UNIFORM BUILDING CODE

1967 Edition

Volume I

AUTHORIZED EDITION

Fifth Printing

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS
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Preface

THE UNIFORM BUILDING CODE is dedicated to the development of better building construction and greater safety to the public by uniformity in building laws; to the granting of full justice to all building materials on the fair basis of the true merits of each material; and to the development of a sound economic basis for the future growth of cities through unbiased and equitable dealing with structural design and fire hazards.

THE UNIFORM BUILDING CODE was first published by the Pacific Coast Building Officials Conference at the Sixth Annual Business Meeting held in Phoenix, Arizona, October 18-21, 1927.

Revised editions of this Code have been published in 1930, 1933, 1937, 1940, 1943, 1946, 1949, 1952, 1955, 1958, 1961, and 1964 following official action on the floor of Annual Business Meetings.

The 1967 Edition of the Uniform Building Code contains new sections, subsections, and standards approved by the Active Class A members at the Forty-Fourth Annual Business Meeting of the International Conference of Building Officials, October 3-7, 1966.

OUTLINE OF CONTENTS BY PARTS, CHAPTERS, AND SECTIONS

Part IV—Requirements Based on Location in Fire Zones

Part V—Requirements Based on Types of Construction

Part VIII—Fire-Resistive Standards for Fire Protection

EFFECTIVE USE OF THE UNIFORM BUILDING CODE

The following procedure may be helpful in using the Uniform Building Code:

1. Classify the building:

   A. **FIRE ZONE:** Determine the fire zone in which the building is located from the city's Fire District Zoning Map. See Chapter 16 for requirements based on Fire Zone.

   B. **OCCUPANCY GROUP:** Determine the Occupancy Group which the use of the building most nearly resembles. See the '01 Sections of Chapters 6 through 15. See Section 503 for buildings with mixed occupancies.

   C. **TYPE OF CONSTRUCTION:** Determine the Type of Construction of the building by the building materials used and the fire resistance of the parts of the building. See Chapters 17 through 22.

   D. **LOCATION ON PROPERTY:** Determine the location of the building on the site and clearances to property lines and other buildings from the plot plan. See Table No. 5-A and '03 Sections of Chapters 18 through 22 for exterior wall and wall opening requirements based on proximity to property lines. See Section 504 for buildings located on the same site.

   E. **FLOOR AREA:** Compute the floor area of the building. See Table No. 5-C for basic allowable floor area based on Occupancy Group and Type of Construction. See Section 506 for allowable increases based on location on property and installation of an approved automatic fire-extinguishing system. See Section 505 (b) for allowable floor area of multistory buildings.

   F. **HEIGHT AND NUMBER OF STORIES:** Compute the height of the building, Section 409, from grade, Section 408, and for the number of stories, Section 420. See Table No. 5-D for the allowable height and number of stories based on Occupancy Group and Type of Construction. See Section 507 for allowable story increase based on the installation of an approved automatic fire-extinguishing system.

   G. **OCCUPANT LOAD:** Compute the occupant load of the building. See Sections 3301 (c) and (d) and Table No. 33-A.

2. Verify compliance of the building with detailed Occupancy requirements. See Chapters 6 through 15.

3. Verify compliance of the building with detailed Type of Construction requirements. See Chapters 17 through 22.

4. Verify compliance of the building with exit requirements. See Chapter 33.

5. Verify compliance of the building with detailed Code regulations. See Chapters 28 through 43, Chapters 47 through 54, and Appendix.

6. Verify compliance of building with engineering regulations and requirements for materials of construction. See Chapters 23 through 28 and Section 4711.

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS
UNIFORM BUILDING CODE

Ordinance No........................

An ordinance regulating the erection, construction, enlargement, alteration, repair, moving, removal, conversion, demolition, occupancy, equipment, use, height, area, and maintenance of buildings or structures in the City of

....;

providing for the issuance of permits and collection of fees therefor; declaring and establishing Fire Districts; providing penalties for the violation thereof, and repealing all ordinances and parts of ordinances in conflict therewith.

Be it ordained by the..
of the City of...as follows:

PART I

ADMINISTRATIVE

CHAPTER 1—TITLE AND SCOPE

Title

Sec. 101. This ordinance shall be known as the "Building Code," may be cited as such, and will be referred to herein as "this Code."

Purpose

Sec. 102. The purpose of this Code is to provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within the city and certain equipment specifically regulated herein.

Scope

Sec. 103. The provisions of this Code shall apply to the construction, alteration, moving, demolition, repair, and use of any building or structure within the city, except work located primarily in a public way, public utility towers and poles, mechanical equipment not specifically regulated in this Code, and hydraulic flood control structures.

Additions, alterations, repairs, and changes of use or occupancy in all buildings and structures shall comply with the provisions for new buildings and structures except as otherwise provided in Sections 104, 306, and 502 of this Code.

Where, in any specific case, different sections of this Code specify different materials, methods of construction or other requirements, the most restrictive shall govern.

Wherever in this Code reference is made to the Appendix, the provisions in the Appendix shall not apply unless specifically adopted.

Application to Existing Buildings

Sec. 104. (a) **General.** Buildings or structures to which additions, alterations, or repairs are made shall comply with all the requirements for new buildings or structures except as specifically provided in this Section.

For construction in Fire Zones see Chapter 16.

(b) **Additions, Alterations, and Repairs: More than 50 Per Cent.** When additions, alterations, or repairs within any 12-month period exceed 50 per cent of the value of an existing building or structure, such building or structure shall be made to conform to the requirements for new buildings or structures.

(c) **Additions, Alterations, and Repairs: 25 to 50 Per Cent.** Additions, alterations, and repairs exceeding 25 per cent but not exceeding 50 per cent of the value of an existing building or structure and complying with the require-

Application to Existing Buildings (Continued)

ments for new buildings or structures may be made to such building or structure within any 12-month period without making the entire building or structure comply. The new construction shall conform to the requirements of this Code for a new building of like area, height, and occupancy. Such building or structure, including new additions, shall not exceed the areas and heights specified in this Code.

(d) **Additions, Alterations, and Repairs: 25 Per Cent or Less.** Structural additions, alterations, and repairs to any portion of an existing building or structure, within any 12-month period, not exceeding 25 per cent of the value of the building or structure shall comply with all of the requirements for new buildings or structures, except that minor structural additions, alterations, or repairs, when approved by the Building Official, may be made with the same material of which the building or structure is constructed. Such building or structure, including new additions, shall not exceed the areas and heights specified in this Code.

