exits* may lead through a *hallway* or lobby, provided that the lobby floor is not more than 15 feet above the *street* level at the entrance thereto;
- (iv) *Exits* from stores of Type 1A or 1B Construction, or 1C with *incombustible* floor assemblies, to the extent that not more than one-half of the interior *stairways* or ramps serving upper floors may discharge onto a *floor-area* not more than 15 feet above the level of the *street* at the entrance thereto, provided that an unobstructed aisle at least as wide as such *stairway* is maintained from each such *stairway* to an *exit* from the building, and provided further that the building is equipped throughout with *approved* automatic sprinklers.

(b) Nothing in this Code shall prohibit the location of office facilities on the ground floor of any *Residential* or *Institutional Building* in a space through which an *exit* passes; provided that such an office is necessary for the control and supervision of the occupancy, that it does not obstruct the *exit*, and that the *exit* and office shall together be enclosed when the *exit* is required to be enclosed.

4.6.4.2 Access to Roofs.—

(a) In all buildings, or parts thereof, of other than Type 1A or 1B Construction, more than three *storeys* or 45 feet *high* with roofs having a pitch of not more than one in four, excepting *detached one- and two-family dwellings*, at least one required interior *stairway* shall be continued to and through the roof by means of a *bulkhead*.

(b) Excepting *detached one- and two-family dwellings*, roofs of buildings more than 25 feet *high* to which *stairway* access is not provided shall be provided with a scuttle not less than 2 by 3 feet with a fixed or hinged ladder leading thereto from the *storey* immediately below. At least one *stairway* or scuttle shall be provided through every 6000 square feet of horizontal roof projection or fraction thereof.

4.6.5. Number, Location, and Width of Exits

4.6.5.1 General.—The size and number of *exits* from any *floor-area* shall be determined from the number of persons for whose accommodation such *floor-area* is designed or intended, provided that in no case shall the number of persons be assumed to be less than the number obtained by dividing the gross *floor-area* by the area per person prescribed in Table 1 of this Section for the occupancy concerned. The gross *floor-*

area shall be the area within the enclosing walls or *partitions*, no deduction being made for other walls or *partitions*, or for corridors, closets, or other subdivisions.

It is not intended that the requirements for aggregate *exit* width (see Item 4.6.5.4) should be cumulative from *storey* to *storey* as the path of an *exit* passes through more than one *storey* toward safety.

TABLE 1 (SECTION 4.6)
MAXIMUM AREA OF FLOOR SPACE PER PERSON TO BE ASSUMED IN
DETERMINING THE NUMBER OF PERSONS TO BE
ACCOMMODATED BY EXITS

Occupancy	Maximum Area of Floor Space per Person, in Square Feet
Arenas, Auditoriums, Churches, Dance Halls, Exhibition Buildings, Lodge Rooms, Passenger Stations, <i>Theatres</i> , and similar <i>places of assembly</i> (see paragraph below).....	15
Libraries, Schools, Courtrooms, Museums, and similar occupancies; <i>Restaurants</i>	40
Stores; Street floor and sales basement.....	30
Other floors.....	60
Offices, Factories, and Workrooms, <i>Stages</i> and 'Back-stage' Areas	100
Hotels and Apartment Houses.....	125
<i>Institutional Buildings</i>	150
Warehouses, <i>Garages</i> , Storage Buildings.....	300

In *places of assembly*, *theatres*, dance halls, lodge rooms, and similar occupancies, when seating arrangements with fixed seats are used or contemplated, the seating capacity shall be established by allowing 6 square feet per person in that portion used for seating, including aisles but excluding foyers, lobbies, toilets, and utility rooms.

The population of a *mezzanine floor* or balcony discharging onto a floor below shall be added to the population of the latter.

For occupancies not specified in Table 1, the *authority having jurisdiction* shall establish the ratio to be assumed.

4.6.5.2 Number of Exits*

(a) **From Rooms.**—Doorways from rooms are not necessarily *exit* doorways. Notwithstanding this fact, the number of such doorways to be provided is herein regulated. (For requirements respecting the widths of such doorways, see Item 4.6.5.4.)

Every room excepting a kitchen or an *accessory room* shall have at least one doorway providing access through not more than one other room to an *exit* from the *floor-area*, or to a corridor or *hallway* leading directly to an *exit* from the *floor-area* in which such room is located.

Every room intended for more than 100 persons shall have at least two doorways, remote from each other, each of which leads through not more than one other room to an *exit* or to a corridor or *hallway* leading directly to an *exit* from the *floor-area* in which such room is located.

*The number of *exits* may also be determined partly from the requirements for location of *exits* (Item 4.6.5.3).

(b) **From Floor-areas on the Ground Floor.**—Every *floor-area* to which there is *direct access* by doorways from a *street* (i.e., a ground floor), and which is designed or intended for more than 100 persons, or which has an area in excess of 3000 square feet, shall have at least two independent *exits*.

(c) **From Floor-areas not on the Ground Floor.**—Every such *floor-area* shall have *direct access* to at least two independent *exits*, except that in the following cases one *exit* shall be sufficient:

- (i) *Floor-areas* of 3000 square feet or less in buildings of Type 1A, 1B, or 1C Construction not over three *storeys* in *height* whose occupancies are included in Division 3 or 4 of Group C, Commercial and Industrial, or in Group D, Residential, or in Group E, Accessory.
- (ii) *Floor-areas* of 3000 square feet or less in buildings of any type of construction not over two *storeys* in *height* whose occupancies are included in Division 3 or 4 of Group C, Commercial and Industrial, or in Group E, Accessory.
- (iii) Any *floor-area* wholly contained within a *dwelling unit* located within two *storeys* of the ground when such *dwelling unit* has principal means of access by a private doorway or *stairway* from the *street*.
- (iv) *Floor-areas* in apartment houses when each apartment has private access to a second *exit*.
- (v) *Floor-areas* of 6000 square feet or less in a building of Type 1A, 1B, or 1C Construction used for any occupancy classified under Division 3 or 4 of Group C, when the building is sprinklered throughout and the maximum distance* from any point on the *floor-area* to an *exit* does not exceed 50 feet; provided, however, that sprinklers shall not be required in office buildings.

(d) **From Places of Assembly.**—

- (i) Every *floor-area*, balcony, gallery, or tier, designed or intended as a *place of assembly*, for 100 or more persons, shall have *direct access* to not less than the number of *exits* indicated in Table 2 of this Section.

TABLE 2 (SECTION 4.6)
EXITS REQUIRED FOR PLACES OF ASSEMBLY

Number of Persons	Number of <i>Exits</i> Required
100 to 600	2
601 to 1,000	3
More than 1,000	4

*In the case of *floor-areas* subdivided into small rooms or offices, the distance may be measured from the corridor entrance of any such room to the *exit*.

- (ii) Where a permanent *stage* employing movable scenery is constructed in a *place of assembly*, such a *stage* and its appurtenant rooms and spaces shall have *exits* separate and apart from the *assembly room exits*. Each side of the *stage* shall have *direct access* to at least one *exit*; any usable space beneath a *stage* shall have *direct access* to at least one *exit* and means of access to at least one other *exit*; each fly gallery or gridiron shall be served by a *stairway* meeting the requirements of Sub-items 4.6.6.6 (d) and (e) leading to the *stage* floor; each tier of dressing rooms shall be considered as a *floor-area*, and shall be provided with at least two *exits*, one of which shall be independent of any *stage exit*.
- (iii) Every *exit stairway* or ramp, serving a *theatre* or *motion-picture theatre* located in a building which contains other occupancies, shall be separate and independent from any *stairway* or ramp serving such other occupancies.
- (iv) Every *exit stairway* or ramp, leading from any balcony or gallery above the first balcony to the exterior of the building or to the main lobby, shall be separate and independent from any other *stairway* or ramp. (See also Sub-item 4.6.7.2(e).)
- (v) *Exits* from a balcony or gallery in a *place of assembly* shall be so located that they may be reached by an ascent of not more than 10 feet, or a descent of not more than 6 feet; and when *exits* at different levels in a gallery are provided, the difference shall not exceed 12 feet.

(e) **From Institutional Occupancies.**—Every *floor-area* which is designed or intended for occupancy by bedridden patients and which exceeds 3000 square feet in area shall have at least one *exit* consisting of a *ramp* or *horizontal exit*, or a doorway leading directly to a *street* or *exterior passageway* and involving no steps.

(f) **From Stadiums and Reviewing Stands.**—Every stadium and reviewing stand shall have at least two *exits*. Not less than one *exit* shall be provided for every 1200 people or major fraction thereof which the *structure* is designed to seat, and *exits* shall be spaced not more than 75 feet apart.

(g) **From Boiler Rooms.**—There shall be at least two separate and independent *exits* from any room below *grade* containing steam boilers other than low pressure domestic heating boilers, or refrigerating machinery using flammable or toxic gas or vapour. For the purposes of this Item, an iron ladder or stair leading directly from the boiler room through a manhole to a *street* or to an *exterior passageway* shall be considered as an *exit*, provided the manhole can be readily opened from the inside.

4.6.5.3 Location of Exits.—

(a) **Distance to Exits.**—*Exits* in buildings of Type 1A, 1B, or 1C (Fire-resistive) Construction, or Type 5 (Unprotected Metal or Fire-retardant Treated Wood) Construction shall be so located that no point

in any *floor-area*, room, or space served by them is more than 150 feet distant from an *exit* measured along the line of *exit* travel; *exits* in buildings of other types of construction shall be so located that no such point is more than 75 feet distant from an *exit*.

When *floor-areas* are subdivided into smaller areas, served by corridors, such as rooms in *hotels* and office buildings, the distance to an *exit* shall be measured from the corridor entrance of such rooms to the nearest *exit*.

(b) Distribution of Exits.—Where separate *exits* are required for a *floor-area*, they shall be placed as remote from each other as practicable.

Where more than two *exits* are required, they shall be distributed as uniformly as practicable within or around the *floor-area*, room, or space served, to effect a rapid discharge of occupants. For distribution of stadium *exits*, see Sub-item 4.6.5.2 (f).

Not more than two-thirds of the required total *exit* capacity serving a *place of assembly* or balcony or tier therein shall be through a main lobby or foyer.

4.6.5.4 Width of Exits.—

(a) General Requirements.—No *hallway*, *stairway*, *passageway*, or ramp shall decrease in width in the direction of *exit* travel except as permitted in Item 4.6.6.9 with respect to doors.

(b) Aggregate Width based on Population.—The required aggregate width of *exits* from any building or *floor-area* shall be in proportion to the relative internal fire hazard of the occupancy, modified in the case of *residential* and *institutional buildings* by the fact that circumstances may militate against rapid evacuation.

The clear width of *exits* (*stairways*, *passageways*, ramps, doorways, etc.) shall be expressed in units of 22 inches, and the least total number of such units required for any *floor-area* shall be determined by dividing the total population on the *floor-area* (see Item 4.6.5.1 and Table 1) by the figure given in Table 3 of this Section for the occupancy concerned. Twelve inches or more of width when added to one or more full 22-inch units may be considered as half a unit.

The required aggregate *exit* width shall not be cumulative from *storey* to *storey*, but shall be cumulative on any one floor; but where one or more *stairways* feed into one *passageway*, such *passageway* shall have a minimum width based on the total population to be served, and any door therefrom likewise, except as provided in Item 4.6.6.8 for door clearances. In addition, the *passageway* and doorway therefrom shall be increased in width as required for any tributary adjacent *floor-area*.

Where elevators are permitted as required *exits* (see Article 4.6.3), one passenger elevator shall be considered an equivalent to one-third of a unit of *exit* width.

Where *enclosed straight slide escapes* are permitted as required *exits* (see Article 4.6.3), one such escape, complying with the requirements of Item 4.6.6.7 shall be considered as constituting two units of *exit* width.

TABLE 3 (SECTION 4.6)
DETERMINATION OF UNITS OF EXIT WIDTH

Occupancy		Number of Persons Per Unit of <i>Exit</i> Width	
General Description	Classification		
	Group	Division	
High hazard industrial occupancies	C	1 and 2	50
<i>Stages</i> and back-stage areas	A	1	50
Institutional occupancies	B	1 and 2	50
Residential occupancies	D	1 and 2	50
Medium or low hazard commercial and industrial occupancies	C	3 and 4	100
<i>Places of assembly</i>	A	1 and 2	100
Stadiums and reviewing stands	E	3	300
Other occupancies	E	1 and 2	100

*This figure of 60 may be increased to 100 when the *exits* lead directly to a *street* or *exterior passageway*, and do not serve any other occupancy.

(c) Minimum Width of Stairways (Interior and Exterior).—
The minimum unobstructed width of any *exit stairway* shall be 44 inches provided:

- (i) that handrails may project not more than 3½ inches into such width;
- (ii) that in Group D Occupancies (Residential) having sleeping accommodation for not more than 50 persons, and in Group C (Commercial and Industrial) or Group E (Accessory Buildings) occupied by a single tenant and limited in occupancy to 50 persons, such width may be 36 inches;
- (iii) that in back-stage areas of *theatres*, *stairways* serving fly galleries, gridirons, or tiers of dressing rooms may have a minimum width of 30 inches, and *stairways* serving the *stage* or sub-stage may have a minimum width of 36 inches;
- (iv) that in Group B Occupancies (Institutional) any *exit stairway* serving bedridden patients shall not be less than 48 inches in width;

(v) that where *stairways* are required by Item 4.6.4.2 to lead to and through a roof and do not serve any occupancy on the roof, their width may be 30 inches;

(vi) that *exit stairways* from stadiums and reviewing stands shall have a minimum width of 88 inches.

(d) **Minimum Width of Ramps.**—*Exit* ramps shall be of the same minimum width as *exit stairways*.

(e) **Minimum Width of Fire Escapes.**—The minimum unobstructed width, clear of handrails and guards, of any platform, balcony, or *stairway* forming part of a *fire escape* shall not be less than 22 inches.

(f) **Minimum Width of Passageways.**—The minimum width of any *interior passageway* shall be 36 inches; provided that every *passageway* serving a stadium or reviewing stand shall have a width of not less than 88 inches.

The minimum width of an *exterior passageway* shall be 3 feet, and in no case less than the sum of the required *exit* widths emptying into it from any one building.

(g) **Minimum Width of Doorways.**—The following requirements respecting the width of doorways may be modified in respect of the clear opening between stops or jambs in accordance with paragraph (i) of Sub-item 4.6.6.9 (a).

No doorway forming part of any *exit* from a *floor-area* or from a building shall have a width of less than 36 inches; provided that in an Institutional Occupancy any doorway serving as an *exit* for bedridden patients shall be not less than 48 inches wide; and provided further that where an *exit* such as a *fire escape* or a 'back-stage' *stairway* has a width of less than 36 inches, such an *exit* may be served by a doorway not less wide and in no case less than 30 inches.

Where a doorway is divided into two or more separate door openings, each such opening shall be measured separately in computing the number of units of *exit* width; and the minimum clear width of any such opening shall not be less than 28 inches.

No single swinging door in any *exit* doorway shall exceed 44 inches in width.

Notwithstanding the fact that doorways from rooms are not necessarily *exit* doorways, every doorway providing egress from a room occupied by more than 30 persons shall conform to the requirements of this Item in respect to width.

4.6.6 Construction of Exits

4.6.6.1 Use of Combustible and Incombustible Construction*.—

(a) **Interpretation.**—When an *exit* or any part thereof is required to be constructed of *incombustible* materials, then all construction which supports such *exit* or such part thereof and transfers its *live* and *dead*

*For requirements regarding enclosure and *fire-resistance ratings* of *exits* and parts thereof, see Article 4.6.7.

loads to the ground shall also be of *incombustible* materials; likewise all enclosure walls and *partitions* and all ceilings forming part of the *exit* shall be of *incombustible* materials.

The regulations of this Item shall be subject to any more restrictive requirements given elsewhere in this Code respecting *exits* from places devoted to certain specified uses.

(b) **Type 1A or 1B Construction.**—*Exits* shall be constructed of *incombustible* materials throughout in buildings of Type 1A or 1B Construction. This requirement shall include all treads, risers, stringers, and landings of *stairways*, but shall not prohibit the use of linoleum or wood finishes for floors of ramps and *passageways*. (See also Sub-item 4.3.3.2 (b).)

(c) **Type 1C or Type 2 Construction.**—In buildings of either Type 1C or Type 2 Construction more than four *storeys high*, all *exits* shall be constructed of *incombustible* materials throughout in accordance with (b) immediately above. When such buildings are four *storeys* or less in height, *combustible* materials may be used in the construction of *exits* except as otherwise required by (e) of this Item.

(d) **Type 3 or 4 Construction.**—*Exits* may be constructed of *combustible* materials in buildings of Type 3 or Type 4 Construction.

(e) **Special Requirements for Combustible Construction.**—Regardless of whether an *exit* or any part thereof is required to be enclosed by Article 4.6.7, all *combustible* floor assemblies, and all *combustible* stairs and landings forming part of any interior *exit* shall have their undersides protected by a ceiling having a *fire-resistance rating* of at least one hour*, furthermore, no upright wood support for any *exit* or part thereof shall have a nominal dimension less than 6 inches, unless it forms part of a *partition* that has a *fire-resistance rating* of at least one hour. These requirements shall not apply to *basement* stairs. In addition, all interior *combustible* walls or *partitions* adjacent to and bounding any *exit* shall have a *fire-resistance rating* of at least one hour.

4.6.6.2 Interior Stairways.—

(a) **General.**—When treads or landings are of *stone*, *masonry*, or ceramic material, they shall be supported under their entire area by solid steel plates at least 1/8 inch thick, securely fastened; provided that when stairs are of *incombustible* construction (e.g., *reinforced concrete*) throughout, such treads and landings may be solidly supported for their entire length and width by the material of which such stairs are constructed.

Treads and landings shall be solid and shall be so constructed as to prevent persons from slipping thereon.

*The *fire-resistance rating* of any ceiling shall mean that of such ceiling in association with any floor construction or flight of stairs immediately above it. This Item shall not require protection of the exposed face of an outside string having a thickness of 1 3/4 inches or more.

In *assembly buildings*, flights of less than 3 risers shall not be used in aisles or in connection with required *exits*. To overcome lesser differences in level, ramps having gradients not exceeding 1 foot in 8 may be used.

Every *stairway* shall have a head room clearance of not less than 6 feet 9 inches, measured vertically above any landing, or the nosing of any stair tread.

(b) Treads and Risers.—

- (i) Treads and risers shall be so proportioned that the product of the width of tread, exclusive of nosing, and the height of riser, in inches, shall be not less than 70 nor more than 75; risers shall not exceed $7\frac{3}{4}$ inches in height, and treads, exclusive of nosing, shall be not less than 9 inches wide; provided that in schools the proportion and dimensions of the treads and risers may, at the discretion of the *authority having jurisdiction*, be adjusted to suit the age of the pupils for which the school is intended. Treads and risers shall be of uniform width and height in any one flight.

All treads less than 10 inches wide shall have a nosing of approximately one inch over the tread or landing immediately below.

- (ii) The use of winders is prohibited in *exit stairways*, except in the case of monumental *stairways* which do not constitute part of the required aggregate width of *stairways*, but in no case shall any tread have a width at any point less than 8 inches, exclusive of nosing.

(c) Landings.—No flight of stairs shall have a vertical rise of more than 12 feet between floors or landings; provided that flights of stairs serving as *exits* from Group A (Assembly) Occupancies shall have a vertical rise of not more than 8 feet between floors or landings.

The length and width of landings shall be not less than the width of *stairways* in which they occur, provided that in a straight run, the distance between risers on a landing shall not be required to exceed 44 inches.

(d) Guards and Handrails.—Every *exit stairway* shall have a wall or a well-secured balustrade or guard on each side.

Every *exit stairway* when less than 44 inches in width shall have a handrail on at least one side, and when 44 inches or more in width, shall have handrails on both sides.

When the required width of a flight of stairs exceeds 88 inches, one or more intermediate handrails, continuous between landings, shall be provided; and the number and position of these intermediate handrails shall be such that there will be not more than 66 inches between handrails, provided that in schools there shall be an intermediate handrail when the width of the *exit stairway* exceeds 66 inches.

Handrails shall be so constructed that there will be no obstruction on or above them tending to break a hand hold.

(e) **Space Under Stairs.**—Except for stairs within and serving only *one dwelling unit*, the space under stairs built in whole or in part of *combustible* materials shall be left entirely open and kept clear and free from encumbrance, or shall be entirely closed without openings thereto.

(f) **Basement Stairs.**—When any *exit stairway* leading from an upper floor to an *exit* from a building is continued past the level of such *exit* so as to provide access to any lower floor, such continuation shall be assumed to be a part of such *exit stairway* and shall comply with the requirements herein specified with respect to enclosure for such *exit stairways*.

(g) **Escalators.**—Any escalator of the horizontal tread type moving downward when serving *storeys* above an *exit* from a building or moving upward when serving *storeys* below such *exit*, and any escalator which is equipped at the head of each flight with a device for stopping all flights simultaneously, may be considered as an *exit stairway*, provided that it conforms in all respects, except minimum width, to the requirements of this Section. The width shall not be less than 24 inches, and no credit for additional width shall be allowed in determining *exit capacity* unless the width is 44 inches or more.

4.6.6.3 Exterior Stairways.—

(a) **General.**—Exterior *stairways* shall conform to the requirements for interior *stairways* as set forth in Sub-items 4.6.6.2 (a), (b), and (c). No part of any exterior *stairway* shall be within 5 feet of a *lot line* unless such *lot line* bounds a *lane*, in which case the minimum distance from the centre line of the *lane* shall be 5 feet.

(b) **Access.**—Access to exterior *stairways* from any *floor-area* shall be through *exit* doors at floor level.

(c) **Guards and Handrails.**—Every exterior *stairway*, its landings and platforms, shall have guards on their open sides at least 4 feet high. Such guards shall be of solid, slatted, grille or mesh construction with no opening greater than 6 inches in any dimension. Handrails shall be provided as required by Sub-item 4.6.6.2 (d).

(d) **Protection of Adjacent Openings.**—The regulations of this Sub-item apply only to the building served by the exterior *stairway* under consideration.

Where exterior *stairways* serve any *storey* above the *second*, all openings, including access doorways, any portions of which are within the limits set forth below, shall be protected by *fire-resistive closures* meeting the requirements of Section 4.12, provided that when an exterior *stairway* is sufficiently enclosed to be subject to the enclosure requirements for interior *stairways*, (see Item 4.6.7.4), this Sub-item shall not apply:

- (i) **Horizontally.**—Openings within 15 feet of any balcony, platform, or *stairway*. Protection need not extend around a right angle corner (outside angle of 270 degrees) except where any part of the exterior *stairway* is within 5 feet of the corner;

- (ii) Below:—Openings within 3 storeys or 35 feet of any balcony, platform, or *stairway*;
- (iii) Above:—Openings within 10 feet of any balcony, platform, or *stairway* measured vertically from any floor or tread.

4.6.6.4 Horizontal Exits.—

(a) **Area on either Side.**—The *floor-area* on either side of a *horizontal exit* shall be sufficient to hold the occupants of both *floor-areas*, allowing not less than $3\frac{1}{2}$ square feet of clear floor space per person.

(b) **Clear Width of Parts.**—When vestibules, open air balconies, or bridges are used as parts of any *horizontal exit*, they shall be constructed of *non-combustible* material and their clear width shall be at least as great as that of the *exit* doorways opening into them, except that hand-rails may project into this clear width not more than $3\frac{1}{2}$ inches.

(c) **Gradients.**—In any *horizontal exit*, where there is a difference in level between the connected *floor-areas*, gradients not exceeding those herein specified for ramps may be provided. No stairs or steps shall be used in a *horizontal exit*, provided that, as a means of avoiding blocking of *exit* doors by snow or ice, a bridge or balcony may be located not more than 8 inches below the level of the floor served.

(d) **Doors for Horizontal Exits.**—Every opening used in connection with a *horizontal exit* shall be protected by either *self-closing* swinging *fire-resistive* doors or by *automatic* sliding *fire-resistive* doors. (See Section 4.12 for requirements pertaining to *fire-resistive* doors and more especially Items 4.12.4.1 and 4.12.4.2.) *Automatic* doors shall only be used when the nature of the occupancy concerned necessitates them.

When swinging doors are used, there shall be two such doors mounted adjacent to each other in each wall or *partition* concerned. These adjacent doors shall swing in opposite directions, and signs on each side of the wall or *partition* shall indicate as the *exit*, the door which swings in the direction of travel from that side. These adjacent doors may be mounted in adjacent but separate openings, or may be mounted in one opening and meet on a mullion, provided that the size of the one opening shall not exceed that permitted in Item 4.12.4.2. Other arrangements providing doors swinging always in the direction of any possible *exit* travel may be *approved* by the *authority having jurisdiction*.

(e) **Guards.**—Guards shall be provided not less than 4 feet high on the open side of any bridge or balcony, such guards may be of solid, slatted, grille or mesh construction, and no opening in such guards shall exceed 6 inches in its least dimension.

(f) **Protection of Adjacent Openings.**—Openings adjacent to bridges and balconies shall be protected as required for exterior *stairways* unless solid sides, at least 6 feet high, are provided.

4.6.6.5 Ramps.—Ramps serving as *exits* or giving access to *exits* shall have a slope not greater than 1 in 8. They shall otherwise comply with all applicable requirements for *exit stairways*. Ramps

shall be provided with an *approved* non-slip surface. Ramps used for purposes other than *exit* travel shall not be limited as to gradient.

4.6.6.6 Fire Escapes.—

(a) **General.**—*Fire escapes* shall be of metal, of the stair type extending to ground level, constructed throughout in a strong, substantial manner, and securely fixed to the building; provided that wooden *fire escapes* may be used on buildings of Type 4 (Wood Frame) Construction if all posts and brackets are not less than 4 inches in their least nominal dimension, and all other *woodwork* is not less than 2 inches in its least nominal dimension. No part of any *fire escape* shall be within 3 feet of a *lot line* unless such *lot line* bounds a *lane*, in which case the minimum distance from the centre line of a *lane* shall be 3 feet.

(b) **Access.**—Access to *fire escapes* shall be from *hallways* or corridors through doors at floor level, except that in any apartment building where *fire escapes* are provided for each apartment, access may be through a casement window located in any room other than a bathroom.

(c) **Protection of Adjacent Openings.**—Where a *fire escape* serves any *storey* above the *second*, all openings including access doorways in the exterior walls of the building to which the *fire escape* is attached, shall be protected by *fire-resistive closures* meeting the requirements of Section 4.12 when they are located within the limits set forth below:

- (i) Horizontally:—Openings within 8 feet of any balcony, platform, or *stairway*;
- (ii) Below:—Openings within 3 *storeys* or 35 feet of any balcony, platform, or *stairway*;
- (iii) Above:—Openings within 6 feet of any balcony, platform, or *stairway*.

(d) **Dimensions of Stairs and Balconies.**—Stairs shall have risers of not more than 10 inches in height and treads of not less than 8 inches in width exclusive of nosing, and shall be inclined at an angle of not more than 50 degrees with the horizontal. *Stairways* shall have not less than 6 feet 9 inches headroom, measured vertically above the nosing of any tread or platform. Where doors open on to balconies such balconies shall have a clear floor-area of not less than 12 square feet. Winders shall not be used unless the requirements for minimum width of tread are observed.

(e) **Guards and Rails.**—The open sides of every platform, balcony, and *stairway* shall be protected by substantial guards not less than 3 feet in height measured vertically above the nosing of any tread or platform. Two equally spaced rails not more than 18 inches apart parallel to stair stringers and to platform edges shall be the minimum of protection, and the top rail may serve as a handrail if free from obstructions which could break a hand hold.

(f) **Access to the Ground.**—When the flight of stairs leading to the ground at the foot of a *fire escape* is not permanently fixed, it shall be held in the 'up' position without a latch or locking device, and shall be fitted with an *approved* counter-balancing device that will permit it to be easily and quickly brought into position for use.

4.6.6.7 Enclosed Straight Slide Escapes.—

(a) **Slope.**—The slope of an *enclosed straight slide escape* shall be not less than 24 degrees and not more than 42 degrees to the horizontal. On all *enclosed slide escapes* having slopes greater than 30 degrees, there shall be a section at the lower end at least 10 feet long, set at an angle not to exceed 15 degrees to the horizontal, connected to the upper section by a transition curve.

(b) **Width.**—*Enclosed straight slide escapes* shall be not less than 24 inches nor more than 42 inches wide, provided that where such escapes are intended for the use of bedridden patients the width shall be not less than 34 inches.

(c) **Access.**—Access to *enclosed slide escapes* shall be through doorways at floor level, provided that where such escapes are used on *existing* buildings in order to correct a deficiency of *exits*, access may be through casement windows swinging in the direction of *exit* travel. The sill height of such casement windows shall not exceed 3 feet above the floor.

(d) **Doors.**—Doors shall be provided at each entrance, swinging with the *exit* travel, so constructed that they will not obstruct the use of the escape. Door openings shall be at least 30 inches wide and at least 6 feet 6 inches high. Where entrance is directly from the building with no intervening landing or balcony, access openings may be not less than 3 feet 6 inches high. No door shall be allowed at bottom or discharge point of the escape. The lower edge of the escape at the discharge point shall be at least 12 inches and not more than 20 inches, above the ground or walk-way level. Where an *enclosed straight slide escape* is provided for use of bedridden patients, the lower end shall terminate with a straight level discharge table at least 15 feet in length so arranged as to allow access to both sides.

Where snow or ice may obstruct the discharge point, a shed shall be provided made of *incombustible* materials, having a clear height of not less than 7 feet, with roof not less than 8 feet wide and not less than 8 feet long, connected with the slide by metal flashing. Where discharge tables are installed, the roof shall extend at least 4 feet beyond the end of the table. All *enclosed slide escapes* shall lead directly to the *street* or to an *exterior passageway*.

(e) **Construction.**—*Enclosed straight slide escapes* shall be constructed of *incombustible* materials throughout. The slide shall be made of galvanized steel with joints lapping over in the direction of descending loads or with edges of adjoining sections flanged so as to form a flush joint; all rivets, bolts, etc., shall be flat-headed, countersunk, and protected by solder. The horizontal distance between vertical supports for *slide escapes* shall not exceed 10 feet.

4.6.6.8 Interior Passageways.—

(a) *Interior passageways* shall have a clear height of not less than 7 feet.

(b) The *passageway* and *stairways* shall be so arranged as to keep the length of *passageway* to a minimum.

(c) When the floor of any *interior passageway* is not level, a gradient of not more than 1 in 8 may be used; provided that when a doorway or *stairway* empties into such a *passageway* through a side wall, there shall be a level area extending across the full width of the *passageway* and for a distance of 12 inches on either side of the wall opening (excepting one side when it abuts an end wall); and provided that when they empty through an end wall, there shall be a level area across the full width of the *passageway* and along its length for at least 36 inches.

4.6.6.9 Doorways.—

(a) Hanging of Doors.—

- (i) The doors of *exit* doorways shall be so hung and arranged that when open they shall not diminish or obstruct the required width of the doorway, *passageway*, *hallway*, *stairway*, or other means of *exit*, by more than 2 inches for each full 22-inch unit. Swinging doors in their swing shall not reduce the effective width of *stairways* or landings to less than 30 inches, nor shall they reduce the effective width of a *passageway* or *hallway* to less than the minimum width required.
- (ii) All doors in *exit* doorways shall open in the direction of *exit* travel excepting doors in Group D Occupancies, Divisions 2 and 3, and doors serving only a ground floor area of not more than 1500 square feet; provided that this requirement shall not prohibit the use of doors swinging both inwards and outwards, nor of sliding doors in stables, *garages*, or shipping and receiving rooms of business buildings and storage buildings. Vertical sliding doors or rolling shutters shall not be used.
- (iii) All doors, whether *exit* doors or not, which lead from rooms occupied by 50 or more persons shall be hung to swing in the direction of *exit* travel.
- (iv) No *exit* door shall open immediately on a flight of stairs, but shall open on a landing of which neither the length nor width shall be less than the width of such door. No riser of any flight of stairs shall be located within one foot of the jamb of an *exit* door.

(b) Revolving Doors.—

- (i) Revolving doors shall be classified as follows: Type A, so designed that simultaneous outward forces exerted by persons of ordinary strength on both sides of the door

pivot will cause the wings to fold back like the leaves of a book in the direction of egress thus providing two paths of egress through the vestibule; Type B, so designed that the wings are maintained in position by braces which may be released manually allowing the wings to be collapsed so as to permit free egress through the vestibule.

- (ii) Revolving doors and their vestibules shall comply with the fire-resistive qualities required for other types of doors and enclosures similarly located. At least one push bar shall be provided on each wing. Any glass in wings or enclosures shall be at least 1/4 inch plate.
- (iii) Revolving doors shall be mechanically governed against speeds in excess of 15 revolutions per minute. Failure of the governor shall not hinder door action.
- (iv) Revolving doors shall be credited as *exits* only to an extent equal to the minimum clear unobstructed width through the vestibule when the wings are collapsed. No revolving door shall be less than 6 feet in diameter.
- (v) Revolving doors shall not be used except in doorways giving *direct access* to a *street* or *exterior passageway*. Revolving doors shall not be used to serve *assembly buildings* or *institutional buildings*, nor shall they be used in the path of an *exit* from any *place of assembly* in which more than 300 persons can congregate. Type A revolving doors shall constitute not more than 75 per cent of the required total width of *street exit* doors at any one location, and Type B revolving doors shall constitute not more than 50 per cent of the required total width of *street exit* doors at any one location; provided that a Type A revolving door may constitute the total required *exit* width when it serves only a ground floor area of not more than 3000 square feet.

(c) Door Fastenings.—

- (i) Fastenings on any required *exit* door shall be such that the door may be readily opened from the inside without the use of keys; provided that this requirement shall not apply to the doors of rooms where persons are under legal restraint. This requirement shall not prohibit the installation of locks on doors of rooms or *floor-areas*, such locks to be used only when such spaces are not occupied by any person.
- (ii) Draw bolts or chains shall not be used on doors in *places of assembly* at any time.
- (iii) No entrance or *exit* door serving a *place of assembly* shall be fastened while occupied, in any manner excepting by fastenings such that a pressure of 20 pounds upon the inside of the door will either break or release the fastenings and allow the door to swing wide open.

4.6.7. Enclosure of Exits

4.6.7.1 General.—Any more restrictive requirements given in Section 4.16 with respect to the enclosure of *vertical openings*, than those contained herein, shall govern.

The requirements of this Article shall be interpreted to mean that when enclosure of any *exit* is required, such enclosure shall consist of walls, ceilings, floors, and doors, as hereinafter specified, so constructed as to provide complete separation from the room or space served and from any room or space through, around, under, or over which such *exit* passes. Such separation shall have a specific *fire-resistance rating* as hereinafter required.

When an *exit* or any part thereof is required to have a minimum *fire-resistance rating*, then all construction which supports such *exit* or part thereof, and which transfers its *live* and *dead loads* to the ground, shall have a *rating* at least equal to that of the *exit* or portion thereof supported.

When any *exit stairway* leading from an upper floor to an *exit* from the building is continued past the level of such *exit* so as to provide access to any lower floor, such continuation shall be assumed to be a part of such *exit stairway* and shall comply with the requirements herein specified with respect to enclosure for such *exit stairway*.

Where a building contains more than one occupancy and where an *exit* from one occupancy passes through a more restricted occupancy, the *exit* shall be enclosed throughout in accordance with the requirements for the more restricted occupancy. (For example, any *exit* from a Residential Occupancy located over a store in a two-storey building must be enclosed if it passes through the *first storey*, in accordance with the requirements for stores, i.e., in one-hour fire-resistive construction.)

4.6.7.2 Detailed Requirements for Interior Exits with Regard to Enclosure.—

(a) Table 4 of this Section shall be used to ascertain when enclosure of *exits* within a building is required. If enclosure is indicated as being required, then, except as otherwise provided in this Item, the various structural components of the enclosure shall have *fire-resistance ratings* at least equal to the *ratings* required for the Type of Construction of the building in which they occur, (see Section 4.3), and in no case less than the minimum requirements set forth in Table 4 of this Section. Where flights of stairs or floor assemblies such as landings, ramps, or *passageways* occur one above another within continuous vertical *enclosure walls* and do not form part of the enclosure, they shall have *fire-resistance ratings* in accordance with the Type of Construction of the building as given in Section 4.3, and in no case less than one hour, or alternatively they shall be entirely *incombustible*.

(b) No openings except doors and windows complying with the requirements of Table 4 of this Section shall be permitted in the walls of any enclosed *exit*, provided that:

- (i) when an enclosed *exit* has only two doorways in it, one giving access from a room or *floor-area* and the other giving egress to a *street* or *exterior passageway*, no fire-resistive access door shall be required;
- (ii) in no case shall any door, opening on a *street* or *exterior passageway*, be required by this Item to have fire-resistive qualities;
- (iii) when any *exit* is allowed to pass through a room or space not used solely for *exit* purposes, as permitted in Item 4.6.4.1, such room or space shall be enclosed as and when required by Table 4, but the requirements respecting protection of openings therein shall not apply except that such room or space shall be cut off from other parts of the *exit* by *self-closing* fire doors opening in the direction of *exit* travel.

(c) All doors on elevator enclosures shall comply with the requirements for *exit* doors as set forth in Table 4 hereof. No elevator shall be constructed within the same enclosure as a *stairway*. Not more than 3 elevators shall be placed in any one enclosure.

(d) In any building of the arena or stadium type having tiers of seats or seats arranged in steps, *exits* therefrom which pass through any space beneath the tiers used for other than *exit* purposes shall be enclosed in accordance with Table 4.

(e) In any *place of assembly*, each balcony or gallery shall, for the purposes of this Section, be considered a *storey* except when it discharges onto the main floor of the auditorium; provided that *exits* serving the first balcony and serving also as principal means of access thereto, shall not require enclosure when the main floor is at or near *grade*. Where the main floor of a *place of assembly* is located at or near *grade* and has an entrance lobby at approximately *street* level, *exits* from balconies above the first balcony, when separated from all rooms and space above the main floor by *2-hour construction*, may be considered enclosed when they discharge through the lobby, provided such lobby is separated from the main floor by smoke-tight metal or metal clad doors with or without wired glass panels.

(f) *Stairways* or elevators serving fly-galleries or gridirons in 'back-stage' areas of *assembly buildings* shall not require enclosure above the level of the *stage*; and one unenclosed *exit* shall be permitted from each tier of dressing rooms

(g) Stairs or ramps from smoking rooms, lounges, or other public rooms in the *basement* of an *assembly building* shall be enclosed in the *basement* or in the *first storey* by *2-hour construction*, and doors thereto shall be *self-closing* and not less fire-resistive than a solid wood-slab $1\frac{3}{4}$ -inch door.

*The requirements of this table do not normally apply to one-storey buildings, nor to *exits* serving no *floor-area* other than a ground floor and/or a *basement*. However, they do apply to sub-grade *storeys* where more than one *storey* exists below the ground floor, a specific number of *storeys* below the ground floor being governed by the requirements for the same number above.

Occupancy	Height of Building or Portion Thereof	ENCLOSURE REQUIREMENTS				
		Minimum Fire-resistance Ratings			Minimum Requirements for Doors Giving Access to Exits	Minimum Requirements for Windows
		(in hours)				
		Floors	Ceilings immediately above exits (1)	Walls or Partitions		
Residential, Group D, Divisions 1 & 2 Commercial and Industrial, Group C, Division 4 Accessory, Group E, Divisions 1 & 2	Two storeys and not more than 35 feet Three storeys and not more than 45 feet				No Special Requirements	
Assembly, Group A, all Divisions Institutional, Group B, all Divisions Commercial and Industrial, Group C Divisions 1, 2, & 3 Accessory, Group E, Division 3	Two storeys and not more than 35 feet	1	1	1	Substantial, snug fitting, self-closing(2) doors of metal, metal clad wood or solid wood-slab type not less than 1-3/4 inches thick in all parts; wired glass lights only; sliding doors not permitted on stair enclosures. Wood frames, if not metal clad, shall be of 2-inch minimum nominal thickness with stops or rebates of at least 5/8 inch.	Every window shall open on a street, or on a yard or court meeting the requirements of Part 5 of this Code. Plain glass may be used and the frames and sash are not herein regulated.
Any Commercial and Industrial Occupancy, on a floor-area not intended or used for more than 50 persons and not more than 30 feet above grade		2	1	2	Self-closing(2) fire-resistive doors, meeting all requirements of Section 4.12 for such doors. Sliding doors not permitted on stair enclosures	Every window within 10 feet of a lot line or of any other opening in any other wall shall be a fire-resistive window meeting the requirements of Section 4.12. All windows shall open on a street, or on a yard or court meeting the requirements of Part 5 of this Code
Any condition of Occupancy or Height not mentioned above, excepting one-story structures (Note:—Detached one- and two-family dwellings are excepted from all requirements of this Section by Article 4.6.1.)						

(1) For the purposes of this Section, the *fire-resistance rating* of any ceiling shall mean that of such ceiling in association with any floor or roof construction immediately above it; similarly, the *rating* of any floor assembly shall mean that of such floor in association with any ceiling attached beneath it, except that for buildings of Type 1A, 1B and 1C Construction, this permissible association shall be limited by Item 4.3.3.4.

(2) Where it can be shown that the nature of an occupancy and character of a *structure* make a *self-closing* door impracticable, the *authority having jurisdiction* shall permit the use of an *automatic* door. Wherever such *automatic* doors are used, the tenant or owner shall afford reasonable proof to the *authority having jurisdiction* that arrangements exist whereby the doors will be shut immediately upon signs of smoke or fire without awaiting action of the fusible link device.

(h) Cell blocks for detention purposes, if constructed entirely of *incombustible* materials shall not be required to have *exits* therefrom enclosed.

4.6.7.3 Enclosure of Interior Stairways other than Exit Stairways.—In any building or part thereof required to have enclosed *exits*, all interior *stairways* connecting two or more *storeys*, whether required as *exits* or not, shall be enclosed as prescribed in this Section for required *exit stairways* subject to the following exceptions:

- (i) Enclosure shall not be required for a *stairway* in a building of Type 1A or Type 1B Construction (Fire-resistive), or in a building of Type 1C Construction (Fire-resistive) or Type 2 Construction (Heavy Timber) or Type 3 Construction (Masonry and Frame) having *approved* automatic sprinklers throughout, when such *stairway* does not serve as a required *exit* and only connects one *floor-area* with another *floor-area* immediately above it; provided that there shall be no other *stairways* except *exit stairways* leading from either of the *floor-areas* served. In an unsprinklered building of either Type 1C Construction or Type 2 Construction or Type 3 Construction, any such *stairway* shall be enclosed in the *storey* above or below or both by *one-hour construction* with openings therein protected as indicated in Table 4 for such an enclosure.
- (ii) Enclosure shall not be required for an ornamental ramp or *stairway* from the main entrance floor of any building to the floor next above provided such ramp or *stairway* does not serve as part of the required aggregate *exit* width.

4.6.7.4 Enclosure of Exterior Stairways and Ramps.—No enclosure of exterior *stairways* or ramps shall be required; provided that any such *stairway* or ramp that is enclosed on more than one side and the roof, shall be subject to the enclosure requirements herein specified for interior *stairways*.

4.6.8 Access to Exits

4.6.8.1 Hallways and Corridors.—The aggregate width of *hallways* or corridors leading to any *exit* shall be at least equal to the required width of such *exit*, and no *hallway* or corridor shall be less than 3 feet in width. *Hallway* and corridor widths shall be measured at the narrowest points, taking into account all projections, radiators, pipes, or other objects.

4.6.8.2 Aisles and Seating, in Places of Assembly having Seats for more than 300 Persons.—

(a) All seats in any *theatre* or *motion-picture theatre* shall have arms and backs and shall be securely fixed to the floors, provided that seats need not be fixed in a railed-in enclosure, box, or loge having a level floor and accommodation for not more than 25 persons.

(b) Any *assembly room*, used for purposes other than as a *theatre* or *motion-picture theatre*, in which the seats are not fixed to the floor shall have such seats secured together in units of at least five seats, provided that in any *assembly room* where food or drink is served on tables, individual unfixed chairs may be used.

(c) Aisles shall be so located, both on main floor, and in balconies and galleries, that there are not more than six seats between any seat and an aisle; provided that this limitation shall not apply where self-raising seats are employed, so placed as to leave when raised a clear walk-way between rows of 22 inches, such walk-way giving access to the exterior of the building or to a *passageway* on each side of the *assembly room* or balcony at the rate of one doorway for every three rows of seats.

(d) Seats with backs shall be spaced not less than 32 inches measured from back to back. Rows of seats without backs shall be spaced at not less than 26 inches measured from back to back. The minimum width per person in a row of seats shall be 18 inches regardless of whether seats have arms or backs. There shall be a space of not less than 14 inches between the back of one seat and the front of the seat immediately behind it, as measured between plumb lines.