(e) **Nonstructural Alterations and Repairs: 25 Per Cent or Less.** Alterations or repairs, not exceeding 25 per cent of the value of an existing building or structure, which are nonstructural and do not affect any member or part of the building or structure having required fire resistance, may be made with the same materials of which the building or structure is constructed.

(f) **Repairs: Roof Covering.** Not more than 25 per cent of the roof covering of any building or structure shall be replaced in any 12-month period unless the new roof covering is made to conform to the requirements of this Code for new buildings or structures.

(g) **Existing Occupancy.** Buildings in existence at the time of the passage of this Code may have their existing use or occupancy continued, if such use or occupancy was legal at the time of the passage of this Code, provided such continued use is not dangerous to life.

Any change in the use or occupancy of any existing building or structure shall comply with the provisions of Sections 306 and 502.

(h) **Maintenance.** All buildings or structures both existing and new, and all parts thereof, shall be maintained in a safe and sanitary condition. All devices or safeguards which are required by this Code in a building or structure when erected, altered, or repaired, shall be maintained in good working order. The owner or his designated agent shall be responsible for the maintenance of buildings and structures.

Moved Buildings

Sec. 105. Buildings or structures moved into or within the city shall comply with the provisions of this Code for new buildings or structures. See Section 1601 (c) for requirements in fire zones.

Alternate Materials and Methods of Construction

Sec. 106. The provisions of this Code are not intended to prevent the use of any material or method of construction not specifically prescribed by this Code, provided any such alternate has been approved.

The Building Official may approve any such alternate provided he finds that the proposed design is satisfactory and complies with the provisions of Chapter 23, and that the material, method, or work offered is, for the purpose intended, at least the equivalent of that prescribed in this Code in quality, strength, effectiveness, fire resistance, durability, and safety.

The Building Official shall require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding its use.

For the requirements as an approved fabricator see Sections 305 and 402.

Tests

Sec. 107. Whenever there is insufficient evidence of compliance with the provisions of this Code or evidence that any material or any construction does not conform to the requirements of this Code, or in order to substantiate claims for alternate materials or methods of construction, the Building Official may require tests as proof of compliance to be made at the expense of the owner or his agent by an approved agency.

Test methods shall be as specified by this Code for the material in question. If there are no appropriate test methods specified in this Code, the Building Official shall determine the test procedure.

Copies of the results of all such tests shall be retained for a period of not less than two years after the acceptance of the structure.

CHAPTER 2—ORGANIZATION AND ENFORCEMENT

Creation of Department

Sec. 201. There is hereby established in the city the "Building Department" which shall be under the jurisdiction of the Building Official designated by the appointing authority.

Powers and Duties of Building Official

Sec. 202. (a) **General.** The Building Official is hereby authorized and directed to enforce all the provisions of this Code. For such purpose he shall have the powers of a police officer.

(b) **Deputies.** In accordance with the procedure and with the approval of the chief appointing authority of the municipality, the Building Official may appoint such number of officers, inspectors and assistants, and other employees as shall be authorized from time to time. He may deputize such employees as may be necessary to carry out the functions of the Building Department.

(c) **Reports and Records.** The Building Official shall submit a report to the proper city official not less than once a year, covering the work of the department during the preceding period. He shall incorporate in said report a summary of his recommendations as to desirable amendments to this Code.

The Building Official shall keep a permanent, accurate account of all fees and other monies collected and received under this Code, the names of the persons upon whose account the same were paid, the date and amount thereof, together with the location of the building or premises to which they relate.

(d) **Right of Entry.** Upon presentation of proper credentials the Building Official or his duly authorized representatives may enter at reasonable times any building, structure, or premises in the city to perform any duty imposed upon him by this Code.

(e) **Stop Orders.** Whenever any building work is being done contrary to the provisions of this Code, the Building Official may order the work stopped by notice in writing served on any persons engaged in the doing or causing such work to be done, and any such persons shall forthwith stop such work until authorized by the Building Official to proceed with the work.

(f) **Occupancy Violations.** Whenever any structure is being used contrary to the provisions of this Code, the Building Official may order such use discontinued and the structure, or portion thereof, vacated by notice served on any person causing such use to be continued. Such person shall discontinue the use within 10 days after receipt of such notice or

Powers and Duties of Building Official (Continued)

make the structure, or portion thereof, comply with the requirements of this Code; provided, however, that in the event of an unsafe building Section 203 shall apply.

(g) **Liability.** The Building Official or any employee charged with the enforcement of this Code, acting in good faith and without malice for the city in the discharge of his duties, shall not thereby render himself liable personally and he is hereby relieved from all personal liability for any damage that may accrue to persons or property as a result of any act required or by reason of any act or omission in the discharge of his duties. Any suit brought against the Building Official or employee, because of such act or omission performed by him in the enforcement of any provisions of this Code, shall be defended by the legal department of the city until final termination of the proceedings.

(h) **Cooperation of Other Officials.** The Building Official may request, and shall receive so far as may be necessary in the discharge of his duties, the assistance and cooperation of other officials of the city.

Unsafe Buildings

Sec. 203. (a) **General.** All buildings or structures which are structurally unsafe or not provided with adequate egress, or which constitute a fire hazard, or are otherwise dangerous to human life, or which in relation to existing use constitute a hazard to safety or health, or public welfare, by reason of inadequate maintenance, dilapidation, obsolescence, fire hazard, or abandonment, as specified in this Code or any other effective ordinance, are, for the purpose of this Section, unsafe buildings. All such unsafe buildings are hereby declared to be public nuisances and shall be abated by repair, rehabilitation, demolition, or removal in accordance with the procedure specified in Subsections (b), (c), (d), and (e) of this Section.

(b) **Notice to Owner.** The Building Official shall examine or cause to be examined every building or structure or portion thereof reported as dangerous or damaged and, if such is found to be an unsafe building as defined in this Section, the Building Official shall give to the owner of such building or structure written notice stating the defects thereof. This notice may require the owner or person in charge of the building or premises, within 48 hours, to commence either the required repairs or improvements or demolition and removal of the building or structure or portions thereof, and all such work shall be completed within 90 days from date of notice, unless otherwise stipulated by the Building Official. If necessary, such notice also shall require the building, structure, or portion thereof to be vacated forthwith and not reoccupied until the required repairs and improvements are completed, inspected, and approved by the Building Official.