(e) Every aisle shall lead to an *exit* or to a cross aisle, i.e., an aisle running parallel with the seat rows and leading in either direction to an *exit*. The minimum width of an aisle with seats on one side shall be 30 inches and with seats on both sides 36 inches, these minimum widths being at points remote from *exits*. Reasonable assumptions, as to the probable number of persons who will pass any particular point in an aisle in reaching an *exit* in a hurry, shall be made, considering every *exit* available; and thus the required width of the aisle at that point shall be determined by Item 4.6.5.4 (b). All aisles shall be proportioned in this manner, the minimum width being added to uniformly as the *exits* are approached in accordance with the probable tributary flow of people if every available *exit* is used.

(f) *Assembly room* main floors having more than 35 rows of seats shall have a cross aisle leading to an *exit* at each end of such cross aisle. Balconies and galleries shall have such a cross aisle for every 20 rows of seats and fraction of 20. Cross aisles shall have a minimum clear width of 44 inches and their width shall be increased as required in accordance with (e) hereof. Cross aisles shall not be required in the case of the proviso to (c) hereof.

(g) Steps shall not be placed in an aisle unless the gradient exceeds 1 foot of rise in 8 horizontally. Steps shall be grouped, and flights of less than 3 risers shall not be permitted. Steps shall extend full width across any aisle and provision shall be made for illuminating each tread. Handrails shall not be required, but flights of steps in aisles shall otherwise be in accordance with Item 4.6.6.2.

(h) The *authority having jurisdiction* may permit arrangements of aisles and seats other than those prescribed in this Item, provided that the total number of persons accommodated and the time required to empty the occupancy are not thereby increased.

4.6.8.3 Aisles and Seating in Stadiums and Reviewing Stands.—

(a) The minimum width of seat per person shall be 18 inches whether seats are marked off or not. Seat boards or seats without backs shall be spaced 26 inches measured from back to back, and seats with backs shall be spaced at 30 inches measured from back to back.

(b) Aisles not less than 44 inches wide at the narrowest point shall be provided so that there are not more than 20 seats between any seat and an aisle. Aisles shall be uniformly increased in width as they approach *exits* in accordance with Sub-item 4.6.8.2 (e).

(c) Steps in aisles shall be in accordance with Item 4.6.6.2.

(d) The *authority having jurisdiction* may permit arrangements of aisles and seats other than those prescribed in this Item, provided that the total number of persons accommodated and the time required to empty the occupancy are not thereby increased.

4.6.9 Marking of Exits.—All *exits* shall be indicated by suitable signs or lights; provided that *exits* from *floor-areas* occupied as *places of assembly* for more than 100 persons shall be plainly marked by *approved exit* signs, sufficiently illuminated when the *floor-area* is occupied, to be readily distinguished. Whenever the requirements of this paragraph necessitate artificial illumination in *theatres* and *motion-picture theatres*, power or means for such illumination shall be available from two independent sources, so arranged that a break-down in one source or in any particular circuit will not result in the lights being extinguished.

Where an *exit* and its light or sign is not visible from every point in the *hallway* or undivided *floor-area* served, suitable directional signs shall be provided indicating the location of the *exit*.

Every *exit* in which it is possible to continue in the direction of *exit* travel past the point at which the *exit* leaves the building, shall be clearly marked to indicate the level and location at which the *exit* leaves the building.

4.6.10 Lighting of Exits.—Adequate facilities shall be provided for the lighting of all *stairways*, *passageways*, *hallways* and other means of *exit* including *fire escapes* and *exterior passageways*. Lighting installations shall be capable of supplying no less illumination than would be supplied by the electrical outlet required in Part 5, Item 5.3.6.3. In considering *stairways*, illumination shall be provided on the basis of the horizontal projection of the *stairway* in each *storey*.

SECTION 4.7 TESTS AND MATERIALS FOR FIRE-RESISTIVE CONSTRUCTIONS

4.7.1 General.—Specific *fire-resistance ratings* for specific materials and combinations of materials are given in succeeding sections as follows:

Section 4.8—Protection of Structural Members

Section 4.9—Fire-resistive Walls and *Partitions*

Section 4.10—Fire-resistive Floors and Roofs.

These *ratings* are acceptable under the requirements of this Code, provided that the materials and constructions employed conform to all applicable regulations and specifications set forth in this Code, and provided that the workmanship is sound and in accordance with good trade practices.

Roof coverings are classified as “fire-retardant” or “ordinary” in Section 4.11.

Regulations with respect to doors, windows, and skylights are given in Section 4.12, including tests and regulations pertaining to *fire-resistive doors* and *windows*.

4.7.2 Tests of Fire-resistive Construction and Materials.—Materials and combinations of materials for which no *ratings* or classifications are given in this Code may be rated or classified as to fire resistance by the *authority having jurisdiction*, in conformity with the recommendations of a publicly owned or other recognized laboratory, on the basis of tests made in accordance with one of the following three specifications:

(a) Standard Specification for the Procedure for Fire Tests on Building Construction and Materials (A54-1940) of the Canadian Engineering Standards Association.

(b) Standard Specification for Fire Tests of Building Construction and Materials (C19-33) of the American Society for Testing Materials.

(c) British Standard Definitions for Fire Resistance, Incombustibility and Non-inflammability of Building Materials and Structures (B.S.S. 476-1932).

Where walls or *partitions* are required to have a specific *fire-resistance rating*, they shall give this *rating* upon exposure of either face to the test fire. For requirements for *fire-resistive doors* and *windows*, see Article 4.12.2.

4.7.3 Quality of Materials for Fire-resistive Construction.—

4.7.3.1 Masonry.—All *masonry* shall comply with the requirements of Section 3.3 of this Code. *Stone* shall not be used as fire protection for structural metal but may be used in *masonry* walls which are required to have specific *fire-resistance ratings* provided such walls are not less than 12 inches thick.

All unit *masonry* shall be laid in cement, cement-lime, or gypsum *mortar*. Gypsum units shall be laid in gypsum *mortar* only.

4.7.3.2 Concrete.—

(a) **Classification of Concrete.**—*Concrete* shall be classified as Grade A *concrete* or Grade B *concrete* depending upon the mineral character of the *aggregate*.

Grade A *concrete* shall mean *concrete* with a *coarse aggregate* of blast-furnace slag, limestone, calcareous gravel, trap rock, burnt clay, or shale, cinders containing not more than 25 per cent of *combustible* material and not more than 5 per cent of volatile material, and other materials containing not more than 30 per cent of quartz, chert, flint, and similar materials.

Grade B *concrete* shall mean *concrete* with a *coarse aggregate* of granite, quartzite, siliceous gravel, sandstone, gneiss, cinders containing more than 25 per cent but not more than 40 per cent of *combustible* material and not more than 5 per cent of volatile material, and other materials containing more than 30 per cent of quartz, chert, flint, and similar materials.

(b) **Proportions.**—*Plain* and *reinforced concrete* for structural purposes shall comply with the requirements of Section 3.4. *Concrete* for fire protection purposes, other than *cellular concrete* and cement plaster, shall be composed of at least one part of *cement* to two parts of sand by volume, with from two to five parts of *coarse aggregate* by volume, measured dry, and shall have a slump not exceeding 6 inches when tested in accordance with Appendix XI of the C.E.S.A. "Standard Specification for Concrete or Reinforced Concrete", No. A23-29.

(c) Where *plain* or *reinforced monolithic concrete* is used as a base for fire-resistive plaster, the *concrete* surfaces shall be prepared for plastering in accordance with the requirements of "Standard Specification for Gypsum Plastering" (A42.1-1938) as approved by the American Standards Association on 29 September, 1938.

(d) *Cellular concrete* for fire protection purposes, when mentioned in this Code without qualification as to its weight, shall have a weight of not less than 50 pounds per cubic foot.

4.7.3.3 Poured and Pre-cast Gypsum.—Poured and pre-cast gypsum shall consist of neat calcined gypsum in accordance with the requirements for gypsum neat plaster given in A.S.T.M. Specification C28-40, together with not more than 12½ per cent for poured gypsum, 5 per cent for pre-cast gypsum partition tiles, and 3 per cent for pre-cast gypsum of wood chips, shavings, or fibre measured in a dry condition as a percentage by weight of the dry mix. No aggregate other than wood chips or fibre shall be used.

4.7.3.4 Gypsum Lath.—Gypsum lath shall comply with A.S.T.M. Specification C37-40. Perforated gypsum lath shall have perforations not less than ¾ inch diameter, distributed over the face of the lath and comprising not less than 2½ per cent of the area of the lath.

Gypsum lath, whether plain or perforated, when used as part of a fire-resistive assembly shall have a minimum thickness of $3/8$ inch, and shall be applied in accordance with the regulations given in "Standard Specifications for Gypsum Plastering" (A42.1-1938) as approved by the American Standards Association on 29 September, 1938; except that supports for gypsum lath shall in no case be spaced farther apart than 16 inches centre to centre, there shall be no space or gap between the edges of adjoining lath, and all ceiling lath shall be applied with nails having a nominal head diameter of at least $3/8$ inch or *approved* clips.

4.7.3.5 Gypsum or Portland Cement Plasters.—

(a) Gypsum plasters, whether neat, ready-sanded or of the wood fibre type, shall comply with A.S.T.M. Specification C28-40. Only gypsum plaster shall be applied to gypsum *masonry*. Wherever the proportion of sand in gypsum plaster is given by this Code without further qualification, such proportion shall be on the basis of weight. Where gypsum plaster is mentioned in this Code without reference to its proportion of sand or fibre, such proportions shall be in accordance with the "Standard Specifications for Gypsum Plastering" (A 42.1-1938) as approved by the American Standards Association on 29 September, 1938. For fire resistive purposes, $1/2$ inch of unsanded gypsum plaster may replace $3/4$ inch of sanded gypsum or portland cement plaster.

(b) Portland cement plasters shall consist of one part portland cement to three parts of *aggregate* by volume to which may be added hydrated lime equal to not more than 10 per cent by weight of the cement or the equivalent in lime putty.

(c) Gunitite or other pneumatically projected *mortar*, plaster, or stucco for fire protection purposes shall contain one part of portland cement to not more than five parts of sand by volume. Such pneumatically projected *mortar* may replace an equal thickness of portland cement plaster.

(d) Portland cement mentioned in this Item shall conform to either C.E.S.A. Specification A5-1940 or to C.E.S.A. Specification A57-1940.

(e) Plaster, in order that it may be considered as adding to the effectiveness of any fire-resistive construction, shall have a thickness of at least $1/2$ inch.

(f) Except in the case of solid plaster *partitions*, when plaster is used for fire protection purposes, and exceeds one inch in thickness beyond the plaster base, it shall be reinforced with metal lath or metal mesh embedded not more than $3/4$ inch from the surface and securely tied in to the supporting construction; provided that all such plaster on monolithic *concrete* ceilings or soffits shall be similarly reinforced.

(g) The effective thickness for fire resistive purposes of plaster on metal lath shall be measured from the plane of the back of the metal lath; except that where the metal lath is provided with continuous backing and the space between the lath and the backing is completely filled with plaster, it shall be measured from the backing.

(h) Wherever gypsum lath is permitted as part of a fire-resistive assembly, the effective thickness of plaster may include two-thirds of the thickness of such lath.

4.7.3.6 Metal Lath.—

(a) **Interpretation.**—The term 'metal lath' shall include expanded metal lath, sheet metal lath, wire lath, wire fabric, and paper-backed wire fabric, wherever such materials are used as a primary base for either gypsum or portland cement plaster.

(b) **Metal Lath for Interior Work.**—When plaster depends on a 'key' for its adhesion, the lath shall have not less than $2\frac{1}{2}$ meshes per inch. All metal lath shall be galvanized or otherwise effectively protected against corrosion. Whenever lath is so fabricated or so applied that it has a continuous backing, from which the lath is held clear in such a way as to provide full embedment of at least $1/16$ inch for at least one-half of the total length of strands and one-half of the total weight of metal, the allowable size of mesh may be increased provided no opening has an area greater than 4 square inches.

4.7.3.7 Metal Mesh for Reinforcing Plaster and Poured Protections.—When the thickness of plaster protections is sufficient to require the reinforcing of the plaster (see Sub-item 4.7.3.5 (f)) with metal lath or metal mesh, any such mesh shall weigh at least 1.1 pounds per square yard, and no opening therein shall have any dimension greater than 4 inches nor an area greater than 6 square inches. Where metal mesh is used to reinforce and tie in poured protections, it shall weigh at least $1\frac{1}{2}$ pounds per square yard, and no opening therein shall have an area in excess of 36 square inches nor a dimension less than 1 or greater than 8 inches.

4.7.3.8 Wired glass shall be not less than $1/4$ inch in thickness and shall be reinforced with wire mesh of .020 inch diameter wire with mesh not larger than $7/8$ inch square.

SECTION 4.8 PROTECTION OF STRUCTURAL MEMBERS

4.8.1 Application.—The requirements of this Section do not apply to *joists* or similar small supports which form part of *floor* or *roof panel* assemblies and which are spaced not more than 30 inches on centres. Such members are dealt with in Section 4.10.

4.8.2 Protection of Structural Steel and Iron

4.8.2.1 General Requirements.—Every structural steel, iron, or cast-iron member required to be protected against fire shall be individually encased in fire-resistive materials unless protection by a ceiling is specifically permitted by Item 4.3.3.4 or Item 4.3.4.2; provided that a truss assembly may be encased as a single structural unit.

Fire-resistive materials protecting structural steel or cast-iron members shall be assumed to have the *fire-resistance ratings* shown in Table 1 of this Section. The figures shown are the minimum net thicknesses of the protecting materials required, no allowance being made for any hollow space or spaces, either within the material (e.g. the cells in

hollow units) or between the material and the member protected, except in the case of hollow gypsum *blocks* where gross thicknesses are specified. Such minimum thicknesses shall be measured from the extreme edges or corners of structural shapes, but the projecting edges of lugs and brackets need only be given a protection equivalent to one inch of Grade A *concrete*. Where the protection is of *masonry* or is poured, part of the required thickness may consist of plaster meeting the requirements of Item 4.7.3.5 and part of it may consist of solid continuous *mortar* backing. The allowance for plaster shall be limited to 1/2 inch in the case of poured protections. The embedment of pipes, conduits, or wires within the minimum specified thicknesses of protection is prohibited. Any space between a member and its protection shall be fire-stopped at each floor level in the case of *columns*, and at the support in the case of *beams* and *girders*.

In factories, warehouses, *garages*, and other buildings where the protective covering of *columns* may be damaged by the movement of goods or vehicles, substantial metal shields shall be placed over the protective covering to a height of approximately 5 feet.

TABLE 1 (SECTION 4.8)
FIRE-RESISTANCE RATINGS FOR VARIOUS THICKNESSES OF
MATERIALS USED TO PROTECT STRUCTURAL STEEL
AND CAST-IRON MEMBERS

Protective Materials	Minimum Net Thicknesses in Inches Required to Afford the <i>Fire-resistance</i> <i> Ratings Indicated</i>			
	4 hrs.	3 hrs.	2 hrs.	1 hr.
Brick or stone	3¾ ⁽²⁾	3¾ ⁽²⁾	2¼ ⁽²⁾	2¼
Grade A concrete; cellular concrete weighing at least 75 pounds per cubic foot ⁽¹⁾	2	2	1½	1
Grade B concrete; cellular concrete weighing at least 50 pounds per cubic foot ⁽¹⁾	3	2½	2	1½
Hollow concrete block or tile	3½ ⁽²⁾	3	2½	2½
Poured gypsum ⁽¹⁾	2	1½	1	1
Gypsum block (2-inch solid)	2½	2½	2	2
Gypsum block (3-inch hollow)	3½ ⁽³⁾	3½ ⁽³⁾	3 ⁽³⁾	3 ⁽³⁾
Hollow clay tile	2½ ⁽²⁾	1¾ ⁽²⁾	1¼ ⁽²⁾	1¼
Metal lath and gypsum or portland cement plaster			1¾	1

(1) All poured protections shall solidly encase the protected member without there being any space between the protection and the member.

(2) In order to qualify for the *fire-resistance rating* indicated, any and all space between the protection and the protected member shall be solidly filled with any one of the poured protections given in Table 1, or shall be solidly filled with the same material used for the protective covering.

(3) Gross thickness.

4.8.2.2 Reinforcement of Poured Protection.—All poured-in-place gypsum or *concrete* protection shall be reinforced with metal mesh or with reinforcing bars so as to insure the integrity of the construction under exposure to fire. Such reinforcement shall consist of metal mesh complying with the requirements of Item 4.7.3.7; or steel wire not less than 0.135 inch in diameter, wound spirally around the member to be protected with a pitch of not more than 8 inches, or equivalent reinforcing bars. In the case of *beams* such reinforcement is only required for the material protecting the soffit of the *beam*. In the case of *columns* having an I section, such reinforcement is only required for the material protecting the flanges. Metal mesh, wire, and other forms of reinforcement shall be held away from the structural members and embedded in the protection not less than 3/4 inch from its outer surface at points of minimum thickness.

4.8.2.3 Reinforcement of Masonry Protections.—All *masonry* protection of more than one-hour resistance, except brick *masonry*, shall be reinforced in all horizontal joints by strips of mesh reinforcement the full width of the joints, or by other *approved* equivalent means; *masonry* required to give one-hour protection and brick *masonry* shall be bonded by running bond or by reinforcement across the vertical joints. Mesh reinforcement shall weigh not less than 3 pounds per square yard.

Where protection for the lower flanges of *beams* and *girders* consists of pre-cast units, each such unit shall be retained in place by metal clips or wire ties, unless shoe tile or similar units providing positive anchorage are used. Tie wire shall have a minimum diameter of 0.08 inch, shall be protected by plaster, and shall not be of copper or brass.

4.8.2.4 Ceilings for the Protection of Structural Members.—

(a) Whenever a ceiling may be used for the protection of structural members, (see Items 4.3.3.2, 4.3.3.3, 4.3.3.4, and 4.3.4.2), it shall be in accordance with the requirements of this Item. Such a ceiling shall have

TABLE 2 (SECTION 4.8)
REQUIRED THICKNESSES OF THE CEILINGS PERMITTED FOR THE
PROTECTION OF STRUCTURAL MEMBERS

Construction of Ceiling	Minimum Net Thicknesses in Inches of Ceilings Required to Provide Protection Equivalent to the <i>Fire-resistance Ratings</i> Indicated*			
	4 hrs.	3 hrs.	2 hrs.	1 hr.
Metal lath with gypsum or cement plaster, Grade A <i>concrete</i> , burned clay products, gypsum, <i>cellular concrete</i> , singly or in association	2½	2	1½	1

*The thicknesses given herein shall not be interpreted as indicating any specific *fire-resistance ratings* for ceilings. These thicknesses are merely the minimum which will be accepted for ceilings permitted in place of full encasement of structural members or assemblies. (Note:—There are no standard fire tests for ceiling protections).

a thickness commensurate with the *rating* required for the members protected unless the required equivalent *rating* is otherwise expressly stated. (See footnote to Table 2 of this Section.)

(b) Ceilings used for fire protection purposes shall have the minimum net thicknesses indicated in Table 2 of this Section, provided that the thicknesses given in Table 2 may be reduced by 1/2 inch to a minimum of 3/4 inch when the ceiling is suspended to form a free air space of not less than one inch between the member and the protection. (See also Sub-item 4.3.3.4 (b).)

(c) Ceilings permitted by this Item shall be positively secured in place by ties or clips. Where clips are used, they shall be sufficiently substantial and so arranged that exposure of the ceiling to fire will not cause the clips to soften and bend thereby releasing the ceiling.

(d) Where ventilation ducts pass through any ceiling permitted by this Item, effective and positive means of fire-stopping such breaks in the ceiling shall be introduced.

4.8.3 Protection of Reinforced Concrete Beams, Girders, and Columns.—The reinforcement in *beams*, *girders*, and *columns*, including spiral reinforcement and ties and stirrups 1/2 inch in size and over, shall have a cover not less than the minimum specified in Table 3 of this Section in order to qualify for the *fire-resistance ratings* specified therein. Ties and stirrups under 1/2 inch in size may extend within the required thickness. Such cover may consist in part of portland cement or gypsum plaster, provided that the minimum cover of *concrete* shall not be less than one inch, and provided further that the plaster on soffits shall be reinforced with metal lath or metal mesh as required by Sub-item 4.7.3.5 (f), such reinforcing being in accordance with Item 4.7.3.7.

TABLE 3 (SECTION 4.8)
FIRE-RESISTANCE RATINGS OF STRUCTURAL MEMBERS OF
REINFORCED CONCRETE IN TERMS OF THICKNESS OF
COVER OVER REINFORCING

Material	Thickness of Cover in Inches Required to Afford the <i>Fire-resistance</i> <i>Ratings</i> Indicated			
	4 hrs.	3 hrs.	2 hrs.	1 hr.
Grade A <i>Concrete</i>	2	1½	1½	1
Grade B <i>Concrete</i> *	2½	2	2	1½

*When Grade B *concrete* is used, supplementary reinforcement as specified in Item 4.8.2.2 for poured protections for structural steel shall be provided, or alternatively the cover shall be one-half inch more than the values specified in Table 3.

SECTION 4.9 FIRE-RESISTIVE WALLS AND PARTITIONS

4.9.1 General Requirements.—The requirements of this Article apply only to walls or *partitions* required to have specific *fire-resistance ratings*. Hollow walls include both walls of *hollow units* and hollow walls of *solid units*.

TABLE 1 (SECTION 4.9)

MATERIALS, THICKNESSES, AND RATINGS FOR FIRE-RESISTIVE WALLS AND PARTITIONS

Materials and Construction		Finished Thickness Face to Face In Inches (Including any Plaster)				
		4 hrs.	3 hrs.	2 hrs.	1 hr.	
Brick or Solid Units of Burned Clay or Shale, of Sand-lime, or of Concrete	Solid construction, no plaster.....	12	10	8	5	3 3/4
	Hollow rolok construction, no plaster.....	12	10	8	5	8
	Hollow rolok construction, plastered both sides.....	9	9	9	9	9
	Hollow rolok-bak construction, 3/4 inch gypsum plaster on one side.....	8 3/4	8 3/4	8 3/4	8 3/4	8 3/4
	Including plaster if any.....	6	5	4	3	
Solid Units of Cellular Concrete	Any aggregate, no allowance for plaster.....	8	8	8	8	
	Grade A, including plaster if any.....	6	5	4	3	
Reinforced Concrete	Grade B, including plaster if any.....	6(1)	5(1)	4(1)	3(1)	
	One cell in wall thickness plastered both sides.....	—	—	—	—	3
Hollow Clay Tile(2)	One unit, one cell in each 4 inches or less thickness, no plaster.....	—	12*	12*	12*	6
	One unit, one cell in each 4 inches or less thickness, plaster on one side.....	—	—	8 1/2	7	6 1/2
	One unit, one cell in each 4 inches or less thickness, both sides plastered.....	9*(3)	9	8 1/2	7	7
	Two units, four cells in aggregate thickness, no plaster.....	16	8*	8*	8*	8*
	Two units, three cells in aggregate thickness, no plaster.....	12*	12*	12*	12*	12*
	One unit, three cells in thickness, no plaster.....	—	—	8	8	8
	One unit, three cells in thickness, double shells, no plaster.....	—	8*	8*	8*	8*
Brick and Clay Tile	4 inches hollow clay tile, or 4 inches hollow concrete block, faced with 3 3/4 inches of brick, stone or cast stone, plastered on tile.....	9	9	9	9	9
Solid Gypsum Blocks	No plaster.....	4	4	3	3	2
	Plastered both sides.....	4	3	3	3	3
Hollow Gypsum Blocks	No plaster.....	6	5	4	4	3
	Plastered both sides.....	5	4	4	4	4
Hollow Concrete Blocks	Face shells not less than 1 1/4 inches thick Core area not more than 50 per cent of gross area: Unplastered.....	—	12	12	8	8
	Plastered one side.....	—	12 1/2	8 1/2	9	8 1/2
	Plastered both sides.....	13	13	9	5	5
	Face shells not less than 1 1/2 inches thick Core area not more than 40 per cent of gross area: Unplastered.....	12	12	8	8	8
	Plastered one side.....	12 1/2	12 1/2	8 1/2	9	8 1/2
Solid Partitions of Gypsum Plaster(4)	Core area not more than 30 per cent of gross area: Unplastered.....	12	12	8	4	4
	Plastered one side.....	12 1/2	8 1/2	8 1/2	4 1/2	4 1/2
	Plastered both sides.....	13	9	5	5	5
	Incombustible studs, metal lath; gypsum plaster, scratch coat 1:2, brown coat 1:3.....	—	—	—	—	2 1/4
	Incombustible studs, metal lath; gypsum plaster, scratch coat 1:1, brown coat 1:1.....	—	—	—	—	2
Incombustible Stud Partitions(4)	Incombustible studs, metal lath; gypsum plaster, scratch coat 1:1/2, brown coat 1:1/2.....	—	—	2 1/4	2	2
	Incombustible studs, metal lath; unsanded, fibred gypsum plaster, not more than 2 per cent, by weight of fibre.....	—	—	2	2	2
	Metal lath; portland cement plaster 7/8 inch thick on each side.....	—	—	—	—	4 3/4
	Metal lath; gypsum plaster 3/4 inch thick on each side, scratch and brown coats 1:2.....	—	—	—	—	4 1/2
	Metal lath; gypsum plaster 1 inch thick on each side, scratch and brown coats 1:1 1/2.....	—	—	5	—	—
Wood Stud Walls or Partitions(4)(5)	Metal lath; gypsum plaster 7/8 inch thick on each side, unsanded and fibred.....	—	—	4 3/4	—	—
	Metal lath, portland cement plaster 7/8 inch thick on each side.....	—	—	—	—	5-3/8
	Metal lath, gypsum plaster 3/4 inch thick on each side, scratch and brown coats 1:2.....	—	—	—	—	5-1/8
	Perforated gypsum lath; gypsum plaster 1/2 inch thick each side, scratch and brown coats 1:2.....	—	—	—	—	5-3/8
	Metal lath; gypsum plaster 1 inch thick each side, unsanded and fibred.....	—	—	5-5/8(6)	—	—
Solid Wood	Solid panels of partition height, tongued and grooved on vertical edges; joints covered both sides by 1 x 4 inch battens of flame-proofed wood; panels composed of a wood core 1 3/4 inches thick all well glued, 1/8 inch cross banding, 1/16 inch veneer.....	—	—	—	—	2-1/8
	Laminated construction, metal or perforated gypsum lath, gypsum plaster 1/2 inch thick each side.....	—	—	—	—	4 3/4

(1) Notwithstanding the minimum thicknesses permitted in Part 3 of the Code for bearing walls of reinforced concrete, no fire-resistive bearing walls or partitions made of Grade B concrete shall have a thickness, exclusive of plaster, of less than 6 inches.

(2) Where the ratings are marked with an asterisk the tile shall conform to the Standard Specifications for Structural Clay Load-Bearing Wall Tile, A.S.T.M. Designation C-34-39, in order to qualify for the indicated rating.

(3) The plaster shall be gypsum plaster, in order to qualify for the indicated rating.

(4) All gypsum plaster proportions are by weight. See Item 4.7.3.5.

(5) Minimum nominal size of wood studs, 2 by 4 inches.

(6) This rating shall only apply to non-bearing partitions.

* See Footnote (2)

Walls and *partitions* of fire-resistive materials shall be assumed to have *fire-resistance ratings* indicated in Table 1 of this Section. Every wall or *partition* thickness given in Table 1 shall be regarded as the minimum thickness for the *rating* indicated, and such thicknesses shall not be broken into or reduced in any way except as regulated by Article 4.9.2.

4.9.2 Fire-resistive Walls supporting Structural Members.—

Incombustible structural members may project into solid or hollow fire-resistive walls of *masonry*, solid plaster, or *reinforced concrete*, provided that no additional hollow spaces are formed within the wall and that the full thickness of the wall or portion of the wall through which the member projects makes full contact with the member on all sides. Such *incombustible* members may be continuous through such walls, subject to the provisions of the preceding sentence.

Combustible structural members shall not project into any solid fire-resistive wall of *masonry* or *reinforced concrete*, unless they are separated from each other and from the opposite side by *solid masonry* having a thickness of at least a full 4½ inches, which thickness may include plaster or *mortar*. *Combustible* structural members shall not project into hollow fire-resistive walls of *masonry* or *reinforced concrete* for a distance in excess of the minimum required for adequate bearing. The end within the wall shall be pocketed in *solid masonry* or *concrete* having a minimum thickness of 4½ inches over all sides and the butt. The pocket shall form an integral part of the wall.

No fire-resistive wall of *hollow masonry* shall be broken into subsequent to its erection, for the insertion of structural members.

4.9.3 Gypsum Lath for Fire-resistive Walls or Partitions.—

(a) Plain gypsum lath not less than 3/8 inch in thickness may be substituted in the construction of interior fire-resistive walls and *partitions* for metal lath, for resistance periods of not more than one hour; provided the plaster is reinforced with metal mesh weighing not less than 1½ pounds per square yard, standing away from the lath and secured to the supporting studs. Alternatively, this over-all reinforcement of the plaster may be omitted where all the gypsum lath joints are covered with strips of metal lath; provided that such metal lath shall have at least 2½ meshes per inch and such strips shall be not less than 3 inches wide; and provided further that the plaster shall consist of not less than 1/2 inch of wood-fibered unsanded gypsum plaster.

(b) Perforated gypsum lath may replace metal lath in the construction of interior fire-resistive walls and *partitions* not required to have *fire-resistance ratings* in excess of one hour. Plaster over the face of such perforated gypsum lath shall be not less than 1/2 inch in thickness, and it shall be composed of one part gypsum plaster to not more than 2 parts of sand, by weight.

4.9.4 Plastered Fire-resistive Walls and Partitions.—Wherever plaster is required as part of a fire-resistive wall or *partition*, it shall be gypsum or portland cement plaster applied to a thickness of at least

1/2 inch. Such plaster shall extend from floor to ceiling in full thickness, undiminished behind baseboards and other interior trim.

Hollow stud walls or *partitions* required to have a specific *fire-resistance rating* shall be fully fire-stopped at each floor, ceiling, and roof. (See Section 4.19.)

4.9.5 Parapet Walls.—The requirements of this Article apply to “absolute” and “special” occupancy separations (see Item 4.2.3.3), to walls separating portions of a *structure* into separate buildings as described in Item 4.2.3.1 and Item 4.5.3.1, and to all *party walls* or *common walls* of *masonry* or *reinforced concrete*.

All such walls shall pass through and extend as *parapet walls* at least 24 inches above any *combustible* roof; except that, in buildings not more than three *storeys in height* designed or intended exclusively for Group D or E Occupancies, such *parapet walls* need not exceed 12 inches in height above the roof and may be omitted where the slope of the roof exceeds 4 inches in 12, and the roof slopes downward from the wall on both sides. The height of a parapet above a sloping roof shall be the vertical distance between any point on the top of the parapet and the plane of the roof.

All walls described in the first paragraph of this Article, which are not herein required to have parapets, shall meet the underside of the roof in such a way as to prevent effectively passage of smoke or flame at that point.

Requirements with respect to the extension of *shaft* walls above a roof are given in Item 4.16.3.4.

SECTION 4.10 FIRE-RESISTIVE FLOORS AND ROOFS

4.10.1 Application.—The requirements and regulations of this Section deal with floors and roofs, or *floor* and *roof panels* or assemblies. Flexural members commonly termed *joists* may be regarded as an integral part of such assemblies provided their spacing does not exceed 30 inches on centres; and such members shall not be required to be individually protected against fire.

4.10.2 Ratings for Fire-resistive Floors and Roofs.—Floor and roof assemblies of fire-resistive materials shall be assumed to have the *fire-resistance ratings* indicated in Table 1 of this Section, provided that their thicknesses and construction are in accordance with the requirements of the Table.

4.10.3 Pre-cast Units.—Where pre-cast units, other than fillers in ribbed construction, are used in fire-resistive floor, roof, or ceiling construction, all joints between adjacent units shall be tight and proof against passage of flame or smoke. Such joints shall be filled or sealed with *mortar* or grout. Unreinforced plaster on the underside shall not be regarded as a satisfactory seal.

TABLE 1 (SECTION 4.10)
DETAILS AND RATINGS FOR FIRE-RESISTIVE FLOORS AND ROOFS

Materials and Nature of Construction	Minimum Thickness in Inches for the Indicated Ratings			
	4 hrs.	3 hrs.	2 hrs.	1 hr.
REINFORCED CONCRETE				
(a) CONSTRUCTIONS WITHOUT CEILINGS				
Flat Slab, or Beam and Slab Construction				
(i) Grade A <i>concrete</i> ⁽¹⁾ minimum slab thickness ⁽²⁾	5	4½	4	3
minimum cover to reinforcing steel in slabs	1	1	¾	¾
(ii) Grade B <i>concrete</i> minimum slab thickness ⁽²⁾⁽³⁾	6	5½	5	4
minimum cover to reinforcing steel in slabs	1½	1¼	1	1
One or Two-way Ribbed Floor Construction, or Pre-cast Joist Construction, No Fillers				
(i) Grade A <i>concrete</i> ⁽¹⁾ minimum slab thickness ⁽²⁾	4½	4	3	2½
minimum cover to reinforcing steel in <i>joists</i> or ribs	1½	1½	1	1
minimum cover to reinforcing steel in slabs	1	1	¾	¾
(ii) Grade B <i>concrete</i> minimum slab thickness ⁽²⁾⁽³⁾	5	4½	4	3½
minimum cover to reinforcing steel in <i>joists</i> or ribs	2	1½	1½	1
minimum cover to reinforcing steel in slabs	1½	1¼	1	1
One or Two-way Ribbed Floor Construction with Fillers ⁽⁴⁾				
Minimum thickness of fire-resistive material, i.e., thickness of slab ⁽²⁾ plus thickness of filler <i>shells</i>	4	3½	3	2½
Minimum cover to reinforcing steel in ribs or <i>joists</i>	1½	1¼	1	1
(b) CONSTRUCTIONS WITH PLASTER CEILINGS⁽⁶⁾				
Flat Slab, or Beam and Slab Construction				
(i) Grade A <i>concrete</i> ⁽¹⁾ minimum slab thickness ⁽²⁾	4	3½	3	3
minimum cover to reinforcing steel in slabs	¾	¾	¾	¾
(ii) Grade B <i>concrete</i> minimum slab thickness ⁽²⁾⁽³⁾	5	4½	4	3
minimum cover to reinforcing steel in slabs	¾	¾	¾	¾
One or Two-way Ribbed Floor Construction or Pre-cast Joist Construction, No Fillers				
(i) Grade A <i>concrete</i> ⁽¹⁾ minimum slab thickness ⁽²⁾	3½	3	2	2
minimum cover to reinforcing steel in <i>joists</i> or ribs	1	1	1	1
minimum cover to reinforcing steel in slabs	¾	¾	¾	¾
(ii) Grade B <i>concrete</i> minimum slab thickness ⁽²⁾⁽³⁾	4	3½	3	2½
minimum cover to reinforcing steel in <i>joists</i> or ribs	1	1	1	1
minimum cover to reinforcing steel in slabs	¾	¾	¾	¾
One or Two-way Ribbed Floor Construction with Fillers ⁽⁴⁾				
Minimum thickness of fire-resistive material, excluding ceiling, i.e., thickness of slab ⁽²⁾ plus thickness of filler <i>shells</i>	3	2½	2	2
Minimum cover to reinforcing steel in ribs or <i>joists</i>	1	1	1	1
GYPSUM, POURED AND PRE-CAST				
Gypsum suspension system, without ceiling	4	3	—	—
Minimum cover of reinforcement in suspension system (see also under Steel Joist Construction below)	1	¾	—	—
STEEL JOIST CONSTRUCTION				
Slab Thickness over Joists				
<i>Concrete</i> , any grade, poured or pre-cast	2½	2½	2	2
Gypsum, poured or pre-cast	2	—	—	—
Required Ceiling Protection for Joists				
Gypsum, poured or pre-cast, including plaster, if any	2½	7/8	—	—
Gypsum-vermiculite ⁽⁶⁾ plaster on metal lath	—	1	¾	1½
Unsanded gypsum plaster on metal lath	—	—	—	1½
Unsanded gypsum plaster, fibred, on perforated gypsum lath	—	—	—	—
Gypsum plaster, not leaner than 1:2, on metal lath	—	1½	7/8	—
Gypsum plaster, not leaner than 1:3, on metal lath	—	—	—	¾
Portland cement plaster on metal lath	—	—	—	7/8
WOOD JOIST CONSTRUCTION				
Flooring over Joists ⁽⁸⁾				
Double deck with asbestos paper weighing at least 14 pounds per 100 square feet between decks:				
(a) minimum thickness of subfloor—				
tongued and grooved or shiplap	—	—	—	¾
plywood	—	—	—	5/8
(b) minimum thickness of top floor	—	—	—	1½
Required Ceiling Protection for Joists				
Gypsum plaster not leaner than 1:2 on perforated gypsum lath, all joints covered with 3 inch strip of expanded metal	—	—	—	¾
Portland cement plaster, on metal lath	—	—	—	1½
—	—	—	—	7/8

(1) Or *cellular concrete* weighing at least 75 pounds per cubic foot.
(2) The required thickness may include any solid *incombustible* finish on top of a structural slab.
(3) Where the slab is poured on permanent centering such as high-ribbed lath or metal pans, the thicknesses given may be reduced to those given for Grade A *concrete*.
(4) Fillers may consist of hollow clay tile, slag *block*, gypsum *block*, *concrete block* or tile, or *cinder block* or tile.
(5) Ceiling shall consist of ¾ inch gypsum plaster on metal lath or equivalent.
(6) Gypsum-vermiculite plaster shall consist of 3 parts gypsum to one part vermiculite by weight.
(7) This thickness is exclusive of the lath.
(8) The thicknesses given apply only to assemblies having flooring above and a ceiling below the joists.

4.10.4 Plaster on Monolithic Concrete.—No plaster on monolithic *concrete* ceilings or soffits shall be considered as effective in resisting fire unless it is reinforced as required by Sub-item 4.7.3.5 (f). (See also Item 4.7.3.7.) This applies to *beams, girders, joists, and slabs of concrete.*

4.10.5 Fire-resistive Steel Joist Construction.—The thicknesses for slabs and ceilings as given in Table 1 of this Section under Steel Joist Construction, apply only to assemblies having both a slab above the *joists* and a ceiling below.

Wood or metal nailing strips may be embedded within the minimum slab thicknesses given, provided that the bottoms of such nailing strips are not closer than $1\frac{1}{4}$ inches to the top of the steel *joists*. There shall be no continuous connection between such strips and steel floor members, but isolated metal chairs attached to such members and thoroughly embedded on all sides in the *concrete* may be employed.

SECTION 4.11 FIRE-RETARDANT ROOF COVERINGS

4.11.1 General.—“Fire-retardant” roof coverings shall include those described in Article 4.11.3. Materials not specifically named in Section 3.10 shall be considered as “fire-retardant” roof coverings only if *approved* by the *authority having jurisdiction* in accordance with Article 3.1.3, in respect of the following factors:

- (a) The ability to give protection against flame and burning brands and radiant heat;
- (b) The tendency to produce dangerous sparks or brands when ignited.

4.11.2 Roof Repairs and Alterations.—Where any *existing* roof covering requires repairs or *alterations* over more than 40 per cent of its area within any period of 12 months, and where such roof covering does not conform to the requirements in respect of fire zones as set forth in Item 4.4.3.4 and Item 4.4.4.3, the whole roof covering shall be renewed in accordance with the requirements of this Code for new buildings.

Required “fire-retardant” roof coverings shall not be placed over wood shingles.

4.11.3 Fire-retardant Roof Coverings

4.11.3.1 Detailed Requirements.—The following roof coverings shall be classed as “fire-retardant” provided they meet all requirements of Section 3.10 with respect to quality, weight, thickness, and application:

- (a) Asphalt asbestos-felt built-up roof covering;
- (b) Asphalt rag-felt built-up roof covering; provided that on *combustible* decks, the covering shall be finished by one of the following four methods:
 - (i) a surface of crushed stone, slag, or gravel weighing at least 3 pounds per square foot embedded in asphalt cement in accordance with good commercial practice;

- (ii) an asphalt rag-felt cap sheet meeting the requirements of A.S.T.M. Specification D371-37T for 45 pound grade;
- (iii) an asphalt rag-felt sheet surfaced with coarse mineral granules, meeting the requirements of A.S.T.M. Specification D249-37T;
- (iv) an asphalt asbestos-felt sheet; containing at least 17.5 pounds of dry felt and weighing at least 50 pounds, per 108 square feet;

(c) Built-up roofs employing coal-tar-pitch cement, provided they are surfaced as in paragraph (i) of Sub-item (b) above;

(d) Asphalt asbestos-felt sheet, containing at least two separate layers of saturated asbestos felt; with a minimum weight of 20 pounds of dry felt and a minimum sheet weight of 58 pounds, per 108 square feet;

(e) Asphalt asbestos-felt or rag-felt shingles surfaced with coarse mineral granules, meeting the requirements of A.S.T.M. Specification D225-37T wherever applicable, provided there are at least two thicknesses of shingles at all points covered and that the total weight of shingles per 100 square feet of roof is not less than 210 pounds;

(f) Asbestos-cement roof coverings, either shingles or flat or corrugated sheets;

(g) Metal roof coverings, either shingles or flat or corrugated sheets;

(h) Slate;

(i) Clay Tile;

(j) Concrete slabs or roof tiles.

4.11.3.2 Classification by Underwriters Laboratories.—Any roof covering meeting the requirements for Class A or Class B covering as set forth in the "List of Inspected Fire Protection Equipment and Materials" dated January, 1941, and published by Underwriters Laboratories Incorporated, (U.S.A.), shall be accepted as a "fire-retardant" roof covering. Subsequent editions of the above List may be used, subject to permission from the *authority having jurisdiction*.

SECTION 4.12 DOORS, WINDOWS, SKYLIGHTS, AND CLOSURES FOR MINOR OPENINGS

4.12.1 Openings in General

(a) For the purposes of this Part of this Code, the measurement of a door-opening, window-opening, or skylight-opening, either to determine its area or its distance from some line or plane, shall be made on the basis of the actual gross opening left in the wall, *partition*, or roof, into which the window, door, or skylight, including any frame is to be installed. The area of any such opening shall be the gross area, no reduction being made for frames or for either horizontal or vertical mullions unless such mullions are an integral part of the main structure and are not less fire-resistive than is required for the wall or *partition* in which they occur.

(b) Notwithstanding any and all other requirements of this Code with respect to the protection of openings, *fire-resistive doors* and *windows* having specific *ratings* shall not be required in external walls of wood frame construction.

4.12.2 Tests for Fire-resistive Doors and Windows

(a) The terms *fire-resistive closure*, *fire-resistive door*, *fire-resistive window*, wherever used in this Code shall mean a *closure* (door, window, or otherwise) for which a definite *fire-resistance rating* has been established in accordance with (c) and (d) of this Article, or which has been tested or inspected and approved by a recognized laboratory.

(b) The regulations of this Section in respect to *fire-resistive doors* (either interior or exterior) and windows presume that all such doors and windows are equally effective against exposure to fire on either side.

(c) *Ratings* for *fire-resistive doors* and *windows* shall be determined in accordance with the procedure outlined in C.E.S.A. Specification A54-1940.

(d) Each type of door or window which is the subject of a fire test shall be rated only after tests on both sides of it have been carried out. The test specimen shall include the frame, trim, mountings, locks, transoms and fixed side-panels if any, as well as any and all accessories, which will form part of the closure in actual service. Exposure tests on both sides of a door or window shall require duplicate specimens of a specific type to be tested. The fire test on the side giving the poorer result shall be the basis for establishing a *rating*. When previous tests on a specific type of door have clearly indicated the relative effectiveness of either side against exposure to fire, and when it is desired to test a specimen of the same type for minimum performance, it shall be permissible to ascertain this performance by exposure to the test fire of only that side which is known to give the poorer result.

Where the test specimen consists of two similar doors mounted on either side of an opening in identical manner, a *rating* may be established on the basis of exposure to the test fire of one side of the composite *closure* only; but where either the doors or mountings are dissimilar, tests on both sides of the composite *closure* shall be required.

4.12.3 Doors and Windows in Exterior Walls

4.12.3.1 Maximum Aggregate Areas of Openings.—In any building, regardless of occupancy or type of construction, the maximum aggregate area of openings permitted in any *storey* of any exterior wall shall be in accordance with Table 1 of this Section. For the correct interpretation of these requirements with respect to buildings on the same property, see Item 4.2.4.1. The requirements of this Item shall not apply to *detached one- and two-family dwellings*.

TABLE 1 (SECTION 4.12)
MAXIMUM AGGREGATE AREAS OF OPENINGS IN EXTERIOR WALLS

LOCATION OF WALLS or parts thereof in terms of distance from any <i>lot line</i> , or from the op- posite side of a <i>street</i> , or from the centre line of a <i>lane</i> ⁽¹⁾	MAXIMUM AREA OF OPENINGS permitted per <i>storey</i> , in percentages of gross superficial area of wall in the <i>storey</i>			
	If the Exterior Wall ⁽³⁾ is the			
	Front of Building or Wall of <i>Outer Court</i> , or Recess Therefrom	Rear of Building or Wall of <i>Outer Court</i> , or Recess Therefrom	Side of Building or Wall of <i>Outer Court</i> , or Recess Therefrom	Wall of Air-well, <i>Inner Court</i> , or Recess Therefrom
Less than 4 feet	Ground Floor <i>Exit</i> Doorways Only			
Not less than 4 feet but less than 10 feet	30%	20%	15%	20%
Not less than 10 feet but less than 20 feet	40%	25%	20%	25%
Not less than 20 feet but less than 30 feet	50%	35%	25%	35%
Not less than 30 feet but less than 40 feet	60% ⁽²⁾	45%	40%	45%
Not less than 40 feet but less than 60 feet	75% ⁽²⁾	60%	50%	55%
Not less than 60 feet but less than 80 feet	90%	80%	70%	75%
Over 80 feet	90%	90%	90%	90%

(1) All distances shall be measured in a straight line at right angles to the vertical plane containing the *lot line*, *street line*, or centre line of *lane*.

(2) These percentages may be multiplied by the factor 1.2 in the case of show windows in the *first storey*.

(3) Where a building is located on a corner *lot* at the intersection of two *streets*, walls fronting on a *street* shall be front walls, and the *structure* shall not be considered as having any rear wall.

4.12.3.2 Classification of Openings requiring Fire-resistive Closures in Exterior Walls.—For the purposes of this Part of this Code, all openings in exterior walls which are required to have *fire-resistive doors* or *windows* shall be classified as being either openings of “greater hazard” or openings of “lesser hazard”.

Where *fire-resistive closures* are required on the basis of distance from a *lot line*, from another building on the same property, from another opening in the same building, or from a roof (see Article 4.2.4), any opening which lies within 2/3 of the criterion distance shall be classified as an opening of “greater hazard”, while any other opening within the criterion distance shall be classified as an opening of “lesser hazard”.

All openings in exterior walls which are required to have *fire-resistive closures* because of their location within or adjacent to an *exit*, shall be classified as openings of "greater hazard". All openings in exterior walls required to have *fire-resistive closures* and not specifically classified herein, shall be classified by the *authority having jurisdiction*.

4.12.3.3 Required Rating for Fire-resistive Closures in Exterior Walls.—

(a) Every door or window filling an opening of "greater hazard" (see Item 4.12.3.2) shall have a *fire-resistance rating* of at least 45 minutes; and every door or window filling an opening of "lesser hazard" shall have a *fire-resistance rating* of at least 30 minutes.

(b) Any *fire-resistive door* or *window* approved by a recognized laboratory as suitable for a specified location, and installed in accordance with *approved* regulations shall be accepted as a required *fire-resistive door* or *window* when installed in such a location*.

4.12.3.4 Maximum Sizes of Protected Exterior Openings.—

The maximum area and dimensions of any individual opening in an exterior wall, which is required to be filled by a *fire-resistive door* or *window*, shall not exceed the values given in Table 2 of this Section.

TABLE 2 (SECTION 4.12)
MAXIMUM DIMENSIONS OF A PROTECTED EXTERIOR OPENING

Kind of Opening	Opening of "Greater Hazard" (See Item 4.12.3.2)			Opening of "Lesser Hazard" (See Item 4.12.3.2)		
	Maximum Area in sq. feet	Maximum Width in feet	Maximum Height in feet	Maximum Area in sq. feet	Maximum Width in feet	Maximum Height in feet
Door	120	12	12	180	15	15
Window	60	15	10	120	30	12

4.12.4 Doors, Windows, and Transoms in Interior Walls and Partitions

4.12.4.1 General.—

(a) Where *fire-resistive closures* in interior walls or *partitions* are required by this Code, they shall have the *fire-resistance ratings* indicated in Item 4.12.4.2; provided that any *fire-resistive closure* that has been tested or inspected and approved by a recognized laboratory and is installed in accordance with *approved* regulations shall be accepted as having the required *rating*.

*Reference may be made to the "Regulations of the National Board of Fire Underwriters for the Protection of Openings in Walls and Partitions Against Fire", Pamphlet No. 80 dated January, 1939 and amended in 1941.

(b) No window, glazed panel, or transom shall be installed in any interior wall or *partition*, required to have openings therein protected, except as follows:

- (i) Any such opening in a one-hour wall or *partitions* may contain a door with wired-glass panels in it and a fixed wired-glass transom over it, provided that the *closure* as a whole has the *rating* required by Item 4.12.4.2, and that the total area of wired glass in any opening in an 'ordinary' occupancy separation does not exceed 5 square feet and in any other opening does not exceed 20 square feet;
- (ii) In any office building and in any Group B (Institutional) or Group D (Residential) Occupancy, where stairs or elevators are enclosed by 2-hour walls or *partitions*, doors opening into such stairs or elevators may contain wired-glass panels the aggregate area of which shall not exceed 5 square feet in any one opening provided that such doors have the *rating* required by Item 4.12.4.2.

(c) In *multiple dwellings*, every doorway between a *dwelling unit* and a public *hallway* shall be filled by a door not less fire-resistive than a snug-fitting wood-slab door at least 1 $\frac{3}{4}$ inches thick in all parts. No transom shall be installed in such a doorway, unless it is fixed and equal in fire-resistance to the door.

4.12.4.2 Minimum Ratings and Maximum Sizes of Fire-resistive Closures in Interior Walls and Partitions.—Where openings in interior walls and *partitions* are required to have *fire-resistive*

TABLE 3 (SECTION 4.12)
MINIMUM RATINGS AND MAXIMUM SIZES OF INTERIOR
FIRE-RESISTIVE CLOSURES

Fire-resistance Rating of Wall or Partition	Required Fire-resistance Rating of Closures	Maximum Area and Dimensions of an Individual Opening		
		Maximum Area in sq. feet	Maximum Height in feet	Maximum Width in feet
3 hours or more	3 hours ⁽¹⁾	120	12	12
2 hours	1 hour 30 minutes ⁽²⁾	120	12	12
	2 hours	180	15	15
1 hour	45 minutes (minimum)	120	12	12
	1 hour (no glass)	180	15	15

(1) When two door assemblies, both previously accepted as entitled to a 1 $\frac{1}{2}$ -hour *fire-resistance rating*, are installed on two sides of the same opening, such combined assemblies shall be accepted as having a 3-hour *fire-resistance rating*.

(2) For doors in openings of *shaft enclosure walls*, this figure may be reduced to one hour when the enclosure extends through more than one *storey*.

closures, such closures shall have *ratings* and sizes commensurate with the fire-resistive qualities of the wall or *partition* in which they occur and in accordance with Table 3 of this Section.

4.12.5 Skylights

(a) The term skylight shall mean a glazed assembly located in or over an opening in a roof, the prime purpose of which is to admit light; and shall include glazed portions of 'saw-tooth' roofs but shall not include greenhouses.

(b) *Fire-resistance ratings* on skylights shall be determined by the procedure for doors, shutters, and glazing as given in C.E.S.A. Specification No. A54-1940, the test fire being applied to only the underside of the skylight. The test specimen shall be truly representative as to material, details, installation, and finish.

(c) When any skylight or part thereof is so located as to be within the criterion distance of a *lot line* or of another building, as given in Article 4.2.4 for various occupancies, at which *fire-resistive doors* and *windows* are required in exterior walls, such a skylight shall have a *fire-resistance rating* in accordance with the requirements pertaining to *fire-resistive closures* in exterior walls as given in Items 4.12.3.2 and 4.12.3.3.

(d) Skylight frames, sash, and lights shall be adequate to carry the *dead*, snow, and wind *loads* given in Section 3.6.

(e) Frames and sash of all skylights on buildings of Types 1A, 1B, or 5 Construction shall be of corrosion-resisting metal. On buildings of Type 1C, Type 2, or Type 3, skylight frames and sash in which the glass is inclined at more than 30 degrees to the vertical shall be of corrosion-resisting metal.

(f) All glass set at a slope of more than 30 degrees to the vertical shall be wired glass, except that skylights over a vertical *shaft* may be glazed with plain glass if protected above and below by screens constructed of wire not less than 0.08 inch in diameter with the mesh not exceeding one inch. The upper screen shall be located without sags at from 4 to 12 inches above the glass, and shall support on any square foot of its area a load of 200 pounds normal thereto without touching glass. The lower screen shall cover the whole skylight opening and shall be substantially supported. All such screens and their supports shall be of corrosion-resisting metal.

An exception to the above requirements for wired glass shall be made in the case of photographers' or artists' studios, where plate glass without screens may be used.

Panes of wired glass inclined at more than 30 degrees to the vertical shall have a width of not more than 18 inches at right angles to the direction of the slope and an area of not more than 1728 square inches.

(g) All skylights, the glass of which is set at an angle of more than 45 degrees to the vertical, shall be set on curb walls extending at least one foot above the highest point at which the roof abutts the curb walls.

Such curbs shall be of the same materials and thickness as the least fire-resistive wall or *partition* supporting the skylight from the *storey* below. Where the skylight is supported by the roof structure, such curbs shall be of the same type of construction as is used in the roof abutting; provided that when the least dimension in horizontal projection of the skylight exceeds 7 feet, all skylight supports (curb walls, *beams*, *girders*, and *columns*) shall have a *fire-resistance rating* of at least one hour, and when the said least dimension exceeds 12 feet, all skylight supports shall have a *rating* of at least 2 hours.

4.12.6 Minor Openings

(a) The term "minor openings" as used in this Article shall mean openings in interior walls, *partitions*, or floors for the passage of power-shafts, power-belts, belt-conveyors, and similar installations.

(b) Minor openings shall not be permitted in any interior wall, *partition*, or floor required by this Code to have both protected openings and a *fire-resistance rating* in excess of one hour, provided that where openings between floors are not required to be enclosed, minor openings shall be permitted.

(c) Any minor opening located in a wall or *partition* required to have protected openings shall be provided with *self-closing fire-resistive doors* slotted as necessary for belts or rails, and/or shall be otherwise closed off against the passage of flame and smoke in a manner satisfactory to the *authority having jurisdiction*.

(d) All minor openings in floors shall be protected as and when required by Section 4.16.

SECTION 4.13 FLUES, CHIMNEYS, SMOKESTACKS, AND FIREPLACES

4.13.1 General Requirements.—Every apparatus installed in or brought into any building for the purpose of producing heat by the combustion of any solid, liquid, or gaseous fuels shall have a suitable connection to an adequate *chimney flue*, *smoke pipe*, metal smokestack, or *gas flue*; except that no such connection shall be required for;

(a) Small appliances for intermittent use, burning liquid fuel, the capacity of which does not exceed 20,000 British Thermal Units per hour;

(b) Certain types of foundry and shop forges and heaters when installed in accordance with good commercial practice and *approved* by the *authority having jurisdiction*;

(c) Certain types of gas appliances, in accordance with the recommendations of the American Gas Association as set forth in the publication entitled, "A.G.A. Requirements for House Piping and Appliance Installation", dated 1928.

4.13.2 Flue Connections.—No *chimney flue*, *smoke pipe*, metal smokestack, or *gas flue* shall have connections thereto in more than one *storey*.

Any *chimney flue* or metal smokestack serving to carry the products of combustion from any solid or liquid fuel shall have but one connection thereto, except as hereinafter provided (Sub-item 4.13.3.3 (e)), provided that any manually operated gas appliance, or any automatic gas appliance having provision for shutting off all the gas supply when the pilot light is extinguished, may be connected to such a *flue* provided its connection is at least 8 inches above and clear of the *smoke pipe* connection.

Where two or more inlets are provided in any *gas flue*, such inlets shall be so located that no horizontal plane can pass through more than one inlet.

No connection shall be made with any *flue* through the bottom or seat or *foundation* of the *flue* enclosure.

4.13.3 Chimneys

4.13.3.1 General Construction Requirements.—

(a) No *chimney* shall carry any load except its own weight, and such load shall be transmitted to the supporting construction in such a manner as to prevent the shearing, cracking, or falling off of any part of the *chimney*. Every *chimney* shall be completely supported by *masonry* or *reinforced concrete*, or by construction having a *fire-resistance rating* of at least 4 hours. Supports, *foundations*, and *footings* for *chimneys* shall be so designed and constructed as to carry the *chimney* without detrimental settlement or deflection sufficient to cause cracking of *chimney* walls.

(b) *Chimneys* shall be constructed of *masonry* or *reinforced concrete*, as specified elsewhere in this Article. All materials entering into the construction of any *chimney* shall meet the requirements for "Materials for flues, furnace casings, hearths, and similar purposes" as given in C.E.S.A. Specification No. A54-1940 entitled, "Standard Specification for the Procedure for Fire Tests on Building Construction and Materials".

(c) Every *chimney* shall extend at least 3 feet above the highest point at which it comes in contact with the roof of a building, and at least 2 feet higher than any ridge, mansard roof, *parapet wall*, or roof structure within 10 feet of it.

(d) No *chimney* or part thereof shall be corbelled from a *masonry* wall more than 8 inches, nor more than one-half of such wall's thickness, nor shall any *chimney* be corbelled from a wall less than 12 inches thick unless it projects equally on either side of the wall. Corbelled *chimneys* shall not be supported by hollow walls or walls of *hollow units*.

(e) No change shall be made in the size or shape of any *chimney flue* within 6 inches above or below *combustible* roof assemblies, i.e., above or below *joists* or *rafters*.

(f) *Chimney flues* shall be as nearly vertical as possible and in no case inclined at more than 45 degrees to the vertical.

(g) Every *chimney flue* other than one serving a fireplace shall be provided with a cleanout opening at its base, such opening being equipped with tight-fitting metal doors.

(h) All *masonry* in *chimney* construction shall be laid with full, *mortar* joints struck smooth where exposed to weather. All *mortar* shall be cement or cement-lime *mortar*. No *mortar* lining shall be permitted.

(i) All firebrick lining shall be laid in fireclay *mortar* or *approved* high temperature cement.

(j) *Smoke pipes* or *gas vents* shall enter *chimney flues* through a fireclay or metal thimble, or a flue ring of *masonry*, no part of which shall extend within the *flue* space. No *woodwork* shall extend within $7\frac{1}{2}$ inches of the *flue* connection.

(k) Upon the completion of a building or the alteration of *existing flues*, the *flues* shall be cleaned and left smooth on the inside, and smoke-tight throughout their entire length.

(l) The *authority having jurisdiction* may require a smoke test to be performed on any *chimney flue*. Such test shall be carried out by the person responsible for the construction of the *flue*, or his agent, in the presence of the *authority having jurisdiction*.

4.13.3.2 Flue Linings.—

(a) Wherever *flue linings* are required by this Code, such *linings* shall fulfil the requirements of this Item.

(b) *Flue linings* shall consist of formed units of fireclay or of other suitable refractory clays adapted to withstand reasonably high temperatures and *flue* gases, and having a softening point not lower than 1994 F. *Flue linings* shall be not less than $\frac{5}{8}$ inch in thickness and shall be built in as the outer walls of the *chimney* are constructed. All joints and spaces between the *masonry* and *lining* shall be thoroughly slushed and grouted full as each course of *masonry* is laid. Only cement *mortar* shall be used in setting *flue linings*. Cracked, broken, or otherwise defective *linings* shall not be used. *Flue linings* shall start from a point not less than 4 inches below the lowest point of *smoke pipe* intakes or, in the case of fireplaces, from the apex of the smoke chamber and shall be continuous to a point not less than 4 inches above the enclosing walls.

(c) Where more than two *flue linings* are installed in one *chimney*, there shall be a partition of *solid masonry* at least $3\frac{3}{4}$ inches thick separating each group of two *flues* from any other *flue*. Joints shall be staggered at least 6 inches in adjacent linings where such a partition is not required. Each *flue* serving a furnace or boiler or fireplace shall be separated from any other *flue* by such a partition.

4.13.3.3 Materials and Thicknesses of Walls of Chimney Flues.—

(a) **General.**—The construction of *chimneys* shall in general be regulated by the classification of the heat producing appliances which they serve (see Article 4.14.2). The *authority having jurisdiction* may,

however, in special cases, authorize the construction of *chimneys* in a manner not conforming with the requirements of this Section, provided that such construction is in accordance with good commercial practice, and provided further that it can be definitely shown that there will be no temperature in excess of 160 F. on any adjacent *combustible* construction or trim when the appliance is operating at full capacity.

Hollow *blocks* or hollow tile of clay or *concrete* shall not be used for the walls of an independent *chimney*; but they may be used when serving only low heat appliances (see Article 4.14.2) for *chimneys* built in connection with exterior, *party*, or *common walls* of *hollow units* in buildings not exceeding three *storeys* in *height*, to the extent that an 8-inch exterior building wall may serve as an exterior wall of the *chimney*, and any wall of a *chimney* may be constructed of two thicknesses of 4-inch *block* or tile set with staggered joints. All such *chimneys* shall be provided with a *flue lining*.

The thicknesses given in (b), (c), (d), and (e) hereof for *masonry* are for *solid masonry* of squared units. Where *rubble* or undressed stone is used, thicknesses shall be increased by 4 inches.

(b) Chimney Flues for Low Heat Appliances.—Every *chimney flue* serving a low heat appliance such as a stove, hot air or hot water furnace, or low pressure steam heating furnace (see Article 4.14.2) shall have walls of *masonry* at least 8 inches thick or *reinforced concrete* at least 6 inches thick, and shall be provided with a *flue lining*; provided that the following shall be sufficient for a *flue* serving only one or two *dwelling units*:

- (i) *Masonry* or *reinforced concrete* $3\frac{3}{4}$ inches thick with a *flue lining*;
- (ii) Grade A *reinforced concrete* (see Item 4.7.3.2) 6 inches thick without a *flue lining*;
- (iii) *Masonry* or Grade B *reinforced concrete* (see Item 4.7.3.2) 8 inches thick without a *flue lining*.

(c) Chimney Flues for Medium Heat Appliances.—Every *chimney flue* serving a medium heat appliance such as a high pressure steam boiler, a smoke house, or a charcoal furnace (see Article 4.14.2) shall have walls of *masonry* or *reinforced concrete* at least 8 inches thick, provided that *stone masonry* shall be not less than 12 inches thick, and in addition shall be lined with not less than 4 inches of firebrick starting at least 2 feet below the *flue* inlet and extending for a distance of at least 25 feet above the *flue* inlet.

(d) Chimney Flues for High Heat Appliances.—*Chimney flues* for high heat appliances such as cupolas, brass furnaces, and porcelain baking kilns (see Article 4.14.2) shall have double walls of *masonry* or *reinforced concrete*, each at least 8 inches thick with a minimum air space between them of 2 inches, and the inside course of the inner wall shall be of firebrick not less than 4 inches thick. Alternatively the *chimney flue* may consist of a steel casing of $\frac{1}{4}$ -inch or thicker plates lined with at least 8 inches of firebrick. Other materials and designs may be used for *chimney flues* serving high heat industrial appliances, subject to permis-

sion from the *authority having jurisdiction*, provided it can be definitely established that no temperatures in excess of 160 F. will exist or be liable to develop on any adjacent *combustible* material or *combustible* construction.

(e) Chimney Flues for Incinerators.—

- (i) For non-fuel-fired incinerators in which the grate area of the combustion chamber is 9 square feet or less, the *chimney* walls shall be at least $3\frac{3}{4}$ inches thick and shall be lined with fireclay *flue lining*. It shall be unlawful to install more than three service openings in such a *chimney* or to use such *chimneys* in *structures* over 3 *storeys* in *height*.
- (ii) For a non-fuel-fired incinerator in which the grate area of the combustion chamber exceeds 9 square feet, the *chimney flue* shall be constructed of unit *masonry* not less than 8 inches thick, the inner course of which shall consist of not less than 4 inches of firebrick for a height of not less than 25 feet above the roof of the combustion chamber.
- (iii) For a fuel-fired incinerator, the primary purpose of which is to dispose of garbage, cleanings, sweepings, and miscellaneous refuse, for example, an incinerator in a *residential building*, an *institutional building*, a church, a school, or a *restaurant*, the *chimney flue* shall be as required for a non-fuel-fired incinerator with a grate area exceeding 9 square feet, but shall be lined to a height of at least 35 feet above the combustion chamber.
- (iv) Every incinerator designed or intended for the disposal or reduction of commercial wastes or cuttings or refuse resulting from commercial processes shall be provided with a *flue* *approved* by the *authority having jurisdiction*, but in no case shall such a *flue* have walls less than 12 inches thick of which the inner 4 inches shall be firebrick for the full height of the *chimney*.
- (v) Any incinerator may be connected to a *flue* serving a medium or high heat appliance provided that the appliance and the incinerator are in the same *storey* and at approximately the same level, and provided further that an *approved* breeching is employed to make the connection, and provided finally that the area of the *chimney flue* is at least four times that of the incinerator breeching.
- (vi) Every *flue* serving an incinerator shall terminate in a substantial spark arrester which shall be maintained in good condition at all times.

4.13.3.4 Size of Chimney Flues.—The cross-sectional area of every *chimney flue* shall be designed and proportioned in accordance with good commercial practice* on the basis of the heat producing apparatus

*For good commercial practice, the Code of Minimum Requirements for the Heating and Ventilating of Buildings of the American Society of Heating and Ventilating Engineers, Edition 1929, may be consulted.

for which it is intended, taking into full account the following factors: *flue* gas temperature, external temperature, draft conditions required, *flue* shape, *flue* height, influence of adjoining *structures* on *flue* action. In no case shall any *flue* have an 'effective' area of less than the following.

Small special stoves and heaters	28 square inches
Cooking stoves, ranges, room heaters . . .	40 square inches
Fireplaces (at least 1/12 the fireplace opening)	40 square inches
Furnaces, warm air, hot water, steam heating	70 square inches

No *chimney flue* shall have a cross-section the breadth of which is less than 2/3 the length.

4.13.4 Metal Smokestacks

4.13.4.1 General.—A metal smokestack may replace a *chimney flue* for any heat producing appliance provided it meets the requirements of this Article.

4.13.4.2 Construction.—Every metal smokestack shall be vertical and unless structurally self-supporting shall be securely guyed and firmly anchored. Cleanout openings shall be provided at the base of any such stack. All such stacks shall extend to at least 4, 8, or 12 feet, respectively, for low, medium, or high heat appliances, above any roof, roof structure, or part thereof within 25 feet. The *authority having jurisdiction* may require any such stack to be fitted with a spark arrester. (See also Article 4.13.5.) Every metal smokestack shall be supported on *masonry* or *reinforced concrete foundations* or may be mounted directly upon a boiler.

4.13.4.3 Exterior Stacks.—No exterior stack shall be closer than 3 feet to any wall or roof of *combustible* construction, or closer than 6 feet to any opening in any wall or to any means of *exit*, or closer than one foot to any *masonry* wall. Such distances may be reduced by the *authority having jurisdiction* when the stack is insulated but the maximum reduction shall be two-thirds. Every exterior metal smokestack shall extend at least 10 feet above any door or window within 50 feet.

4.13.4.4 Interior Stacks.—Every interior metal smokestack which passes through more than one *storey* or through an enclosed attic space shall be enclosed above the room in which the heat producing appliance is located with walls having a *fire-resistance rating* of not less than 4 hours in which every opening is protected by *self-closing fire-resistive doors*. Where such stack is less than 24 inches in diameter, the space between the enclosing walls and the stack shall be sufficient to render the entire stack accessible for examination and repair. In the case of a stack having a greater diameter than 24 inches such space shall not be less than 4 inches. The space between the stack and enclosing walls shall not be used to vent any room other than the one in which the heating appliance is located. The enclosing walls shall be continuous to and through the roof, and the space between the walls and the stack shall be vented to the outside air, suitable air inlets being provided at the base.

Every metal smokestack in one-storey buildings, or within the *storeys* in which the heating apparatus is contained, shall be kept 3 feet clear of any *combustible* material; except that, where it passes through a *combustible* roof assembly, this distance may be reduced to 18 inches in the case of a medium heat appliance and 12 inches in the case of a low heat appliance, provided the stack is guarded by a metal thimble extending at least 9 inches above and below the roof assembly including *joists*. Such thimble shall have double cylindrical walls with a ventilated space between the walls and between the stack and the thimble. The clearances given in this paragraph are minimum; and in addition no *combustible* material or construction shall be so located adjacent to a metal smokestack as to have a surface temperature in excess of 160 F.

4.13.5 Special Industrial Chimneys and Stacks.—*Chimneys* or stacks serving high heat appliances such as cupolas and blast furnaces shall extend at least 20 feet above any roof or part thereof within 50 feet and shall be fitted with an *approved* spark arrester.

4.13.6 Isolated Chimneys.—*Hollow masonry* shall not be used in the construction of isolated *chimneys*, provided that this shall not prohibit the use of perforated radial *chimney* bricks having a *net area* of not less than 65 per cent of their *gross area*. In any such *chimney*, provision shall be made for all conditions of stress that may occur, in accordance with well established principles of mechanics and sound engineering practice. The requirements and regulations of Part 3 with respect to wind loads, permissible stresses, and allowable materials of construction shall be observed.

4.13.7 Gas Flues.—Where a gas appliance is connected to any *flue* other than a *chimney flue* (see definition of *gas flue*) every such *flue* shall meet the requirements of this Article.

Every *gas flue* shall have a cross-sectional area at least equal to the area of the largest *gas vent* connected thereto plus 50 per cent of the aggregate area of all other additional inlets, and in no case shall any circular *flue* have a diameter less than 3 inches, nor shall any rectangular *flue* have any dimension less than 2 inches or an area less than 12 square inches.

Every *flue* shall be carried to and through the roof and shall be vertical wherever possible, and in no case offset or inclined more than 60 degrees to the vertical. Every *flue* shall extend 2 feet above any portion of a roof or *structure* within 10 feet. In *existing* buildings, subject to special permission by the *authority having jurisdiction*, *gas flues* which have a vertical rise of more than one *storey* may reach the exterior air by passing through a wall, providing the change in direction is made by a curved fitting and the *flue* terminates in an *approved* cap or fitting clear of air circulation obstructions.

Gas flues shall be in the form of pipe with bell and spigot, screw, or other equally gas-tight joints, or they shall be in the form of special *flue* blocks or *flue linings* of clay or *concrete* built into a *masonry* wall. Such blocks or linings shall be laid with full *mortar* joints. The materials

employed in forming any *gas flue* shall be *incombustible* and corrosion-resistant. They shall be of such types and thicknesses or so arranged as to avoid any temperature in excess of 160 F. on adjacent *combustible* materials. No sheet metal *flue* shall be permitted. Where *gas flues* extend through *combustible* walls or *partitions*, they shall have a full one inch air space between their exterior walls and any *combustible* material.

4.13.8 Fireplaces

4.13.8.1 Standard Fireplaces.—The requirements of this Item shall apply to any fireplace burning solid or liquid fuel.

The back and sides of every fireplace shall be constructed of clay or shale *brick*, or *ashlar* at least 8 inches thick or of rubble or hollow clay or *concrete* units at least 12 inches thick. Walls of *hollow units* shall consist of two units in thickness with joints staggered. All fireplace walls shall be lined with firebrick or other *approved* material, or alternatively the minimum wall thicknesses shall be increased 4 inches. Firebrick shall be laid in fireclay *mortar* or high-temperature cement. Where the firebrick lining has a minimum thickness of 4 inches, it may be included as part of the required minimum wall thickness.

Every fireplace shall be connected to a *chimney flue*.

Every fireplace shall have a hearth projecting at least 16 inches from the *chimney* breast and extending at least 8 inches beyond each side of the fireplace opening. Support for such hearths shall be provided either by *masonry* trimmer arches haunched against a trimmer joist, or by *masonry* or *reinforced concrete* construction corbelled or cantilevered from the *chimney* or otherwise carried by *approved* fire-resistive construction. The minimum thickness of *incombustible* material composing the hearth and its supports shall be 6 inches. Wood centering under hearths shall be entirely removed after construction.

No heater burning solid or liquid fuel shall be placed in a fireplace not complying with this Article. No wood shall be placed within 8 inches of the jambs or 12 inches of the top or arch of any fireplace opening.

4.13.8.2 Imitation Fireplaces.—Fireplaces for gas heaters shall not be constructed in imitation of standard fireplaces unless they conform in all respects including *chimney flues* to standard fireplaces; except, however, that gas space heaters may be installed in recesses not more than 6 inches in depth, provided such recess is constructed entirely in *incombustible* materials.

Imitation fireplaces for *approved* electrical appliances may be constructed provided the recess is lined on sides, back, and top with at least one inch of *incombustible* material. No *flue* or *vent* shall enter such recess.

4.13.9 Fire-stopping Around Chimneys.—No wood framing shall be placed closer than 2 inches to any *chimney*, regardless of its use, nor closer than 4 inches to the back of any fireplace. The space between such framing and the *chimney* or fireplace back shall be filled with loose or porous *incombustible* material.

No *combustible* studding, furring, lathing, grounds, or wood plugs shall be placed directly against or within 2 inches of any *chimney*, or in its joints. Wood trim may be placed against a *chimney* if insulated therefrom by at least 1/8 inch of asbestos paper, and secured by *incombustible* devices to the *masonry*.

SECTION 4.14 HEAT PRODUCING APPLIANCES AND MISCELLANEOUS EQUIPMENT

4.14.1 General.—All appliances and apparatus hereafter installed in buildings for the purpose of furnishing heat or containing fire shall be subject to the requirements of this Section, with the exception of portable space heaters, hot plates, coffee urns, toasters, warmers, and similar portable appliances. Notwithstanding any or all the requirements of this Section, the *authority having jurisdiction* may authorize the installation of any heat producing appliance in a manner not conforming with the requirements given herein, provided such installation is in accordance with good commercial practice, and provided further that it can be definitely shown that there will be no temperatures in excess of 160 F. on any adjacent *combustible* construction or trim when the appliance is operating at full capacity.

4.14.2 Classification of Heat Producing Appliances.—Excepting incinerators which are dealt with separately in Article 4.14.11, every heat producing appliance which comes within the scope of this Section shall be classified as a low, medium, or high heat appliance as follows:

Low Heat Appliances, which shall include bakers' ovens; boiling vats; candy furnaces; coffee roasting ovens; cooking ranges; core ovens; cruller furnaces; domestic hot water boilers; domestic stoves; drying furnaces for spent materials; feed drying furnaces; fertilizer drying ovens; forge furnaces; gas producers; hardening furnaces (below dark red); warm air heating furnaces; hot water and low pressure steam heating boilers*; japanning ovens; metal drying furnaces; lead melting furnaces; nickel plate furnaces; paraffine furnaces; rendering furnaces; rosin melting furnaces; stereotype furnaces; sulphur furnaces; type-foundry furnaces; wood drying appliances; and wood impregnating appliances;

Medium Heat Appliances, which shall include charcoal furnaces; direct fire heated feed driers; direct fire heated fertilizer driers; direct fire heated pulp driers; galvanizing furnaces; hardening furnaces (cherry to pale red); porcelain biscuit kilns; smoke houses; steam boilers other than low pressure heating boilers*; water-glass kilns; wood-distilling furnaces; and wood-gas retorts;

High Heat Appliances, which shall include annealing furnaces; blast furnaces; bone calcining furnaces; brass furnaces; carbon point furnaces; cement, brick and tile kilns, coal and water gas

*For the purposes of this classification a low pressure steam boiler shall mean one in which no gauge pressure in excess of 15 pounds per square inch can be developed.

retorts; cupolas; earthenware kilns; gas blow furnaces; glass smelting furnaces; glass kilns; open hearth furnaces; ore roasting furnaces; porcelain baking and glazing kilns; regenerative furnaces; reverberatory furnaces; stacks, carburetor or superheating furnaces in water gas works; welding furnaces; and wood carbonizing furnaces.

Where it is desired to install in any building a heat producing apparatus not classified in this Article, the *authority having jurisdiction* shall classify such apparatus in one of the above three groups, taking into account the temperature of the gas in the *chimney flue* or *gas flue*, the maximum temperatures developed in and about the apparatus, and the general features of the installation.

4.14.3 Mountings and Clearances for Heat Producing Appliances

4.14.3.1 General.—Except as provided otherwise in this Section for specific types of appliances, either by specific regulations or by specific

TABLE 1 (SECTION 4.14)

CLEARANCES FROM COMBUSTIBLE MATERIALS FOR HEATING APPLIANCES*

*The clearances given are subject to special provisions given elsewhere for specific types of equipment. See Items 4.14.3.2 and 4.14.3.3.

Location of Combustible Materials	Classification of Apparatus	Minimum Clearance in Feet	
		No Special Insulation	Special Insulation ⁽¹⁾
Above the level of the top of the appliance	Low Heat	4 ⁽²⁾	2 ⁽³⁾
	Medium Heat	5 ⁽²⁾	3 ⁽³⁾
	High Heat	15	15
On any side except one contain- ing an ash or stoking door	Low Heat	3 ⁽²⁾	1½ ⁽³⁾
	Medium Heat	4 ⁽²⁾	2 ⁽³⁾
	High Heat	10	10
On any side containing an ash or stoking door	Low Heat	4	4
	Medium Heat	8	8
	High Heat	30	30

(1) Special insulation shall be interpreted as meaning nothing less than a 1½-inch encasement of the appliance on all sides and the top with brick, asbestos cement, magnesia, or other suitable *incombustible* material.

(2) This figure may be reduced by 18 inches in the case of wood stud walls or *partitions* having a *fire-resistance rating* of at least one hour, and likewise in the case of a ceiling forming part of a floor assembly having a *fire-resistance rating* of at least one hour.

(3) This figure may be reduced by 9 inches in the case of wood stud walls or *partitions* having a *fire-resistance rating* of at least one hour, and likewise in the case of a ceiling forming part of a floor assembly having a *fire-resistance rating* of at least one hour.

reference to published standards of good practice, every heat producing appliance shall be mounted and located in accordance with this Item. This Item does not apply to *smoke pipes* or breechings.

Except as provided herein, every heat producing apparatus shall be mounted on the ground or on a *masonry* or *reinforced concrete* floor or on a hearth supported by a trimmer arch, extending in all cases at least 12 inches beyond all sides of the apparatus, and at least 36 inches beyond any side containing an ash or stoking door.

Every appliance shall be separated from *combustible* material, *combustible* floor assemblies above, and *combustible* stud walls or *partitions*, by a clear distance in accordance with Table 1 of this Section.

4.14.3.2 Stoves and Ranges.—

(a) Notwithstanding the requirements of Table 1 (Item 4.14.3.1), clearances from *combustible* construction and trim for stoves or ranges used for heating, cooking, or laundry purposes shall be regulated by this Item.

(b) Such stoves, consuming solid or liquid fuel may be supported on *combustible* floors or benches provided they are supported at least 12 inches clear of the floor and are set on a metal covered asbestos pad at least 3/8 inch thick extending 6 inches beyond all sides and 12 inches in front of the appliance. Alternatively, such stoves or ranges may be supported on wood floors by 4 inches of *hollow masonry*, provided such *masonry* is both separated from the floor and covered on top with continuous sheet metal plates, the *masonry* being so arranged as to allow free air circulation through it.

Such stoves or ranges, when serving only one *dwelling unit*, need not be supported more than 4 inches clear of the floor when on legs or pedestals, and an asbestos pad shall not be required, but the floor shall be covered with sheet metal for 6 inches beyond all sides and 12 inches in front of the appliance.

No stove or range shall be placed within 6 inches of any wood stud wall, wood furred wall, or *combustible* trim; and when within 18 inches shall be protected therefrom by a shield of metal* or suitable *incombustible* material extending at least 12 inches above and 6 inches beyond the sides of the appliance, and so arranged as to leave a free air space behind it of at least 2 inches.

(c) Gas stoves, gas ranges, gas hot plates and heaters shall be supported at least 6 inches above any wood floor or *combustible* materials, and when less than 12 inches shall be set on a metal covered pad of 3/16-inch asbestos board, or its equivalent; provided that where such appliances serve one *dwelling unit* only, these minimum distances shall be reduced to 3 inches and 6 inches respectively.

No gas appliance shall rest on a *combustible* floor or bench unless separated therefrom by sheet metal or suitable *incombustible* materials.

*Attention is directed to the fact that metal shields should have a bright surface.

In any *dwelling unit*, *combustible* walls, *partitions*, or trim within 6 inches of any range, hot plate, or ordinary water heater operated by gas, or within 3 inches of any domestic automatic storage hot water heater operated by gas, shall be protected therefrom by at least 3/16-inch asbestos board or equivalent, covered on the exposed side with metal; or alternatively the walls may be covered with 3/4-inch plaster (see Item 4.7.3.5) on metal or perforated gypsum lath. Similar protection shall be provided for gas appliances installed within 12 inches of *combustible* walls or materials in any place other than a *dwelling unit*.

Where gas appliances of the fully insulated type are installed, they may, subject to approval by the *authority having jurisdiction*, be exempted from the above requirements for clearances and protection.

4.14.3.3 Warm Air, Hot Water, and Low Pressure Steam Furnaces.—

(a) Warm air, hot water, and low pressure steam furnaces used for heating buildings and having a grate area of less than 3 square feet may be supported on *combustible* floors by 4 inches of *hollow masonry*, provided such *masonry* is both separated from the floor and covered on top with continuous sheet metal plates, the *masonry* being so arranged as to allow free air circulation through it. Such *masonry* shall extend 18 inches beyond all sides of the appliance, and 36 inches in front of any appliance burning solid fuel.

(b) All warm air, hot water, and low pressure steam heating furnaces shall have clearances from *combustible* walls or *partitions* in accordance with Table 1 of this Section; provided that a minimum clearance of 18 inches shall be permitted when the *combustible* wall or *partition* is separated for its full height from the furnace by sheet metal held clear of contact with wood by asbestos board or plaster board or sheet metal attached to *incombustible* furring.

(c) Excepting pipeless furnaces, there shall be a clear air space of at least 9 inches above the top of any warm air, hot water, or low pressure steam heating furnace. *Combustible* floor construction shall be permitted above any such furnace, provided that if it is within 18 inches thereof, it shall be protected by a plastered ceiling equal to that required for one-hour fire-resistive wood-joint floor assemblies (see Section 4.10). Except where it meets a wall or *partition* permitted within 3 feet of the appliance, such ceiling shall extend at least 3 feet beyond any side of the appliance and the space between any edge of the ceiling and the floor boarding above it shall be sealed up. Every pipeless warm air furnace shall be so installed that the top of the heater is at least 18 inches below any part of any *combustible* floor assembly above and adjacent thereto. Every other warm air furnace shall have the casing-top covered with at least 2 inches of sand, asbestos, or magnesia.

4.14.3.4 Smoke Pipes, Breechings, and Gas Vents.—

(a) Except as permitted in Sub-item (c) (ii) hereof, every *smoke pipe*, or breeching shall be connected to a *chimney flue* or metal smoke-stack, and shall be as short and straight as practicable.

(b) Nothing in this Code shall be deemed to prohibit the joining of two or more *smoke pipes* to form a single inlet connection to a *chimney flue*, provided the areas of the inlet connection and *chimney flue* are sufficient to serve all the connected appliances.

(c) No *smoke pipe* shall pass through any *combustible* floor, roof, wall or *partition*, except as follows:

- (i) In buildings limited in use to Commercial and Industrial Occupancies of Group C, Division 3 or 4, and/or a *one-family dwelling*, a *smoke pipe* serving a stove and not exceeding 7 inches in diameter may pass through a *combustible* floor, interior wall, or *partition*, provided the building exceeds neither two storeys in height nor 1000 square feet in area, and is not located in Fire Zone No. 1. Where such a *smoke pipe* passes through a floor, interior wall, or *partition*, it shall be encased with 4 inches of *solid masonry* with an air space between the casing and the pipe, or it shall pass through a metal thimble composed of two concentric rings of sheet metal, distant at least 2 inches from each other and so constructed as to permit free circulation of air between them and between the *smoke pipe* and the nearest ring. The thimble or *masonry* as the case may be shall extend through the full thickness of the floor and shall not be overlapped by any other construction or material.
- (ii) In one-storey buildings, a *smoke pipe* serving a stove and not exceeding 7 inches in diameter may pass vertically through a *combustible* roof, provided that there is no *combustible* roof material or roof covering within $7\frac{1}{2}$ inches of it. Where a terra cotta *smoke pipe* is used with all joints thoroughly sealed, this minimum clearance may be 4 inches. Such a pipe may also pass through a *combustible* exterior wall of a one-storey building, provided no *combustible* wall material is within $7\frac{1}{2}$ inches of the pipe.

(d) The clear distance on all sides between any *smoke pipe* or breeching and *combustible* construction shall be 18 inches for low heat appliances, 3 feet for medium heat appliances, and 5 feet for high heat appliances, except as follows:

- (i) These clearances may be reduced by one-half, where the *smoke pipe* or breeching is insulated with at least one inch of asbestos cement, magnesia, or equally effective materials; or where a sheet metal shield having a width equal to three pipe diameters is spaced 2 inches clear of the *combustible* construction over the full length of the pipe; or where the *combustible* construction is covered with $\frac{3}{4}$ inch of plaster on metal lath or $\frac{1}{2}$ inch plaster on perforated gypsum lath. (For plaster requirements, see Item 4.7.3.5.)
- (ii) In the case of a *smoke pipe* serving only ordinary heating or cooking stoves, the minimum clearance may be 9 inches, no further reduction being permitted.

(e) A *gas vent* pipe may pass through a *combustible* floor or *partition* provided it is surrounded by 4 inches of *solid masonry*, or provided it passes through a metal thimble which provides at least one inch of free air space around the pipe, such space being open to free air circulation. *Gas vent* pipes leading to *gas flues* shall have a clear space of at least 3 inches on all sides. Any gas appliance requiring to be vented to a *chimney flue* (i.e., when flue gas temperature does not permit a *gas flue*; see definition) shall be connected to the *chimney flue* by a *smoke pipe* meeting the requirements of this Item.

4.14.4 Warm Air Heating Systems

4.14.4.1 Gravity Warm Air Systems.—Every gravity warm air heating system, including ducts, stacks, registers, air supply, and *smoke pipe* shall be designed, constructed, and installed in accordance with "The Standard Gravity Code for the Design and Installation of Warm Air Heating Systems", dated 1 January, 1939, as published by the National Warm Air Heating and Air Conditioning Association of Columbus, Ohio, U.S.A., except with respect to the clearances from and protection for *combustible* materials above the furnace and the *smoke pipe*. Regulations with respect to these latter items will be found in Article 4.14.3.

4.14.4.2 Mechanical Warm Air Heating Systems.—

(a) Every mechanical warm air heating system shall be designed and constructed in accordance with good commercial practice. For the purposes of this Item, "The Technical Code for the Design and Installation of Mechanical Warm Air Heating Systems", dated 1 January, 1939, as published by the National Warm Air Heating and Air Conditioning Association of Columbus, Ohio, U.S.A., shall be accepted as good commercial practice for systems falling within its scope. For larger or more complicated systems, the recommendations of the American Society of Heating and Ventilating Engineers as shown in that society's Guide, Volume 17, dated 1939, shall be accepted as good commercial practice.

(b) The "Regulations of the National Board of Fire Underwriters for the Installation of Air Conditioning, Warm Air Heating, Air Cooling and Ventilating Systems" dated in the U.S.A. on 1 August, 1939, (N.B.F.U. Pamphlet No. 90) shall be observed when installing any such system subject to the following exceptions and notes:

- (i) The term "department having jurisdiction" shall be replaced by "*authority having jurisdiction*";
- (ii) The first sentence of Clause 124 shall be changed to read as follows:

Every stack, riser, or duct which forms a vertical *shaft*, or possible means of communication of fire between the *storeys* of a building of Type 1A, 1B, 1C, or 2 Construction shall be encased or enclosed in fire-resistive construction as and when the *exits* are required to be enclosed (see Article 4.6.7 and Table 4 accompanying it).

- (iii) The term "fire wall" as used in Clause 131 shall be interpreted as meaning any wall or *partition* forming a 'special' occupancy separation (see Sub-item 4.2.3.3 (c));
- (iv) The term "fire partition" as used in Clause 134 shall mean any fire-resistive interior wall or *partition* required by this Code to have openings therein protected by *fire-resistive doors*, excepting 'special' occupancy separations;
- (v) In Clause 181, "National Electrical Code" shall be replaced by, "Canadian Electrical Code, Part 1, dated 1939, as published by the Canadian Engineering Standards Association";
- (vi) In Clause 301, the term "in residences" shall be replaced by, "serving only and wholly contained within one *dwelling unit*".