Unsafe Buildings (Continued)

Proper service of such notice shall be by personal service upon the owner of record, if he shall be found within the city limits. If he is not found within the city limits such service may be made upon said owner by registered mail or certified mail, provided, that if such notice is by registered mail or certified mail, the designated period within which said owner or person in charge is required to comply with the order of the Building Official shall begin as of the date he receives such notice.

(c) **Posting of Signs.** The Building Official shall cause to be posted at each entrance to such building a notice to read: "DO NOT ENTER. UNSAFE TO OCCUPY. Building Department, City of............................" Such notice shall remain posted until the required repairs, demolition, or removal are completed. Such notice shall not be removed without written permission of the Building Official and no person shall enter the building except for the purpose of making the required repairs or of demolishing the building.

(d) **Right to Demolish.** In case the owner shall fail, neglect, or refuse to comply with the notice to repair, rehabilitate, or to demolish and remove said building or structure or portion thereof, the City Council may order the owner of the building prosecuted as a violator of the provisions of this Code and may order the Building Official to proceed with the work specified in such notice. A statement of the cost of such work shall be transmitted to the City Council, who shall cause the same to be paid and levied as a special assessment against the property.

(e) **Costs.** Costs incurred under Subsection (d) shall be paid out of the City Treasury. Such costs shall be charged to the owner of the premises involved as a special assessment on the land on which the building or structure is located, and shall be collected in the manner provided for special assessments.

Board of Appeals

Sec. 204. In order to determine the suitability of alternate materials and methods of construction and to provide for reasonable interpretations of the provisions of this Code, there shall be and is hereby created a Board of Appeals, consisting of five members who are qualified by experience and training to pass upon matters pertaining to building construction. The Building Official shall be an ex officio member and shall act as Secretary of the Board. The Board of Appeals shall be appointed by the Mayor and shall hold office at his pleasure. The Board shall adopt reasonable rules and regulations for conducting its investigations and shall render all decisions and findings in writing to the Building Official with a duplicate copy to the appellant and may recommend to the City Council such new legislation as is consistent therewith.

Violations and Penalties

Sec. 205. It shall be unlawful for any person, firm, or corporation to erect, construct, enlarge, alter, repair, move, improve, remove, convert or demolish, equip, use, occupy, or maintain any building or structure in the city, or cause the same to be done, contrary to or in violation of any of the provisions of this Code.

Any person, firm, or corporation violating any of the provisions of this Code shall be deemed guilty of a misdemeanor, and each such person shall be deemed guilty of a separate offense for each and every day or portion thereof during which any violation of any of the provisions of this Code is committed, continued, or permitted, and upon conviction of any such violation such person shall be punishable by a fine of not more than $300, or by imprisonment for not more than 90 days, or by both such fine and imprisonment.

CHAPTER 3—PERMITS AND INSPECTIONS

Application for Permits

Sec. 301. (a) **Permits Required.** No person, firm, or corporation shall erect, construct, enlarge, alter, repair, move, improve, remove, convert, or demolish any building or structure in the city, or cause the same to be done, without first obtaining a separate building permit for each such building or structure from the Building Official.

(b) **Application.** To obtain a permit the applicant shall first file an application therefor in writing on a form furnished for that purpose. Every such application shall:

1. Identify and describe the work to be covered by the permit for which application is made;
2. Describe the land on which the proposed work is to be done, by lot, block, tract, and house and street address, or similar description that will readily identify and definitely locate the proposed building or work;
3. Show the use or occupancy of all parts of the building;
4. Be accompanied by plans and specifications as required in Subsection (c) of this Section;
5. State the valuation of the proposed work;
6. Be signed by the permittee, or his authorized agent, who may be required to submit evidence to indicate such authority;
7. Give such other information as reasonably may be required by the Building Official.

(c) **Plans and Specifications.** With each application for a building permit, and when required by the Building Official for enforcement of any provisions of this Code, two sets of plans and specifications shall be submitted. The Building Official may require plans and specifications to be prepared and designed by an engineer or architect licensed by the state to practice as such.

> EXCEPTIONS: When authorized by the Building Official plans and specifications need not be submitted for the following:
>
> 1. One-story buildings of Type V conventional wood-stud construction with an area not exceeding six hundred square feet (600 sq. ft.).
> 2. Group J, Division 1, Occupancies of Type V conventional wood-stud construction.
> 3. Small and unimportant work.

(d) **Information on Plans and Specifications.** Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall be of sufficient clarity to indicate the nature and extent of the work proposed and show in detail that it will conform to the provisions of this Code and all relevant laws, ordinances, rules, and regulations. The first sheet of each set of plans shall give the house and street address of the work and the name and address of the owner and person who prepared them. Plans shall include a plot plan showing the location of the proposed building and of every existing building on the property. In lieu of detailed specifications, the Building Official may approve references on the plans to a specific section or part of this Code or other ordinances or laws.

Application for Permits (Continued)

Computations, stress diagrams, and other data sufficient to show the correctness of the plans, shall be submitted when required by the Building Official.

Building Permits

Sec. 302. (a) **Issuance.** The application, plans, and specifications filed by an applicant for a permit shall be checked by the Building Official. Such plans may be reviewed by other departments of the city to check compliance with the laws and ordinances under their jurisdiction. If the Building Official is satisfied that the work described in an application for permit and the plans filed therewith conform to the requirements of this Code and other pertinent laws and ordinances, and that the fee specified in Section 303 (a) has been paid, he shall issue a permit therefor to the applicant.

When the Building Official issues the permit, he shall endorse in writing or stamp on both sets of plans and specifications "APPROVED." Such approved plans and specifications shall not be changed, modified, or altered without authorization from the Building Official, and all work shall be done in accordance with the approved plans.

The Building Official may issue a permit for the construction of part of a building or structure before the entire plans and specifications for the whole building or structure have been submitted or approved provided adequate information and detailed statements have been filed complying with all pertinent requirements of this Code. The holder of such permit shall proceed at his own risk without assurance that the permit for the entire building or structure will be granted.

(b) **Retention of Plans.** One set of approved plans, specifications, and computations shall be retained by the Building Official for a period of not less than 90 days from date of completion of the work covered therein, and one set of approved plans and specifications shall be returned to the applicant, which set shall be kept on such building or work at all times during which the work authorized thereby is in progress.