4.14.5 Air Conditioning, Air Cooling, and Ventilating Systems.—Air conditioning, air cooling, and ventilating systems shall be designed, constructed, and installed in accordance with good commercial practice. For the purposes of this Article, the recommendations of the American Society of Heating and Ventilating Engineers as shown in that society's Guide, Volume 17, dated 1939, shall be accepted as good commercial practice. In addition, all such installations shall fulfill the requirements of Sub-item 4.14.4.2 (b).

4.14.6 Blower and Exhaust Systems for the Removal of Vapour, Dust, Refuse, and Stock.—All blower and exhaust systems for the removal of vapour, dust, refuse, or stock shall be designed and constructed in accordance with good commercial practice. For the purposes of this Article, the recommendations of the American Society of Heating and Ventilating Engineers as shown in that society's Guide, Volume 17, dated 1939, shall be accepted as good commercial practice. In addition, the "Regulations of the National Board of Fire Underwriters for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal", Pamphlet No. 91, dated in the U.S.A. on 15 October, 1937, shall be observed, subject to the following exceptions and notes:

- (i) In Clauses 221 and 263 "National Electrical Code" shall be changed to, "The Canadian Electrical Code, Part 1, dated 1939, as published by the Canadian Engineering Standards Association";
- (ii) In Clause 248 the term "fire wall" shall be interpreted as meaning any wall or *partition* forming a 'special' occupancy separation (see Sub-item 4.2.3.3 (c));
- (iii) In Clauses 331 and 332, the clearance of hoods over cooking equipment and ducts therefrom, from unprotected *combustible* material shall be reduced to 9 inches.

4.14.7 Gas Fired Appliances.—All gas burning heat producing appliances together with the necessary piping and connection with a gas main shall be designed, constructed, and installed in accordance

with good commercial practice. Every appliance shall be connected to a *gas flue* or a *chimney flue* as and when required by such practice and by such other requirements as are given in this Section. For the purposes of this Article, the recommendations of the American Gas Association as given in "A.G.A. Requirements for House Piping and Appliance Installation", dated 1928, shall be accepted as good commercial practice.

4.14.8 Oil Burning Appliances.—All oil burning appliances including supply tanks and necessary piping shall be designed, constructed, and installed in accordance with good commercial practice. All oil burning appliances, other than small domestic heating and cooking appliances, which consume commercial fuel oil, furnace oil, diesel oil, or other flammable liquid fuel, and all supply tanks for such appliances shall be constructed and installed in accordance with the "Regulations of the National Board of Fire Underwriters for the Installation of Oil Burning Equipments", Pamphlet No. 31, dated in the U.S.A. on 1 April, 1934, as amended in 1940, subject to the following notes and amendments:

- (i) Clause 3a shall be amended to read: "Oil burners shall be of a type approved by a recognized laboratory";
- (ii) In Clause 21, "National Electrical Code" shall be replaced by, "Canadian Electrical Code, Part 1, dated 1939, as published by the Canadian Engineering Standards Association";
- (iii) The Appendix shall not apply.

Small domestic heating and cooking appliances consuming kerosene or fuel oil shall be constructed and installed in accordance with "Regulations of the National Board of Fire Underwriters for the Installation, Maintenance, and Use of Small Heating and Cooking Appliances", Pamphlet No. 310, dated in the U.S.A. on 15 November, 1937, subject to the following amendments:

- (i) Clause 2 shall be amended to read: "Only appliances approved by a recognized laboratory and operated with the grade of fuel for which they have been found suitable shall be used.";
- (ii) In Clauses 12 and 14, "National Electrical Code" shall be replaced by, "Canadian Electrical Code, Part 1, dated 1939, as published by the Canadian Engineering Standards Association";
- (iii) In Clause 16, in the first sentence, the term "suitable flues" shall be changed to, "suitable *chimney flues* or metal smokestacks".

4.14.9 Drying Rooms and Kiln Driers.—Drying rooms or kilns within a building shall be constructed entirely of *incombustible* materials unless equipped with steam jets or other means of maintaining a humid atmosphere. Heating pipes shall be so located and shielded as to preserve at all times a clear space of at least 2 inches between them and the contents.

4.14.10 Steam and Hot Water Pipes.—All steam and hot water heating pipes shall be kept clear of *combustible* materials and construction by at least 1/4 inch in the case of hot water pipes and by at least one inch in the case of steam pipes, which latter distance may be increased by the *authority having jurisdiction* where the temperature of the steam exceeds 400 F. All pipe coverings or insulation shall be *incombustible*. Where any such pipe passes through a floor, wall, or *partition*, the opening shall be closed off, above and below or on both sides, by tight-fitting metal caps; and where such floors, walls, or *partitions* are required to have specific *fire-resistance ratings* and *fire-resistive closures*, then the openings shall be sealed tight with *incombustible* material against flame or smoke.

4.14.11 Incinerators.—Incinerators constructed as an integral part of a building and intended for the reduction of garbage, refuse, rubbish, or waste shall be constructed and installed in accordance with this Article.

The combustion-chamber enclosure walls of any non-fuel-fired incinerator shall be 8 inches thick if the grate area does not exceed 9 square feet and otherwise 12 inches thick, and in both cases at least 4 inches of this thickness shall consist of firebrick lining. Fuel-fired incinerators, the primary purpose of which is to dispose of garbage, cleanings, sweepings, and miscellaneous refuse, for example, incinerators in *residential* or *institutional buildings* or in churches, schools, or *restaurants*, shall have combustion-chamber enclosure walls of 12 inches of *solid masonry* of which 4 inches shall be firebrick lining. Fuel-fired incinerators for the disposal or reduction of commercial or industrial wastes, cuttings, or refuse, whether the fuel is specially supplied or itself consists of waste, shall have *solid masonry* walls at least 16 inches thick of which 8 inches shall be firebrick lining.

All firebrick shall be laid in fireclay *mortar* or in high-temperature cement.

The outer 4 inches of *masonry* of any incinerator wall 12 inches or more in thickness may be replaced by a steel plate casing having a minimum thickness of 3/16 inch.

Service openings into non-fuel-fired incinerators of the combined chute-and-flue type shall be equipped with self-closing hoppers so constructed that the *flue* is closed off when the hopper is being charged. Service openings shall not exceed in area of cross section one-third the *flue* area.

Every incinerator including *smoke pipe* or breeching shall be separated from the rest of the building as and when required by Article 4.14.13. In addition every fuel-fired incinerator shall be located in a separate room or in a room devoted only to heating plant or steam plant, and in either case such room shall be separated from the rest of the *structure* by 2-hour fire-resistive construction with all interior openings protected by *fire-resistive doors*.

Flue connections or breechings from fuel-fired incinerators shall be lined with at least 2 inches of firebrick when the diameter or greatest dimension exceeds 12 inches, which thickness shall be increased to 4

inches when the diameter or greatest dimension exceeds 24 inches. There shall be a clear distance of at least 18 inches between such a *flue* connection or breeching and any *combustible* construction.

4.14.12 Refuse Chutes*.—No refuse, waste, or by-product chute shall feed directly into the combustion chamber of a furnace or incinerator, excepting garbage chutes in *residential* or *institutional buildings* or in churches, schools, or *restaurants*, or comparable occupancies.

Any type of garbage chute, or refuse chute connecting two or more *storeys* of a building shall be enclosed in *incombustible* walls having a *fire-resistance rating* of not less than 2 hours, and all openings to such chutes shall be fitted with fire-resistive metal doors in metal frames.

4.14.13 Rooms and Locations for Furnaces, Boilers, and Incinerators.—The requirements of this Article shall apply to any central heating plant, steam boilers, or incinerators installed in any building. Where such apparatus is required to be separated from the *structure* served by fire-resistive separations, the *smoke pipes* or breechings and the firing space and any inside fuel storage space shall be similarly enclosed along with the apparatus.

In any building of Group A Occupancy, i.e., *assembly buildings*, any heating plant, steam boiler or incinerator consuming solid or liquid fuel shall be separated from the rest of the building by a 'Special Occupancy Separation' (see Sub-item 4.2.3.3 (c)); and any plant consuming gaseous fuel shall be separated by at least an 'Ordinary Occupancy Separation' (see Sub-item 4.2.3.3 (c)). Any exterior opening or part thereof in the enclosure thus required, if located below openings in another *storey* or if less than 10 feet from any other door or window in the same building, shall be protected by a *self-closing fire-resistive door* or fixed *fire-resistive window* (see Section 4.12).

In any building of Group B Occupancy, i.e., *institutional buildings*, heating plants, boilers, and incinerators shall be separated from the rest of the building by a 'Special Occupancy Separation' when solid or liquid fuel is employed, and by at least an 'Ordinary Occupancy Separation' when gaseous fuel is employed.

In any room within a Group C Occupancy, i.e., *commercial* and *industrial buildings*, in which volatile flammable liquids are used or stored, no device generating a glow or flame capable of igniting gasoline vapour shall be installed so that the glow or flame is within 24 inches of the floor, metal legs or supports being excepted.

In any occupancy belonging to Division 1 or 2 of Group C, all equipment used for heating the occupancy or for producing steam power for its operation shall be completely separated from such occupancy by fire-resistive construction having a *rating* of at least 2 hours with all interior openings protected by *self-closing fire-resistive doors*, provided that such separation shall not be required in buildings having neither an *area* of more than 1000 square feet nor a *height* of more than one *storey*. In addition, in any dry cleaning plant employing volatile flammable liquids, there shall be no direct connection between any room where such liquids are used or stored and a boiler or furnace room.

*See also Article 5.6.7.

Any boiler, furnace, or incinerator serving a residential occupancy of Group D, Division 1 or 2, shall be completely separated from such occupancy by construction having a *fire-resistance rating* of at least one hour with all interior openings protected by *self-closing fire-doors*.

In any building of Group E, Division 3, i.e., stadiums, reviewing stands, and amusement park *structures*, any furnace, boiler, or incinerator installed in such a *structure* shall be entirely separated therefrom by fire-resistive construction as required for *assembly buildings* in this Article.

4.14.14 Sources of Heat Generally.—In any building, any source of heat or flame not specifically mentioned in this Section shall be so constructed, installed, and protected that when it is in full operation no wood or other *combustible* material used in the construction of floors, ceilings, walls, *partitions*, roofs, doors, or other parts of the building, shall be heated to a temperature in excess of 160 F. No source of heat or flame shall be constructed or installed in such a way as to cause undue corrosion or deterioration, either of the building, the *flues* or *chimneys*, or within the heating appliance itself. No source of heat or flame shall be so installed as to be subject to accidental overturn or other disarrangement conducive to dangerous conditions.

4.14.15 Fusible Links.—All fusible links required by this Code or used to fulfil any requirement of this Code for automatic heat-actuated devices shall be of a type *approved* by the *authority having jurisdiction*.

Every such fusible link shall have a strength appropriate to the load on the link, and shall break at a temperature approximately 60 F. above the maximum to be expected in the given location, in accordance with the following:

- (a) For normal room temperatures with a probable maximum of 100 F., links shall break at 160 F. to 165 F.
- (b) For temperatures between 100 F. and 150 F., links shall break at 212 F.
- (c) For temperatures between 150 F. and 225 F., links shall break at 285 F.
- (d) For temperatures between 225 F. and 300 F., links shall break at 360 F.

SECTION 4.15 ELECTRICAL EQUIPMENT, INSTALLATIONS, AND WIRING

All electrical equipment, installations, and wiring in any building shall conform to the requirements of the Canadian Electrical Code, Part 1, dated 1939, as published by the Canadian Engineering Standards Association.

SECTION 4.16 PROTECTION AND ENCLOSURES FOR SHAFTS AND VERTICAL OPENINGS

4.16.1 General.—*Vertical openings* and *shafts* forming part of an *exit* shall be constructed in accordance with Section 4.6 generally, and shall be enclosed as required by Article 4.6.7 therein.

Ducts forming part of any warm air heating or any forced draft system shall be regulated by the requirements of Articles 4.14.4, 4.14.5, and 4.14.6. Garbage and refuse chutes shall be subject to the requirements of Article 4.14.12.

All other *vertical openings* such as elevators, dumbwaiters, chutes, air wells, access ways, and hatchways shall meet the requirements of this Section. In addition, unless otherwise specifically stated, *vertical openings* to or through which stairs or ramps pass shall be enclosed as required herein, even though such stairs or ramps may not require enclosure in Section 4.6, *Exits*.

Where an intermediate floor becomes an additional *storey* (see definition of *height of building*), it shall be separated by walls or *partitions* from the *storey* below whenever *vertical openings* are required to be enclosed.

4.16.2 Protection of Vertical Openings

4.16.2.1 Assembly Buildings.—This Item shall be subject to the provisions and exceptions of Sub-items 4.6.7.2 (c) and (f) and Item 4.6.7.3.

In every *theatre* or *motion-picture theatre*, every *vertical opening*, other than openings in balcony floors above a main floor, shall be protected. A *vertical opening* located neither above nor below another *vertical opening* shall be enclosed either in the *storey* above or the *storey* below, or shall be protected by a trap door; but a series of two or more *vertical openings* one above another shall be enclosed in all *storeys* between which they occur.

In all other *assembly buildings*, *vertical openings* shall be protected in accordance with the preceding sentence in such a way as to prevent fire or smoke in any *storey* from passing through more than one floor.

4.16.2.2 Institutional Buildings.—This Item shall be subject to the exceptions given in Item 4.6.7.3. Otherwise, every *vertical opening* located neither above nor below another *vertical opening* shall be enclosed either in the *storey* above or the *storey* below, or shall be protected by a trap door; and every series of two or more *vertical openings* one above another shall be enclosed in all *storeys* between which they occur. *Mezzanine floors* or *vertical openings* therein shall not require enclosure by this Item. Cell blocks for detention purposes, if constructed entirely of *incombustible* material shall not be subject to this Item.

4.16.2.3 Commercial and Industrial Buildings.—

(a) In *commercial and industrial buildings* classified as belonging to Division 1 or 2, every *vertical opening* shall be protected. An opening located neither above nor below another opening shall be enclosed either

in the *storey* above or the *storey* below, or shall be protected by a trap door; and every series of two or more openings shall be enclosed in all *storeys* between which they occur. This provision shall not apply to ramps for the movement of automobiles between *storeys* in *public garages*. *Mezzanine floors* shall be enclosed when otherwise the total *floor-area* in one *storey* would exceed the maximum *area of building* allowed in Section 4.5. *Vertical openings* in the floors of enclosed mezzanines shall be enclosed below the mezzanine.

(b) In *commercial and industrial buildings* classified as belonging to Division 3, *vertical openings* shall be protected so as to prevent fire or smoke in any *storey* from passing through more than one floor. In providing this protection, *vertical openings* located neither above nor below another opening may be enclosed either in the *storey* above or the *storey* below, or shall be protected by a trap door; and a series of two or more *vertical openings* one above another shall be enclosed in all *storeys* between which they occur. *Mezzanine floors* and openings therein shall not require enclosure.

The requirements of this Item shall not apply to book stacks of *incombustible* materials in libraries of Type 1A or 1B Construction.

Ramps for the movement of trucks or freight between *storeys* shall not require enclosure if they do not serve as *exits* and are cut off in each *storey* by an *automatic fire-resistive door* hung in a wall having a *fire-resistance rating* of at least 2 hours.

(c) In *commercial and industrial buildings* classified as belonging to Division 4, *vertical openings* shall not be required by this Section to be enclosed.

4.16.2.4 Residential Buildings.—

(a) In *residential buildings* classified as belonging to Group D, Divisions 1 or 2, *vertical openings* shall be protected so as to prevent fire or smoke in any *storey* from passing through more than one floor. Such protection for an opening located neither above nor below another opening may consist of enclosure in one *storey* or a trap door; but a series of two or more openings one above another shall be enclosed in all *storeys* in which they occur, except that in buildings consisting only of two *storeys* and a *basement* or *cellar*, enclosure within the *basement* or *cellar* only shall be sufficient.

Mezzanine floors and openings therein shall not be required by this Item to be enclosed.

(b) In *one- and two-family dwellings*, *vertical openings*, between *storeys* wholly contained within such occupancy, shall not be required to be enclosed. Where *vertical openings* are enclosed to form dumbwaiters or laundry chutes or for similar purposes, the enclosure shall be of one-hour construction, or alternatively, the *shaft* shall be lined throughout with sheet metal separated from all wood studs or other wood construction, by at least 1/2 inch of plaster on *incombustible* lath or by 1/2 inch of gypsum board or 1/4 inch of asbestos board. Wood doors into such a *shaft* shall be covered on the *shaft* side with metal or asbestos board, and door frames likewise.

4.16.2.5 Accessory Buildings and Other Structures.—In *structures* classified as belonging to Group E Occupancy, *vertical openings* shall not be required by this Section to be enclosed.

4.16.3 Construction of Shafts

4.16.3.1 Walls or Partitions.—Subject to the more restrictive requirements of Section 4.3, Types of Construction, where enclosure of *vertical openings* is required, the enclosing walls or *partitions* of *shafts* shall be of one-hour construction when the *shaft* does not exceed two *storeys* plus a *basement* or *cellar* in height. *Shafts* exceeding two *storeys* plus a *basement* or *cellar* in height shall be enclosed in 2-hour *incombustible* construction, except that in *residential buildings* not exceeding three *storeys in height*, one-hour *combustible* construction may be employed.

4.16.3.2 Fire-stopping Around Shafts.—All hollow stud walls or *partitions* used to enclose any *shaft* shall be fire-stopped at each floor level, and shall be completely cut off by suitable fire-stops from every *combustible* floor, attic, or other concealed space through which they may pass.

4.16.3.3 Openings in Shafts.—There shall be no unnecessary openings into *shafts* provided that in *shafts* for elevators there shall be at least one door in every 30 feet of height.

Where *shaft* walls are required to be of one-hour construction, only snug-fitting doors of metal, metal-clad wood, or of the solid wood-slab type not less than $1\frac{3}{4}$ inches thick in all parts, shall be used; and where *shaft* walls are required to be of 2-hour construction, all openings, including windows in air wells, shall be protected by *fire-resistive closures* meeting the requirements of Section 4.12. All doors in the *shaft* shall be *self-closing*, provided that *automatic doors* may be used where it can be shown that the *shafts* require such doors.

4.16.3.4 Tops of Shafts.—The top of every *shaft* which does not extend into the top *storey* shall be enclosed by construction having the same *fire-resistance rating* as the walls or *partitions* forming the *shaft*.

Every *shaft* required to be of one-hour construction which extends into the top *storey* shall be continued through and at least one foot above the roof, or alternatively it shall be continued through any attic space to the underside of the roof *sheathing* or roof slab and make a smoke-tight joint at that point. *Combustible* construction over the top of such a *shaft* shall be protected on the inside with sheet metal, asbestos board, or fire-resistive plaster.

Every *shaft* required to be of 2-hour construction which extends into the top *storey* shall be continued through any attic space. Every such *shaft* shall make a smoke-tight joint with the underside of an *incombustible* roof, and in the case of a *combustible* roof it shall be carried through and at least 24 inches above the highest point at which the roof abuts the *shaft*. If the *shaft* is covered in by a roof or *bulkhead*, such construction shall have a *fire-resistance rating* of at least one hour. This Item shall not be interpreted to mean that windows in *shaft bulkheads*, or skylights over *bulkheads* are required to be of fire-resistive

construction. (For requirements with respect to skylights, see Article 4.12.5.)

This Item shall not apply to an enclosure one *storey* only in height, protecting a *vertical opening* in the floor of the *storey* above.

4.16.3.5 Bottoms of Shafts.—Every *shaft* which does not extend to the bottom of the building shall be enclosed at its lowest point with floor construction having a *fire-resistance rating* equal to that of the *shaft* walls.

4.16.3.6 Shaft Linings.—No *combustible* materials shall be used to line or finish the inside of the walls of any required *shaft* except that in *stairway* or ramp enclosures wood trim may be used.

4.16.4 Trap Doors and Hatches.—This Article shall apply only to trap doors used for the protection of *vertical openings*. The use of such doors for the protection of *vertical openings* is limited by Article 4.16.2. Any opening giving access from a top *storey* to an unused attic space may be protected by an unhinged hatch in place of a trap door.

Any trap door in a floor shall be able to support its own weight plus a concentrated load of 200 pounds; and unless protected by a curb not less than 8 inches high or a railing, shall be able to support the prescribed *live load* for the floor in which it is placed. Trap doors other than those in a *stage* floor shall be *self-closing* or shall be arranged to close *automatically* in a manner satisfactory to the *authority having jurisdiction*.

Every trap door or hatch, installed in a floor required to have a specific *fire-resistance rating* shall be a *fire-resistive door* and shall have a *rating* equal to that of the floor, when tested in accordance with Section 4.12, except that in one-hour wood-joist floor construction, the trap door and its frame may be of wood provided that the frame has a minimum nominal dimension of 2 inches clad on all sides with metal, and that the door is of two layers of wood each having a nominal one inch thickness the whole being metal clad. Finish flooring may be applied to the top side of the trap door. No trap door or hatch shall be required to have a *fire-resistance rating* in excess of 2 hours. Every trap door installed in a *structure* of Type 2 Construction (Heavy Timber) shall be of the same thickness and construction as the floor in which it is installed, or alternatively shall be a *fire-resistive door* of at least one-hour *rating*. Trap doors in wood floors of buildings of Type 3 (Masonry and Frame) or Type 4 (Wood Frame) Construction, where such floors are not required to have specific *fire-resistance ratings*, shall be of the same thickness and construction as the floor including finish, above the *joists*. Trap doors in the floor of a building of Type 5 Construction (Unprotected Metal or Fire-retardant Treated Wood) shall be of metal.

Any trap door or hatch giving access to an attic space through a ceiling of specific fire-resistive properties shall be a metal or metal-clad door; and in any other ceiling it may be of wood if at least 1¼ inches thick with tongued and grooved joints.

No trap door or pair of doors serving as required protection for a *vertical opening* shall exceed 6 feet in either dimension and all such doors shall be snug-fitting, well seated, and reasonably smoke-tight.

4.16.5 Alternatives.—The *authority having jurisdiction* may waive in part or modify the requirements of this Section for the protection of *vertical openings* less than 4 square feet in area, subject to such conditions as he shall in each case specify as being necessary to prevent rapid spread of fire through a *structure*, and subject always to Item 4.16.3.6 and Sub-item 4.16.2.4 (b).

4.16.6 Safety.—A *parapet wall* not less than 12 inches in height shall be provided around all open *shaft* or air-well enclosures extending through the roof.

Unprotected *vertical openings* in floors, and openings protected by trap doors, shall be protected by guards or railings as and when required by the *authority having jurisdiction*.

SECTION 4.17 ROOF STRUCTURES*

4.17.1 Prohibited Uses of Roofs.—No roof shall be used as a *place of assembly* unless it has been designed for that purpose, is provided with the required *exits*, and has substantial guard rails, fences, or parapets around the part so used, nor shall any roof be used for household purposes unless the edges of the roof are guarded in a like manner.

4.17.2 Penthouses and Bulkheads

4.17.2.1 Uses.—The use of any *bulkhead* shall be strictly limited in accordance with the definition in Part 2. No *bulkhead* or part thereof shall be used as a *habitable room*, or *work room*, or a storage room.

The use of a *penthouse* shall be limited to, a *one- or two-family dwelling* completely detached from other *structures* above the roof of the main *structure*, an artist's or photographer's studio, a greenhouse or conservatory, or a place for scientific observations requiring a roof location.

4.17.2.2 Height.—*Bulkheads* shall not be considered as adding to the *height of a building* either in feet or in *storeys* provided they meet all the requirements of Article 4.17.2.

Penthouses shall not be considered as adding to the *height of a building* in feet provided they meet all requirements of Article 4.17.2. However, every *penthouse* shall be considered a *storey* with respect to *exits* therefrom.

No *bulkhead* or *penthouse* shall exceed 12 feet in height above the roof on which it is located, except that a *bulkhead* enclosing a water tank or an elevator running to the roof may have a maximum height of 30 feet.

4.17.2.3 Area.—No individual *penthouse* or *bulkhead* shall exceed in area 10 per cent of the *roof-area* on which it is located. The aggregate area of all *penthouses*, *bulkheads*, cupolas, and towers erected above a *roof-area* shall not exceed 25 per cent of such *roof-area*.

* For requirements respecting skylights, see Article 4.12.5.

4.17.2.4 Walls and Roofs.—The walls of *penthouses*, *bulkheads*, and cupolas on buildings of Type 1A, 1B, or 1C Construction shall be of *incombustible* materials and shall have *fire-resistance ratings* in accordance with Table 1 of Section 4.3, provided that any wall over a main exterior wall shall have a *rating* equal to that required for the main wall.

Every wall of such a *penthouse* or *bulkhead* which is substantially parallel to and within 5 feet of an exterior wall of a building of Type 2 or Type 3 Construction shall have a *fire-resistance rating* equal to that required for the exterior wall of the *storey* immediately below. Every such wall shall project 2 feet above and 2 feet beyond the sides of the *penthouse* or *bulkhead*, except that the side projection shall not be required when the adjoining side walls are of *incombustible* construction. Walls, other than those substantially parallel to and within 5 feet of an exterior wall of a building of Type 2 or Type 3 Construction, shall have *fire-resistance ratings* of not less than one hour.

Walls of such roof structures on buildings of Type 4 or Type 5 Construction shall be as required for the main exterior walls.

Roofs and roof coverings of such roof structures shall conform to the requirements for the roof of the main *structure*. In addition, roof-structure walls of *combustible* construction shall be covered with "fire-retardant" roof covering wherever the main roof is required to be so covered.

Greenhouses or conservatories erected on the roof of a building shall not be required to have walls or roofs of specific *fire-resistance ratings*, but the walls and roofs shall in all cases be constructed of *incombustible* materials.

4.17.2.5 Protection of Exterior Openings.—Openings in the walls of *penthouses* or *bulkheads* shall be protected by *fire-resistive closures* on the same basis as openings in the walls of the main *structure*.

4.17.2.6 Non-conforming Penthouses and Bulkheads.—When any *penthouse* or *bulkhead* is used for purposes other than as permitted by Item 4.17.2.1, or when it fails in any way to conform with all the other requirements of Article 4.17.2, such *penthouse* or *bulkhead* shall be considered an integral part of the main *structure* and shall fulfil all the requirements of this Code for the main *structure*.

4.17.3 Towers, Spires, and Belfries.—No tower, spire, or belfry shall occupy more than 1/4 of the *street* frontage of any building to which it is attached nor more than 1/20 of the *roof-area* above which it rises, unless it conforms entirely to the type-of-construction requirements of the building to which it is attached and is limited in height as a main part of the building. If the area of a tower, spire, or belfry exceeds 100 square feet at any horizontal cross section, such a structure shall be supported on walls or on a frame extending directly to the ground.

Every tower, spire, or belfry forming part of a building of Type 1A, 1B, or 1C Construction shall be constructed of *incombustible* materials throughout. All portions of any supporting frame below the main roof

shall be protected as required by the type of construction of the building. The structural frame of a tower, spire, or belfry above a main roof need not be protected when a 2-hour fire-resistive floor with or without fire-resistive access hatches separates it from the *structure* below, provided that any tower, spire, or belfry which exceeds 225 square feet in area or is less than 20 feet from a *lot line* or is used for any purpose other than as an ornament, belfry, or vent outlet, shall have its structural members protected throughout. However, ornamental towers, domes, or cupolas, not exceeding 150 square feet in horizontal projected area or 20 feet in height above the main roof of a building of Type 1A, 1B, or 1C. Construction may be constructed of timbers of substantial and adequate dimensions; provided that either the whole of such ornament or each individual member shall be completely covered with *incombustible* corrosion-resisting material, and the ornament shall be separated from the rest of the building by 2-hour construction.

In any building of Type 2, 3, or 4 Construction, exterior vertical walls forming part of a tower or belfry shall be constructed as required for the main exterior walls of the building. In any such building, towers, domes, spires, or cupolas may otherwise be constructed and enclosed in wood, provided such roof structure does not exceed 225 square feet in area and is at least 20 feet from a *lot line*, provided further that exposed wood framing shall meet the requirements for heavy timber construction and that all wood *sheathing*, and wood louvres shall be covered over with *incombustible* material, and provided finally that such roof structures shall exceed neither 30 feet in height above the main roof nor 75 feet above *grade*. All such roof structures exceeding the above limits on height and area shall be constructed throughout of *incombustible* material. All such roof structures shall be sealed off from the main *structure* by at least one-hour fire-resistive construction with any opening therein protected by a fire-resistive trap door.

4.17.4 Scuttles and Covers.—Any roof-scuttle and its cover not exceeding 4 square feet in area may be constructed of wood. Larger roof-scuttles and covers in *incombustible* roofs shall be of *incombustible* materials. Every wood roof-scuttle and its cover shall have the risers and top edges of the scuttle curbs and the outer surface and bottom edges of the cover covered with metal.

4.17.5 Tanks and Cooling Towers.—One or more water-storage tanks or water-cooling towers for the use of a building may be erected on the roof thereof under conditions as follows:

- (a) The bottom of each such storage tank shall be not less than 4 feet above the highest point of the roof abutting the tank supports;
- (b) The top of each such storage tank or water-cooling tower shall not be more than 25 feet above the maximum *height* permitted for the building;
- (c) Every such storage tank shall have an outlet not less than 4 inches in diameter at or near the bottom thereof, fitted with a quick-opening valve to discharge the contents of such tank into an adequate drain or onto the roof;

(d) Every such storage tank or water-cooling tower shall be carried from the *foundations* by *incombustible* material, provided that in business buildings of heavy timber construction, a wood tank may be supported on heavy timber construction. Where *incombustible* supports are required for any storage tank, all structural steel members of such supports excepting the immediate supporting *beams* of the tank shall have at least one-hour fire-resistive protection both within and without the building. In buildings of Types 1A, 1B, or 1C, the *rating* of such protection shall be increased as required for the particular Type of Construction;

(e) No part of any storage tank or cooling tower or supports thereof shall be vertically above any *exit* or part of an *exit*.

4.17.6 Ventilators.—Intakes or outlets above the roof for forced draft systems shall be of *incombustible* material. *Combustible* huts not exceeding 5 feet in height may be erected above any *combustible* roof, for use as a convection-type ventilator. All other ventilating structures above any roof, excepting *bulkheads* housing ventilating equipment, shall be of *incombustible* construction.

4.17.7 Mansard, Gambrel, and Deck Roofs.—No *combustible* roof having a slope in excess of 60 degrees with the horizontal shall be placed on any building having a *height* in excess of three *storeys* or 45 feet. Excepting buildings of Type 4 (Wood Frame) Construction, no *combustible* roof shall contain more than one *storey* plus unused attic space.

4.17.8 Dormers.—Dormer windows shall be of the same Type of Construction* as the roof on which they are placed or as the side walls of the building. *Combustible* dormers shall have their tops, sides, and fronts other than fronts similar in construction to the exterior walls of the building, covered with a "fire-retardant" (see Section 4.11) roof covering when the main roof is required to have such a covering.

SECTION 4.18 PROJECTIONS FROM THE BUILDING

4.18.1 Bays and Oriels.—The term "bay" or "bay window" shall mean a rectangular, curved, or polygonal projection containing windows, supported on a *foundation* extending beyond a main exterior wall of a building.

The term "oriel" or "oriel window" shall mean a projection from a main exterior wall of a building, containing windows and carried by brackets or corbels.

The walls of bays or oriels shall conform to the requirements for the main exterior walls of the building; except that on buildings of Type 3 (Masonry and Frame) Construction, bays or oriels not exceeding two *storeys* or 25 feet in *height* or 10 feet in width and having at least 5 feet of *masonry* between any two such projections may have walls of any materials affording a minimum *fire-resistance rating* of one hour, provided such walls are covered on the exterior with metal, stucco, or *masonry*,

*Type of Construction here refers to the classified types in Section 4.3.

and provided that this concession shall not apply to bays or oriels in which *fire-resistive windows* are required. The structural floor of an oriel on a building of Type 1A, 1B, 1C, 2, or 3 Construction shall be *incombustible* and shall have a *fire-resistance rating* not less than that required for the walls of the oriel. The roof construction and roof covering of bays and oriels shall be as required for the roof of the main structure.

For the purposes of this Part of this Code, bays and oriels shall be considered an integral part of an exterior wall when determining the distance of a building from a *lot line* or from a *street* or *lane*.

4.18.2 Porches and Balconies.—All porches or balconies on buildings of Type 1A, 1B, 1C, or Type 2 Construction shall be of *incombustible* materials but protection against fire of structural members shall not be required; provided that loading platforms for warehouses, freight depots, and similar buildings may be of heavy timber construction with wood floors of not less than 2 inches nominal thickness. Such wood construction shall not be carried through the exterior walls.

On buildings of Type 3 Construction, open porches and balconies not more than two *storeys* high may be of wood construction, provided that they shall not be closer than 3 feet to a *lot line* or centre line of a *lane*. Open porches more than 2 *storeys* high shall be of *incombustible* materials. Enclosed porches shall have enclosing walls as required for exterior walls of the building.

Every exterior balcony cantilevered from a *masonry* wall shall be carried by *incombustible* brackets, *beams*, or ties. Every balcony shall be protected with a railing at least 36 inches in height above the balcony floor.

Wherever any requirements of this Part of this Code are based on the proximity of a building to a *lot line* or to a *street* or *lane*, open porches and balconies constructed in accordance with this Code need not be considered. However, porches and balconies shall be included in determining the *area* of any *building*.

4.18.3 Cornices, Marqueses, Gutters, and Half-Timbering.—On buildings of Type 1A, 1B, or 1C, or Type 2 Construction, all cornices, marqueses, and gutters shall be of *incombustible* construction. On buildings of Type 3 Construction such appendages shall also be of *incombustible* construction except that cornices may be of wood.

Wood half-timbering and wood decorative treatment may be used on the face of *masonry* construction in buildings of Type 2 (Heavy Timber) or Type 3 (Masonry and Frame) Construction.

4.18.4 Projections from Buildings of Type 5 Construction.—All projections from the walls of buildings of Type 5 (Unprotected Metal or Fire-retardant Treated Wood) Construction shall be of *incombustible* construction or of fire-retardant treated wood.

SECTION 4.19 FIRE-STOPPING

4.19.1 General.—Every building regardless of its Type of Construction shall have all concealed draft openings in walls, *partitions*, or floors fire-stopped in such a manner as to form an effective fire barrier between *storeys* and between the upper *storey* and the roof space.

For required protection around steam or hot water pipe openings, see Article 4.14.10.

For required protection of minor openings in walls, *partitions*, or floors, see Article 4.12.6.

For required protection of *vertical openings* (i.e., openings in floors or ceilings), see Section 4.16.

4.19.2 Materials.—The materials used in providing fire-stops shall be *incombustible*; provided that wood fire-stops may be used in *combustible* walls, *partitions*, or floors, except as otherwise required by Article 4.9.4 with respect to *combustible* walls or *partitions* having specific *fire-resistance ratings*.

Wood fire-stops shall be at least 2 inches in nominal thickness, provided that where the width of the opening is such that more than one piece is required, there shall be two thicknesses of one-inch lumber with broken joints.

4.19.3 Fire-stopping in Wood Framing.—The requirements of this Article shall apply to all wood construction in any building, regardless of the Type of Construction under which the building is classified.

Fire-stops shall be located in the following places:

(a) In exterior or interior hollow stud walls, at ceiling and floor levels.

(b) In all hollow stud walls and *partitions*, including furred spaces so placed that the maximum vertical dimension of any concealed space is not over 7 feet. Furred spaces as herein mentioned shall include spaces formed by furring on *masonry* or *reinforced concrete* walls.

(c) Between stair stringers having a ceiling on their underside, at least once in the middle portion of each run, and by a header beam at top and bottom; also where a stud wall or *partition* abuts a stair stringer, such a wall or *partition* shall be fire-stopped along and in line with the run of the stair.

(d) Around top, bottom, sides, and ends of sliding door pockets.

(e) Spaces between *chimneys* and wood framing at floor levels; these shall be completely filled with *mortar*, loose cinders or other *incombustible* material held in place by *incombustible* supports.

(f) Where a ceiling is attached directly to the underside of wood *floor joists*, the space between the *joists* shall be fire-stopped over all *beams*, walls or *partitions* supporting the *joists*.

4.19.4 Cornices.—Exterior cornices of wood construction, whether covered with metal or not, shall be fire-stopped at maximum intervals of 20 feet. All cornice ends shall be closed.

4.19.5 Attic Draft Stops.—In buildings of Type 3 (Masonry and Frame) or Type 4 (Wood Frame) Construction where ceilings occur beneath the roof, leaving an unused attic space, such space shall be divided into areas not exceeding 2500 square feet. Such draft stops shall be composed of *incombustible* material such as metal or plaster board applied on wood studs or attached to the *ceiling joists* and *roof rafters* in such a way as to leave no cracks or joints through which smoke could pass. Any openings in such draft stops shall be filled by *self-closing doors* of similar materials as permitted for the draft stops.

SECTION 4.20 SPRINKLERS, STANDPIPES, AND BASEMENT PIPE INLETS

4.20.1 Sprinklers

4.20.1.1 Locations requiring sprinklers.—Standard automatic sprinklers shall be installed in the following locations:

(a) Throughout the *cellar* and all sub-grade *storeys*, of every building, provided that sprinklers shall not be required in the *cellar* of a *detached one- or two-family dwelling* nor in any *cellar* having a ceiling more than 3 feet above *grade*, nor in any *cellar* having an area of less than 1500 square feet;

Throughout every *cellar* under any Group A Occupancy falling in Sub-division (a) (see Table 1, Section 4.2);

(b) In all places back of the proscenium wall of a *stage* having movable scenery, under the gridiron, under the *stage* floor, under all fly galleries, and in all dressing rooms, store-rooms, property rooms, carpenter shops, paint shops, corridors, and passages. Also, a line of open sprinklers controlled by a manually operated quick opening valve shall be installed not more than 5 feet above the proscenium arch on the *stage* side, immediately back of the proscenium curtain;

(c) Throughout all Group C Occupancies of Division 2, other than electrical sub-stations, including any place used to manufacture, assemble, or renovate mattresses or stuffed furniture, and any place used as a film exchange;

(d) In that part of any *cellar* or *basement* under a Group A or Group B Occupancy, used for storage purposes or for maintenance work or shop work of any kind;

(e) In rubbish or incinerator-feed storage bins excepting when such bins are outside the main walls of any building and separated from any building by a 'special occupancy separation';

(f) In and about industrial conveyors handling highly flammable products;

(g) Over every sales floor in a business building where such *floor-area* exceeds 10,000 square feet; and where the *floor-area* exceeds 20,000 square feet there shall be two independent water supplies to the system.

4.20.1.2 Installation Requirements for Sprinkler Systems.—

Every automatic sprinkler system required by this Code, and every such system installed for the purpose of gaining a concession under the regulations of this Code, shall be planned, constructed, installed, and tested in accordance with the mandatory regulations contained in "Standards of the National Board of Fire Underwriters for the Installation of Sprinkler Equipments" as set forth in that Board's pamphlet Number 13, dated July 1940, subject to the following amendments:

(a) Paragraphs 400, 401, and 402 of the above pamphlet shall be deleted and the following requirements relating to piping substituted:

All pipe shall be wrought iron or steel. Wrought iron pipe shall meet the requirements of either A.S.T.M. Specification A72-39 or C.E.S.A. Specification B62-1940. Steel pipe shall conform to the requirements of A.S.T.M. Specification A120-40. Used pipe shall not be re-used.

(b) A sprinkler system required only to serve a *basement, cellar, and/or sub-grade storeys*, or required only in order to comply with Sub-item 4.20.1.1 (e) or (f), may obtain its water supply from the domestic water supply line of the building (i.e., a separate supply line shall not be required), provided the pressure and amount of water required by the above Standards of the National Board of Fire Underwriters will be provided at the most distant sprinkler thereby.

4.20.1.3 Plans of Sprinkler System.—Before any sprinkler system is installed or remodelled, complete working plans shall be submitted to the *authority having jurisdiction* for approval. Plans shall be drawn to an indicated scale and shall show all pipe lines, valves, heads, and other essential details.

4.20.2 Dry Standpipes

4.20.2.1 Definition.—A dry standpipe shall mean a fire extinguishing apparatus consisting of a pipe extending vertically throughout all *storeys* of a building including *basement* and *cellars*, having one or more inlets close to the ground on the exterior walls of the building adjacent to a *street* or *lane*, and having outlets in every *storey, basement, and cellar* except the *first storey*; such apparatus being intended for use by the municipal fire department. A dry standpipe is not normally attached to any water supply.

4.20.2.2 Buildings Requiring Dry Standpipes.—Every building more than one *storey high* which exceeds either four *storeys* or 55 feet in *height* shall be equipped with one or more dry standpipes.

4.20.2.3 Number, Location, and Plans of Dry Standpipes.—The number and location of dry standpipes shall be such that no point on any floor other than the ground floor will be beyond reach of a 30-foot stream of water delivered from a 75-foot hose connected to a standpipe. All standpipes and their connections, inlets, and outlets shall be so located that they will not be subject to mechanical damage. Standpipes shall

be located within *stairway* enclosures in such a way as not to diminish the required *exit* width; or alternatively they may be carried up within or immediately on the inside of an exterior wall provided that the pipe is not more than one foot from an opening in each *storey* above *grade* giving access to an *exterior stairway* or *fire escape*. Where more than one standpipe is required, they shall be uniformly distributed about the building.

No standpipe or connections thereto shall be constructed, altered, or added to unless a detailed plan drawn to scale and a description of the installation has been submitted to the *authority having jurisdiction* and *approved* by him.

4.20.2.4 Construction of Dry Standpipes.—Dry standpipes shall be constructed of wrought iron or galvanized steel, and together with fittings, valves, and connections shall be designed for a working pressure of 100 pounds per square inch in excess of the maximum static head of water possible in the pipe. All pipe shall at least meet the requirements for 'standard-weight' pipe as given in one of the following specifications: A.S.T.M., A120-40; A.S.T.M., A53-40; A.S.T.M., A72-39; C.E.S.A., B62-1940; or C.E.S.A., B63-1941.

Every standpipe in any building less than 75 feet in *height* shall have a minimum diameter of 4 inches, and in buildings 75 feet or more in *height* the minimum diameter shall be 6 inches.

Every standpipe shall extend from the lowest *storey* (including *basement* or *cellars*) to and through the roof of the building or part thereof in which it is located. Adequate provision for expansion and contraction due to temperature changes shall be made in every standpipe. All standpipes and connections thereto shall be securely supported and tied to the building in a manner which will sustain the dead and possible hydraulic live loads without movement or vibration. Fittings in the main water supply connections shall be of the long turn pattern. Standpipes shall be carried up, ready for service, as the building is constructed.

4.20.2.5 Fire Department Connections.—Every standpipe shall connect at or near *grade* level with a pipe not smaller than the standpipe which shall extend as directly as possible to an exterior wall fronting on a *street*, or a *lane* not less than 15 feet wide, and there be connected to an *approved* siamese-type fire department connection; provided that where a building is set back from the *street*, and such exterior walls are not readily accessible as determined by the *authority having jurisdiction*, the connecting pipe shall be extended underground to an *approved* accessible location for the siamese connection.

A 4-inch standpipe shall require a two-way siamese connection; a 6-inch standpipe shall require a four-way siamese connection. All siamese inlets shall be equipped with clapper-checks and protective caps. Each inlet shall have a female thread suitable for connection with 2½-inch hose of the municipal fire department.

Siamese connections shall be located not less than one foot nor more than 4 feet above the adjoining ground or sidewalk.

All siamese connections shall be recessed in a wall or otherwise substantially protected. An iron or bronze sign with raised letters at least one inch high shall be rigidly fixed adjacent to each fire department connection, and shall read "TO DRY STANDPIPE".

4.20.2.6 Outlets.—At least one 2½-inch outlet shall be provided from every dry standpipe in every *storey, basement, or cellar* excepting the *first* or ground floor *storey*. Each such outlet shall consist of an *approved* stop valve having a bronze nipple threaded in accordance with the standard used by the municipal fire department. Such outlets shall be located not more than 4 feet above the floor level at each *storey* and all nipples shall be protected by caps. There shall be attached to each outlet by a chain of suitable length, a combination tool suitable for removing the cap and tightening up a 2½-inch hose connection.

Every standpipe shall have an *approved* siamese Y outlet located above the roof of the building, with a valve, nipple, and cap, as previously detailed on each branch with a combination tool attached. Such twin outlet if not located in a bulkhead shall be protected from the weather by a removable sheet metal housing. The bulkhead or metal housing shall have the words "STANDPIPE OUTLET" painted conspicuously on it.

Every standpipe and its connections, fittings, inlets, and outlets shall be so constructed and provided with valves that the whole can be completely drained without damage to the building or its contents.

4.20.2.7 Interpretation.—Nothing in this Article shall prohibit the use of a dry standpipe as a wet pipe and the connection thereto of tanks, pumps, or water mains, provided that a check valve shall be installed in each fire department connection pipe and between each pump or tank and the standpipe. Neither shall anything in this Article prohibit the attachment of hose to any standpipe provided the hose connections are independent of the fire department outlets required by Item 4.20.2.6 and in no way interfere with such outlets.

In no case shall any stop valve be introduced between a fire department connection and a standpipe.

4.20.2.8 Tests.—Upon the completion of each standpipe, and at intervals thereafter as required by the *authority having jurisdiction*, every standpipe shall be tested with outlets closed under a hydrostatic pressure sufficient to give a pressure of at least 50 pounds per square inch at the topmost outlet. The pipe, fittings, and valves shall show no leakage at this pressure. The *authority having jurisdiction* shall not be responsible for any possible damage resulting from this test. After testing, all water shall be removed from the standpipe system.

4.20.3 Basement Pipe Inlets.—Every *basement, cellar, or sub-cellar* which by use may be classified as belonging to Group C Occupancy (Commercial and Industrial) or which is located immediately beneath such an occupancy, and which is not equipped with sprinklers shall be provided with floor thimbles which will permit fire hose to be passed from the ground floor to the lower spaces. At least one such inlet shall

be provided for every 3000 square feet of unsprinklered, sub-grade, floor area or fraction thereof. The location of such inlets shall be *approved* by the *authority having jurisdiction*.

Every such floor thimble shall consist of a cylindrical, incorrodible metal tube not less than 8 nor more than 10 inches in diameter. It shall be installed in the floor construction flush with the finished floor and shall project below the finished ceiling not less than 1/2 inch. Each thimble shall be provided with a solid, snug-fitting, cast metal cover recessed into and flush with the top of the thimble, having a thickness of at least 1/8 inch. The cover shall be provided with a recessed lift ring and shall have the words "FOR FIRE DEPARTMENT, DO NOT COVER OVER" cast into it.

SECTION 4.21 STAGES, PLATFORMS, AND PROSCENIUM CURTAINS

4.21.1 General.—The requirements of this Section with regard to *stages* shall apply to any *stage* falling within the definition given in Part 2, except where otherwise expressly qualified. Any other raised structure in an *assembly room* serving as a dais, rostrum, or imitation stage, or used for the presentation of plays, or other forms of entertainment, shall be considered a platform and shall meet the requirements for platforms as given herein.

4.21.2 Stage Construction

4.21.2.1 Proscenium Wall.—Every *stage* shall be separated from the auditorium by *incombustible* construction having a *fire-resistance rating* of not less than 3 hours in the case of buildings of Type 1A, 1B, 1C, 2 or 5 Construction, and 2 hours in the case of Type 3 or 4 Construction. Such separation shall be known as the proscenium wall, and may be offset or arranged in plan in any desired way provided the degree of separation from the auditorium is maintained. Such wall shall extend from a *foundation* on ground to at least 3 feet above the *stage* roof or shall meet a floor or roof assembly over the *stage* having a *rating* equal to that required for the wall.

The proscenium wall shall have no openings therein other than the main proscenium opening and doorways having an area not in excess of 21 square feet. All such doorways shall be protected by *fire-resistive doors* meeting the requirements of Item 4.12.4.2. In a 3-hour wall, the *closure* shall consist of an *automatic fire-resistive door* on one side and a *self-closing* door on the other side of the wall. In a 2-hour wall, one *self-closing fire-resistive door* shall be installed.

The main proscenium opening shall be provided with a fire-resistive automatic curtain in accordance with Article 4.21.3.

4.21.2.2 Stage Floors.—Every part of every *stage* floor shall be of *incombustible* construction having the *fire-resistance rating* required by the Type of Construction of the building in which it is located; provided that the part of the *stage* floor extending back from and the

full width of the proscenium opening may be of unprotected metal or of wood construction having tongued and grooved flooring of a minimum nominal thickness of 2 inches. No part of such *combustible* construction shall extend into or through the proscenium opening. *Combustible* floor finishes may extend through the opening and may be applied over any part of the *stage* floor provided there are no concealed spaces under any such finish.

Openings in *stage* floors shall be equipped with tight-fitting trap doors meeting the requirements of Article 4.16.4.

4.21.2.3 Rooms accessory to the Stage.—All dressing rooms, workshops, and storerooms appurtenant to any *stage* shall be located on the *stage* side of the proscenium wall and shall be separated from each other and from the *stage* by *incombustible* construction having a *fire-resistance rating* of at least 2 hours with all openings therein protected by *fire-resistive closures*. Any usable space vertically beneath *combustible stage* construction shall be cut off by 2-hour fire-resistive construction with all openings therein protected by *fire-resistive closures* and no such space shall be used for any purpose other than for the working of traps and mechanical apparatus necessary for a performance on the *stage*.

4.21.2.4 Gridirons.—All gridirons, fly galleries, and pin rails shall be of *incombustible* materials, but protection of metal against fire shall not be required.

4.21.2.5 Ventilators.—There shall be one or more ventilators opening directly to the outer air constructed of *incombustible* materials, located near the centre and above the highest part of any *stage* and having a total ventilating area equal to not less than 5 per cent of all the floor space at *stage* level back of the proscenium wall which is not separated from the *stage* by 2-hour construction. Where any such ventilator is not located on a roof, i.e., where there is another *storey* above the *stage*, the ventilator shall open into a *masonry* or *reinforced concrete shaft* open to the air at its top, having walls of 3-hour fire-resistive construction with no openings therein.

Ventilator doors or covers shall open by force of gravity sufficient to overcome the effects of neglect, rust, snow and ice, and expansion under normal conditions. Doors or covers shall be held closed and manually operated by means of cables extending to each side of the *stage*. These cables shall each be equipped with 3 fusible links, one of which shall be placed in the ventilator above the highest ceiling level over the *stage* and the other two at *approved* points not affected by sprinkler heads. Fusible links shall release at 160 F. The emergency operation of the proscenium curtain by heat actuated devices shall result in the opening of the ventilators.

A suitable screen shall be installed under every ventilator containing plain glass, regardless of whether the glass is vertical or inclined. Where the glass is inclined or horizontal, a screen shall be provided above the ventilator also. Such screens shall meet the requirements set forth in Sub-division (f) of Article 4.12.5.

4.21.3 Proscenium Curtains

4.21.3.1 Fire Tests on Proscenium Curtains.—When fire tests on proscenium curtains are required, the procedure outlined in C.E.S.A. Specification A54-1940, Fire Tests on Building Construction and Materials, as applicable to non-load-bearing *partitions* shall be followed, subject to the following amendments:

(a) The test shall continue for a period of at least 15 minutes unless failure shall have previously occurred.

(b) The temperatures of the exposing fire shall be attained at 1/4 the time designated on the standard time temperature curve, a temperature of 1700 F. being attained at the end of the first 15 minutes.

(c) The temperatures on the unexposed surface may be measured by thermocouples with wires not over 0.02 inch in diameter, so mounted as to indicate the unexposed surface temperature as accurately as possible. The thermocouples shall not be covered over.

(d) Acceptance of any curtain following test shall be on the following basis:

- (i) The average temperature on the unexposed side shall not exceed 700 F. at the end of 15 minutes;
- (ii) The unexposed face of the curtain shall not glow within the test period nor shall there be any passage of flame through the curtain;
- (iii) The curtain shall not give off smoke in amounts sufficient to cause distress to any person on the unexposed side, nor shall it allow smoke to pass through it or around it.

4.21.3.2 Minimum Requirements.—The curtain shall be mounted on rigid guides so as to close the proscenium opening and intercept flame, hot gases, and smoke from a fire on the *stage*. The curtain shall be of a type known to fulfill the test requirements set forth in Item 4.21.3.1*. New types shall be tested in accordance with Item 4.21.3.1 before approval.

The curtain with its mountings shall be designed and constructed to withstand, when in the closed position, a lateral pressure of not less than 10 pounds per square foot. The weight of the counterweights shall be such that the curtain will close by gravity when released, while subjected to a lateral pressure of 5 pounds per square foot. Hoisting machines and cables shall have a factor of safety of not less than eight.

The speed of closure of any curtain shall be so regulated that closure will be effected within 45 seconds, but the last 5 feet of travel shall require at least 5 seconds, and the curtain shall settle on the stage without shock.

*Results of tests and other pertinent information on theatre curtains may be found in Bureau of Standards Journal of Research, V. 11, No. 4, October 1933.

The operation of every curtain shall be controlled by at least three *approved* fusible links releasing at 160 F., any one of which will alone release the curtain. Such links shall be located at *approved* positions, one on either side of the proscenium opening near the *stage* floor and one or more elsewhere. In addition there shall be an emergency device so arranged that the curtain can be released by hand from either side of the *stage*. The emergency operation of the curtain, whether manual or automatic shall cause the *stage* ventilators to open.

Complete details of any proposed proscenium curtain, its mechanism, guides, and supports shall be submitted to the *authority having jurisdiction* for approval, together with satisfactory proof that such installation meets the requirements of this Article for strength, and for fire resistance and smoke tightness when tested in accordance with Item 4.21.3.1. No part of any curtain shall be supported by or fastened to *combustible* construction.

After completion of any curtain, operating tests shall be carried out in the presence of the *authority having jurisdiction*. No public performance shall be staged until his approval of the installation has been given.

4.21.3.3 Materials.—Where asbestos cloth is used as part of any curtain, it shall be reinforced with suitable wire incorporated in the yarn before weaving and shall weigh at least 3 pounds per square yard. It shall have not less than 180 pounds strength per inch of warp and 65 pounds per inch of filling. Cotton fibre content of the curtain shall not exceed 5 per cent by weight of asbestos fibre. All asbestos cloth shall be filled with casein sodium silicate paint employing only mineral pigments. No paint containing any oil shall be applied to any curtain.

4.21.4 Platforms.—All walls or *partitions* bounding a platform in a *place of assembly* shall have a *fire-resistance rating* of at least one hour. The ceiling over any such platform shall, in conjunction with any floor or roof of which it forms a part, be so constructed as to afford a *fire-resistance rating* of at least one hour.

Every platform shall be of the same type of construction as the auditorium floor, provided that it may be of wood if the auditorium floor extends under the full area of the platform.

Where there is any usable space beneath a platform and the floor next below it, and where access to such space is provided, all walls and floors enclosing such space shall afford a *fire-resistance rating* of at least one hour.

4.21.5 Fire Protection Apparatus on Stage.—On the *stage* side of every proscenium wall there shall be provided at least two water supply pipes each having a minimum diameter of 2 inches. These pipes shall be filled with water under static pressure of at least 30 pounds per square inch at the hose connection. To each such pipe there shall be connected 50 feet of 1½-inch unlined linen hose fitted with a 5/8-inch smooth bore nozzle. The supply pipes shall be capable of supplying water for a period of at least 15 minutes without diminution of static head below 30 pounds per square inch.

SECTION 4.22 MOTION PICTURE MACHINE BOOTHS

4.22.1 Construction Requirements.—Every motion picture machine using flammable films, together with all electrical devices, rheostats, sewing machines, and all films present in any *place of assembly* shall be enclosed in a booth large enough to permit the operator to walk freely on either side or back of the machine, not less than 7 feet high and having a floor-area of not less than 50 square feet for each motion picture machine in such booth.

The floor of such booth shall be of *incombustible* construction or shall be covered with not less than 2 inches of *masonry*. The walls shall be of not less than one-hour *incombustible* fire-resistive construction but may be supported by *combustible* construction. The top of the booth shall be of not less than one-hour fire-resistive construction, *incombustible* except when it forms part of the roof of the building.

The entrance to the booth shall be equipped with a tight-fitting *self-closing fire-resistive door*. Such door shall open outwardly and shall not be equipped with any latch.

4.22.2 Port Hole Protection.—Each port hole opening in the projection booth wall shall be completely covered with a pane of plate glass. Each such opening and every fresh air inlet shall be provided with a shutter of sheet steel not less than 1/16 inch thick. Such shutters shall be equipped to close automatically, positively and completely, by the action of fusible links opening at 160 F. The shutters shall be so installed that they may be closed manually, either individually or collectively, and a master release cord controlling them shall be located immediately adjacent to the entrance doorway.

4.22.3 Ventilation of Booth.—Every booth shall be equipped with a ventilating inlet not less than 30 square inches in area placed near the floor on each of three sides and protected by wire netting. At the top of every booth there shall be at least a 10 inch diameter vent for each motion picture machine. Such vent shall be constructed of sheet metal not less than No. 24 U.S. gauge and shall connect into a *masonry* flue or go directly through the roof and 12 inches above, and shall be provided with an exhaust fan which will produce a complete change of air in the booth every 10 minutes. No wood or other *combustible* material shall be allowed to come within 4 inches of the vent. There shall be not more than one elbow or change in direction of this metal vent in any attic space. Where such vent does not pass directly through the roof of the building immediately over the booth, it shall be encased in not less than 4 inches of *solid masonry* or *reinforced concrete*.

4.22.4 Film Cabinets.—All films not in actual use shall be stored in metal cabinets or boxes constructed of galvanized iron or steel with metal partitions and shelves. Each such compartment shall have a capacity not in excess of 10 reels of film, and shall have tight self-closing doors of iron or steel. No solder shall be used in the construction of such metal boxes or cabinets.

PART 5
OF THE
NATIONAL BUILDING CODE

REQUIREMENTS BEARING ON
HEALTH AND SANITATION

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PART 5

REQUIREMENTS BEARING ON HEALTH AND SANITATION

SECTION 5.1 GENERAL REQUIREMENTS

5.1.1 Scope.—Every building hereafter erected or *altered* and all additions to *existing* buildings shall be constructed, arranged, and equipped to comply with the regulations herein prescribed.

In addition, no room shall be subdivided by means of a fixed or temporary *partition*, curtain, or portiere so as to create any separate space that does not comply with the regulations herein prescribed.

5.1.2 Interpretation.—Whenever *yards*, *courts*, windows, skylights, air wells, or systems of mechanical ventilation are referred to in this Code, their design and construction shall conform to the requirements herein prescribed; provided that, subject to Item 5.3.5.2 (c), these regulations shall not limit the construction or use of such facilities as may be provided in excess of such requirements.

5.1.3 Rooms in Cellars.—No *habitable room* shall be constructed in any *cellar*.

5.1.4 Alcoves.—Any *alcove* having a floor area exceeding 35 square feet, except a bay window; or a depth greater than its width; or of which the area of the connecting opening is less than 80 per cent. of the cross-sectional area of such *alcove* in the plane of such opening; shall be considered to be a separate room and shall be independently lighted and ventilated in accordance with the requirements herein specified.

Any other *alcove* shall be considered a part of the room upon which it opens, for purposes of lighting and ventilation, and the combined floor areas of such *alcove* and such room shall be employed in the computation of lighting and ventilation requirements. When the area of any *alcove* is included with that of a room for the purpose of computing minimum floor area, the height of such *alcove* shall not be less than seven feet six inches.

5.1.5 Access to Rooms and Dwelling Units.—In any building containing more than one *dwelling unit*, access shall be provided to each *dwelling unit* without the necessity of passage through any other *dwelling unit*.

In every *dwelling unit*, or group or suite of rooms, containing more than one bedroom, access shall be provided to living rooms, bedrooms, and kitchens, and to at least one water-closet room, without the necessity of passage through any bedroom.

No bath room or water-closet room shall be used for any other purpose except as a lavatory, and no such room shall open directly into any kitchen or cooking space either by a door, window, or other opening. Every bath room or water-closet room shall have a door completely closing the entrance to it.

All public wash rooms, bath rooms, and water-closet rooms in *residential buildings* shall be directly accessible from a *public hallway*.

SECTION 5.2 DIMENSIONS OF ROOMS

5.2.1 Habitable Rooms

5.2.1.1 Height.—The *height* of any *habitable room* shall not be less than eight feet; provided that the height of any bedroom shall not be less than seven feet six inches; and provided that for any bedroom situated in an attic where sloping ceilings occur, the height shall not be less than seven feet six inches over at least 50 per cent of the minimum required floor area.

5.2.1.2 Floor area.—Every bedroom, dining room, or living room shall have a gross floor area of at least 80 square feet and shall not be less than seven feet wide in any part. Every kitchen shall have a gross floor area of at least 50 square feet and shall not be less than five feet wide in any part, provided that a kitchen that is intended for use as a dining room also, shall have a gross floor area of at least 80 square feet and shall be not less than six feet wide in any part.

Every *dwelling unit* shall contain at least one room having not less than 120 square feet of gross floor area.

Any part of the floor over which the *height* of a room is less than four feet six inches shall not be considered in the computation of the minimum floor area.

5.2.2 Accessory Rooms

5.2.2.1 Height.—Except as hereinafter provided, every *accessory room* including those in *basements* and *cellars* shall have a *height* of not less than six feet six inches.

5.2.2.2 Bath Rooms and Water-closet Rooms.—

(a) **Height.**—The *height* of any bath room or water-closet room shall not be less than seven feet.

(b) **Floor Area.**—Every water-closet room or individual water-closet compartment shall be at least two feet six inches wide and shall have a gross floor area of at least 11 square feet.

5.2.3 Assembly Rooms.—The *height* of any *assembly room* shall not be less than ten feet.

Not less than six square feet of floor area inclusive of aisles but exclusive of *stage* area shall be provided for each unit of seating capacity.

SECTION 5.3 LIGHTING AND VENTILATION

5.3.1 Lighting and Ventilation of Rooms

5.3.1.1 Habitable Rooms.—Every *habitable room* shall be provided with one or more windows opening directly on a *street, yard, or court*; provided that in jails and other places of detention such windows may light and ventilate individual cells or similar areas, within a room, indirectly.

5.3.1.2 Accessory Rooms.—

(a) Every bath room or water-closet room in any *dwelling unit* that is located in any building containing not more than two *dwelling units* shall be provided with one or more windows opening directly on a *street, yard, or court*.

(b) Every other bath room or water-closet room, and every other *accessory room* of floor area greater than 35 square feet, other than a *private hallway* or *private stairway*, shall be provided with one or more windows opening on a *street, yard, court*, or air well, or with one or more skylights, or with artificial lighting and a system of mechanical ventilation.

5.3.1.3 Business Rooms and Work Rooms.

(a) **General.**—Any *business room* or *work room* shall be provided with one or more windows opening directly on a *street, yard, or court*, or with one or more skylights, or with artificial lighting and a system of mechanical ventilation; provided that a system of mechanical ventilation shall be compulsory for any such room that is situated in a *cellar*.

(b) **Hazardous Occupancies.**—Every *business room* or *work room* in which—by reason of use or occupancy—dust, fumes, gases, vapours, or other noxious or deleterious impurities, tending to injure the health of occupants or to create a fire hazard, may exist or develop, shall be provided with an exhaust system of ventilation to remove effectually such impurities during occupancy.

5.3.1.4 Assembly Rooms.—Every *assembly room* shall be provided with artificial lighting, and with a system of mechanical ventilation unless the space within such room exceeds 150 cubic feet for each unit of seating capacity and the requirements of this Code with respect to *habitable rooms* are fulfilled; provided that a system of mechanical ventilation shall be compulsory for any such room that is situated in a *cellar*.

The capacity of an *assembly room* shall be determined in accordance with the provisions of Item 4.6.5.1.

The space above any *stage* shall not be considered in the computation of volume.

5.3.2 Lighting and Ventilation of Hallways and Stairways

5.3.2.1 General.—

(a) Subject to Item 5.3.2.2, every *public hallway* and every *public stairway* shall be provided with one or more windows opening directly on a *street, yard, or court*, or with one or more ventilating skylights.

(b) Not less than one window or skylight shall be located in each 40 linear feet, or part thereof, of every *public hallway*; provided that when a window is located in an end wall of such *hallway*, one such window shall be considered sufficient for 60 linear feet of *hallway*.

(c) Not less than one window shall be provided in any *public stairway* for each *storey* opening on such *stairway*, or through which it passes; provided that a ventilating skylight may be used in place of such window or windows to serve not more than four *storeys* if such *stairway* has a single unobstructed vertical light well not less in area than one-quarter of the required glass area of such skylight.

5.3.2.2 Public Hallways and Stairways in Buildings of Fire-resisting Construction.—In any building of Type 1 Construction, having one or more passenger elevators opening on *public hallways* or *public vestibules*, such *public hallways* or *public vestibules*, and also *public stairways* within such buildings, may be constructed without windows or skylights, provided that every such *hallway*, vestibule, or *stairway* shall be equipped with artificial lighting and with a system of mechanical ventilation.

5.3.2.3 Returns in Hallways.—In *public hallways* every recess or return, the length of which, between the open and closed ends, exceeds twice the width, and every part of such *hallway* that is shut off from any other part by a door or doors, shall be deemed a separate *hallway* for purposes of lighting and ventilation.

5.3.3 Windows and Skylights

5.3.3.1 Areas Tributary to Windows.—Every window required by Article 5.3.1 or 5.3.2 shall open directly on a *street*, or on a *yard, court*, or air well, of not less than the sizes set forth in Article 5.3.4 and shall also comply with the requirements of this Article.

5.3.3.2 Glass Area of Windows.—The requirements of this Item are predicated upon the use of clear glass having a light transmission value of not less than 88 per cent. Any other type of glass, including glass block, may be used in place of clear glass; provided that the amount of light transmitted by any such installation shall not be less than the amount transmitted by the required area of clear glass.

The aggregate unobstructed glass area of any window or windows required by Article 5.3.1 or 5.3.2 shall not be less than one-tenth of the floor area of the room or *hallway* served by them; provided that in any bath room or water-closet room it shall not be less than four square feet; and provided that, for *stairways*, the required glass areas shall be based

upon the projected area, on a horizontal plane, of stairs, landings, and any light well associated with such *stairway*.

For the purposes of this Item, a glazed door opening directly on a *street*, *yard*, or *court* shall be considered as a window.

5.3.3.3 Openable Area of Windows.—Windows required by Article 5.3.1 or 5.3.2 shall be so openable that the aggregate open space will not be less than one-twentieth of the floor area of the room served by such windows, and the top of the openable area of at least one window in any *habitable room* shall not be less than six feet six inches above the floor level; provided that movable sashes, or louvres, otherwise complying with these requirements, of equal net openable area, may be substituted for such window openings.

5.3.3.4 Openable Area of Storm Sash.—Whenever storm sash are provided over required windows, not less than one such storm sash per room or *hallway* ventilated shall be openable from within; the aggregate openable area so provided shall not be less than one-eighth of the glass area required for the room or *hallway* so ventilated.

5.3.3.5 Skylights.—Every skylight permitted in Article 5.3.1 or 5.3.2 in place of a window or windows shall have an unobstructed glass area at least as great as that required for the window or windows replaced. Every such skylight shall open directly to the sky, provided that it shall not be located in the bottom of any air well. It shall be equipped with movable sashes, or louvres, of an aggregate net openable area not less than that required for the window or windows replaced, or with equivalent means of natural ventilation.

5.3.4 Dimensions of Yards, Courts, and Air Wells

5.3.4.1 General.—Any *yard*, *court*, or air well required by Article 5.3.3 shall comply with the requirements of this Article.

In computing the width of a *yard* of any building, on a *lot* which has a *street* or registered *lane* at the side of such *yard*, the width of such *street* or *lane*, adjacent and opposite to such *yard* may be deemed to be a portion of such *lot*. In addition a permanent easement obtained on an adjoining *lot* or *lots* may be used to serve as a *yard* or portion thereof, provided that the minimum width of such *yard* shall then be six feet and shall be subject to the additions prescribed in Item 5.3.4.2.

If any *court* or other open space within the outer walls of a building is connected to the exterior of the building by an open passage so arranged and proportioned as to create the condition of an *inner court* partially bounded by an *outer court*, then such *court* and such passage shall be considered to be separated by an imaginary line and shall be subject to the requirements herein specified for *inner* and *outer courts* respectively. Similarly when any bay or other recess in any wall of a *court* serves to create the condition of a *court* opening on a *court*, such bay or recess and such *court* shall be considered to be separated by an imaginary line, and the bay or recess shall be considered to be an air well and shall be

subject to the requirements herein specified for air wells; provided that if the width of such bay or recess is at least as great as the height of the highest wall bounding it, it may be considered as an *inner court*.

5.3.4.2 Yards.—Any *yard* provided for a window or windows lighting or ventilating *habitable rooms* shall not be less than four feet wide plus two feet for each *storey* above such window; provided that such width need not exceed 15 feet; and provided that if the distance of any required window in the wall bounding such *yard* is in excess of 25 feet from the nearer end of such wall, such width shall be increased by not less than 10 per cent of such excess length.

Any *yard* provided for any window or skylight lighting or ventilating any room other than a *habitable room*, or any *hallway*, shall not be less than four feet wide plus one foot for each *storey* above such window or skylight.

5.3.4.3 Inner Courts.—Any *inner court* provided for a window or windows lighting or ventilating *habitable rooms* shall be so constructed that its least horizontal dimension will not be less than its height.

Any *inner court* provided for any window or skylight lighting or ventilating any room other than a *habitable room* shall be so constructed that its least horizontal dimension will not be less than one-half its height.

5.3.4.4 Outer Courts.—Any *outer court* provided for a window or windows lighting or ventilating *habitable rooms* shall be so constructed that its width will not be less than its length.

Any *outer court* provided for any window or skylight lighting or ventilating any room other than a *habitable room* shall be so constructed that its length will not be more than three times its width, and its width will not be less than one-third its height; provided that its width need not exceed its length.

Every *outer court* shall open on a *street*, or on a *yard* conforming to the requirements of Item 5.3.4.2 for *habitable* or other rooms as the case may be.

5.3.4.5 Avoidance of Obstructions in Court and Yard Areas.—The area of any *court* or *yard* at any level shall be open and unobstructed above such level, except for parapets, window sills, belt courses, cornices, and other ornamental features projecting not more than eight inches from the walls bounding such *court* or *yard*; and for *fire escapes*; and for drop awnings; and for clothes poles, garden trellises and similar accessories; provided that *accessory buildings* may be located on the ground level of any *yard* or *outer court* if the distance of any such building from any wall of the main building bounding such *yard* or *court* is not less than the height of such *accessory building*.

5.3.4.6 Air Wells.—

(a) The cross-sectional area of any air well shall not be less than 100 square feet. When an air well is in excess of two *storeys* in *height* this area shall be increased throughout by ten per cent for each *storey* above

the *second*. Any air well shall be ventilated at its lowest level by a free air inlet and at its extreme height by a free air outlet, each of which shall have a minimum free cross-sectional area equivalent to ten per cent of the minimum cross-sectional area of the well, and shall be installed in such a manner as to ensure a free and continuous current of air.

(b) Whenever an air well meets the requirements of an *inner court* in respect of size it may be used as such.

5.3.5 Mechanical Ventilation

5.3.5.1 General.—Every system of mechanical ventilation required by this Code shall be designed and constructed in accordance with the requirements of this Article.* (See also Article 5.1.2.)

5.3.5.2 Sources of Air.—

(a) All air for ventilating purposes shall be drawn from the exterior of the building, any intake being so located that the air entering the system will contain no more bacteria, dust, odours, toxic substances, or moisture than the normal exterior air of the locality in which such building is situated.

(b) No room other than an *accessory room* and no *public hallway* shall receive such air from any other room. No *private accessory room* shall receive such air from any *hallway* or room other than one to which it is accessory. Any ventilation system serving a bath room or water-closet room shall be of the exhaust type.

(c) Notwithstanding the permissive requirements of Article 5.1.2,—Items 5.3.5.2 (b) and 5.3.5.3 (a), hereof, shall govern all ventilating systems whether required or not.

5.3.5.3 Recirculated Air.—

(a) Any system of mechanical ventilation may recirculate vitiated air, provided that no air from any *dwelling unit* shall be circulated, directly or indirectly, to any other *dwelling unit* or *public hallway*.

(b) Such air shall not be considered in the computation of the volume of air supplied; provided that when the ventilation system includes facilities for the effective removal of dust, odours, and toxic substances, air so treated may replace not more than 75 per cent of the volume of fresh air specified in Item 5.3.5.7.

5.3.5.4 Warming of Air.—Facilities shall be provided whereby, during winter months, air may be warmed to the minimum temperature at which it is desired to maintain the room or *hallway* ventilated, before it enters such space.

* The regulations set forth in this Article apply only to systems of mechanical ventilation and are based upon considerations of health only. They should not be used as a guide to warm-air heating, or air-conditioning or ventilation from the point of view of comfort.

5.3.5.5 Design and Construction.—Every system of mechanical ventilation shall be designed and constructed for continuous operation in accordance with accepted good commercial practice. For the purposes of this Item the recommendations of the American Society of Heating and Ventilating Engineers as shown in that Society's Guide, Volume 17, dated 1939, shall be accepted as good commercial practice.

Every system of mechanical ventilation shall be operable by the building management and not by individual tenants; provided that this requirement shall not prohibit the regulation of the rate of air flow within any rented premises by the tenant thereof.

5.3.5.6 Avoidance of Air Currents.—Air entering or leaving a room or *hallway* by any system of mechanical ventilation shall be so controlled that at no place less than seven feet from the floor and more than two feet from any wall, will there be air currents of velocity greater than three feet per second; provided that when the air is delivered at a temperature higher than that prevailing in the room the maximum velocity may be five feet per second.

5.3.5.7 Capacity of Mechanical Ventilating Systems.—Every mechanical ventilating system shall be capable of providing, within any room or *hallway* so ventilated, not less than the amount of fresh air set forth in Table 1 of this Section, the term "fresh air" referring to exterior air supplied in accordance with the requirements of Item 5.3.5.2 hereof.

TABLE 1 (SECTION 5.3)
MINIMUM REQUIRED AIR SUPPLY

Space Ventilated	Cubic Feet of Fresh Air per Minute per Square Foot of Floor Area
<i>Public</i> bath rooms or water-closet rooms.....	2
<i>Private</i> bath rooms or water-closet rooms.....	2
Other <i>accessory</i> rooms.....	1
<i>Assembly</i> rooms in <i>cellars</i>	2½ ⁽¹⁾
Other <i>assembly</i> rooms.....	2 ⁽¹⁾
<i>Business</i> or <i>work</i> rooms in <i>cellars</i> ⁽²⁾	2 ⁽¹⁾
Other <i>business</i> or <i>work</i> rooms ⁽²⁾	1 ⁽¹⁾
<i>Hallways</i>	1

(1) This volume shall be considered as a minimum requirement; in no case shall the volume of air supplied be less than 15 cubic feet per minute for each person for whose accommodation such room is designed or intended.

(2) Additional provisions shall be made for ventilation of any room when required by Item 5.3.1.3 (b).

5.3.6 Artificial Lighting

5.3.6.1 General.—Whenever it is proposed to install a permanent system of artificial lighting in a building, and whenever artificial lighting is required by the provisions of Article 5.3.1 or 5.3.2 hereof, the requirements of this Article shall be fulfilled.

5.3.6.2 Distribution of Facilities.—One or more lighting outlets or fixtures shall be provided at suitable locations in all *habitable rooms*;

in all bath rooms, water-closet rooms, and other *accessory rooms* of floor area greater than 35 square feet; in all *business or work rooms*; in all *assembly rooms*; and in all *public hallways and stairways*.

5.3.6.3 Standards of Illumination.—In all electrical installations the wiring and outlets shall be capable of delivering not less than the power necessary to fulfil the requirements of Table 2 of this Section. All other installations shall be capable of supplying equivalent illumination.

TABLE 2 (SECTION 5.3)
MINIMUM WATTAGE REQUIREMENTS FOR ELECTRIC LIGHTING*

	Watts per Square Foot of Floor Area
<i>Habitable Rooms</i>	
(1) Classrooms and study rooms in schools and educational institutions.....	4
(2) All other <i>habitable rooms</i>	2
<i>Accessory Rooms</i>	
(1) Bath rooms and water-closet rooms.....	1
(2) All other <i>accessory rooms</i>	½
<i>Business Rooms and Work Rooms</i>	
(1) Rooms in which close work is to be done, including operating rooms in hospitals.....	4
(2) Offices and laboratories.....	3
(3) Office vaults, <i>public garages</i>	1
(4) Storage rooms.....	½
(5) All other <i>business and work rooms</i>	2
<i>Assembly Rooms</i>	
(1) <i>Public</i> reading rooms or study rooms such as in libraries.....	4
(2) All other <i>assembly rooms</i>	1
<i>Public Hallways and Stairways</i>	½

*— The requirements of Table 2 apply only to the outlets necessary for general lighting purposes. Additional provision shall be made for all other demands to be anticipated as a result of the operation of specialized lighting equipment, or devices and appliances consuming electric power. Minimum wattage requirements are also prescribed in the Canadian Electrical Code (See Item 5.3.6.4). These shall be complied with in addition to the requirements of Table 2.

5.3.6.4 Standards of Electrical Installations.—All electrical wiring and facilities shall conform to the requirements of the Canadian Electrical Code, Part 1, dated 1939, as published by the Canadian Engineering Standards Association.

5.3.6.5 Artificial Lighting Other Than Electrical.— Where electric power is not available, or other conditions prevent its use, artificial lighting shall be provided by the use of such means as acetylene, natural or manufactured gas, or liquid petroleum derivatives, in such form and in such manner as will be accepted as good commercial practice. For the purposes of this Item the regulations and requirements set forth in the publication "National Fire Codes for Flammable Liquids and Gases, 1938" of the National Fire Protection Association (United States) shall be accepted as good commercial practice.

SECTION 5.4 HEATING FACILITIES

5.4.1 General—In any building intended for human occupancy between the 1st day of October and the 1st day of May of the following year, all *habitable rooms* shall be provided with suitable heating facilities capable of maintaining a minimum temperature of not less than 65 degrees Fahrenheit in weather 15 degrees Fahrenheit above the lowest temperature recorded by the Weather Bureau⁽¹⁾, during the preceding ten years, for the locality in which the heating system is to be installed. Such minimum temperature shall be measured in the centre of the room at a point five feet above the floor.⁽²⁾ If Weather Bureau reports are not available for the locality in question, the reports for the station nearest such locality shall be used.

5.4.2 Capacity of Heating Equipment.—The capacity of every heating system required herein shall be determined by computation in accordance with accepted good commercial practice.

For the purposes of this Article, the Heating Codes approved in 1939 by the Ontario Chapter, Canadian Division, of the American Society of Heating and Ventilating Engineers shall be accepted as good commercial practice.

5.4.3 Design and Installation of Heating Equipment.—Every heating system required by this Section shall be designed, constructed, and installed in accordance with accepted good commercial practice. (See also Sections 4.13 and 4.14).

SECTION 5.5 REQUIRED PLUMBING FACILITIES

5.5.1 General.—Whenever a municipal water supply is available within 100 feet of the building, every *residential building, institutional building, commercial or industrial building, or assembly building*, whether new or *existing*, shall be provided with a plumbing system including an adequate supply of potable water, and suitable sanitary facilities with drainage to a public sanitary sewer, private sewage disposal system, or other *approved* means of sewage disposal.

When such municipal water supply is not available, a plumbing system shall not be mandatory, but any new plumbing system that is installed in any building, and any to which alterations or additions are made, shall comply with the requirements of this Section. When no plumbing system is installed, there shall be provided sanitary privies, chemical closets, or other means for the disposal of human excreta, *approved* by the *authority having jurisdiction*.

5.5.2 Quality, Design, and Construction.—The quality, design, and construction of any plumbing system or part thereof shall conform to the requirements of the Standard Plumbing By-law, dated 1940,⁽³⁾ as prepared by the National Building Code Committees, or to such more restrictive requirements as the *authority having jurisdiction* may designate.

(1) Meteorological Service, Dominion of Canada, Toronto, Ontario.

(2) This requirement is based upon considerations of health and should not be used as a criterion for requirements based upon comfort.

(3) Appendix K.

5.5.3 Fixtures Required

5.5.3.1 General Requirements.—As a minimum requirement, every *residential building, institutional building, commercial or industrial building, or assembly building* shall be provided with at least one water-closet and one lavatory or sink. Every *residential building or institutional building* shall also be provided with at least one bath-tub or one shower-bath.

Additional fixtures shall be provided, when necessary to meet the requirements hereinafter prescribed; provided that—

(a) Whenever more than one water-closet, one lavatory or sink, or one bath-tub or shower-bath is installed in a single room ~~other than in a private dwelling unit~~, the use of such room shall be restricted to one sex only.

(b) Whenever separate water-closet rooms or bath rooms are provided for each sex separately, they shall be closed by a full-sized door and shall be clearly and properly marked.

(c) Whenever water-closet rooms are provided for the exclusive use of males, urinals may be substituted for one-half of the required number of water-closets.

5.5.3.2 Residential Buildings and Institutional Buildings.—

(a) Every *dwelling unit* shall be provided with at least one *private* water-closet, one *private* bath-tub or shower-bath, and one *private* lavatory or sink.

(b) Every *residential building or institutional building* shall be provided with not less than one water-closet, one lavatory or sink, and one bath-tub or shower-bath for every ten bedrooms. When any bedroom is provided with a *private* water-closet, lavatory or sink, and bath-tub or shower-bath, such room and such fixtures shall not be considered in the computation of the required number of fixtures.

Whenever bedroom accommodation is to be provided for both sexes and more than one water-closet, one lavatory or sink, and one bath-tub or shower-bath is required, such facilities shall be provided in separate rooms for each sex.

Whenever sleeping accommodation is to be provided for more than two persons in one room—as in a dormitory—one water-closet, one lavatory or sink, and one bath-tub or shower-bath for every 15 persons shall be installed on the basis of the total number of persons for whose accommodation such building is designed or intended.

(c) Whenever sleeping accommodation is to be provided in *detached* rooms having private entrances—as, for example, in a tourist camp—water-closet, bath, and lavatory accommodation may be provided in a *detached* building on the same premises, if such building and facilities otherwise comply with the requirements of this Code.

5.5.3.3 Industrial and Commercial Buildings.—Every *industrial* and *commercial building* shall be provided with water-closets and lavatories or sinks depending upon the number of employees for whose accommodation such building is designed or intended, in accordance with the requirements of Table 1 of this Section; provided that any separate business occupancy—for example, a retail store—within a building, shall have separate facilities, in accordance with the Table, if the total number of employees for whose accommodation such occupancy is designed or intended is in excess of nine.

TABLE 1 (SECTION 5.5)
REQUIRED WATER-CLOSETS AND SINKS

Number of Persons	Minimum Number of Water-closets	Minimum Number of Lavatories or Sinks
1 to 9.....	1	1
10 to 24.....	2	2
25 to 49.....	3	3
50 to 100.....	5	5
Over 100.....	one water-closet and one lavatory or sink for each additional 30 persons	

Whenever any *industrial* or *commercial building* or occupancy is designed or intended for the accommodation of both sexes, separate facilities shall be provided for each sex independently, in accordance with Table 1, if the total number of employees is in excess of nine.

5.5.3.4 Assembly Buildings.—

(a) In every school or college building there shall be provided for each sex, not less than one water-closet for every twenty, and not less than one lavatory or sink for every forty persons of such sex for whose accommodation such building is designed or intended.

(b) In every other *assembly building* there shall be provided for each sex, not less than one water-closet for every 150 persons, and not less than one lavatory or sink for every 300 persons of such sex for whose accommodation such building is designed or intended.

5.5.3.5 Temporary Facilities.—Suitable toilet facilities shall be provided for the use of workmen during the construction of any building. These toilet facilities shall be maintained in a sanitary condition.

5.5.4 Drinking Water.—Facilities to provide an adequate supply of potable water for drinking purposes shall be installed in readily accessible places in every *industrial or commercial, institutional, or assembly building*. All such water shall be from an *approved* source.

SECTION 5.6 OTHER REQUIREMENTS

5.6.1 Construction of Bath Rooms, Wash Rooms, and Water-Closet Rooms

(a) All enclosing walls of any bath room or water-closet room shall extend from floor to ceiling; provided that such ceiling need not be more than eight feet above the floor; and provided further that dwarf partitions may be used to separate individual water-closet or urinal compartments within any such room.

(b) All *public* wash rooms and water-closet rooms shall have floors, and walls to a height of not less than 6 inches, of vitrified tile, terrazzo *concrete* one inch in thickness, asphalt mastic one inch in thickness, or other equally suitable material. All such floors and walls shall be finished smooth with a cove base, so as to be readily cleaned. The walls to a height of 4 feet shall be of vitrified tile, portland cement plaster one inch thick painted with water-resistant oil paint, or other equally suitable material. The remainder of the walls and the ceiling shall be of gypsum plaster painted with water-resistant oil paint, Keene's cement, or other equally suitable material.

(c) Any ceiling below a shower-bath which does not discharge into a tub or other fixture shall be protected from leakage by an apron or tray of lead or other equally corrosion-resistant metal draining into the shower drain.

5.6.2 Damp-proofing of Basements.—When any *habitable room* is located in a *basement*, the floor and exterior walls of such *basement* shall be so constructed or treated as to render the *basement* water-tight and damp-proof. In addition, when buildings, with *basements* enclosing *habitable rooms*, are located on a site where ground-water conditions exist or are likely to occur, such as might produce any hydrostatic head against the *basement* walls or floors, the floors shall be constructed on porous backfill and all walls shall be backfilled with porous material to within twelve inches of ground level and above that with relatively impermeable soil; and an adequate drainage system shall be laid which will collect the water from the bottom of all porous backfill and conduct it away from the building.

The walls and floors of *habitable rooms* located in *basements* shall be so insulated, heated, or ventilated that there will be no condensation of moisture ('sweating') on their interior surface during periods of high humidity in summer months. Such insulation, when required, may be provided by the application of a lining of wood or similar material supported on furring strips and thus held clear of *masonry* or *reinforced concrete walls*.

5.6.3 Drainage and Ventilation Below Ground Floor Level.—In any building, any *basement*, *cellar*, or other space below the ground floor shall be effectively drained so as to prevent at all times any accumulation of water. In addition any such *basement*, *cellar*, or other space, that is not ventilated in accordance with the requirements herein specified for a room, shall be ventilated by means of openings in the exterior wall.

Such openings shall have a net free cross-sectional area of not less than 20 square inches for every 25 linear feet or major fraction thereof, of exterior wall, and shall be securely covered with screen or grillage to comply with Article 5.6.6. Such openings need not be placed in the front wall of the building if equivalent areas are provided in the other walls.

When *residential buildings* have *basement* or *cellar* walls of *hollow units* (such as hollow *concrete blocks*), the exterior of such *basement* walls shall be rendered with cement *mortar* from the *footings* to at least two feet above *grade*.

5.6.4 Thermal Insulation

5.6.4.1 Walls.—Except in buildings specifically designated for summer occupancy only, no exterior wall of any *habitable room* shall have an overall coefficient of heat transfer (*u*) greater than 0.25 B.t.u. per hour per square foot per degree Fahrenheit difference in temperature between the air on the two sides, when based on an exterior wind velocity of fifteen miles per hour.

5.6.4.2 Roofs.—Except in buildings specifically designated for summer occupancy only, no roof construction above any *habitable room*, including the ceiling of such room, shall have an overall coefficient of heat transfer (*u*) greater than 0.35 B.t.u. per hour per square foot per degree Fahrenheit difference in temperature between the air on the two sides, when based on an exterior wind velocity of fifteen miles per hour.

The overall coefficients of heat transfer (*u*) for building construction as given in "A Code for the Design and Installation of Steam and Hot Water Heating Systems for Residences Having up to 50,000 Cubic Feet of Volume" as approved by the Ontario Chapter, Canadian Division, of the American Society of Heating and Ventilating Engineers, on November 7, 1938, shall be acceptable for the purposes of this Article.

5.6.5 Sound Insulation

5.6.5.1 Walls and Floors.—Walls and floors separating *dwelling units* within any building shall be of a type of construction having a sound transmission loss*, or sound reduction, of not less than 45 decibels.

The sound transmission loss shall be as determined by laboratory measurements of typical specimens of the construction employed. Such measurements shall be made at not less than 9 frequencies, spaced at approximately one-half octave intervals. Twice as many of these measurements shall be made at frequencies below 1024 cycles as above it. The arithmetic average of these measurements shall be taken as the sound transmission loss.