Plans, submitted for checking, for which no permit is issued, and on which no action is taken by the applicant for 90 days, shall be returned to the last known address of the applicant; to renew action on said plans, a payment of a new plan-check fee shall be required.

Building Permits (Continued)

(c) **Validity.** The issuance or granting of a permit or approval of plans and specifications shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of this Code. No permit presuming to give authority to violate or cancel the provisions of this Code shall be valid, except insofar as the work or use which it authorizes is lawful.

The issuance of a permit based upon plans and specifications shall not prevent the Building Official from thereafter requiring the correction of errors in said plans and specifications or from preventing building operations being carried on thereunder when in violation of this Code or of any other ordinance of the city.

(d) **Expiration.** Every permit issued by the Building Official under the provisions of this Code shall expire by limitation and become null and void, if the building or work authorized by such permit is not commenced within 60 days from the date of such permit, or if the building or work authorized by such permit is suspended or abandoned at any time after the work is commenced for a period of 120 days. Before such work can be recommenced a new permit shall be first obtained so to do, and the fee therefor shall be one-half the amount required for a new permit for such work, provided no changes have been made or will be made in the original plans and specifications for such work; and provided, further, that such suspension or abandonment has not exceeded one year.

(e) **Suspension or Revocation.** The Building Official may, in writing, suspend or revoke a permit issued under provisions of this Code whenever the permit is issued in error or on the basis of incorrect information supplied, or in violation of any ordinance or regulation or any of the provisions of this Code.

Fees

Sec. 303. (a) **Building Permit Fees.** A fee for each building permit shall be paid to the Building Official as set forth in Table No. 3-A.

The determination of value or valuation under any of the provisions of this Code shall be made by the Building Official.

Where work for which a permit is required by this Code is started or proceeded with prior to obtaining said permit, the fees above specified shall be doubled, but the payment of such double fee shall not relieve any persons from fully complying with the requirements of this Code in the execution of the work nor from any other penalties prescribed herein.

TABLE NO. 3-A—BUILDING PERMIT FEES

Fees (Continued)

TOTAL VALUATION	FEE
$1.00 to $500.00	$5.00
$501.00 to $2,000.00	$5.00 for the first $500.00 plus $1.00 for each additional $100.00 or fraction thereof, to and including $2,000.00
$2,001.00 to $25,000.00	$20.00 for the first $2,000.00 plus $3.00 for each additional thousand or fraction thereof, to and including $25,000.00
$25,001.00 to $50,000.00	$89.00 for the first $25,000.00 plus $2.50 for each additional thousand or fraction thereof, to and including $50,000.00
$50,001.00 to $100,000.00	$151.50 for the first $50,000.00 plus $1.50 for each additional thousand or fraction thereof, to and including $100,000.00
$100,001.00 and up	$226.50 for the first $100,000.00 plus $1.00 for each additional thousand or fraction thereof

(b) **Plan-checking Fees.** When the valuation of the proposed construction exceeds $1,000.00 and a plan is required to be submitted by Subsection (c) of Section 301, a plan-checking fee shall be paid to the Building Official at the time of submitting plans and specifications for checking. Said plan-checking fee shall be equal to one-half of the building permit fee as set forth in Table No. 3-A.

Inspections

Sec. 304. (a) **General.** All construction or work for which a permit is required shall be subject to inspection by the Building Official, and certain types of construction shall have continuous inspection by special inspectors, as specified in Section 305.

A survey of the lot may be required by the Building Official to verify compliance of the structure with approved plans.

(b) **Inspection Record Card.** Work requiring a building permit shall not be commenced until the permit holder or his agent shall have posted an inspection record card in a conspicuous place on the front premises and in such position as to allow the Building Official conveniently to make the required entries thereon regarding inspection of the work. This card shall be maintained in such position by the permit holder until the Certificate of Occupancy has been issued.

(c) **Approvals Required.** No work shall be done on any part of the building or structure beyond the point indicated in each successive inspection without first obtaining the writ-

Inspections (Continued)

ten approval of the Building Official. Such written approval shall be given only after an inspection shall have been made of each successive step in the construction as indicated by each of the inspections required in Subsection (d).

There shall be a final inspection and approval on all buildings when completed and ready for occupancy.

(d) **Called Inspections.** No reinforcing steel or structural framework of any part of any building or structure shall be covered or concealed in any manner whatever without first obtaining the approval of the Building Official.

The Building Official upon notification from the permit holder or his agent shall make the following inspections of Type V buildings and shall either approve that portion of the construction as completed or shall notify the permit holder or his agent wherein the same fails to comply with the law.

1. FOUNDATION INSPECTION: To be made after trenches are excavated and forms erected and when all materials for the foundation are delivered on the job. Where concrete from a central mixing plant (commonly termed "transit mixed") is to be used, materials need not be on the job.
2. FRAME INSPECTION: To be made after the roof, all framing, fire-blocking, and bracing are in place and all pipes, chimneys, and vents are complete.
3. LATH AND/OR WALLBOARD INSPECTION: To be made after all lathing and/or wallboard, interior and exterior, is in place and all plastering materials are delivered on the job, but before any plastering is applied or before wallboard joints and fasteners are taped and finished.
4. FINAL INSPECTION: To be made after building is completed and ready for occupancy.

(e) **Other Inspections.** In addition to the called inspections specified above, the Building Official may make or require any other inspections of any construction work to ascertain compliance with the provisions of this Code and other laws which are enforced by the Building Department.

For the purpose of determining compliance with Section 104 (h), the Building Official may cause any structure to be reinspected.

Special Inspections

Sec. 305. (a) **General.** In addition to the inspections to be made as specified in Section 304, the owner or his agent shall employ a special inspector who shall be present at all times during construction on the following types of work:

1. CONCRETE: On concrete work when the design is based on an "f'_c" in excess of 2000 pounds.

2. MASONRY: Masonry work shall have special inspection when required in Chapter 24.
3. WELDING: On all structural welding.
4. REINFORCED GYPSUM CONCRETE: When cast-in-place reinforced gypsum concrete is being mixed or deposited.
5. SPECIAL CASES: On special construction or work involving unusual hazards or requiring constant inspection.

Special Inspections (Continued)

EXCEPTION: The Building Official may waive the requirement for the employment of a special inspector if he finds that the construction or work is such that no unusual hazard exists.

(b) **Special Inspector.** The special inspector shall be a qualified person approved by the Building Official.