For the purposes of this Item, Sound Transmission Loss is defined as follows:

$$T.L. = 10 \log_{10} \frac{E_1 S}{E_2 a_2}$$

in which

- T.L.* = Sound Transmission Loss, in decibels;
- E_1/E_2 = ratio of sound energy density on the transmitting side to the sound energy density on the receiving side;
- S* = area of the test partition;
- a_2 = equivalent absorption of the receiving room.

For the purposes of this Item, the constructions described and illustrated in Appendix I shall have the sound transmission loss values assigned to them therein.

5.6.5.2 Attachment of Fixtures, etc., to Separating Walls.—

No plumbing fixture, water-supply pipe, drainage pipe, or mechanical equipment which produces or is liable to produce noise during operation shall be fastened to or supported by any wall separating *dwelling units* within any building, unless the fastenings or supports are of non-rigid or other construction, adequate to prevent the transmission of solid-borne noises to such wall.

5.6.6 Rat-proofing of Buildings.—Every building or part thereof that is designed or intended for use as a dwelling, or for the handling, storage, or sale of foodstuffs, shall conform to the requirements of this Article.

Every such building unless supported on posts shall have continuous *foundation walls* extending from at least two feet below ground level to at least six inches above ground level; or shall have a continuous floor of *masonry* or *reinforced concrete* or other equally rat-proof material.

All openings in such *foundations* or floors, including doors, windows, and drains, and all junctions between *foundation walls* and building walls shall be effectively rat-proofed; i.e., windows and doors shall be tight fitting; other openings shall be securely covered with rat-proof screening or grillage, or shall be tightly closed with metal sheeting, *concrete*, or other equally rat-proof material.

5.6.7 Refuse Chutes.*—Every garbage or rubbish chute shall be lined throughout with sheet metal having a corrosion resistance at least equal to that of galvanized iron weighing not less than 2.156 pounds per square foot (No. 18 Gauge). Every joint and seam in such sheet metal work shall be smoothly finished and fully soldered or welded. Every door serving any garbage chute shall be of metal and shall fit snugly into a metal frame; and every such frame shall make a tight joint, fully soldered or welded, with the sheet metal lining.

Every garbage or rubbish chute shall be designed and constructed so that no solid or liquid entering such chute can come in contact with any wood or *masonry*, and that there will be no egress for odours or vermin from such chute when the doors are closed. Adequate means of access for cleaning any chute shall be provided.

Every garbage or rubbish chute above the ground floor shall be vertical, provided that inlets at any floor level may be offset on an angle of not less than 45 degrees to the horizontal.

5.6.8 Sanitary Privies and Frost-Proof Closets.—No sanitary privy, chemical closet, or frost-proof closet shall be installed within any building used for human occupancy nor within 10 feet of any dwelling, nor in any location where it could contaminate any domestic water supply.

APPENDICES AND INDEX
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N.R.C. NO. 1068 (BOOK 5)

APPENDICES

APPENDIX "A"

BOARD OF APPEAL

In order to determine the suitability of alternate materials and types of construction and to provide for reasonable interpretations of the provisions of this Code, there shall be and is hereby created a Board of Appeal consisting of five members, who are qualified by experience and training to pass upon matters pertaining to building construction. Wherever practicable, one member shall be an architect, one a builder, one a lawyer and two structural or civil engineers, each of whom shall have had at least 5 years experience in his respective profession. The *authority having jurisdiction* or his representative shall be an ex-officio member and shall act as Secretary of the Board. The Board of Appeal shall be appointed by the municipality and such appointments shall be subject to periodic review by the municipality. The Board shall adopt reasonable rules and regulations for conducting its investigations and shall render all decisions and findings in writing to the *authority having jurisdiction* with a duplicate copy to the appellant and may recommend to the municipality such new legislation as is consistent therewith.

The Board of Appeal may interpret the provisions of this Code to cover a special case, if it appears that the provisions of this Code do not definitely cover the point raised or that a manifest injustice might be done, provided that every such decision shall be by unanimous vote of the Board of Appeal. Decisions as to the use of alternate materials and types of construction shall be by majority vote and if not permitted by this Code shall become effective only when authorized by an amendment to this Code.

APPENDIX "B"

ALLOWABLE CLEAR SPANS FOR JOISTS AND RAFTERS

TABLE 1 (APPENDIX B)

ALLOWABLE CLEAR SPANS FOR FLOOR JOISTS DRESSED IN ACCORDANCE WITH C.E.S.A. SPECIFICATION A43-1937 AS AMENDED IN 1940 (SEE NOTES 2 AND 3)

- Notes: 1. Spans are calculated for a *live load* of 40 pounds per square foot and allowance is made for a ceiling load of 10 pounds per square foot. If no ceiling is used the allowable spans may be increased by one inch per foot of span.
2. Where *joists* dressed to the sizes given in the following table are used, the allowable spans given below shall be reduced by one-half inch per foot of span.

Nominal Size	Actual Dimensions
2" x 6"	1-5/8" x 5-5/8"
2" x 8"	1-5/8" x 7-1/2"
2" x 9"	1-5/8" x 8-1/2"
2" x 10"	1-5/8" x 9-1/2"

3. Where rough lumber having full nominal dimensions is used, the allowable spans given below may be increased by one inch per foot of span.

APPENDIX "B"—Continued

Species and Nominal Dimensions	Spacing of Joists				
	12" o.c.	14" o.c.	16" o.c.	18" o.c.	20" o.c.
Eastern Cedar					
2" x 6"	7'-3"	6'-9"	6'-4"	6'-0"	5'-8"
2" x 8"	11'-7"	9'-10"	9'-3"	8'-9"	8'-4"
2" x 9"	11'-11"	11'-1"	10'-4"	9'-10"	9'-4"
2" x 10"	13'-3"	12'-4"	11'-7"	11'-0"	10'-5"
Western Cedar					
2" x 6"	8'-0"	7'-5"	7'-0"	6'-7"	6'-3"
2" x 8"	11'-7"	10'-9"	10'-1"	9'-6"	9'-1"
2" x 9"	13'-0"	12'-2"	11'-4"	10'-9"	10'-3"
2" x 10"	14'-6"	13'-6"	12'-9"	12'-0"	11'-5"
Eastern White Pine, Western White Pine					
2" x 6"	8'-5"	7'-10"	7'-4"	6'-11"	6'-7"
2" x 8"	12'-3"	11'-4"	10'-8"	10'-1"	9'-7"
2" x 9"	13'-9"	12'-10"	12'-0"	11'-5"	10'-10"
2" x 10"	15'-4"	14'-3"	13'-5"	12'-8"	12'-1"
Spruce, Eastern Hemlock, Jack Pine, Lodgepole Pine, Amabilis Fir, Balsam Fir					
2" x 6"	8'-10"	8'-3"	7'-8"	7'-3"	6'-11"
2" x 8"	12'-10"	11'-11"	11'-2"	10'-7"	10'-1"
2" x 9"	14'-5"	13'-5"	12'-7"	11'-11"	11'-4"
2" x 10"	16'-1"	15'-0"	14'-1"	13'-3"	12'-8"
Red Pine, Western Yellow Pine, Larch (Tamarack), Douglas Fir (Mountain)					
2" x 6"	9'-3"	8'-7"	8'-1"	7'-7"	7'-3"
2" x 8"	13'-5"	12'-5"	11'-8"	11'-0"	10'-6"
2" x 9"	15'-1"	14'-1"	13'-2"	12'-6"	11'-10"
2" x 10"	16'-10"	15'-8"	14'-8"	13'-11"	13'-3"
Western Hemlock, Western Larch					
2" x 6"	9'-7"	8'-11"	8'-5"	7'-11"	7'-6"
2" x 8"	14'-0"	13'-0"	12'-2"	11'-6"	10'-11"
2" x 9"	15'-9"	14'-7"	13'-9"	13'-0"	12'-4"
2" x 10"	17'-6"	16'-3"	15'-4"	14'-6"	13'-9"
Douglas Fir (Coast)					
2" x 6"	10'-8"	9'-11"	9'-3"	8'-10"	8'-4"
2" x 8"	15'-5"	14'-5"	13'-6"	12'-9"	12'-2"
2" x 9"	17'-5"	16'-3"	15'-3"	14'-5"	13'-8"
2" x 10"	19'-5"	18'-1"	17'-0"	16'-1"	15'-3"

TABLE 2 (APPENDIX B)

ALLOWABLE CLEAR SPANS FOR CEILING JOISTS DRESSED IN ACCORDANCE WITH C.E.S.A. SPECIFICATION A43-1937 AS AMENDED IN 1940 (SEE NOTES 2 AND 3)

- Notes: 1. Spans are calculated for a *live load* of 10 pounds per square foot and a *dead load*, excluding the weight of the *joists*, of 10 pounds per square foot.
2. Where *joists* dressed to the sizes given in the following table are used, the allowable spans given below shall be reduced by one-half inch per foot of span.

APPENDIX "B"—Continued

Nominal Size	Actual Dimensions
2" x 4"	1-5/8" x 3-5/8"
2" x 5"	1-5/8" x 4-5/8"
2" x 6"	1-5/8" x 5-5/8"
2" x 8"	1-5/8" x 7-1/2"

3. Where rough lumber having full nominal dimensions is used, the allowable spans given below may be increased by one inch per foot of span.

Species and Nominal Dimensions	Spacing of Joists		
	12" o.c.	16" o.c.	20" o.c.
Eastern Cedar			
2" x 4"	7'-9"	6'-9"	6'-1"
2" x 5"	9'-8"	8'-6"	7'-8"
2" x 6"	11'-7"	10'-2"	9'-3"
2" x 8"	16'-8"	14'-8"	13'-4"
Western Cedar			
2" x 4"	8'-6"	7'-5"	6'-8"
2" x 5"	10'-7"	9'-4"	8'-5"
2" x 6"	12'-9"	11'-2"	10'-1"
2" x 8"	18'-3"	16'-1"	14'-7"
Eastern White Pine, Western White Pine			
2" x 4"	8'-11"	7'-10"	7'-0"
2" x 5"	11'-2"	9'-10"	8'-10"
2" x 6"	13'-5"	11'-10"	10'-8"
2" x 8"	19'-4"	17'-0"	15'-4"
Spruce, Eastern Hemlock Jack Pine, Lodgepole Pine, Amabilis Fir, Balsam Fir			
2" x 4"	9'-5"	8'-3"	7'-5"
2" x 5"	11'-9"	10'-4"	9'-4"
2" x 6"	14'-1"	12'-4"	11'-2"
2" x 8"	20'-2"	17'-10"	16'-1"
Red Pine, Western Yellow Pine, Larch (Tamarack), Douglas Fir (Mountain)			
2" x 4"	9'-10"	8'-7"	7'-9"
2" x 5"	12'-3"	10'-9"	9'-9"
2" x 6"	14'-8"	12'-11"	11'-8"
2" x 8"	21'-2"	18'-7"	16'-10"
Western Hemlock, Western Larch			
2" x 4"	10'-2"	8'-11"	8'-0"
2" x 5"	12'-9"	11'-3"	10'-1"
2" x 6"	15'-4"	13'-5"	12'-2"
2" x 8"	21'-11"	19'-4"	17'-6"
Douglas Fir (Coast)			
2" x 4"	11'-4"	9'-11"	8'-1"
2" x 5"	14'-2"	12'-5"	11'-3"
2" x 6"	17'-0"	14'-11"	13'-5"
2" x 8"	24'-4"	21'-6"	19'-5"

TABLE 3 (APPENDIX B)

ALLOWABLE CLEAR SPANS FOR RAFTERS DRESSED IN ACCORDANCE WITH C.E.S.A. SPECIFICATION A43-1937 AS AMENDED IN 1940 (SEE NOTES 3 AND 4)

- Notes: 1. Spans are calculated for the combined snow and wind loads specified in Articles 3.6.4 and 3.6.5 assuming a basic snow load of 40 pounds per square foot on a horizontal surface.
 2. The span is to be measured on the slope between points where the *rafter* is tied or supported.
 3. Where *joists* dressed to the sizes given in the following table are used, the allowable spans given below shall be reduced by one-half inch per foot of span.

Nominal Size	Actual Dimensions
2" x 4"	1-5/8" x 3-5/8"
2" x 5"	1-5/8" x 4-5/8"
2" x 6"	1-5/8" x 5-5/8"
2" x 8"	1-5/8" x 7-1/2"

4. Where rough lumber having full nominal dimensions is used, the allowable spans given below may be increased by one inch per foot of span.

Species and Nominal Dimensions	Spacing of Rafters		
	16" o.c.	20" o.c.	24" o.c.
Eastern Cedar			
2" x 4"	4'-11"	4'-5"	4'-0"
2" x 5"	6'-3"	5'-7"	5'-1"
2" x 6"	7'-7"	6'-9"	6'-2"
2" x 8"	11'-1"	9'-11"	9'-0"
Western Cedar			
2" x 4"	5'-5"	4'-10"	4'-5"
2" x 5"	6'-10"	6'-2"	5'-7"
2" x 6"	8'-4"	7'-5"	6'-9"
2" x 8"	12'-2"	10'-10"	9'-11"
Eastern White Pine, Western White Pine			
2" x 4"	5'-9"	5'-1"	4'-8"
2" x 5"	7'-3"	6'-6"	5'-11"
2" x 6"	8'-9"	7'-10"	7'-2"
2" x 8"	12'-10"	11'-6"	10'-6"
Spruce, Eastern Hemlock, Jack Pine, Lodgepole Pine, Amabilis Fir, Balsam Fir			
2" x 4"	6'-0"	5'-4"	4'-11"
2" x 5"	7'-7"	6'-10"	6'-2"
2" x 6"	9'-2"	8'-3"	7'-6"
2" x 8"	13'-5"	12'-0"	11'-0"
Red Pine, Western Yellow Pine, Larch (Tamarack), Douglas Fir (Mountain)			
2" x 4"	6'-3"	5'-7"	5'-1"
2" x 5"	7'-11"	7'-1"	6'-6"
2" x 6"	9'-7"	8'-7"	7'-10"
2" x 8"	14'-1"	12'-7"	11'-6"
Western Hemlock, Western Larch			
2" x 4"	6'-6"	5'-10"	5'-4"
2" x 5"	8'-3"	7'-5"	6'-9"
2" x 6"	10'-0"	8'-11"	8'-2"
2" x 8"	14'-8"	13'-1"	10'-11"
Douglas Fir (Coast)			
2" x 4"	7'-3"	6'-6"	5'-11"
2" x 5"	9'-2"	8'-2"	7'-6"
2" x 6"	11'-1"	9'-11"	9'-1"
2" x 8"	16'-3"	14'-6"	13'-3"

APPENDIX "C"

METHOD OF COMPARING THE RIGIDITY OF STUD WALLS
WHEN VARIOUS MATERIALS ARE USED AS SHEATHING

C1. Introduction.—The method consists of subjecting a test panel and a standard panel to equal lateral forces and comparing the lateral deflections produced thereby.

C2.—Standard Panel.—The standard panel shall be 4 feet 6 inches high by 7 feet long and shall be constructed using nominal 2- by 4-inch studding spaced at 16-inch centres with a stud at each end of the panel. The sill and the plate shall each be nominal 2 by 4 inches nailed to each stud with two 4-inch nails. Studs shall not be toe-nailed to the sill. *Sheathing* shall consist of shiplap 5/8 inch thick and not more than 6 inches wide placed horizontally with each board nailed to every stud that it crosses with two 2½-inch nails. No plaster or other finish shall be applied to the interior face of the studs. Grades of studding and *sheathing* used in the standard panel shall comply with the requirements of Item 3.2.3.3.

C3. Test Panel.—The framing of the test panel shall be identical with that of the standard panel. *Sheathing* shall be applied in the manner in which it is proposed that it be used in service. If the *sheathing* material is supplied in sheets or is otherwise jointed, a vertical and horizontal joint shall be included in the test panel as shown in Figure 1 of this Appendix.

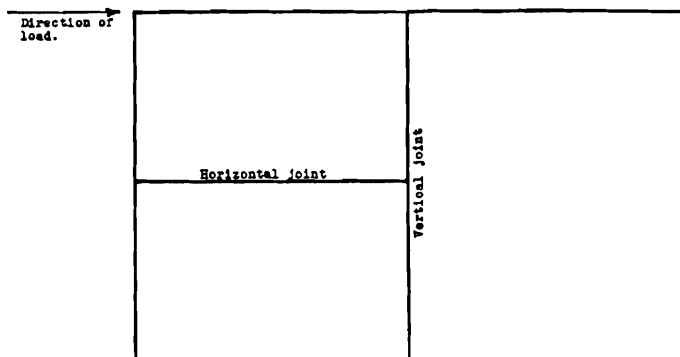


FIG. 1

C4. Method of Test.—The test shall be conducted by applying equal and opposite horizontal forces simultaneously to the plate of the standard panel and to the plate of the test panel. Suitable reactions shall be provided in order to hold the panels in position. An acceptable method of test is shown in Figure 2 of this Appendix.

Measurements shall be taken of the lateral movement of the plate relative to the sill for each panel.

Straining shall be increased in suitable increments and readings of deflection taken for each measurement until either the test panel or the standard panel shows a deflection of 6 inches.

C5. Interpretation of Results.—The sheathing shall be considered to have adequate racking strength if the deflection of the test panel does not exceed the deflection of the standard panel for any increment of load.

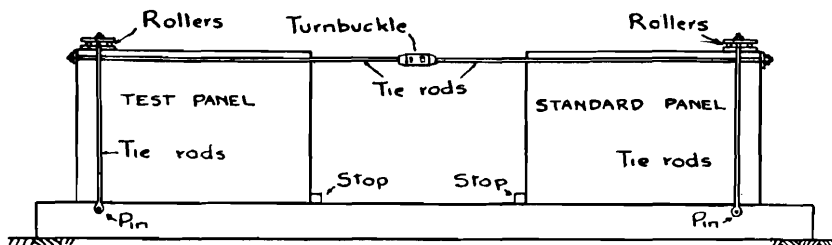


FIG. 2

APPENDIX "D"

TENTATIVE METHOD OF MAKING PHYSICAL TESTS OF FIBRE BUILDING BOARD*

D1. Determinations shall be made by the following procedures:

(a) Transverse Strength and Deflection.—Tests for transverse strength and deflection shall be made under prevailing atmospheric conditions except in case of dispute. These tests shall then be made on samples conditioned for at least 24 hours at a relative humidity of 65 per cent plus or minus 5 per cent and at a temperature of 70 to 75F.

A specimen 3 inches wide and 18 inches long is placed on horizontal parallel supports 12 inches apart and the load is applied at midspan on a bearing parallel to the end supports, at such a rate that failure occurs in not less than 20 seconds and not more than 40 seconds after the commencement of loading. The bearing and supports are rounded to a radius of approximately 3/8 inch to prevent injury to the specimen.

The specimen is cut from the board in such a way that the break occurs in the direction giving the lower strength. In addition, if the specimen shows any difference in breaking strength depending upon which face is uppermost it is broken in the position giving the lower strength.

The transverse strength is taken as the average of six determinations.

Ultimate deflection is determined at the time each specimen breaks in the transverse strength test.

(b) Water Absorption.—A specimen 12 by 12 inches is dried at 160F. for 24 hours and cooled to room temperature in a dry atmosphere. The thickness of the sample is measured and the volume calculated.

*Separate copies of this Appendix, designated NRC-19-1940, may be obtained from the National Research Council.

The sample is then carefully weighed and submerged horizontally under one inch of distilled water maintained at a temperature of 70F. plus or minus 5F. After 2 hours of submersion the sample is stood on end to drain for 10 minutes, at the end of which time the excess surface water is removed by hand with a blotting paper, and the sample is weighed immediately. The volume of water absorbed is expressed as a percentage of the initial volume of the sample, the specific gravity of the water absorbed being assumed to be 1.00.

(c) **Linear Expansion.**—The maximum linear expansion is determined from a specimen 3 by 12 inches that has been cut parallel with the long direction of the board and from a like specimen cut at right angles thereto. The expansion is measured between two points approximately 10 inches apart on the centre line of each specimen. The specimens are conditioned for 24 hours at 50 per cent relative humidity and measurements are then made of the distance between the two reference points. The specimens are then conditioned for 24 hours at 97 per cent relative humidity after which the distance between the two reference points is again measured. The expansion may be measured by any convenient method provided that the results are accurate within .005 inch. The measurements are made in air, conditioned as specified in each case, or as quickly as possible after each specimen is removed therefrom. The linear expansion is reported as the increase in length between the reference marks expressed as a percentage of the length at 50 per cent relative humidity. (In the absence of other facilities, a convenient means of conditioning the specimens at the specified humidity conditions is to expose them in an enclosed space immediately above saturated solutions of suitable salts, e.g., sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$) for 50 per cent relative humidity, and potassium sulphate (K_2SO_4) for 97 per cent relative humidity.)

APPENDIX "E"

METHOD OF TEST FOR MOISTURE RESISTANCE OF PLYWOOD

E1. Tests for Moisture Resistant Class.—Five samples 6 by 6 inches shall be taken from each test panel. They shall be submerged in water at room temperature for a period of 4 hours, followed by drying at a temperature not to exceed 100 F. for a period of 20 hours. This cycle shall be repeated a second time, after which the samples must show not more than 2 inches of delamination along the edge.

E2. Tests for Exterior Class.—Five samples shall be cut as shown in Figure 1 of this Appendix from each test piece. They shall be submerged in water at room temperature for a period of 48 hours and dried for 8 hours at a temperature of 145 F. ($\pm 5\text{F.}$) and then followed by two cycles of soaking for 16 hours and drying for 8 hours under the conditions described above. The samples shall again be soaked for a period of 16 hours and tested while wet in a shear testing machine by placing them in the jaws of the device to which a load shall be applied at the rate of 600

to 1,000 pounds per minute until failure. The test specimens must show no less than 30 per cent minimum and 60 per cent average wood failure, and no delamination. If the number of plies exceeds 3, the cuts shall be made so as to test any two of the joints, but the additional plies need not be stripped except as demanded by the limitations of the width of the retaining jaws on the testing machines. When desired, special jaws may be constructed to accommodate the thicker plywood. If number of plies exceeds 3, the choice of joints to be tested shall be left to the discretion of the *authority having jurisdiction*, but at least one-half the tests shall include the innermost joints.

An alternate test applicable at the manufacturer's option to the one above mentioned consists of taking the samples as described above and boiling them in water for 4 hours, followed by a drying of 20 hours at the above mentioned temperature. They shall be boiled again for a period of 4 hours and the samples tested while wet, as above described. The test specimens must show no less than 30 per cent minimum and 60 per cent average wood failure, and no delamination.

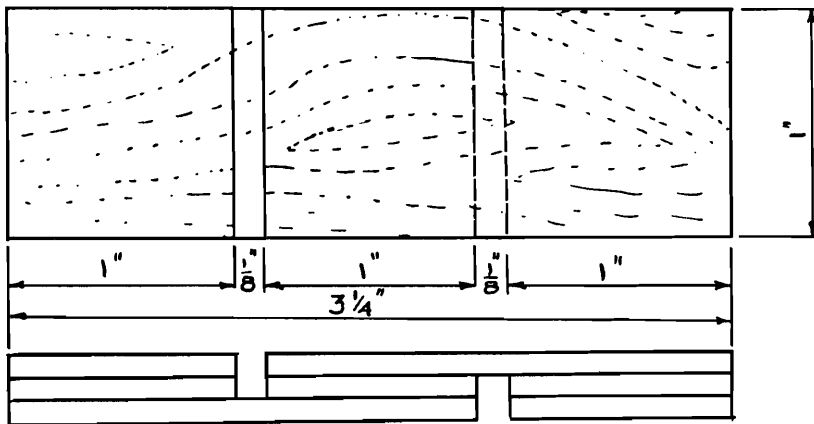


FIG. 1

APPENDIX "F"

CALCULATION OF BENDING MOMENTS IN STRUCTURAL STEEL COLUMNS

F1. Definitions.*—For the purposes of this Appendix—

Clip angle shall mean an end connection angle attached to the upper surface of the top flange of a *beam*.

Fixed end moment shall mean the bending moment that would be present at the end of a *beam* if both ends were completely fixed in direction.

*See also general definitions given in Part 2.

Length of a Member.—For the purpose of determining its *stiffness*, the *length* of a *column* shall mean the distance between the neutral axes of the *beams* or other members providing lateral support; and the *length* of a *beam* shall mean the clear distance between the *columns* to which it is connected.

Seat angle shall mean an end connection angle attached to the lower surface of the bottom flange of a *beam*.

Stiffness when used in reference to a member resisting bending shall mean its moment of inertia about the neutral axis of the area of cross-section divided by the *length of the member*.

Web angle shall mean an end connection angle attached to the web of a *beam*.

F2. Classification of Connections.—For the purpose of calculating bending moments in *columns* the connections of *beams* to *columns* shall be classified as follows:

Rigid Connections

- (a) Wind bracing connections,
- (b) Connections having *clip angles* more than 1/2 inch thick with or without *web angles*,
- (c) Connections having *clip angles* more than 3/8 inch thick with *web angles*,
- (d) Rigid or nearly rigid welded connections,
- (e) All connections in which the upper flange of the *beam* and the portions of the *column* adjacent to it are encased in *concrete*.

Semi-rigid Connections

- (a) Connections having *web angles*, with or without *seat angles*, but without *clip angles*,
- (b) Connections having *clip angles* not more than 1/2 inch thick, with *seat angles*, but without *web angles*,
- (c) Flexible welded connections.

Non-rigid Connections

Connections not capable of transmitting any appreciable bending moment.

F3. Calculation of Bending Moments.—The bending moments in a *column* about either of the principal axes shall be calculated by the following method. Considering the moments in a plane at any panel point; the algebraic sum of the moments transmitted by the connections together with the algebraic sum of the moments due to the vertical reactions at the ends of the *beams*, resulting from the most unfavourable arrangement of *live load*, shall be distributed between the *column* lengths above and below the panel point and the *beams* framing into the *column*, in proportion to their *stiffnesses*.

A rigid connection shall be assumed to be capable of transmitting the total *fixed end moment* and the effective *stiffness* of the *beam* connected by it shall be assumed to be its moment of inertia divided by its *length*.

A semi-rigid connection shall be assumed to be capable of transmitting one-half the *fixed end moment* and the effective *stiffness* of the *beam* connected by it shall be assumed to be one-half its actual *stiffness*, viz., one-half its moment of inertia divided by its *length*.

A non-rigid connection shall be assumed to be incapable of transmitting any appreciable moment and the effective *stiffness* of a *beam* connected by it shall be assumed to be negligible.

APPENDIX "G"

ALLOWANCE FOR END RESTRAINT OF STRUCTURAL STEEL BEAMS

G1. Definitions.*—For the purposes of this Appendix—

Clip angle shall mean an end connection angle attached to the upper surface of the top flange of a *beam*.

Fixed end moment shall mean the bending moment that would be present at the end of a *beam* if both ends were completely fixed in direction.

Girder shall mean a *beam* supporting *columns* or *beams* other than *joists*.

Length of a Member.—For the purpose of determining its *stiffness* the *length* of a *column* shall mean the distance between the neutral axes of the *beams* or other members providing lateral support; and the *length* of a *beam* shall mean the clear distance between the *columns* to which it is connected.

Seat angle shall mean an end connection angle attached to the lower surface of the bottom flange of a *beam*.

Static bending moment shall mean the bending moment that would be present in a *beam* if both ends were simply supported.

Stiffness when used in reference to a member resisting bending shall mean its moment of inertia about the neutral axis of the area of cross-section, divided by the *length of the member*.

Supplementary steel shall mean steel provided to ensure a high degree of restraint at the end of a *beam* connected to a *girder*.

Web angle shall mean an end connection angle attached to the web of a *beam*.

G2. Beams Connected to Girders.—

(a) Where a *beam* is connected at one end to a *girder* that is solidly encased in *concrete* and where *supplementary steel* capable of resisting a tensile force $T = \frac{f_s A_s}{4}$ is provided, a restraining moment equal to one-third of the static bending moment may be assumed to be present at the end of the *beam*. (f_s is the fibre stress in tension in the *beam*. A_s the area of cross-section of the *beam*.)

(b) Where a *beam* is connected at one end to a *girder* that is not solidly encased in *concrete*, no allowance shall be made for end restraint of the

*See also general definitions given in Part 2.

beam, except that when *beams* of approximately equal span are supported on either side of the web of a *girder* on *seat angles* having four rivets connecting the angles to the flanges of the *beam*, a restraining moment equal to one-third of the *static bending moment* due to the *dead load* may be assumed to be present at the ends of the *beams* if *supplementary steel* capable of resisting a tensile force

$$T = \frac{\text{dead load bending moment}}{\text{live load bending moment}} \times \frac{(A_s f_s)}{4}$$

is provided.

(c) *Supplementary steel* shall be provided in either of the following manners or in a combination of the two:

- (i) By steel plates rigidly attached to the *beam* or *beams* by rivets or welds.
- (ii) By properly anchored reinforcing bars located near the top of a *concrete* slab and in the vicinity of the *beam*. (For anchorage requirements, see Item 3.4.14.9.) If reinforcing bars are used, care shall be taken to ensure that the *dead load* does not cause stress in the *beam* before the *concrete* has set; if this is not the case, allowance for restraint shall be made only for that portion of the load applied after the *concrete* has set.

G3. Beams Connected to Columns.—

(a) Classification of Connections.—

- (i) When allowance is to be made for the restraint at the end of a *beam* connected to a *column*, the connection at that end shall comply with the requirements of the succeeding paragraphs of this Item and shall also fulfil the requirements of one of the classes set forth in Table 1 of this Appendix.

TABLE 1 (APPENDIX G)
MINIMUM REQUIREMENTS FOR CLASS A, CLASS B, AND
CLASS C CONNECTIONS

Class	Details of Connection	Required <i>Concrete</i> Encasement
A	6" x 4" x ½" <i>clip angle</i>	none required
B	6" x 4" x 3/8" <i>clip angle</i> with <i>web angles</i> *	none required
	6" x 4" x 3/8" <i>clip angle</i>	solid encasement of the upper flange of the <i>beam</i> and a 2" slab as shown in Figure 1.
C	6" x 4" x ½" <i>clip angle</i>	solid encasement of the upper flange of the <i>beam</i> 3½" slab and special reinforcement as shown in Figure 2.
	Split I.	none required
	Gusset plate.	none required

**Web angles* shall be adequate to carry the total end shear.

- (ii) Where a *clip angle* is used, the horizontal leg shall be fastened to the *beam* with not less than four rivets.
- (iii) The *seat angle* shall be adequate to carry, in conjunction with the *web angles* (if any), the total end shear and shall be at least as strongly connected as the *clip angle*.

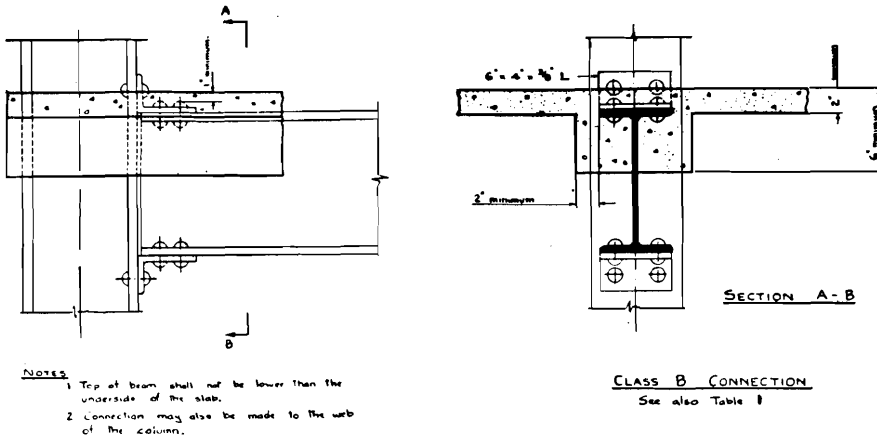


FIG. 1

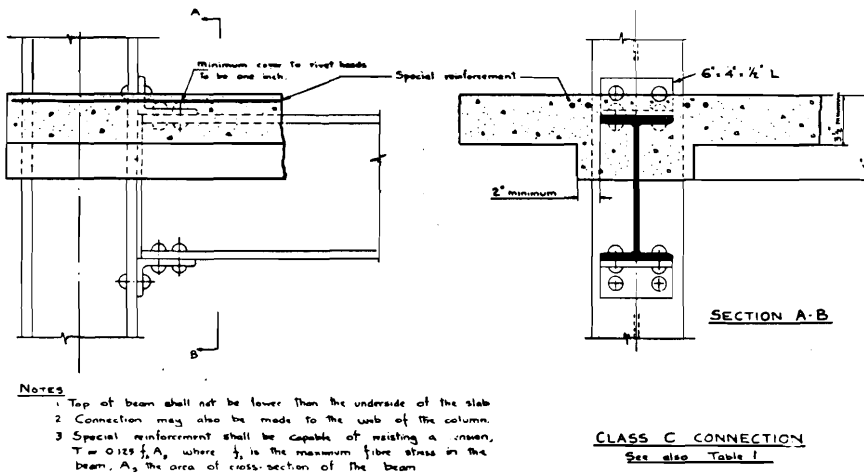
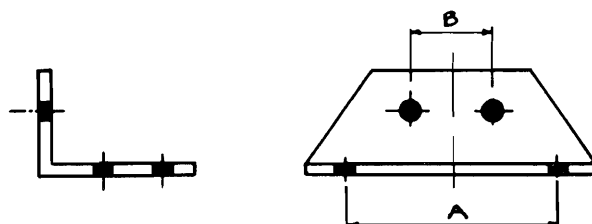


FIG. 2

- (iv) The *clip angle* shall not be less than 5 inches long and rivets not less than $3/4$ inch in diameter shall be used, except that if the width of the flange or the width of the *column* to which it is attached is less than 5 inches, the length of the angle shall be at least equal to the lesser width and the rivets shall be the largest that can be used but in no case less than $5/8$ inch diameter.

- (v) The rivets connecting the *clip angle* to the *beam* are to be symmetrically arranged about the vertical axis of the cross-section of the *beam*.
- (vi) The inner row of rivets in each leg of the *clip angle* shall be not more than $2\frac{1}{4}$ inches from the back of the angle, provided that a variation of $\frac{1}{8}$ inch may be permitted on this dimension.
- (vii) The lateral spacing of the rivets connecting the *clip angle* to the *column* shall not differ from the spacing of those connecting it to the *beam* by more than 8 inches (see Figure 3).



(A - B) shall not exceed 8 inches.

FIG. 3

- (viii) Steel erection packings up to $\frac{3}{8}$ inch in thickness may be introduced between the flange of the *beam* and either the *clip* or *seat angles*.
- (ix) When *concrete* encasement is specified, the *concrete* shall have a minimum strength of 2000 pounds per square inch, and shall provide a minimum cover of one inch over all rivet heads and other projecting parts.
- (x) When *concrete* encasement is specified, care shall be taken to ensure that the *dead load* does not cause deformation of the connection before the *concrete* has set; or the connection shall be considered as unencased for that portion of the load applied before the *concrete* has set.
- (xi) Where a *beam* frames eccentrically into the flange of a *column*, no allowance shall be made for end restraint if the distance between the centre line of the *beam* and the centre line of the *column* exceeds $\frac{1}{6}$ of the width of the *column* flange or 2 inches, whichever is the lesser.
- (xii) When a *beam* makes a *skew* connection to a *column*, no allowance shall be made for end restraint if the angle of *skew* exceeds 15 degrees.

(b) Classification of Beams.—When allowance is to be made for restraint at the end of a *beam* having a Class A or Class B connection, the *beam* shall be classified in accordance with the relation between its section modulus and its depth, as set forth in Table 2 of this Appendix and as shown graphically in Figure 4.

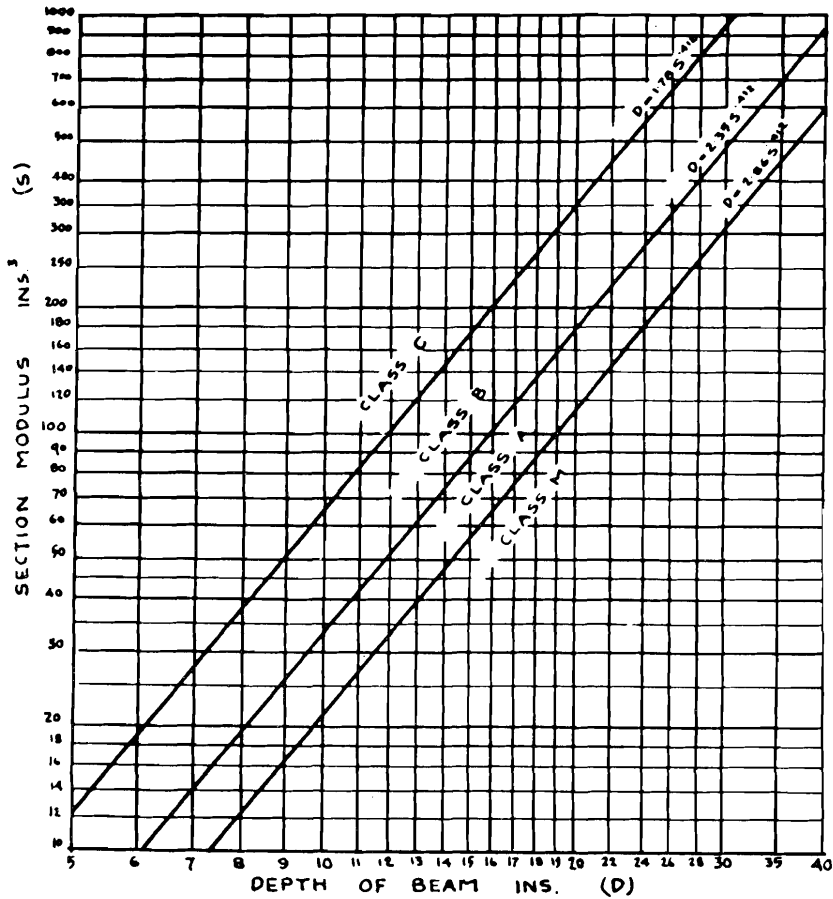


FIG. 4. CLASSIFICATION OF BEAMS (For allowable end restraint)

TABLE 2 (APPENDIX G)
CLASSIFICATION OF BEAMS

Class	Relation of Depth to Section Modulus	Beams Included
M	Depth of <i>beam</i> greater than $2.86 S^{0.412}$	Most <i>beams</i> lighter than American Standard <i>beams</i> .
A	Depth of <i>beam</i> greater than $2.35 S^{0.412}$ and less than $2.86 S^{0.412}$	American Standard <i>beams</i> , British Standard <i>beams</i> (light sections), some Wide Flange <i>beams</i> .
B	Depth of <i>beam</i> greater than $1.78 S^{0.412}$ and less than $2.35 S^{0.412}$	British Standard <i>beams</i> (heavy sections), some Wide Flange <i>beams</i> .
C	Depth of <i>beam</i> less than $1.78 S^{0.412}$	Some Wide Flange <i>beams</i> .

S is the section modulus of the *beam*, in inches³.

(c) Allowable End Moments

- (i) Where a *beam* is attached at one end to the flange of a *column*, allowance may be made for the restraining moment present at that end in the following manner:

The value of M_F , the mean of the *fixed end moments* at both ends of the *beam* shall be calculated*. When Class A or Class B connections are used, the allowable degree of fixity (k) shall be determined from the curves in Figures 5 and 6 of this Appendix. When Class C connections are used, k shall be assumed to be 0.4. The allowable restraining moment shall be assumed to be kM_F . Where, in extreme cases, such as the upper *storeys* of certain buildings, the *stiffness* of the *beam* divided by the sum of the *stiffnesses* of the *column lengths* above and below the *beam* is found to exceed 1.5, no allowance shall be made for the restraining moment. In determining the *stiffness* of the members, allowance may be made for the increase in moment of inertia due to solid *concrete* encasement.

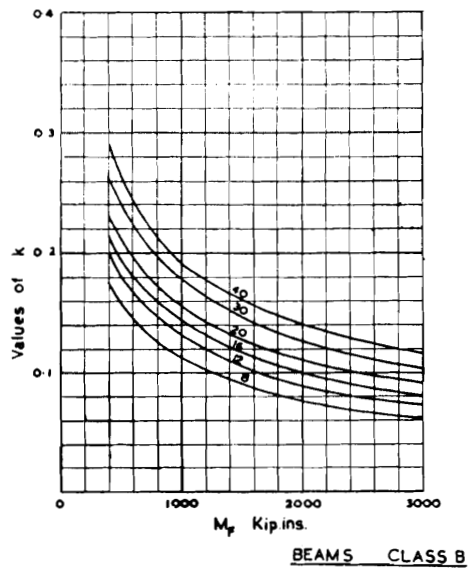
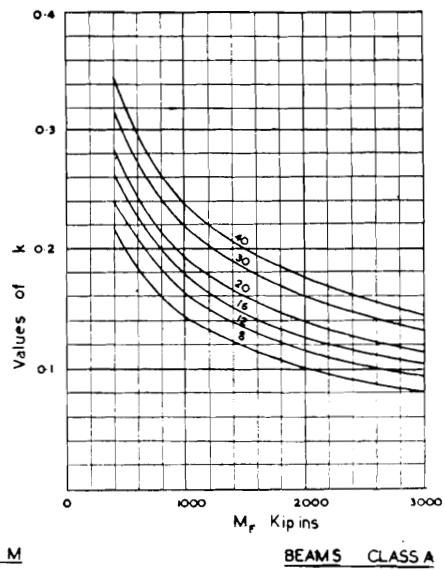
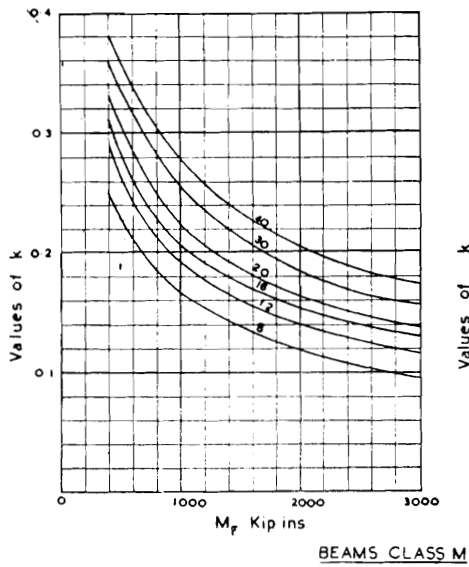
- (ii) Where a *beam* is connected at one end to the web of a *column*, allowance may be made for the restraining moment at that end only under the following conditions:

- (1) Where there is no *beam* framing in on the other side, the *column* shall be solidly encased in *concrete*, or special provision shall be made to stiffen the web of the *column*,

*For a uniform load over the whole span:..... $M_F = \frac{WL}{12}$

For a concentrated load P dividing the span into segments a and b :..... $M_F = \frac{Pab}{2L}$

For a distributed load on part of the span, where W is the total load distributed over a length d , and a and b are the segments into which the centre line of the load divides the span:..... $M_F = \frac{Wab}{2L} - \frac{Wd^2}{24L}$

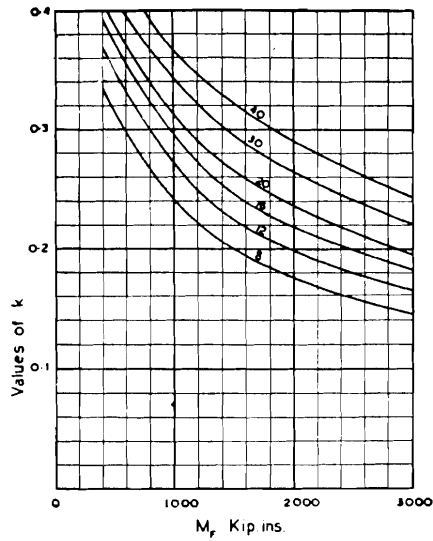


CURVES SHOWING THE RELATION
BETWEEN ALLOWABLE RESTRAINT
AND FIXED END MOMENT WHEN
CLASS A CONNECTIONS ARE USED

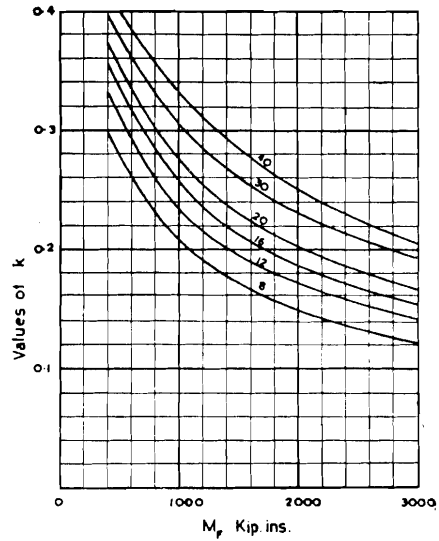
Note

The figures on the curves indicate
the length of the beam in feet.

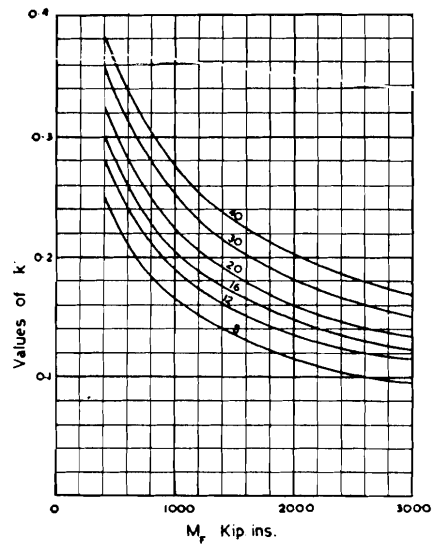
FIG. 8



BEAMS CLASS M



BEAMS CLASS A



BEAMS CLASS B

CURVES SHOWING THE RELATION
BETWEEN ALLOWABLE RESTRAINT
AND FIXED END MOMENT WHEN
CLASS B CONNECTIONS ARE USED

Note

The figures on the curves indicate
the length of the beam in feet.

FIG. 6

in which case allowance may be made for the restraining moment provided that the *stiffness* of the *beam* divided by the sum of the *stiffnesses* of the *column lengths* above and below the *beam* does not exceed 1.5.

- (2) Where the *beam* connection is balanced by a connection of the same class on the opposite side of the *column* and the rivets in the vertical legs of the angles serve both connections, allowance may be made for the restraining moment provided that the *fixed end moment* shall be taken as being that portion which is balanced by the *fixed end moment* due to *dead load* only in the *beam* on the opposite side of the member.
- (iii) No allowance shall be made for end restraint when *beams* of Class C are used.

APPENDIX "H"

METHOD OF CALCULATING HORIZONTAL FORCES DUE TO EARTHQUAKES

Every *structure* or portion of a *structure*, located in a region where destructive earthquakes are probable, shall be capable of resisting a horizontal force computed in accordance with the following formula and assumed to be applied at its centre of gravity:

$$F = C W$$

where F is the horizontal force;

W the total *dead load* plus one-half the *live load*;

C a constant as given in Table 1 of this Appendix.

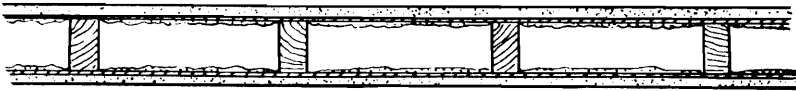
TABLE 1 (APPENDIX H)
HORIZONTAL FORCE FACTORS

Part or Portion	Value of "C"	Direction of Force
The building as a whole: Allowable bearing value of soil more than 2000 pounds per square foot	.02	Any direction horizontally
Allowable bearing value of soil 2000 pounds per square foot or less	.04	
<i>Bearing walls, curtain walls, enclosure walls, panel walls</i>	.05	Normal to surface of wall
Cantilever parapet and other cantilever walls, except retaining walls	.25	Normal to surface of wall
Exterior and interior ornamentations and appendages	.25	Any direction horizontally
Towers, tanks, towers and tanks plus contents, <i>chimneys</i> , smokestacks, and <i>penthouses</i>	.05	Any direction horizontally

APPENDIX I

SOUND TRANSMISSION LOSS VALUES FOR CERTAIN
TYPICAL WALL AND FLOOR CONSTRUCTIONSSOUND TRANSMISSION LOSS VALUES FOR CERTAIN
TYPICAL WALL CONSTRUCTIONS

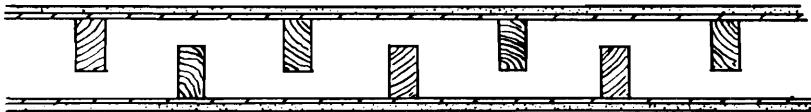
Sound Transmission Loss = T.L.
Decibel = db.



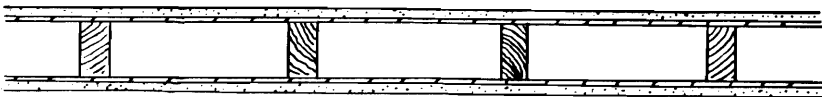
1. Wood studs; wood lath; scratch and brown coats of lime plaster; smooth white finish.	T.L. = 42db
2. Wood studs; wood lath; scratch and brown coats of gypsum plaster; smooth white finish	T.L. = 36db
3. Wood studs; metal lath; scratch and brown coats of lime plaster; smooth white finish.	T.L. = 44db
4. Wood studs; metal lath; scratch and brown coats of gypsum plaster; smooth white finish.	T.L. = 39db



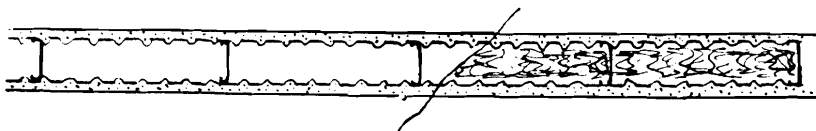
5. Wood studs; ½ inch fibre building board applied to both sides; joints filled.	T.L. = 29db
6. Wood studs; ½ inch fibre building board applied to both sides; scratch and brown coats of gypsum plaster on both sides; smooth white finish.	T.L. = 47db
7. Same as 6, except two layers of ½ inch fibre building board applied to each side.	T.L. = 49db



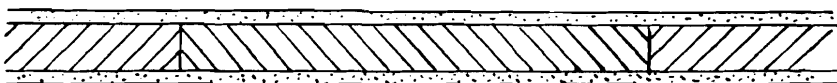
8. Staggered wood studs; ½ inch fibre building board applied to both sides; scratch and brown coats of gypsum plaster, smooth white finish.	T.L. = 51db



9. Wood studs; gypsum lath nailed to studs with nails 6 inches apart; scratch and brown coats of sanded gypsum plaster; smooth white finish; thickness of plaster ½ inch.	T.L. = 41db



10. Three-inch one-piece metal studs, spaced 16 inches centre to centre; expanded metal lath; scratch and brown coats of gypsum plaster; smooth white finish. T.L. = 37db
11. Same as 10, except space between studs filled with rock wool bats packed to a density of 4.3 pounds per cubic foot. T.L. = 38db



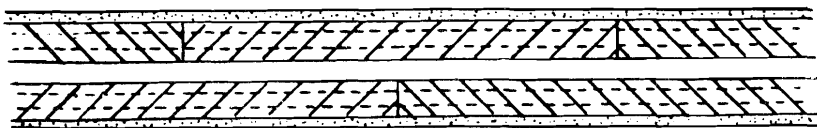
12. Solid gypsum tile, 3 inches thick; brown coat of gypsum plaster on both sides; smooth white finish. T.L. = 38db



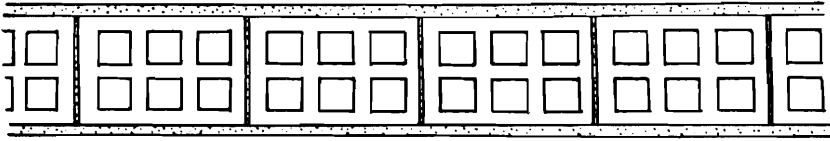
13. Two panels of solid gypsum tile, each 2 inches thick; 4-inch air space. T.L. = 51db



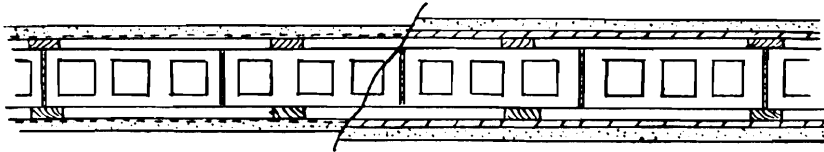
14. Two panels of solid gypsum tile, each 2 inches thick; 2 inches of felt between panels. T.L. = 51db



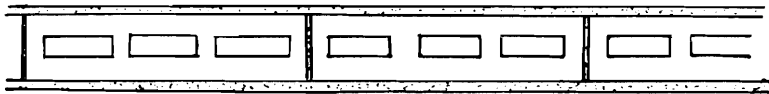
15. Two panels of hollow gypsum tile, each 3 inches thick; 1½ inch air space between panels; brown coat of gypsum plaster on each panel; smooth white finish. T.L. = 49db



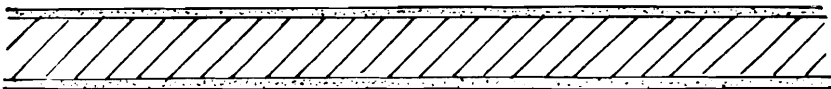
16. Hollow clay tile, 8 by 12 by 12 inches, six cells; brown coat of gypsum plaster on both sides; smooth white finish. T.L. = 46db



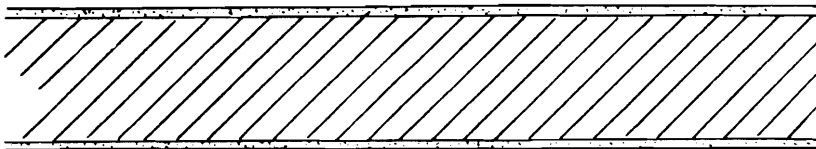
17. Hollow clay tile, 4 by 12 by 12 inches, three cells; wood furring strips; metal lath; scratch and brown coats of gypsum plaster; smooth white finish. T.L. = 52db
18. Hollow clay tile, 4 by 12 by 12 inches, three cells; wood furring strips; fibre building board; brown coat of gypsum plaster; smooth white finish. T.L. = 54db



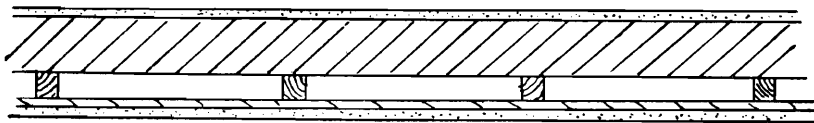
19. Hollow cinder block, 4 by 8 by 16 inches, three cells; 5/8 inch brown coat of gypsum plaster on both sides; smooth white finish. T.L. = 45db



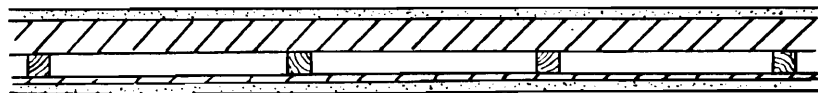
20. Four inch brick panel; brown coat of lime plaster on both sides; smooth white finish. T.L. = 45db
21. Four inch brick panel; brown coat of gypsum plaster on both sides; smooth white finish. T.L. = 47db



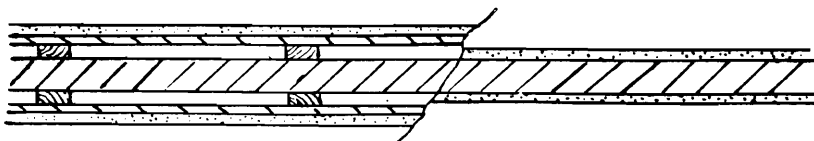
22. Eight inch brick panel; brown coat of gypsum plaster on both sides; smooth white finish. T.L. = 50db



23. Four inch brick panel; brown coat of gypsum plaster and smooth white finish on one side; on the other side, 2 by 2 inch furring strips, 1/2 inch fibre building board, brown coat of gypsum plaster, smooth white finish. T.L. = 54db

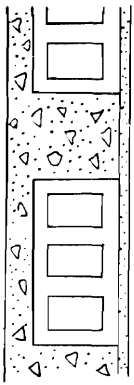
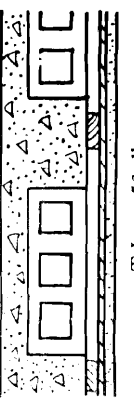
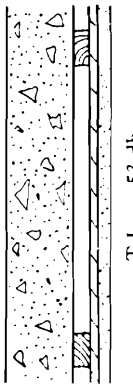
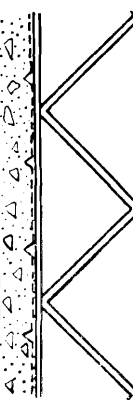
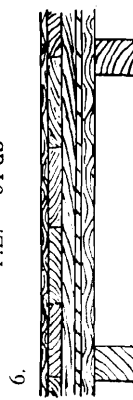
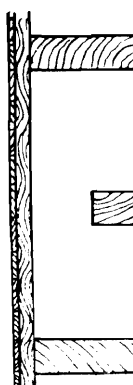
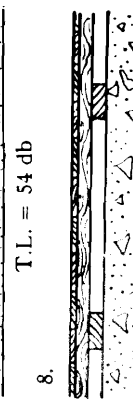


24. Brick on edge; brown coat of gypsum plaster and smooth white finish on one side; on the other side, 2 by 2 inch furring strips, 1/2 inch fibre building board, brown coat of gypsum plaster, smooth white finish. T.L. = 51db



25. Brick on edge; furring strips (wired); gypsum plaster board; scratch and brown coats of gypsum plaster on both sides; smooth white finish. T.L. = 52db
26. Brick on edge; furring strips (nailed); 1/2 inch fibre building board; scratch and brown coats of gypsum plaster on both sides; smooth white finish. T.L. = 53db
27. Brick on edge; brown coat of gypsum plaster on both sides; smooth white finish. T.L. = 41db

SOUND TRANSMISSION LOSS VALUES FOR CERTAIN TYPICAL FLOOR CONSTRUCTIONS

1.		Concrete and three-cell partition tile, 6 by 12 by 12 inches; furring strips; 1/2 inch fibre building board; plaster, smooth white finish. (1)	T.L. = 48 db
2.		Concrete and three-cell partition tile, 4 by 12 by 12 inches; furring strips; 1/2 inch fibre building board; plaster, smooth white finish. (1)	T.L. = 53 db
3.		Four inch, reinforced, concrete slab; furring strips; 1/2 inch fibre building board; brown coat of gypsum plaster; smooth white finish. (1)	T.L. = 53 db
4.		Battleship linoleum; 2 1/2 inches of concrete on high rib metal lath; open web steel joists; high rib metal lath; gypsum scratch and brown coats; smooth white finish.	T.L. = 54 db
5.		3/8 inch finished flooring; rough flooring; wood joists; wood lath; plaster; smooth white finish. Note: Insertion of 1/2 inch of fibre building board between rough and finished flooring gives T.L. = 43 db. (1)	T.L. = 42.5
6.		Floating floor consisting of finished flooring, sub-flooring and nailing strips; 1/2 inch fibre building board; rough flooring; wood joists; wood lath; plaster; smooth white finish. (1)	T.L. = 54 db
7.		3/8 inch finished flooring; rough flooring; wood joists; ceiling separately supported, ends of ceiling and floor joists being nailed to a common support; 1/2 inch fibre building board; plaster; smooth white finish. (1)	T.L. > 49
8.		Same as 3, except floating floor added. This floor consists of 1 by 2 inch nailing strips, rough flooring, and 3/8 inch hard-wood finished flooring.	T.L. = 58 db

Note: (1) The weight per cubic foot of the fibre board used in these constructions shall not exceed 22 pounds.

APPENDIX "J"

LIST OF SPECIFICATIONS AND OTHER PUBLICATIONS
REFERRED TO IN THE TEXT OF THE CODEA. NATIONAL BUILDING CODE COMMITTEES, NATIONAL RESEARCH COUNCIL, OTTAWA
Standard Plumbing By-law, 1940 (Appendix K)B. CANADIAN ENGINEERING STANDARDS ASSOCIATION, NATIONAL RESEARCH
COUNCIL BUILDING, OTTAWA

- A5-1940 Specification for Portland Cement (issued with No. A57)
- A23-1929 and as revised-1941 Specification for Concrete and Reinforced Concrete
- A43-1937 Specification for Structural Timber as amended 1940
- A54-1940 Specification for Fire Tests on Building Construction and Materials
- A56-1941 Specification for Wood Piling
- A57-1940 Specification for High Early Strength Portland Cement (issued with No. A5)
- B62-1940 Specification for Welded Genuine Wrought-iron Pipe
- B63-1941 Specification for Welded and Seamless Steel Pipe
- G28-1929 Specification for Carbon Steel Castings
- G30-1938 Specification for Billet-steel Concrete Reinforcing Bars
- G31-1938 Specification for Rail-steel Concrete Reinforcing Bars
- G32-1938 Specification for Cold-drawn Steel Wire for Concrete Reinforcement
- G45-1938 Specification for Fabricated Steel Bar or Rod Mats for Concrete Reinforcement
- G46-1938 Specification for Welded Steel Wire Fabric for Concrete Reinforcement.—Note: G30, G31, G32, G45 and G46 are printed in one booklet entitled "Reinforcing Materials for Concrete"
- S16-1940 Steel Structures for Buildings
- S39-1935 Specification for Mild Structural Steel
- S40-1935 Specification for Medium Structural Steel
- S42-1935 Specification for Structural Rivet Steel
- S47T-1938 Tentative Welding Qualification Code for Fabricators, Contractors, Supervisors & Welders (Metallic Arc Process for Welded Steel Building)
- S48T-1938 Specification for Metallic Arc (Iron & Steel) Electrodes for Welded Steel Buildings
- Canadian Electrical Code, Part 1, Dated 1939

C. THE AMERICAN SOCIETY FOR TESTING MATERIALS, PHILADELPHIA, PA., U.S.A.

- A53-40 Specification for Welded and Seamless Steel Pipe
- A72-39 Specification for Welded Wrought-Iron Pipe
- A120-40 Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses
- A191-38 Method of Test for Uniformity of Coating by the Preece Test (Copper Sulfate Dip) on Zinc-Coated (Galvanized) Iron or Steel Wire
- A205-37T Specification for Iron and Steel Filler Metal (Arc-Welding Electrodes and Gas-Welding Rods)
- C5-26 Specification for Quicklime for Structural Purposes
- C6-31 Specification for Hydrated Lime for Structural Purposes
- C10-37 Specification for Natural Cement
- C19-33 Specification for Fire Tests of Building Construction and Materials
- C28-40 Specification for Gypsum Plasters
- C34-39 Specification for Structural Clay Load-Bearing Wall Tile
- C37-40 Specification for Gypsum Lath
- C39-39 Method of Test for Compressive Strength of Concrete
- C52-33 Specification for Gypsum Partition Tile or Block
- C55-37 Specification for Concrete Building Brick
- C56-39 Specification for Structural Clay Non-Load-Bearing Tile
- C57-39 Specification for Structural Clay Floor Tile
- C61-40 Specification for Keene's Cement

- C62-40T Specification for Building Brick (Made from Clay or Shale)
- C73-39 Specification for Sand-Lime Building Brick
- C77-40 Methods of Sampling and Physical Testing of Portland Cement
- C79-34 Specification for Gypsum Sheathing Board
- C90-39 Specification for Hollow Load-Bearing Concrete Masonry Units
- C91-40 Specification for Masonry Cement
- C94-38 Specification for Ready Mixed Concrete
- C98-30T Method of Test for Compressive Strength of Natural Building Stone
- C99-36 Method of Flexure Testing of Natural Building Stone
- C101-32T Method of Sampling Natural Building Stone and Preparation of Sample for Testing
- C129-39 Specification for Hollow Non-Load-Bearing Concrete Masonry Units
- C130-39 Specification for Lightweight Aggregates for Concrete
- C132-40T Specification for Fire-Retardant Properties of Wood for Scaffolding and Shoring
- C140-39 Methods of Sampling and Testing Concrete Masonry Units
- C141-38T Specification for Hydraulic Hydrated Lime for Structural Purposes
- C144-39T Specification for Aggregate for Masonry Mortar
- C145-40 Specification for Solid Load-Bearing Concrete Masonry Units
- D225-37T Specification for Asphalt Shingles Surfaced with Coarse Mineral Granules
- D226-41T Specification for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs
- D227-41 Specification for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs
- D249-37T Specification for Asphalt Roofing Surfaced with Coarse Mineral Granules
- D250-27 Specification for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs
- D312-41 Specification for Asphalt for Use in Constructing Built-Up Roof Coverings
- D371-37T Specification for Asphalt Cap Sheet Surfaced with Coarse Mineral Granules
- D450-41 Specification for Coal-Tar Pitch for Roofing, Dampproofing, and Waterproofing
- E8-40T Methods of Tension Testing of Metallic Materials
- D. AMERICAN STANDARDS ASSOCIATION, NEW YORK, N.Y., U.S.A.
A42.1-1938 Standard Specification for Gypsum Plastering
- E. BRITISH STANDARDS INSTITUTION (Copies may be obtained from the Canadian Engineering Standards Association).
476-1932 British Standard Definitions for Fire Resistance, Incombustibility and Non-inflammability of Building Materials and Structures
- F. CANADIAN GOVERNMENT PURCHASING STANDARDS COMMITTEE, NATIONAL RESEARCH COUNCIL, OTTAWA
11-GP-1-1937 Specification for Creosote
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Pamphlet No. 13, dated July, 1940—Installation of Sprinkler Equipments
Pamphlet No. 31, dated U.S.A. 1 April, 1934 as amended in 1940—Installation of Oil Burning Equipments
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Pamphlet No. 310, dated U.S.A. 15 November, 1937—Installation, Maintenance and Use of Small Heating and Cooking Appliances

- H. NATIONAL FIRE PROTECTION ASSOCIATION, BOSTON, MASS., U.S.A.
National Fire Codes for Flammable Liquids and Gases, 1938
- I. UNDERWRITERS LABORATORIES, CHICAGO, ILL., U.S.A.
List of Inspected Fire Protection Equipment and Materials, January, 1941
- J. AMERICAN GAS ASSOCIATION, NEW YORK, N.Y., U.S.A.
Requirements for House Piping and Appliance Installation, 1928
- K. AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, NEW YORK, N.Y., U.S.A.
Code of Minimum Requirements for the Heating and Ventilating of Buildings, 1929 Edition
Guide 1939—Heating, Ventilating and Air Conditioning
Canadian Division, Ontario Chapter, Heating Codes approved in 1939
- L. NATIONAL WARM AIR HEATING AND AIR CONDITIONING ASSOCIATION, COLUMBUS, OHIO, U.S.A.
The Standard Gravity Code for the Design and Installation of Warm Air Heating Systems, 1 January, 1939
The Technical Code for the Design and Installation of Mechanical Warm Air Heating Systems, 1 January, 1939

APPENDIX "K"

A STANDARD PLUMBING BY-LAW*

In preparing this plumbing by-law the Committee has taken cognizance of by-laws now in force in various communities and, with the co-operation of the Advisory Committee and numerous municipal officials, has sought to bring the various clauses into harmony with modern conditions in the plumbing field. The document as it stands represents the work of a technical committee but legal considerations have not been dealt with except in so far as they bear on technical matters. In some instances where common practice in this country has been deemed to run counter to modern conceptions of public health, the Committee has set down what, in its opinion, is in the best public interest, realizing fully that some municipalities may wish to modify slightly certain regulations to meet local conditions more satisfactorily.

*At the Annual Meeting of the Canadian Institute on Sewage and Sanitation held at Kitchener, Ont., on October 16 and 17, 1941, a resolution was unanimously adopted "commending the said By-law to the consideration of authorities—municipal, provincial, or others, as the case may be—having jurisdiction over plumbing regulations throughout Canada, as a guide, with a view to its adoption when plumbing regulations are being prepared, or when amendments of existing regulations may be contemplated."

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A STANDARD PLUMBING BY-LAW

PART K1—GENERAL REQUIREMENTS

K1.1 Scope of this By-law.—All new buildings, and all existing buildings not already provided with a plumbing system or in which alterations or additions are made to any plumbing system, shall be subject to the requirements of this By-law.

When any requirement of this By-law is at variance with any other By-law of this municipality or with any provincial enactment applying to this municipality, the more restrictive regulation shall be fulfilled.

Whenever dated editions of codes, specifications, or other publications are cited herein, subsequent editions may be used, subject to permission from the authority having jurisdiction.

K1.2 Definitions

K1.2.1 For the purposes of this By-law, the definitions given in Articles 1.2.2. to 1.2.33, inclusive, shall govern.

K1.2.2 Approved, when applied to materials, design, or workmanship, shall mean approved by the authority having jurisdiction.

K1.2.3 Authority having jurisdiction shall mean the Plumbing Inspector, the Health Officer, or other official authorized by municipal enactment to administer any regulation contained in this By-law.

K1.2.4 Assembly building shall mean a building in which persons congregate for civic, political, educational, religious, social or recreational purposes; including among others, court houses, schools, colleges, libraries, museums, exhibition buildings, lecture halls, churches, assembly halls, lodge rooms, dance halls, theatres, bath houses, armouries, arenas, gymnasiums, recreation piers, passenger stations.

K1.2.5 Business building shall mean a building occupied for the transaction of business; for the rendering of professional services; for the display, sale, or storage of goods, wares or merchandise; for the supplying of food, drink, or other bodily needs or comforts; or for the performance of work or labour; including among others, office buildings, stores, markets, restaurants, factories, workshops, laboratories.

K1.2.6 Institutional building shall mean a building into which persons are admitted to receive care or treatment, or in which persons are held under restraint; including among others, hospitals, asylums, sanatoria, police stations, jails.

K1.2.7 Residence building shall mean any building except an institutional building in which sleeping accommodation is provided; including among others one-family dwellings, two-family dwellings, multiple dwellings, hotels, lodging houses, dormitories, convents, studios, club houses, fire stations.

K1.2.8 Dead end shall mean any portion of a pipe that is more than two feet in developed length and does not terminate in a fitting designed to admit air or liquids to the pipe.

K1.2.9 House drain shall mean that part of the lowest horizontal piping of a drainage system which receives the discharge from soil, waste, or other drainage pipes and conveys it to a point, not less than three feet beyond the wall of the building, there discharging it to a house sewer.

K1.2.10 Sub-house drain shall mean that portion of any drainage system which cannot drain by gravity into the house sewer.

K1.2.11 Drainage system, with reference to any building, shall mean all piping that conveys sewage, rain-water, or other liquid waste to a house sewer, together with all joints, fittings, vents, and vent pipes appurtenant to such piping.

K1.2.12 Dwelling unit shall mean a room, or suite of two or more rooms, in which facilities are provided for cooking or for the installation of cooking equipment.

K1.2.13 Horizontal, with reference to any pipe or fitting, shall mean that it is installed with its longitudinal axis at an angle of more than 60 degrees with the vertical.

K1.2.14 Leader shall mean any pipe, located in or outside of a building, which conveys storm or rain-water from any roof or area to any sewer or storage container.

K1.2.15 Developed length, with reference to any pipe, shall mean its length along the centre line of pipe and fittings.

K1.2.16 Main, with reference to any drainage system, shall mean that part of such system which receives waste, vents, or back-vents, from fixture outlets or traps, directly or through branch pipes.

K1.2.17 Plumber

Master plumber shall mean a person, firm or corporation licensed by this municipality to engage in plumbing, either himself or through his employees.

Journeyman plumber shall mean a person who is licensed by this municipality to engage in plumbing as an employee of a master plumber.

Apprentice shall mean a person who is duly registered with the authority having jurisdiction as one undergoing training with a view to becoming a journeyman plumber.

K1.2.18 Plumbing shall mean the installation, alteration, or repair, in or appurtenant to any building, of a plumbing system or part thereof.

K1.2.19 Plumbing fixture shall mean a receptacle intended to receive water and to discharge water or other liquid or water-borne waste into a drainage system.

K1.2.20 Plumbing system shall mean, severally and individually, the water distribution system; all fixtures and fixture traps; the drainage system; the house sewer; any private sewage disposal system; all leaders; together with all their devices, appurtenances and connections.

K1.2.21 Septic tank shall mean a settling tank constructed to receive sewage from one or more house sewers and to retain the sludge in such sewage for such a time and in such a way as to secure adequate decomposition of organic solids by anaerobic bacterial action.

K1.2.22 Sewers

House sewer shall mean any piping system that conveys sewage, rain-water, or other liquid waste from the house drain to a street sewer or to a sewage disposal system.

Sanitary sewer shall mean a street or common sewer intended to receive effluent from a sanitary house sewer only.

Sanitary house sewer shall mean a house sewer intended to receive discharge from plumbing fixtures only.

Storm sewer shall mean a street or common sewer intended to receive surface or sub-surface water only.

Storm house sewer shall mean a house sewer intended to receive storm-water or sub-surface water only.

Combined sewer shall mean a sewer intended to carry both liquid or water-borne wastes and surface or sub-surface water.

K1.2.23 Size, with reference to any pipe or fitting, shall mean the nominal diameter in accordance with accepted commercial usage.

K1.2.24 Soil pipe shall mean any pipe that conveys the discharge of any water-closet, with or without that of other fixtures, to a house drain.

K1.2.25 Stack shall mean a vertical line of soil, waste, or vent piping as indicated in the context.

K1.2.26 Trap shall mean a fitting, or device so constructed as to prevent the passage of air or gas through a pipe or fixture, without materially affecting the flow of liquids.

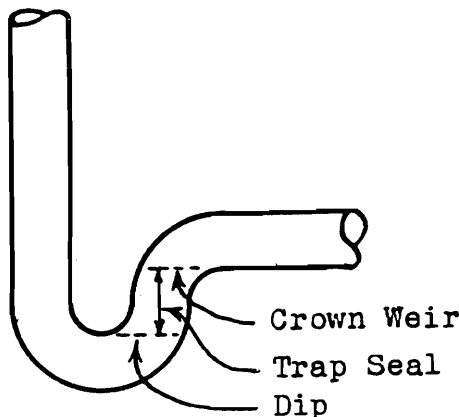
The **crown weir** of any trap shall mean the highest portion of the inside lower surface.

The **dip** of any trap shall mean the lowest portion of the inside upper surface.

The **trap seal** shall mean the vertical distance between the crown weir and the dip of a trap.

K1.2.27 Crown vent shall mean a vent pipe connected to the crown of a trap.

K1.2.28 Vent pipe shall mean any pipe provided to ventilate a drainage system and to prevent trap siphonage and back pressure.



K1.2.29 Ventilating pipe shall mean a pipe through which foul air is removed from a room or fixture.

K1.2.30 Vertical, with reference to any pipe or fitting, shall mean that it is installed with its longitudinal axis at an angle of not more than 60 degrees with the vertical.

K1.2.31 Waste pipe shall mean any pipe that conveys the discharge of one or more fixtures, other than water-closets, to a soil pipe or house drain.

K1.2.32 Water distribution system shall mean the piping, together with its fittings and connections, that conveys water from the service pipe to plumbing fixtures or other apparatus or devices.

K1.2.33 Water service pipe shall mean a pipe from a water-main, or private pumping system, to the building served.

PART K2—ADMINISTRATION

K2.1 Licensing of Plumbers

K2.1.1 Required Licences.—No person, firm, or corporation shall engage in plumbing work, unless duly licensed by this municipality as a Master Plumber or Journeyman Plumber or registered as an apprentice; provided that tile drains shall be laid by a competent tile-drain layer.

K2.1.2 Qualifications of Master Plumbers.—Every Master Plumber shall be a licensed Journeyman Plumber or shall have in his employ a sufficient number of licensed Journeyman Plumbers and apprentices to do all plumbing work which he may undertake.

K2.1.3 Application for Master Plumber's Licence.—Every application for a Master Plumber's licence shall be made in writing and shall give the name and business address of the applicant. If the applicant is a partnership, the application shall contain the names and addresses of the various partners of the firm; if the applicant is a corporation, the names and addresses of the President, Secretary, and Treasurer shall be shown.

K2.1.4 Qualifications of Journeyman Plumbers.—Licences as Journeyman Plumbers shall be granted only to persons who have furnished sufficient evidence that they are capable of properly performing plumbing work, and have passed such tests as the authority having jurisdiction may require.

K2.1.5 Application for Journeyman Plumber's Licence.—Every application for a Journeyman Plumber's licence shall be made in writing. Such application shall contain the applicant's name, address, age, and a statement of his experience and qualifications.

K2.1.6 Transfer of Licences.—Licences shall be personal and not transferable and must be renewed each year during the month of January. Licences not renewed before the first day of February shall be renewable as new licences only.

K2.1.7 Posting of Licences.—Master Plumber's licences shall be posted in a conspicuous place in the place of business of the licensee.

K2.1.8 Responsibility of Master Plumbers.—Every Master Plumber shall be responsible for the workmanship of his employees. He shall not allow anyone except Journeyman Plumbers, and apprentices under their supervision, to do any plumbing work.

K2.1.9 Revocation of Licences.—Violation of any of the requirements of this By-law shall be cause for revocation of any Master Plumber's licence.

K2.2 Permits

K2.2.1 Required Permits.—No person shall proceed to construct, alter, or add to any plumbing system until a permit for the performance of such work has been obtained from the authority having jurisdiction provided that no permit shall be required for the clearing of stoppages or the repairing of leaks in pipes, valves, or fixtures, when such repairs do not involve or require alteration or rearrangement of pipes or fixtures.

K2.2.2 Applications for Permits.—Every application for a plumbing permit shall be made on the form provided and shall be signed by the owner or an agent bearing his written authorization. Such application shall give the name of the master plumber by whom the work is to be done. It shall be accompanied by: (a) information that will serve to give the exact location of the building concerned, including the street number and block plan number; (b) a description of the proposed work, giving the number, size, kind, and weight of all pipes, traps, and fittings, together with a description of all fixtures; (c) when required by the authority having jurisdiction, a plan legibly drawn to scale, showing the proposed plumbing system and the location of the building with reference to the street sewer or sewage disposal system.

K2.2.3 Changes in Plans and Descriptions.—After a plumbing permit has been issued, no departure shall be made from the plan or description submitted with the application for such permit, without the written approval of the authority having jurisdiction.

K2.2.4 Permit Limitations

K2.2.4.1 Term of Permits.—A plumbing permit shall be granted or refused within five days from the time of filing the application; if issued, it shall be valid for six months only and must be renewed if the work authorized is not begun within that period.

K2.2.4.2 Responsibility after Issuance of Permit.—Neither the granting of a permit, nor the approval of plans and descriptions, nor inspections made by the authority having jurisdiction, shall in any way relieve the Master Plumber from full responsibility for carrying out the work in strict accordance with this By-law.

K2.2.5 Allowable Responsibility of Journeyman Plumbers.—Provided that the regulations of this Section are otherwise fulfilled, a licensed Journeyman Plumber may obtain a permit and do plumbing

work in a commercial or industrial establishment in which he is steadily employed for such purpose. In such instance the observance of the requirements of Item 2.2.4.2 shall be the responsibility of such Journeyman Plumber.

K2.2.6 Fees.—No plumbing permit shall be issued until the following minimum fees have been paid:

(a) A fee of \$2.00 for a permit authorizing any plumbing work which consists of installing, altering, extending, or renewing, not more than one soil or other stack, and not more than four fixtures.

(b) An additional fee of 25 cents for each additional stack and for each additional fixture to be installed, altered, extended, or renewed.

PART K3—REQUIRED PLUMBING FACILITIES

K3.1 General.—Whenever a municipal water supply is available within 100 feet of the building, every residence building, institutional building, business building, or assembly building, whether new or existing, shall be provided with a plumbing system including an adequate supply of potable water, and suitable sanitary facilities with drainage to a public sanitary sewer, private sewage disposal system, or other approved means of sewage disposal.

When such municipal water supply is not available a plumbing system shall not be mandatory but any plumbing system that is installed in any building, and any to which alterations or additions are made, shall comply with the requirements of this part of this By-law. When no plumbing system is installed there shall be provided sanitary privies, chemical closets, or other means for the disposal of human excreta, approved by the authority having jurisdiction.

K3.2 Fixtures Required

K3.2.1 General Requirements.—As a minimum requirement, every residence building, institutional building, business building, or assembly building shall be provided with at least one water-closet and one lavatory or sink. Every residence building or institutional building shall also be provided with at least one bath-tub or one shower-bath.

Additional fixtures shall be provided, when necessary to meet the requirements hereinafter prescribed; provided that:

(a) Whenever more than one water-closet, one lavatory or sink, or one bath-tub or shower-bath is installed in a single room other than a private dwelling unit, the use of such room shall be restricted to one sex only;

(b) Whenever separate water-closet rooms or bath-rooms are provided for each sex separately, they shall be closed by a full-sized door and shall be clearly and properly marked;

(c) Whenever water-closet rooms are provided for the exclusive use of males, urinals may be substituted for one-half of the required number of water-closets

K3.2.2 Residence Buildings and Institutional Buildings

(a) Every dwelling unit in a one-family, two-family, or multiple dwelling, shall be provided with at least one private water-closet, one private bath-tub or shower-bath, and one private lavatory or sink.

(b) Every residence building or institutional building shall be provided with not less than one water-closet, one lavatory or sink, and one bath-tub or shower-bath for every ten bedrooms. When any bedroom is provided with a private water-closet, lavatory or sink, and bath-tub or shower-bath, such room and such fixtures shall not be considered in the computation of the required number of fixtures.

Whenever bedroom accommodation is to be provided for both sexes and more than one water-closet, one lavatory or sink, and one bath-tub or shower-bath is required, such facilities shall be provided in separate rooms for each sex.

Whenever sleeping accommodation is to be provided for more than two persons in one room—as in a dormitory—one water-closet, one lavatory or sink, and one bath-tub or shower-bath, for every 15 persons, shall be installed on the basis of the total number of persons for whose accommodation such building is designed, intended, or used.

(c) Whenever sleeping accommodation is to be provided in detached rooms having private entrances—as, for example, in a tourist camp—water-closet, bath, and lavatory accommodation may be provided in a detached building on the same premises, if such building and facilities otherwise comply with the requirements of this By-law.

K3.2.3 Business Buildings.—Every business building shall be provided with water-closets and lavatories or sinks depending upon the number of employees for whose accommodation such building is designed, intended, or used, in accordance with the requirements of Table 1, provided that any separate business occupancy,—for example, a retail store—within a building, shall have separate facilities, in accordance with the table, if the total number of employees for whose accommodation such occupancy is designed, intended, or used, is in excess of nine.

TABLE 1.
REQUIRED WATER-CLOSETS AND SINKS

Number of Persons	Minimum Number of Water-closets	Minimum Number of Lavatories or Sinks
1 to 9	1	1
10 to 24	2	2
25 to 49	3	3
50 to 100	5	5
Over 100	one water-closet and one lavatory or sink for each additional 30 persons.	

Whenever any business building or occupancy is designed, intended, or used for the accommodation of both sexes, separate facilities shall be provided for each sex independently, in accordance with Table 1, if the total number of employees is in excess of nine.

K3.2.4 Assembly Buildings

(a) In every school or college building there shall be provided for each sex, not less than one water-closet for every twenty, and not less than one lavatory or sink for every forty persons of such sex for whose accommodation such building is designed, intended, or used.

(b) In every other assembly building there shall be provided for each sex, not less than one water-closet for every one hundred and fifty persons, and not less than one lavatory or sink for every three hundred persons, of such sex for whose accommodation such building is designed, intended, or used.

K3.2.5 Temporary Facilities.—Suitable toilet facilities shall be provided for the use of workmen during the construction of any building. These toilet facilities shall be maintained in a sanitary condition.

K3.3 Drinking Water.—Facilities to provide an adequate supply of potable water for drinking purposes shall be installed in readily accessible places in every business, institutional, or assembly building. All such water shall be from an approved source.

PART K4—QUALITY AND DESIGN OF FIXTURES, PIPING, FITTINGS, AND ACCESSORIES

K4.1 Fixtures

K4.1.1 Materials and Design

K4.1.1.1 General.—All plumbing fixtures shall be of non-absorbent materials, impermeable to water, and shall be finished with a smooth surface free from flaws or blemishes that would serve to prevent ready cleaning. No sink, tub, water-closet bowl, or other fixture shall be encased in wood or other absorbent material.

All water-closets and urinals shall be of vitrified earthenware, glazed porcelain, or vitreous china; other fixtures shall be of these materials or of porcelain-enamelled cast iron, or stainless alloys, provided that for special industrial purposes other materials may be used if approved by the authority having jurisdiction.

Equipment already installed in, or removed from, any building may be used only if it complies in all respects with the requirements of this Section.

K4.1.1.2 Water-closets.—Water-closet bowls and traps shall be made in one piece and of such form as to hold a sufficient quantity of water, when filled to the trap overflow, to prevent fouling of surfaces, and shall be provided with integral flushing rims so constructed as to flush the entire interior of the bowl.

Every water-closet and every urinal shall be flushed by means of an approved tank or flush valve, adjusted to prevent waste of water. Each water-closet shall receive not less than four gallons of water and each urinal not less than two gallons at each flushing. The flush pipe for any water-closet shall not be less than $1\frac{1}{4}$ inches in diameter and the water from the flushing system shall not be used for any other purpose.

Any seat on a water-closet to which the public has access shall be of the open-front type.

K4.1.1.3 Drinking Fountains.—Every drinking fountain shall be designed as a separate fixture and shall be of such form that it may be cleaned readily. The water orifice shall be of the shielded type and shall be above the extreme overflow level of the bowl. The orifice shall direct the water stream at an angle of approximately 45 degrees with the horizontal. Means for regulating the flow of water shall be provided.

K4.1.1.4 Fixture Strainers.—All fixtures other than water-closets shall be provided with substantial metal strainers having outlet areas not less than that of the interior of the trap and waste pipe. For the purpose of this regulation, floor and shower-bath drains shall be considered as fixtures.

K4.1.2 Prohibited Fixtures

K4.1.2.1 Prevention of Back Siphonage.—No plumbing fixture, device, or construction shall be installed that will provide any cross connection between a water distribution system and any part of a drainage system so as to make possible the backflow or siphonage of any liquid into the water distribution system.

All water supply inlets to fixtures, including those provided with automatic valves, such as "flushometers", shall be located a sufficient height above the maximum possible water-level in the fixture that there will be no possibility of back-siphonage of any of the contents of the fixture under any degree of vacuum in the supply lines, provided that the authority having jurisdiction may permit the installation of fixtures having a water inlet at or below the overflow level if such fixtures are provided with an approved vacuum-breaker on the supply lines.

Pan and valve plunger, offset washout, and other water-closets having invisible seals, unventilated space, or walls not thoroughly washed at each flush, shall not be installed.

K4.1.2.2 Frost-Proof Closets.—Frost-proof closets shall be installed only when specifically permitted by the authority having jurisdiction. The soil pipe between the hopper and the trap shall not be more than six feet long, shall be of at least three inches in internal diameter, and shall be of lead or of cast iron enamelled on the inside.

K4.2 Pipe

K4.2.1 General.—All piping used in any plumbing system shall be free from defects and shall comply with the requirements of Article 4.2.2.

K4.2.2 Quality and Weight.—All pipe shall conform to the Specifications indicated in Table 2 hereof.

TABLE 2
SPECIFICATIONS GOVERNING QUALITY OF PIPE

Kind of Pipe	A.S.T.M.* Specn. No.	C.E.S.A.* Specn. No.
Clay sewer pipe.....	C13-35	A60-1940
Concrete sewer pipe.....	C14-35	—
Reinforced concrete sewer pipe.....	C75-35	—
Cast-iron pipe (1).....	A74-39T	—
Wrought-iron pipe (2).....	A72-39	B62-1940
Steel pipe (3).....	A120-36	—
Lead pipe (4).....	—	B67-1940
Brass pipe.....	B43-39T	B64-1940
Copper pipe.....	B42-39T	B64-1940
Copper tubing.....	B88-39	B66-1940

*When both A.S.T.M. and C.E.S.A. specifications are cited, they are alternatives; materials complying with either are acceptable.

- (1) This Specification shall cover all cast-iron pipe for use in drainage systems. The weight in pounds shall be marked on each unit. Dimensions and weights shall be in accordance with the publication entitled American Standard Cast-Iron Soil Pipe and Fittings, as approved by the American Standards Association in October 1935 (A.S.A. No. A40.1-1935) such weights being known commercially as 'extra heavy'; provided that, in buildings less than 5 storeys in height, it shall be permissible to use 1½, 2, 3 and 4 inch pipe, having minimum weights respectively of 17, 20, 30, and 45 pounds per single-hub length of five feet, such weights being known commercially as 'medium'. All cast-iron pipe in contact with the ground shall be 'extra heavy' and coated.
- (2) Wrought-iron pipe shall be galvanized.
- (3) Steel pipe shall be galvanized.
- (4) Lead pipe used above ground shall be 'strong' or heavier; that used below ground shall be 'extra strong' or heavier.

K4.3 Fittings

K4.3.1 General.—Fittings shall comply with the specifications herein cited for the corresponding pipe when specifically covered by such specification; otherwise they shall be of quality equivalent to that of the pipe and of corresponding weight in accordance with approved commercial practice.

K4.3.2 Prohibited Fittings.—No double hub or double tee shall be used on any soil or waste line. The drilling and tapping of house drains, soil, waste, or vent pipes, and the use of saddle hubs and bands are prohibited. (See also Article 5.2.12.)