The special inspector shall furnish continuous inspection on the construction and work requiring his employment. He shall report to the Building Official in writing, noting all Code violations and other information as required.

(c) **Approved Fabricators.** Special inspections required by this Section and elsewhere in this Code shall not be required where the work is done on the premises of a fabricator approved by the Building Official to perform such work without special inspection. The certificate of approval shall be subject to revocation by the Building Official if it is found that any work done pursuant to the approval is in violation of this Code.

Certificate of Occupancy

Sec. 306. (a) **Use or Occupancy.** No building or structure in Groups A to H, inclusive, shall be used or occupied, and no change in the existing occupancy classification of a building or structure or portion thereof shall be made until the Building Official has issued a Certificate of Occupancy therefor as provided herein.

(b) **Change in Use.** Changes in the character or use of a building shall not be made except as specified in Section 502 of this Code.

(c) **Certificate Issued.** After final inspection when it is found that the building or structure complies with the provisions of this Code, the Building Official shall issue a Certificate of Occupancy which shall contain the following:

1. The building permit number.
2. The address of the building.
3. The name and address of the owner.
4. A description of that portion of the building for which the certificate is issued.
5. A statement that the described portion of the building complies with the requirements of this Code for group

Certificate of Occupancy (Continued)

of occupancy in which the proposed occupancy is classified.

6. The name of the Building Official.

(d) **Temporary Certificate.** A temporary Certificate of Occupancy may be issued by the Building Official for the use of a portion or portions of a building or structure prior to the completion of the entire building or structure.

(e) **Posting.** The Certificate of Occupancy shall be posted in a conspicuous place on the premises and shall not be removed except by the Building Official.

PART II

DEFINITIONS AND ABBREVIATIONS

CHAPTER 4—DEFINITIONS AND ABBREVIATIONS

Definitions

Sec. 401. General. For the purpose of this Code, certain abbreviations, terms, phrases, words and their derivatives shall be construed as specified in this Chapter. Words used in the singular include the plural and the plural the singular. Words used in the masculine gender include the feminine, and the feminine the masculine.

A

Sec. 402. AGRICULTURAL BUILDING is a building located on agricultural property and used to shelter farm implements, hay, grain, poultry, livestock, or other farm produce, in which there is no human habitation, and which is not used by the public.

ALLEY is any public space or thoroughfare less than sixteen feet (16′) but not less than ten feet (10′) in width which has been dedicated or deeded to the public for public use.

ALTER or **ALTERATION** is any change, addition or modification in construction or occupancy.

APARTMENT shall mean a dwelling unit as defined in this Code.

APARTMENT HOUSE is any building, or portion thereof, which is designed, built, rented, leased, let, or hired out to be occupied, or which is occupied as the home or residence of three or more families living independently of each other and doing their own cooking in the said building, and shall include flats and apartments.

APPROVED as to materials and types of construction, refers to approval by the Building Official as the result of investigation and tests conducted by him, or by reason of accepted principles or tests by national authorities, technical or scientific organizations.

APPROVED AGENCY is an established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by the Building Official.

APPROVED FABRICATOR is an established and qualified person, firm, or corporation approved by the Building Official pursuant to Section 305 (c) of this Code.

AREA (See "Floor Area.")

Definitions (Continued)

ASSEMBLY BUILDING is a building or a portion of a building used for the gathering together of 50 or more persons for such purposes as deliberation, worship, entertainment, amusement or awaiting transportation or of 100 or more persons in drinking and dining establishments.

ATTIC STORY is any story situated wholly or partly in the roof, so designated, arranged, or built as to be used for business, storage, or habitation.

B

Sec. 403. **BALCONY** is that portion of the seating space of an assembly room, the lowest part of which is raised four feet (4′) or more above the level of the main floor.

BALCONY, EXTERIOR EXIT. See Section 3301 (c).

BASEMENT is that portion of a building between floor and ceiling, which is partly below and partly above grade (as defined in this Chapter), but so located that the vertical distance from grade to the floor below is less than the vertical distance from grade to ceiling. (See "Story.")

BAY WINDOW is a rectangular, curved, or polygonal window, supported on a foundation extending beyond the main wall of the building.

BOILER ROOM is any room containing a steam or hot water boiler.

BOILER, HIGH PRESSURE is a boiler furnishing steam at pressures in excess of 15 pounds per square inch or hot water at temperatures in excess of 250°F., or at pressures in excess of 160 pounds per square inch.

BOILER, LOW PRESSURE HOT WATER AND LOW PRESSURE STEAM is a boiler furnishing hot water at pressures not exceeding 160 pounds per square inch and at temperatures not more than 250°F., or steam at pressures not more than 15 pounds per square inch.

BUILDING is any structure built for the support, shelter, or enclosure of persons, animals, chattels, or property of any kind.

BUILDING, EXISTING, is a building erected prior to the adoption of this Code, or one for which a legal building permit has been issued.

BUILDING OFFICIAL is the officer charged with the administration and enforcement of this Code, or his regularly authorized deputy.

C

Sec. 404. **CAST STONE** is a precast building stone manufactured from portland cement concrete and used as a trim, veneer, or facing on or in buildings or structures.

Definitions (Continued)

CELLAR is that portion of a building between floor and ceiling which is wholly or partly below grade (as defined in this Chapter) and so located that the vertical distance from grade to the floor below is equal to or greater than the vertical distance from grade to ceiling. (See "Story.")

CENTRAL HEATING PLANT is comfort heating plant equipment installed in such a manner to supply heat by means of ducts or pipes to areas other than the room in which the equipment is located.

CHIEF OF THE FIRE DEPARTMENT is the head of the Fire Department or his regularly authorized deputy.

CITY, as used in this Code, is any political subdivision which adopts this Code for regulation within its jurisdiction.

COURT is a space, open and unobstructed to the sky, located at or above grade level on a lot and bounded on three or more sides by walls of a building.

D

Sec. 405. DEAD LOAD in a building is the weight of the walls, permanent partitions, framing, floors, roofs, and all other permanent stationary construction entering into and becoming a part of the building.

DISPERSAL AREA, SAFE. See Section 3322.

DORMITORY is a room occupied by more than two guests.

DWELLING is any building or any portion thereof, which is not an "Apartment House," "Lodging House" or a "Hotel" as defined in this Code, which contains one or two "Dwelling Units" or "Guest Rooms," used, intended, or designed to be built, used, rented, leased, let, or hired out to be occupied, or which are occupied for living purposes.