K4.3.3 Threaded Fittings.—Plain screwed fittings shall be of cast iron, malleable iron, brass, or copper.

Drainage fittings shall be of cast iron, malleable iron, brass, or copper, of recessed pattern, with smooth interior waterways, and with threads tapped out of solid metal.

All malleable iron fittings and all cast-iron fittings made for water distribution, shall be galvanized.

K4.3.4 Caulking Ferrules.—Caulking ferrules shall be of the best quality annealed cast brass, or of annealed cold-drawn seamless brass tubing, with weights and dimensions in accordance with Table 3.

TABLE 3
MINIMUM WEIGHTS AND DIMENSIONS OF CAULKING
FERRULES

Pipe Size	Actual Inside Diameter	Length	Weight
2 in.	2¼ in.	4½ in.	1 lb. 0 oz.
3 "	3¼ "	4½ "	1 " 12 "
4 "	4¼ "	4½ "	2 " 8 "

K4.3.5 Soldering Nipples and Bushings.—Soldering nipples shall be of brass pipe (iron pipe size), or of heavy cast brass of not less than the weights shown in Table 4.

TABLE 4
WEIGHTS OF SOLDERING
NIPPLES

Diameter	Weight
1¼ in.	6 oz.
1½ "	8 "
2 "	14 "
2½ "	1 lb. 6 "
3 "	2 " 0 "
4 "	3 " 8 "

Soldering bushings shall be of brass pipe (iron pipe size), or of heavy cast brass.

K4.3.6 Floor Flanges for Water-closets.—Floor flanges for water-closets shall be of brass, and shall be not less than 3/16 inch in thickness.

K4.3.7 Pipe Clean-outs.—The bodies of clean-out ferrules shall be made of standard pipe sizes, shall conform in thickness to that required for pipe of the same metal, and shall extend not less than one-quarter inch above the hub. The clean-out cap or plug shall be of heavy brass not less than one-eighth inch thick in any part and shall be provided with a raised nut, recessed socket, or other suitable means of removal.

K4.3.8 Traps.—All fixture traps shall be of vitrified earthenware, glazed porcelain, vitreous china, lead, brass, copper, cast iron, galvanized

malleable iron, stainless alloys, or porcelain enamelled inside. They shall have smooth interior waterways of full-sized bore. (See also Item 5.5.6.2.)

All traps shall have a water seal of not less than two inches or more than four inches; provided that traps for floor drains shall have a seal of not less than four inches. Every trap that is not so combined with a fixture that the seal is plainly visible and accessible shall be provided with a screw clean-out of ample size, protected by the water seal.

Traps which depend for their seal upon movable parts or concealed interior partitions shall not be used, provided that grease traps may have integrally cast partitions of corrosion-resistant material.

K4.3.9 Back-water Valves.—Back-water valves shall have all bearing parts of corrosion-resisting metal and shall be so designed and constructed as to assure a positive seal against back-pressure but permit the free flow of waste.

K4.4 Sheet Metal

K4.4.1 Sheet lead shall not weigh less than 5.0 lb. per square foot.

K4.4.2 Sheet brass and copper shall not be thinner than 0.040 inch (or B. and S. Gauge No. 18) provided that for local and interior ventilating pipes and flush tanks having movable tops the minimum thickness shall be 0.0126 inch (or B. and S. Gauge No. 28).

K4.4.3 Galvanized sheet iron or steel for pipe shall not be thinner than the sizes shown in Table 5.

TABLE 5
MINIMUM THICKNESS OF SHEET IRON AND STEEL
FOR PIPE

Pipe Size in Inches	Thickness in Inches	Brown and Sharpe Gauge
2 to 12	0.015	26
13 to 20	0.020	24
21 to 26	0.025	22

K4.5 Use of Materials other than those Specified.—Materials other than those hereinbefore specified may be used in a plumbing system provided specific approval of them has been given in writing by the authority having jurisdiction. Such authority may require that tests be conducted by a publicly owned or other recognized laboratory.

PART K5—INSTALLATION

K5.1. General Regulations

K5.1.1 Grades of Horizontal Piping.—All horizontal piping shall be run in true alignment and at a uniform grade of not less than one-quarter inch per foot; provided that water distribution pipe may be run at not less than one-eighth inch per foot; and provided that, when necessary in the opinion of the authority having jurisdiction, house drains and sewers may be run at not less than one-eighth inch per foot. All pipe shall be so supported or anchored as to maintain the required grade.

K5.1.2 Support of Piping

(a) All stacks and pipes shall be rigidly secured and adequate provision shall be made for expansion, contraction, and structural settlement.

Vertical piping shall be supported at the base and at every alternate floor, provided that supports shall not be more than 25 feet apart. All stacks shall rest on a solid base and all horizontal runs of drainage piping shall be supported on masonry piers or hung from overhead joists by substantial hangers.

Pipe in the ground shall be laid on a firm bed throughout their length. Horizontal lead pipes shall have continuous support throughout their length.

All other horizontal pipe shall be supported at intervals of not less than ten feet.

(b) Strap hangers may be used for all pipe of diameter up to two inches; ring hangers shall be used for all pipe of greater size. Hangers shall be metal of heavy pattern and shall be securely attached to the building construction.

K5.1.3. Expansion Bolts.—Connection of wall hangers, pipe supports, or fixture settings with masonry, stone, or concrete backing shall be made with expansion bolts without the use of wooden plugs.

K5.1.4 Changes in Direction.—All changes in direction of drainage pipes shall be made by the appropriate use of 45 degree wyes, half wyes, long sweep quarter bends, sixth, eighth, or sixteenth bends, except that single sanitary tees may be used on stacks, and short quarter bends may be used in soil and waste pipes when the change in direction is from the horizontal to the vertical. Tees and crosses may be used in vent pipes.

Soil and waste stacks shall be plumb whenever possible and shall be free from sharp bends and turns.

K5.1.5. Dead Ends.—Dead ends shall be avoided in the installation of drainage systems.

K5.1.6 Protection of Piping.—All pipes passing under or through walls or floors shall be protected from breakage and from external corrosion.

No water-supply or drainage pipe shall be installed outside a building or in any outside wall, unless adequate provision is made to protect it from frost.

K5.1.7 Restrictions on Location of Soil and Waste Pipes.—No soil or waste pipe shall pass directly over a water tank or over any place where drinking water, ice, or food is prepared, stored, or handled.

K5.1.8 Workmanship.—Workmanship shall be such as to assure the results required by all sections of this By-law, and shall be executed in a thorough and approved manner.

K5.2 Joints and Connections

K5.2.1 Tightness of Joints and Connections.—All joints and connections shall be made gas and water tight as required by Part 6 hereof.

K5.2.2 Joints in Concrete and Vitrified Pipe.—Joints of cement mortar or bituminous material may be used only in concrete and vitrified clay sewer pipe. In making such joints the bell of the pipe shall be firmly packed with oakum or hemp and shall be secured with cement mortar or asphaltic compound at least one inch deep all around the pipe.

K5.2.3 Caulked Joints.—All caulked joints shall be made with the spigot end in the direction of flow. They shall be firmly packed with oakum or hemp and shall be secured with pure lead not less than one inch deep, run in one pouring, and caulked tight. No paint, varnish, or putty shall be permitted until the joints have been tested.

K5.2.4 Screw Joints.—All screw joints shall be of approved standard pattern with threads sharp and true, and all burrs due to cutting shall be reamed out.

K5.2.5. Joints in Lead Pipes.—Joints in lead pipes, or between lead pipes and brass or copper pipes, shall be full-wiped joints, except that solder-brazed or sweated joints may be used on reamed, concave bushings of brass connecting to exposed brass or lead traps. Wiped joints shall have an exposed surface of solder of not less than three-quarter inch on each side of the joint and a minimum thickness of three-eighths inch at the thickest part of the joint.

K5.2.6 Joints of Lead to Cast Iron, Steel, or Wrought Iron.—Joints of lead to cast iron, steel, or wrought iron shall be made by means of a caulking ferrule, soldering nipple, or bushing.

K5.2.7 Joints in Copper and Brass Pipe and Tubing.—Except as otherwise permitted in Article 5.2.11, screwed joints shall be used in copper or brass pipe; alternatively, joints shall be soldered by the use of a suitable flux, a thin film of solder being provided between pipe and fittings. A torch shall be used to heat the assembly to soldering temperature. Subject to the approval of the authority having jurisdiction, flux and solder shall be as recommended by the manufacturer of

the pipe and fittings and his instructions for making joints shall be followed. Joints in tubing shall be soldered in accordance with the foregoing.

K5.2.8 Slip Joints and Unions.—Slip joints shall be permitted only in trap seals, or on the inlet side of a trap. Unions on the sewer side of a trap shall be ground faced and shall not be concealed or enclosed.

K5.2.9 Closet, Urinal, and Trap Slop Sink Connections.—The connection between soil or waste pipes and water-closets, floor outlet slop sinks, urinals, and earthenware trap standards shall be made by means of brass flanges, caulked or screwed to the drainage pipes. They may be wiped or soldered to lead pipes. The connections shall be bolted with heavy brass bolts and heavy brass washers, to the earthenware with a gasket or washer between the earthenware and the connection.

K5.2.10 Increases and Reducers.—Any increaser or reducer, connecting different pipe sizes, shall be of the required size and shall have a pitch of not more than 45 degrees with its central axis.

K5.2.11 Welding of Plumbing Joints and Connections.—The welding of any cast-iron pipe, and of drain, soil, vent, or waste pipe of any material is forbidden. The welding of any galvanized pipe using ferrous filler metal is forbidden. Joints and connections in water-supply pipes made of brass or copper, or combinations of these materials, may be made by bronze-welding. Joints and connections in galvanized water-supply pipes may be made by bronze-welding, provided that such joints and connections are prepared and welded in a manner which will preserve the galvanizing material on the inside of the pipe or fitting, and provided further that the exterior of the finished weld and the adjacent area on which the galvanizing material may have been destroyed shall be adequately protected against corrosion. The welding of any joints or connections is forbidden unless specifically permitted herein.

All welding shall be performed in accordance with accepted good commercial practice. The welding requirements of the American Standards Association as set forth in Chapter 3 of Section 5 of the publication entitled American Tentative Standard Code for Pressure Piping, numbered B 31.1-1935, shall be accepted as good commercial practice and all welders shall be qualified in accordance with the qualification tests set forth therein.

K5.2.12 Prohibited Joints and Connections.—Any fitting or connection which has an enlargement, chamber, or recess, with a ledge, shoulder, or reduction of the pipe area in the direction of flow, on the outlet or drain side of any trap, is prohibited. (See also Article 4.3.2.)

K5.2.13 Joints not Specified.—Types of joints other than those herein specified may be used when specifically approved in writing by the authority having jurisdiction.

K5.3 Water Distribution Systems

K5.3.1 Distribution.—All water distribution systems shall be entirely independent of any other piping system and no connection shall be made or condition permitted whereby any foreign matter might enter such distribution system whether by gravity, syphonage, leakage, or back pressure.

K5.3.2 Adequacy of Water Supply.—The water service pipe to any building shall be of sufficient size to permit a continuous flow of water from all outlets at one time provided that in no case shall its internal diameter be less than five-eighths inch. All plumbing fixtures shall be provided with a water supply sufficient to keep them in a clean and sanitary condition.

K5.3.3 Sizes of Pipe.—The minimum internal diameters of water distributing pipes to fixtures shall be one-half inch for sill cocks, hot water boilers, laundry trays, sinks, bath-tubs, and urinals, and three-eighths inch for lavatories and water-closet tanks.

K5.3.4 Restrictions on Materials.—All water-distribution pipe shall be of lead, or of galvanized wrought iron or steel, brass, copper, or cast iron, with brass or galvanized iron fittings, or of copper tubing with soldered-on bronze fittings. No pipe or fittings that have been used for any other purpose shall be used for distributing water.

K5.3.5 Protection.—All concealed or exposed water pipes, storage tanks and flushing cisterns shall be adequately protected against frost.

K5.3.6 Control Valves.—Control valves shall be provided on water piping as follows: a stop or curb valve at or near the curb; a stop and waste valve inside the foundation wall; control valves for each flat or apartment; an interior stop valve for each exterior outlet and for each hot water tank.

K5.3.7 Relief Valves.—Whenever a check valve, water meter, or pressure regulating valve is installed on the water supply pipe between the street main and a hot water tank, a suitable relief valve shall be installed on the hot water distribution system.

K5.3.8 Protection against Results of Water-stoppage.—Protection shall be provided in the installation of any device connected with a water distribution system to ensure the safety of the occupants of any building in the event of an interruption of the water supply.

K5.4 Plumbing Fixtures

K5.4.1. Support.—All wall-hung fixtures shall be rigidly supported by approved metal hangers or bolts and all floor-outlet fixtures shall be rigidly secured to the floor by approved screws or bolts. Water-tight joints shall be made at the junction of fixtures with walls or floors.

K5.4.2 Access to Fixtures and Connections.—All fixtures shall be installed free from any enclosing work that would prevent access for cleaning. Where practicable, all pipes from fixtures shall run directly to a wall and any pipe or trap of a type liable to damage, such as lead or ceramic material, shall be adequately protected if it extends to within 12 inches of the floor.

K5.4.3 Fixture Overflow.—The overflow pipe from a fixture shall be connected on the house or inlet side of the trap and be so arranged that it may be readily and effectively cleaned.

K5.4.4 Shower Drains.—Any ceiling below a shower-bath which does not discharge into a tub or other fixture shall be protected from leakage by an apron or tray of lead or other equally corrosion-resistant metal draining into the shower drain.

K5.4.5 Location of Fixtures.—No bath room or water-closet room shall be used for any other purpose except as a lavatory. Any such room shall have a full-sized door completely closing the entrance to it, shall either have a window opening directly to the exterior of the building or shall be provided with adequate mechanical ventilation, and shall comply in construction and design with the Building By-law.

K5.4.6 Location of Sanitary Privies and Frost-proof Closets.—No sanitary privy, chemical closet, or frost-proof closet shall be installed within any building used for human occupancy nor within 10 feet of any dwelling, nor in any location where it could contaminate any domestic water supply.

K5.5 Drainage Systems and House Sewers

K5.5.1 General.—Every plumbing fixture in any building shall be connected to a drainage system, which shall convey all liquid or water-borne wastes to a house sewer. Except as hereinafter provided, the drainage from every fixture shall discharge into a soil or waste stack extending full size through the roof.

K5.5.2 Restrictions on Materials.—Any drainage system, other than one restricted to storm-water, shall be of cast iron, galvanized steel or wrought iron, lead, brass, or copper; provided that galvanized steel or wrought iron pipe shall not be used underground.

Any house sewer shall be of cast iron, vitrified clay, or concrete pipe.

K5.5.3 Fixture Units.—Table 6 shall be used to determine the number of fixture units equivalent to the fixtures indicated.

TABLE 6
EQUIVALENT FIXTURE UNITS

Fixture	Number of Fixture Units
One drinking fountain	1
One household ice-chest	1
One lavatory or wash basin	2
One kitchen sink	2
One bath-tub	2
One laundry tray	3
One dishwashing unit	3
One combination fixture	3
One urinal	3
One shower-bath	3
One floor drain	3
One slop sink	3
One water-closet	6
One bathroom group containing one water-closet, one lavatory, and one bath-tub	8
180 square feet of roof or other drained area	1

K5.5.4 Soil and Waste Pipes

K5.5.4.1 Minimum Sizes.—Table 7 shall be used to determine the minimum size of fixture traps and soil or waste pipes draining single fixtures.

TABLE 7
**MINIMUM SIZES OF FIXTURE TRAPS AND SOIL OR
WASTE PIPES FROM SINGLE FIXTURES**

Number of Fixture Units in a Single Fixture as Established by Article 5.5.3	Minimum Size of Fixture Trap, Soil or Waste Pipe
1	1¼ inches
2	1½ "
3	2 "
6	3 inches or more

Table 10 shall be used to determine the minimum size of other horizontal soil or waste pipes.

Table 8 shall be used to determine the minimum size of any soil or waste stack, on the basis of the distribution and total number of fixture units connected to the stack, provided that no water-closet shall discharge into a stack of less than three inches in diameter.

TABLE 8
REQUIRED RELATION OF FIXTURE UNITS TO THE
LENGTH AND DIAMETER OF SOIL OR WASTE STACKS

Diameter of Stack	With "Sanitary T" Inlets		With all 45°Y or Combination Y and 1/8 Bend Inlets		Maximum Length Including Extension as Vent
	Fixture Units on One Branch Interval*	Fixture Units on Any One Stack	Fixture Units on One Branch Interval*	Fixture Units on Any One Stack	
1¼ inches	1	1	1	1	50 feet
1½ inches	2	8	4	12	65 feet
2 inches	9	16	15	36	85 feet
3 inches	24	48	45	72	212 feet
4 inches	144	256	240	384	300 feet
5 inches	324	680	540	1020	390 feet
6 inches	672	1380	1122	2070	510 feet
8 inches	2088	3600	3480	5400	750 feet

*The term "branch interval" shall be interpreted to mean a vertical length of stack, not less than eight feet long, within which a branch or branches are connected.

K5.5.4.2 Fixture Connections.—All soil and waste stacks and branches shall be provided with correctly faced inlets for fixture connections.

No fixture connections shall be made to a lead branch from a water-closet, or similar fixture. No soil or waste vent, circuit or loop vent, above the highest installed fixture on a branch or main shall subsequently be used as a soil or waste pipe.

K5.5.4.3 Indirect Wastes

(a) Indirect wastes shall be discharged into a water-supplied, trapped, and vented sink; a floor drain; a funnel; or other approved receptacle. Indirect waste pipes receiving the discharge from fixtures on more than three floors, or exceeding 100 feet in length, shall extend full size through the roof. Fixtures connected to indirect waste pipes shall be trapped but need not be vented.

(b) Soda and drinking fountains may be installed with indirect wastes.

(c) Drip pipes from refrigerators, ice boxes, or any receptacle where food is stored, shall be installed as indirect wastes. Such pipes shall be not less than 1¼ inches for one opening, 1½ inches for three openings, and two inches for four to ten openings. They shall have a trap at each opening and clean-outs at all angles, and shall be so arranged as to permit flushing and cleaning. Such waste pipes shall be continued full size through the roof, except where such fixtures are located in the basement or first floor.

K5.5.4.4 Overflow Pipes.—Pipes from any water supply tank, or exhaust from a water lift, shall not be connected directly with any house drain, soil pipe, or waste pipe.

K5.5.4.5 Flammable Wastes.—Flammable liquids shall not be discharged into any drain discharging directly or indirectly into a street sewer.

Floor drains or catch basins from garages, gasoline service stations, or other establishments handling petroleum or other flammable liquids shall be equipped with oil intercepting traps of approved design.

Grease or oil changing pits shall not be connected with a street sewer.

K5.5.4.6 Steam Exhaust, etc.—No steam exhaust, blow-off, or drip pipe shall discharge directly into any plumbing system. Such pipes shall be connected to a condenser or cooling tank. Water or vapour at a higher temperature than 150° Fahrenheit or any substance liable to be injurious to any part of such plumbing system or to the sewage system shall not be discharged into any plumbing system.

K5.5.4.7. Acid Wastes.—Pipes conveying acid wastes shall be of lead, glazed earthenware, high-silicon iron, or other material of equal corrosion resistance, provided that other pipes may be used if they are not enclosed in walls or partitions and are so arranged as to be replaceable without damage to the structure or finish of the building.

All acid waste pipes shall have attached to them automatic flush tanks, shall discharge into a diluting tank of adequate dimensions, and thence directly to a drain or over a catch basin.

K5.5.4.8. Hazardous Wastes and Solid Wastes.—No materials which may give off explosive gas, or which form or may tend to form explosive substances shall be discharged into a street sewer either directly or indirectly. No materials which may settle or form deposits in a sewer or which may in any way tend to diminish the capacity of a sewer, shall be discharged into a street sewer either directly or indirectly.

K5.5.5 House Drains

K5.5.5.1 Minimum Sizes.—Table 10 shall be used to determine the maximum number of fixture units that may be drained by any sanitary house drain or part thereof, provided that no water-closet shall discharge into a house drain less than four inches in diameter.

K5.5.5.2 Excavation.—All excavations for the installation of a drainage system within the walls of a building shall be open-cut and shall be kept open until the piping has been inspected and approved. (See Article 6.2.2.)

K5.5.5.3 Depth and Location.—All house drains shall be laid at sufficient depth to protect them from frost and, where possible, shall be brought into the building below the lowest floor. No joints shall be made in or under any foundation wall.

K5.5.5.4 Back-water Valves.—Any back-water valve shall be installed in such a way as to be readily accessible for cleaning.

K5.5.6 Traps and Clean-outs

K5.5.6.1 General.—Each fixture shall be separately trapped, except that a battery of two or three laundry trays, one sink and two laundry trays, or a two-compartment sink, the outlets of which are two inches or less, may connect with a single trap, provided the trap is centrally placed. Traps shall be as near to the fixture as possible, and in all cases, within two feet of developed length from the outlet of the fixture. The waste from a bath-tub or other fixture shall not discharge into a water-closet trap or bend. No fixture shall be double trapped.

K5.5.6.2 Size of Traps.—The nominal inside diameter of any trap, except grease traps, shall be equal to that of the soil or waste pipe with which it is connected. (See Item 5.5.4.1.)

K5.5.6.3 Setting and Protection of Traps.—All traps shall be so located as to be accessible, shall be rigidly supported, set true with respect to their water seals, and protected from frost and evaporation.

K5.5.6.4 Grease Traps.—Water-jacketed grease traps shall be installed in all waste pipes from kitchen sinks in hotels, restaurants, and institutional buildings.

Grease traps shall be placed as near as possible to the fixture from which they receive the discharge and shall have twice the capacity of such fixture.

K5.5.6.5 Sand Traps and Catch Basins.—Sand traps or catch basins when installed shall be designed and placed so as to be readily accessible for cleaning. When installed within or in close proximity to any building, adequate means shall be provided to protect their seal against evaporation.

K5.5.6.6 Basement Floor Drains.—Any cellar or basement floor drain shall be connected to a trap which is provided with a water-seal and so constructed that it can be readily cleaned. When subject to back-flow or back-pressure, any such drain shall be equipped with an adequate back-water valve.

K5.5.6.7 Clean-outs.—Easily accessible clean-outs shall be provided at the foot of each vertical waste or soil stack, at each change of direction in horizontal runs, inside the wall near the connection between the house drain and the sewer, and in such locations as shall make every part of the drainage system readily accessible. The distance between clean-outs in horizontal soil lines shall not exceed 50 feet. Clean-outs shall be of the full size of the pipe up to four inches in diameter and not less than four inches for larger pipe.

K5.5.6.8 Manholes.—All underground traps and clean-outs in any building, except where clean-outs are flush with the floor, and all exterior underground traps shall be made accessible by manholes. Wherever possible, clean-outs in a building shall be brought to the surface of the floor.

K5.5.6.9 Clean-out Equivalent.—Any floor or wall connection of a fixture trap when bolted or screwed to the floor or wall shall be regarded as a clean-out.

K5.5.7 Storm-water Drains

K5.5.7.1 General.—The run-off from roofs and paved areas may be drained into storm, or combined sewers, but shall not be drained into sanitary sewers. When such drains are connected with combined sewers they shall be effectively trapped, except that roof leaders and conductors, for which the roof or gutter opening is located 12 feet or more from a door, window, or air shaft, need not be trapped. One trap may serve for all such connections, but must be set below the frost line, or on the inside of the building.

K5.5.7.2 Size of Gutters and Leaders.—No gutter or inside vertical leader shall be of a size less than that indicated in Table 9.

TABLE 9
SIZES OF GUTTERS AND LEADERS*

Drained Area (square feet)	Gutter (inches)	Leader (inches)
Up to 90	3	1½
91 " 270	4	2
271 " 810	4	3
811 " 1800	5	3
1801 " 3600	6	4
3601 " 5500	8	5
5501 " 9600	10	6

*Leader sizes as given in Table 9 indicate the diameter of circular sections, and gutter sizes indicate the diameter of semicircular sheet-metal sections. Other shapes of leaders and gutters shall have equivalent areas.

K5.5.7.3 Size of Horizontal Storm-water Drains.—The required sizes of horizontal storm-water drains shall be determined in accordance with Table 11 hereof.

The size of combined storm and sanitary drains shall conform to the requirements for sewers as set forth in Item 5.5.8.8.

K5.5.7.4 Inside Leaders.—When placed within the walls of any building, or in an inner court or air well, all conductors or roof leaders shall be constructed of cast iron, or galvanized wrought iron or steel pipe.

K5.5.7.5 Outside Leaders.—When outside leaders or down spouts of sheet metal are connected with the house drain, they shall be so connected by not less than one length of cast iron pipe extending vertically at least one foot above the grade line.

K5.5.7.6 Connections with Leaders Prohibited.—Rain water leaders shall not be used as soil, waste, or vent pipes, nor shall any soil, waste, or vent pipes be used as rain water leaders, provided that a roof having an area of less than 1000 square feet may be drained into a soil or waste stack below any portion of such stack serving as a vent. The size of any such stack shall be adequate for its combined purposes.

K5.5.8 House Sewers

K5.5.8.1 General.—Where practicable, the plumbing system of any new building or dwelling, or a new plumbing system in any existing building, shall be entirely separate from and independent of that of any other building and every building or dwelling shall have an independent connection with a public or private sewer, when available.

When one building stands in the rear of another building on the same lot, and no private sewer is available or can be constructed to the rear building, the house drain from the front building may be extended to the rear building and the whole considered as one house sewer.

K5.5.8.2 Old House Sewers.—Old house sewers may be used in connection with new buildings or new plumbing only when they are found, on examination and test, to conform in all respects to the requirements governing new sewers as prescribed in this By-law.

K5.5.8.3 House Sewer Discharges.—Every house sewer shall be connected to a street sewer; provided that when a street sewer is not available such house sewer shall be connected to a septic tank or other approved private sewage disposal system.

K5.5.8.4 Excavation.—Excavations for house sewers shall be open-cut trenches, except that tunnelling may be permitted in yards and courts for distances not exceeding six feet.

K5.5.8.5. Depth and Location.—All house sewers shall be laid at sufficient depth to protect them from frost. No sewer shall be laid within three feet of any bearing wall.

K5.5.8.6 Size of Sanitary House Sewers

(a) All sanitary house sewers from a point three feet outside of the outer wall of the building, shall have an inside diameter of not less than six inches; provided that when cast iron pipe is used it shall be of not less than four inches in diameter. No sewer shall be of smaller diameter than any drain pipe served by it.

(b) Table 10 shall be used to determine the maximum number of fixture units that may be drained by any sanitary house sewer or part thereof.

TABLE 10
HOUSE DRAINS, HOUSE SEWERS, AND HORIZONTAL
SOIL OR WASTE PIPES

Diameter of Pipe in Inches	Maximum Number of Fixture Units		
	1/8 inch fall per foot	1/4 inch fall per foot	1/2 inch fall per foot
1¼	1	1	1
1½	2	2	3
2	5	6	8
3	15	18	21
4	84	96	114
5	180	234	280
6	330	440	580
8	870	1,150	1,680
10	1,740	2,500	3,600
12	3,000	4,200	6,500

K5.5.8.7 Sizes of Storm-water House Drains and Sewers.—The required sizes of storm-water house drains and sewers shall be determined on the basis of the total drained area in horizontal projection in accordance with Table 11 hereof.

TABLE 11
STORM-WATER DRAINS AND SEWERS

Diameter of Pipe in Inches	Maximum Drained Area in Square Feet		
	1/8 inch fall per foot	1/4 inch fall per foot	1/2 inch fall per foot
3	865	1,250	1,750
4	1,860	2,650	3,800
5	3,300	4,700	6,650
6	5,250	7,500	10,700
8	11,000	16,000	22,200
10	19,500	27,500	40,000
12	32,500	45,500	65,500
15	58,000	81,000	115,000

Note: Table 11 is based on gravity flow in a full pipe, and a maximum rate of rainfall of four inches per hour. Subject to the approval of the authority having jurisdiction, the table may be modified, when necessary, to meet local conditions of rainfall, by multiplying each given roof area by $4/x$, where x is the rate of rainfall to be provided for in inches per hour.

K5.5.8.8 Sizes of Combined House Drains and Sewers.—The required sizes of all house drains and sewers carrying storm and sanitary flow shall be determined by adding to the total drained area an allowance

in square feet for each fixture unit on the sanitary system and using the total area so obtained with Table 11. This allowance shall be determined in accordance with Table 12 hereof.

TABLE 12
DRAINED-AREA EQUIVALENT OF FIXTURE UNITS

30	square feet for each of the first	6	units
20	" " " " " " next	4	units
14	" " " " " " "	10	units
9	" " " " " " "	10	units
6	" " " " " " "	1,470	units
5	" " " " " " "	1,500	units
4	" " " " " " "	2,000	units
3	square feet for each fixture unit thereafter.		

K5.5.8.9 House Sewers in Made Ground.—When house sewers are laid in made or filled-in ground, they shall be of vitrified clay or concrete pipe laid in a concrete cradle or on an approved grillage, or of cast iron pipe.

K5.5.8.10 Drainage below Sewer Level.—In all buildings in which the whole, or part, of the house drainage and plumbing system lies below the level of the crown of the street sewer, sewage or house wastes shall be lifted by approval means and discharged into the house sewer

K5.5.8.11 Sumps and Receiving Tanks.—All sub-house drains shall discharge into an air-tight sump or receiving tank, so located as to receive the sewage by gravity, from which sump or receiving tank the sewage shall be lifted and discharged into the house sewer by pumps, ejectors, or other equally efficient method, operated automatically. When sub-house drains do not receive the discharge from plumbing fixtures other than cellar floor drains the sump or receiving tank need not be air-tight or vented.

K5.5.8.12 Motors, Compressors, etc.—All motors, air compressors, and air tanks shall be located where they are open for repair and inspection at all times.

K5.5.8.13 Sub-soil Drains.—Sub-soil drains below the sewer and cellar floor drains shall be discharged into an independent sump or receiving tank and the contents automatically discharged into the sewer. The discharge of automatic systems shall be protected against back-pressure.

K5.5.9. Vents

K5.5.9.1 General.—Every fixture trap shall be protected against siphonage and back-pressure, and air circulation shall be assured throughout the drainage system by means of a soil or waste stack vent, a continuous soil or waste vent, or a loop or circuit vent. No crown vent shall be installed.

Branch vents shall be so installed as to eliminate any possibility of their functioning as soil or waste pipes.

K5.5.9.2 Required Size of Vents

(a) **Branch and Individual Vents.**—No vent shall be less than $1\frac{1}{4}$ inches in diameter. No branch or main vent shall have a diameter less than one-half that of the soil or waste pipe served, and in no case shall the length of a branch vent of given diameter exceed the maximum length permitted for a main vent serving the same size soil or waste stack.

(b) **Vent Stacks or Main Vents.**—The required size of main vents or vent stacks shall be determined from the size of the soil or waste stack vented, the total number of fixture units drained into it, and the developed length of the vent, in accordance with Table 13 hereof, interpolating when necessary between permissible lengths of vent.

TABLE 13
MAXIMUM PERMISSIBLE LENGTHS OF MAIN VENTS OR VENT STACKS
(IN FEET)

Diameter of soil or waste stack (inches)	Number of Fixture Units	Diameter of vent (in inches)									
		$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4	5	6	8	10
$1\frac{1}{4}$	1	45									
$1\frac{1}{2}$	8	35	60								
2	18	30	50	90							
$2\frac{1}{2}$	36	25	45	75	105						
3	12		34	120	180	212					
3	18		18	70	180	212					
3	24		12	50	130	212					
3	36		8	35	93	212					
3	48		7	32	80	212					
3	72		6	25	65	212					
4	24			25	110	200	300	340			
4	48			16	65	115	300	340			
4	96			12	45	84	300	340			
4	144			9	30	72	300	340			
4	192			8	30	64	282	340			
4	264			7	20	56	245	340			
4	384			5	18	47	206	340			
5	72				40	65	250	390	440		
5	144				30	47	180	390	440		
5	288				20	32	124	390	440		
5	432				16	24	94	320	440		
5	720				10	16	70	225	440		
5	1,020				8	13	58	180	440		
6	144					27	108	340	510		
6	288					15	70	220	510	630	
6	576					10	43	150	425	630	
6	864					7	33	125	320	630	
6	1,296					6	25	92	240	630	
6	2,070					4	21	75	186	630	
8	320						42	144	400	750	900
8	640						30	86	260	750	900
8	960						22	60	190	750	900
8	1,600						16	40	120	525	900
8	2,500						12	28	90	370	900
8	4,160						7	22	62	252	840
8	5,400						5	17	52	212	705

K5.5.9.3 Distance of Vent from Trap Seal.—The maximum distance from any trap to its vent shall not be more than five feet of horizontal developed length. The vent opening from the soil or waste pipe, except for water-closets and similar fixtures, shall be above the dip of the trap.

K5.5.9.4 Vent Connections.—All main vents or vent stacks shall connect in full size, at their base, to the main soil or waste pipe at or below the lowest fixture branch, and shall extend undiminished in size, above the roof, or shall be reconnected with the main soil or waste stack, at least three feet above the highest fixture branch.

Where a vent pipe connects to a horizontal soil or waste pipe, the vent pipe shall be taken off above the centre line of the soil or waste pipe, and shall rise vertically, or at an angle of not more than 45 degrees with the vertical, to a point six inches above the fixture it is venting before offsetting horizontally or connecting to a branch or main vent or to a waste or soil vent.

K5.5.9.5. Vent Pipe Grades.—All vent and branch vent pipes shall be free from drops or sags, and shall be so graded and connected as to drip back to the soil or waste pipe by gravity.

K5.5.9.6 Roof Extensions.—Roof extensions of soil, waste, or vent stacks shall extend full size at least two inches above the roof. When climatic conditions are such that there is danger of condensation and freezing in such extensions, any extension exceeding three inches shall be adequately protected.

Any soil, waste, or vent stack extending above a roof used for purposes other than protection against the weather shall extend not less than six feet above such roof. Any such pipe or vent terminating within 12 feet of any door, window, or air shaft shall extend at least three feet above the top of such opening.

Soil, waste, or vent stacks extended through the roof shall be at least four inches in diameter. Stacks smaller than four inches shall be provided with a long increaser at least one foot below the roof.

K5.5.9.7 Circuit and Loop Vents.—A circuit or loop vent shall be permitted as follows: A branch soil or waste pipe to which two, and not more than eight, water-closets, urinals, trap-standard slop sinks, or shower stalls are connected in a series or battery formation may be vented by a circuit or loop vent, which shall be taken off in front of the last fixture connection. When fixtures discharge above such branch, each branch shall be provided with a relief vent one-half the diameter of the soil or waste stack, taken off in front of the first fixture connection. Not more than eight fixtures shall be connected to a battery type branch soil or waste pipe, unless a two-inch relief vent is provided between each additional eight fixtures or fraction thereof.

K5.5.9.8 Venting of Ejector Systems.—The soil or waste pipe leading to an ejector or other appliance for raising sewage or other waste matter to the street sewer shall be provided with a vent pipe. The vent

for any such soil pipe shall be not less than four inches in diameter, and the vent for any such waste pipe shall be of the same diameter as the waste pipe.

K5.5.9.9 Vents not Required.—No vent shall be required on a down spout or rain leader trap, a back-water trap, a sub-soil catch basin trap, or on a cellar floor drain, provided the cellar floor drain branches into the house drain on the sewer side at a distance of five feet or more from the base of the stack.

K5.5.9.10 Common Vents for Adjacent Fixtures.—Two fixtures of the same kind set back to back, side by side, or on opposite sides of a wall or partition, may be served by a common vent; provided that each fixture drains separately into a double fitting having inlet openings at the same level.

PART K6—INSPECTION AND TESTING

K6.1 Required Inspections.—Every part of any plumbing system shall be subject to inspection by the authority having jurisdiction who shall have the right of entry to any building within this municipality for the purpose of making inspection, reinspections, or otherwise performing such duties as may be necessary to approval in accordance with this By-law.

K6.2 Regulations pertaining to Inspections

K6.2.1 Notification.—It shall be the duty of the plumber to notify the authority having jurisdiction, in writing, when the work is ready for inspection or testing.

K6.2.2 Covering of Work.—No plumbing system, or part thereof, shall be covered until it has been inspected, tested, and approved.

K6.2.3 Material and Labour for Tests.—All equipment, materials, and labour necessary for inspection and testing shall be furnished by the plumber.

K6.2.4. Defective Materials or Workmanship.—If inspection or testing shows defective materials or workmanship, such defective work or materials shall be replaced and the inspection and test repeated, until satisfactory.

K6.2.5 Maintenance.—Any part of a plumbing system that becomes defective or unsanitary shall be repaired, replaced, or removed within 30 days after receipt of written notice from the authority having jurisdiction; the quality and design of materials and the workmanship employed in such work shall in all respects comply with the requirements of this By-law.

K6.3 Certificate of Approval.—Upon the satisfactory completion and final testing of any plumbing system, a certificate of approval shall be issued to the plumber by the authority having jurisdiction, and no owner or occupier of any building shall use any plumbing or fixture until such certificate has been granted.

K6.4 Tests

K6.4.1 Water Distribution Systems.—Upon the completion of any water distribution system it shall be tested and proven tight under water pressure not less than the maximum working pressure under which it is to be used.

K6.4.2. Fixtures, Drainage Systems, and House Sewers

(a) Every part of any drainage system shall be tested by means of a water test before being concealed or built in. After all plumbing fixtures have been set the system shall be subjected to a final smoke test.

(b) **Water and Air Tests.**—When specifically permitted by the authority having jurisdiction, the air test may be used in place of the water test; otherwise the latter shall be applied to all drainage systems and house sewers. Both tests, when used, shall be applied to the whole system, either in one operation or by sections.

The water test shall be conducted by closing all openings and filling the system completely with water under a pressure equal to that exerted by a column of water at least ten feet high in all parts. The air test shall be conducted in a similar manner, a minimum air pressure of five pounds per square inch being employed.

In neither test shall there be any discernible leakage of water or air, nor shall there be any loss of pressure when the system is brought to the test pressure and held for 15 minutes without further addition of water or air.

(c) **Smoke Test.**—This test shall be applied to the entire drainage system and house sewer with all traps filled with water. A dense smoke, produced by one or more approved smoke machines, shall be introduced into the entire system. As soon as smoke issues in substantial quantities from the stack openings on the roof, such openings shall be tightly closed and a pressure equal to that exerted by a column of water at least one inch high shall be applied to the system. There shall be no evidence of smoke leakage at any joint or in any fixture.

PART K7—PRIVATE SEWAGE DISPOSAL SYSTEMS

K7.1 General.—Whenever a street or common sewer is not available any sanitary house sewer shall be connected to a private sewage disposal system. Such system shall consist of a septic tank with a tile disposal field or other approved means of disposal.

K7.2 Location.—Any septic or other sewage disposal tank shall be located outside, and be separated from any wall, of a dwelling house. Any disposal field or area shall be located as far as practicable from any dwelling and in no case shall disposal tiles be nearer at any point than ten feet to any dwelling.

No sewage disposal system shall be so located that it is liable to contaminate any existing domestic water supply nor shall it be located under any roadway or traffic way.

K7.3 Materials.—The walls and floors of any septic tank or other sewage disposal tank shall be of substantial water-tight construction.

K7.4 Capacity.—No septic tank or other sewage disposal tank for dwellings shall have a capacity, below the invert of the outlet pipe, of less than 150 gallons, and this capacity shall be increased by not less than 60 gallons for each bedroom, in excess of two, in the dwelling served.

For schools and similar establishments whose daily requirements are of limited duration the capacity below the invert of the outlet pipe shall be not less than 300 gallons and shall be in proportion to the total number of persons for whose accommodation such establishment is designed, intended, or used, at a minimum rate of 15 gallons per person.

Adequate provision shall be made for any condition that may result in a flow of sewage greater than 150 gallons per day in any dwelling or 15 gallons per person per day in any school or similar establishment. When computations or assumptions are made as to the expected flow of sewage, the septic tank shall be sufficiently large to allow a detention period of 24 hours and shall contain in addition a reasonable space for sludge storage.

K7.5 Design.—The digestion or treatment and dosing chambers of any septic tank or other sewage disposal tank shall be securely covered with concrete, metal, or wood and shall be provided with adequate means of access and ventilation.

The depth of the digestion chamber shall not be less than 42 inches below the level of the liquid outflow. A space of at least 12 inches shall be provided above the level of liquid outflow, for scum formation and gas escape.

The inlet and outlet pipes shall be of a size not less than that of the sewer served and shall be so provided with baffle plates or with inverted sanitary tee fittings as to prevent any excess turbulence or disturbance of the scum. The outlet baffle or tee fitting shall extend not less than six inches above and 15 inches below the water line. The inlet tee fitting or baffle shall extend several inches above and 10 to 15 inches below the water level in the tank. The level of the outlet shall be two to four inches below that of the inlet.

The length of rectangular digestion chambers shall be at least one and one-half times their width and the direction of flow of sewage shall be parallel to the longest dimension of the tank.

K7.6 Dosing Chambers.—Any septic tank or other sewage disposal tank discharging into a sub-surface tile disposal field or sand filter shall be provided with a dosing chamber of liquid capacity at least one-quarter that of the treatment or digestion chamber.

K7.7 Dosing Siphons.—Dosing chambers shall be provided with siphons or other discharging devices and shall be automatic unless other means are provided for their proper operation. Such siphons or other discharging devices shall be made of corrosion-resistant material.

K7.8 Storm-Water.—Surface or storm-water shall not be drained into any private sanitary sewage disposal system.

K7.9 Vent Pipes.—No vent pipe or fresh air inlet of any sewage disposal system shall terminate within 20 feet of any window, door, or other air intake of any building used for human habitation; provided that if such vent pipe opening or inlet is at least three feet above any window, door, or other air intake, it may terminate not less than ten feet from it.

K7.10 Effluent Pipe from Sewage Tank.—The effluent pipe from any septic tank or other sewage tank to the disposal field or area shall comply with the requirements for house sewers as set forth in this By-law. Every effluent pipe shall be placed at a depth such that it is wholly below the level of the floor of any dosing chamber serving it.

K7.11 Capacity of Tile Disposal Field.—The capacity of any private sub-surface irrigation field for sewage shall depend on the character of the soil and the capacity of the dosing chamber.

The length of open-joint tiling shall be not less than 130 lineal feet per dwelling in porous soils and shall be increased in proportion to the number of bedrooms in excess of two at the minimum rate of 50 lineal feet per bedroom.

For schools and similar establishments whose daily requirements are of limited duration, the length of open-joint tiling shall be not less than 260 lineal feet and shall be increased in proportion to the accommodation provided in such establishment at the minimum rate of 12 feet per person.

The volume of the disposal tile and feeder pipes shall in no case be less than 120 per cent of the discharge volume of the dosing chamber.

K7.12 Tile Disposal Field in Impervious Soil.—No sub-surface sewage irrigation field shall be constructed in clay or other heavy or impervious soil unless porous filtration media and adequate drainage are provided by removing such impervious soil and replacing it with porous filtering material such as coarse sand, gravel, cinders, or broken stone, to a depth below the bottom of the disposal tile of not less than 18 inches and preferably not less than 24 inches.

K7.13 Size of Open-Joint Tile and Method of Laying.—Ordinary field drainage tile of a size not less than four inches shall be used. They shall be laid on a firm base of broken stone, gravel, or on tile supports and shall have a depth of cover not less than 12 inches nor greater than 24 inches. Open joints of $\frac{1}{8}$ to $\frac{3}{8}$ inch shall be left between tiles, and the upper half of such joints shall be covered by tarred paper, broken tile, or other approved protection. The tile trench shall be back-filled with coarse sand, gravel, cinders or broken stone of particle size not greater than one-half inch in any dimension, to a depth of six inches over the top and around the sides of the tile wherever the soil is less porous than coarse sand or gravel. Tiling shall not be laid under any roadway or traffic way.

K7.14 Grade of Tiling.—The open-joint tiling shall be laid at a small uniform down grade not exceeding two inches per 100 feet.

K7.15 Lateral Branches of Tiling.—Lateral branches of open-joint tiling shall be not less than three feet apart and shall be connected to the liquid effluent pipe or to a header by sewer pipe branch fittings. Header pipes shall be of a quality equal to that required for house sewer pipes.

PART K8—PENALTIES

Any person convicted of a breach of any of the provisions of this By-law shall be liable to a fine, with or without costs, and in default of immediate payment of the said fine, with or without costs, to an imprisonment; the amount of said fine and the term of said imprisonment to be fixed by the convicting magistrate at his discretion. The fine shall not exceed \$50.00 and the term of imprisonment shall not be for a longer period than sixty days.

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