DWELLING UNIT is one or more habitable rooms which are occupied or which are intended or designed to be occupied by one family with facilities for living, sleeping, cooking and eating.

E

Sec. 406. EXISTING BUILDING. (See "Building, Existing.")

EXIT. See Section 3301 (c).

EXIT COURT. See Section 3301 (c).

EXIT PASSAGEWAY. See Section 3301 (c).

F

Sec. 407. FAMILY is an individual or two or more persons related by blood or marriage or a group of not more than five persons (excluding servants) who need not be related by blood or marriage living together in a dwelling unit.

FIRE ASSEMBLY. See Section 4306 (b).

Definitions (Continued)

FIRE RESISTANCE or **FIRE-RESISTIVE CONSTRUCTION** is construction to resist the spread of fire, details of which are specified in Chapters 42 and 43 of this Code.

FIRE-RETARDANT TREATED WOOD is lumber or plywood impregnated with chemicals and when tested in accordance with U.B.C. Standard No. 42-1-67 for a period of 30 minutes shall have a flame-spread of not over 25 and show no evidence of progressive combustion. The fire-retardant properties shall not be considered permanent where exposed to the weather.

All material shall bear identification showing the fire performance rating thereof issued by an approved agency having a re-examination service.

FLOOR AREA is the area included within the surrounding exterior walls of a building or portion thereof, exclusive of vent shafts and courts. The floor area of a building, or portion thereof, not provided with surrounding exterior walls shall be the usable area under the horizontal projection of the roof or floor above.

FOOTING is that portion of the foundation of a structure which spreads and transmits loads directly to the soil or the piles.

FRONT OF LOT is the front boundary line of a lot bordering on the street, and in the case of a corner lot may be either frontage.

G

Sec. 408. **GARAGE** is a building or portion thereof in which a motor vehicle containing gasoline, distillate or other volatile, flammable liquid in its tank, is stored, repaired, or kept.

GARAGE, PRIVATE, is a building, or a portion of a building, not more than one thousand square feet (1000 sq. ft.) in area, in which only motor vehicles used by the tenants of the building or buildings on the premises are stored or kept. (See Section 1501.)

GARAGE, PUBLIC, is any garage other than a private garage.

GRADE (Adjacent Ground Elevation) is the lowest point of elevation of the finished surface of the ground between the exterior wall of a building and a point five feet (5′) distant from said wall, or the lowest point of elevation of the finished surface of the ground between the exterior wall of a building and the property line if it is less than five feet (5′) distant from said wall. In case walls are parallel to and within five feet (5′) of a public sidewalk, alley or other public way, the grade shall be the elevation of the sidewalk, alley or public way.

Definitions (Continued)

GRADE (Lumber) is the classification of lumber in regard to strength and utility.

GUEST is any person hiring or occupying a room for living or sleeping purposes.

GUEST ROOM is any room or rooms used, or intended to be used by a guest for sleeping purposes. Every one hundred square feet (100 sq. ft.) of superficial floor area in a dormitory shall be considered to be a guest room.

H

Sec. 409. **HABITABLE ROOM** is any room meeting the requirements of this Code for sleeping, living, cooking or dining purposes excluding such enclosed spaces as closets, pantries, bath or toilet rooms, service rooms, connecting corridors, laundries, unfinished attics, foyers, storage spaces, cellars, utility rooms and similar spaces.

HEIGHT OF BUILDING is the vertical distance from the "Grade" to the highest point of the coping of a flat roof or to the deck line of a mansard roof or to the average height of the highest gable of a pitch or hip roof.

HELIPORT. A heliport is an area of land or water or a structural surface which is used, or intended for use, for the landing and takeoff of helicopters, and any appurtenant areas which are used, or intended for use, for heliport buildings and other heliport facilities.

HELISTOP. A helistop is the same as a heliport, except that no refueling, maintenance, repairs or storage of helicopters is permitted.

HORIZONTAL EXIT. See Section 3301 (c).

HOTEL is any building containing six or more guest rooms intended or designed to be used, or which are used, rented or hired out to be occupied, or which are occupied for sleeping purposes by guests.

I

Sec. 410. **INCOMBUSTIBLE** as applied to building construction material means a material which, in the form in which it is used, is either one of the following:

1. Material of which no part will ignite and burn when subjected to fire. Any material conforming to U.B.C. Standard No. 4-1-67 shall be considered incombustible within the meaning of this Section.

2. Material having a structural base of incombustible material as defined in item No. 1 above, with a surfacing material not over one-eighth inch (⅛") thick which has a flame-spread rating of 50 or less.

"Incombustible" does not apply to surface finish materials. Material required to be incombustible for reduced clearances

Definitions (Continued)

to flues, heating appliances, or other materials shall refer to material conforming to Section No. 1. No material shall be classed as incombustible which is subject to increase in combustibility or flame-spread rating beyond the limits herein established, through the effects of age, moisture or other atmospheric condition.

Flame-spread rating as used herein refers to rating obtained according to tests conducted as specified in U.B.C. Standard No. 42-1-67.

J

Sec. 411. No definitions.

K

Sec. 412. No definitions.

L

Sec. 413. LINTEL is the beam or girder placed over an opening in a wall, which supports the wall construction above.

LIVE LOADS are all loads except dead and lateral loads.

LODGING HOUSE is any building or portion thereof, containing not more than five guest rooms which are used by not more than five guests where rent is paid in money, goods, labor or otherwise. A lodging house shall comply with all the requirements of this Code for dwellings.

M

Sec. 414. MARQUEE is a permanent roofed structure attached to and supported by the building and projecting over public property. Marquees are regulated in Chapter 45.

MASONRY is that form of construction composed of stone, brick, concrete, gypsum, hollow clay tile, concrete block or tile, or other similar building units or materials or combination of these materials laid up unit by unit and set in mortar.

MASONRY, SOLID, is masonry of solid units built without hollow spaces.

MEZZANINE or **MEZZANINE FLOOR** is an intermediate floor placed in any story or room. When the total area of any such "Mezzanine Floor" exceeds 33⅓ per cent of the total floor area in that room, it shall be considered as constituting an additional "Story." The clear height above or below a "Mezzanine Floor" construction shall be not less than seven feet (7').

N

Sec. 415. No definitions.

O

Sec. 416. OCCUPANCY is the purpose for which a building is used or intended to be used. The term shall also include the building or room housing such use. Change of occupancy is not intended to include change of tenants or proprietors.

OCCUPANT LOAD. See Section 3301 (c).

ORIEL WINDOW is a window which projects from the main line of an enclosing wall of a building and is carried on brackets or corbels. **Definitions (Continued)**

Sec. 417. **PANIC HARDWARE.** See Section 3301 (c). **P**

PERSON is a natural person, his heirs, executors, administrators, or assigns, and also includes a firm, partnership, or corporation, its or their successors or assigns, or the agent of any of the aforesaid.

PLATFORM, ENCLOSED, is a partially enclosed portion of an assembly room the ceiling of which is not more than five feet (5′) above the proscenium opening and which is designed or used for the presentation of plays, demonstrations, or other entertainment wherein scenery, drops, decorations, or other effects may be installed or used.

PUBLIC WAY. See Section 3301 (c).

Sec. 418. No definitions. **Q**

Sec. 419. **REPAIR** is the reconstruction or renewal of any part of an existing building for the purpose of its maintenance. The word "Repair" or "Repairs" shall not apply to any change of construction. **R**

Sec. 420. **SHAFT** is a vertical opening through a building for elevators, dumb-waiters, mechanical equipment, or similar purposes. **S**

SHALL as used in this Code, is mandatory.

STAGE is a partially enclosed portion of an assembly building which is designed or used for the presentation of plays, demonstrations, or other entertainment wherein scenery, drops, or other effects may be installed or used, and where the distance between the top of the proscenium opening and the ceiling above the stage is more than five feet (5′).

STAIRWAY. Two or more risers shall constitute a stairway.

STORY is that portion of a building included between the upper surface of any floor and the upper surface of the floor next above, except that the topmost story shall be that portion of a building included between the upper surface of the topmost floor and the ceiling or roof above. If the finished floor level directly above a basement, cellar or unused underfloor space is more than six feet (6′) above grade as defined herein for more than 50 per cent of the total perimeter or is more than twelve feet (12′) above grade as defined herein at any point, such basement, cellar or unused underfloor space shall be considered as a story.

Definitions (Continued)

STREET is any thoroughfare or public space not less than sixteen feet (16') in width which has been dedicated or deeded to the public for public use.

STRUCTURE is that which is built or constructed, an edifice or building of any kind, or any piece of work artificially built up or composed of parts joined together in some definite manner.

STRUCTURE, Residential Patio, is a one-story roofed structure open on one or more sides for use with a Group I or Group J Occupancy exclusive of carports.

T

Sec. 421. No definitions.

U

Sec. 422. U.B.C. STANDARDS is the 1967 Edition of the "Uniform Building Code Standards." (See Chapter 60.)

V

Sec. 423. VALUE or **VALUATION** of a building shall be the estimated cost to replace the building in kind, based on current replacement costs, as determined in Section 303 (a).

VENEER. See Section 2902.

W

Sec. 424. WALLS shall be defined as follows:

Bearing Wall is a wall which supports any load other than its own weight.

Exterior Wall is any wall or element of a wall, or any member or group of members, which defines the exterior boundaries or courts of a building.

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

Nonbearing Wall is a wall which supports no load other than its own weight.

Parapet Wall is that part of any wall entirely above the roof line.

Retaining Wall is any wall used to resist the lateral displacement of any material.

WEATHER-EXPOSED SURFACES are all surfaces of walls, ceilings, floors, roofs, soffits and similar surfaces exposed to the weather excepting the following:

1. Ceilings and roof soffits enclosed by walls or by beams which extend a minimum of twelve inches (12") below such ceiling or roof soffits.

2. Walls or portions of walls within an unenclosed roof area, when located a horizontal distance from an exterior opening equal to twice the height of the opening. **Definitions (Continued)**
3. Ceiling and roof soffits beyond a horizontal distance of ten feet (10′) from the outer edge of the ceiling or roof soffits.

WINDOW. (See "Bay Window"; see "Oriel Window.")

Sec. 425. No definitions. **X**

Sec. 426. YARD is an open, unoccupied space, other than a court, unobstructed from the ground to the sky, except where specifically provided by this Code, on the lot on which a building is situated. **Y**

PART III

REQUIREMENTS BASED ON OCCUPANCY

CHAPTER 5—CLASSIFICATION OF ALL BUILDINGS BY USE OR OCCUPANCY AND GENERAL REQUIREMENTS FOR ALL OCCUPANCIES

Occupancy Classified

Sec. 501. Every building, whether existing or hereafter erected, shall be classified by the Building Official according to its use or the character of its occupancy, as a building of Group A, B, C, D, E, F, G, H, I, or J, as defined in Chapters 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15, respectively. (See Table No. 5-A.)

Any occupancy not mentioned specifically or about which there is any question shall be classified by the Building Official and included in the Group which its use most nearly resembles based on the existing or proposed life and fire hazard.

Change in Use

Sec. 502. No change shall be made in the character of occupancies or use of any building which would place the building in a different division of the same group of occupancy or in a different group of occupancies, unless such building is made to comply with the requirements of this Code for such division or group of occupancy.

EXCEPTION: The character of the occupancy of existing buildings may be changed subject to the approval of the Building Official, and the building may be occupied for purposes in other Groups without conforming to all the requirements of this Code for those Groups, provided the new or proposed use is less hazardous, based on life and fire risk, than the existing use.

No change in the character of occupancy of a building shall be made without a Certificate of Occupancy, as required in Section 306 of this Code.

Mixed Occupancy

Sec. 503. (a) **General.** When a building is used for more than one occupancy purpose each part of the building comprising a distinct "Occupancy," as described in Chapters 5 through 15, shall be separated from any other occupancy as specified in Section 503 (d).

When a building is used for more than one occupancy purpose, it shall be subject to the most restrictive requirements for the occupancies concerned.

EXCEPTIONS: 1. When a one-story building houses more than one occupancy, each portion of the building shall conform to the requirements for the occupancy housed therein. The area of the building shall be such that the sum of the actual areas divided by the allowable area for each separate occupancy shall not exceed one.

Mixed Occupancy (Continued)

2. Where minor accessory uses do not occupy more than 10 per cent of the area of any floor of a building, nor more than 10 per cent of the basic area permitted in the occupancy by Table No. 5-C, the major use of the building shall determine the occupancy classification provided the uses are separated as specified in Section 503 (d).

(b) **Forms of Occupancy Separations.** Occupancy separations shall be vertical or horizontal or both or, when necessary, of such other form as may be required to afford a complete separation between the various occupancy divisions in the building.

(c) **Types of Occupancy Separation.** Occupancy separations shall be classed as "Four-Hour Fire-Resistive," "Three-Hour Fire-Resistive," "Two-Hour Fire-Resistive," and "One-Hour Fire-Resistive." (See U.B.C. Standard No. 30-1-67 for fire dampers in air ducts piercing occupancy separations.)

1. A "Four-Hour Fire-Resistive Occupancy Separation" shall have no openings therein and shall be of not less than four-hour fire-resistive construction.

2. A "Three-Hour Fire-Resistive Occupancy Separation" shall be of not less than three-hour fire-resistive construction. All openings in walls forming such separation shall be protected by a fire assembly having a three-hour fire-resistive rating. The total width of all openings in any three-hour fire-resistive occupancy separation wall in any one story shall not exceed 25 per cent of the length of the wall in that story and no single opening shall have an area greater than one hundred and twenty square feet (120 sq. ft.).

All openings in floors forming a "Three-Hour Fire-Resistive Occupancy Separation" shall be protected by vertical enclosures extending above and below such openings. The walls of such vertical enclosures shall be of not less than two-hour fire-resistive construction and all openings therein shall be protected by a fire assembly having a one and one-half-hour fire-resistive rating.

3. A "Two-Hour Fire-Resistive Occupancy Separation" shall be of not less than two-hour fire-resistive construction. All openings in such separation shall be protected by a fire assembly having a one and one-half-hour fire-resistive rating.

4. A "One-Hour Fire-Resistive Occupancy Separation" shall be of not less than one-hour fire-resistive construction. All openings in such separation shall be protected by a fire assembly having a one-hour fire-resistive rating.

(d) **Fire Ratings for Occupancy Separations.** Occupancy separations shall be provided between the various groups and divisions of occupancies as set forth in Table No. 5-B. Where any occupancy separation is required the minimum shall be a "One-Hour Fire-Resistive Occupancy Separation."

Mixed Occupancy (Continued)

Where the occupancy separation is horizontal, structural members supporting the separation shall be protected by equivalent fire-resistive construction. [See also Subsection 802 (b).]

Location on Property

Sec. 504. (a) **General.** Buildings shall adjoin or have access to a public space, yard, or street on not less than one side. Required yards shall be permanently maintained.

For the purpose of this Section, the center line of an adjoining street or alley shall be considered an adjacent property line.

Eaves over required windows shall be not less than thirty inches (30") from the side and rear property lines. For eaves, see Section 1710.

(b) **Fire Resistance of Walls.** Exterior walls shall have fire resistance and opening protection as set forth in Table No. 5-A, Part III, and in accordance with such additional provisions as are specified in Part IV and Part V. Distance shall be measured at right angles from the property line. The above provisions shall not apply to walls at right angles to the property line.

Projections beyond the exterior wall shall not extend beyond:

1. A point one-third the distance to the property line from an exterior wall; or
2. A point one-third the distance from an assumed vertical plane located where fire-resistive protection of openings is first required due to location on property, whichever is the least restrictive.

When openings in exterior walls are required to be protected due to distance from property line, the sum of the area of such openings shall not exceed 50 per cent of the total area of the wall in each story.

(c) **Buildings on Same Property and Buildings Containing Courts.** For the purpose of determining the required wall and opening protection, buildings on the same property and court walls shall be assumed to have a property line between them.

When a new building is to be erected on the same property with an existing building, the assumed property line from the existing building shall be the distance to the property line for each occupancy as set forth in Table No. 5-A and Part V.

> EXCEPTION: Two or more buildings on the same property may be considered as portions of one building if the aggregate area of such buildings is within the limits specified in Section 505 for a single building.
>
> When the buildings so considered house different occupancies or are of different types of construction, the area shall be that allowed for the most restricted occupancy or construction.

Allowable Floor Areas

Sec. 505. (a) **One-Story Areas.** The area of a one-story building shall not exceed the limits set forth in Table No. 5-C except as provided in Section 506, nor the limits specified in Chapter 16.

For buildings located in Fire Zone No. 3 the basic area may be increased 33⅓ per cent. Basements and cellars need not be included in the total allowable areas provided such basement or cellar does not qualify as a story.

(b) **Areas of Buildings Over One Story.** The total area of all floors of multistory buildings shall not exceed twice the area allowed for one-story buildings. No single floor area shall exceed that permitted for one-story buildings. Basements and cellars need not be included in the total allowable areas.

(c) **Area Separation Walls.** Each portion of a building separated by one or more area separation walls may be considered a separate building provided the area separation walls meet the following requirements:

1. Area separation walls shall be not less than four-hour fire-resistive construction in Types I, II or III buildings and two-hour fire-resistive construction in Types IV or V buildings. The total width of all openings in such walls shall not exceed 25 per cent of the length of the wall in each story. Except as set forth in Table No. 33-B, all openings shall be protected by a fire assembly having a three-hour fire-resistive rating in four-hour fire-resistive walls and one and one-half-hour fire-resistive rating in two-hour fire-resistive walls.

2. Area separation walls need not extend to the outer edges of horizontal projecting elements such as balconies, roof overhangs, canopies, marquees or architectural projections provided the exterior wall at the termination of the area separation wall and the projecting elements above are not less than one-hour fire-resistive construction for a width equal to the depth of the projecting elements. Wall openings within such widths shall be protected by not less than three-fourths-hour fire-resistive assemblies.

3. Area separation walls shall extend from the foundation to a point at least thirty inches (30″) above the roof.

> **EXCEPTIONS:** 1. Area separation walls may terminate at the roof soffit provided the roof is of at least two-hour fire-resistive construction.
>
> 2. Two-hour area separation walls may terminate at the underside of roof sheathing provided that the roof has at least one-hour fire-resistive time period for a width of not less than five feet (5′) on each side of the area separation wall termination.

4. Where an area separation wall separates portions of a building having different heights, such wall may terminate at a point thirty inches (30″) above the lower roof level provided the exterior wall for a height of ten feet (10′) above

Allowable Floor Areas (Continued)

the lower roof is of one-hour fire-resistive construction with openings protected by three-fourths-hour fire-resistive assemblies.

EXCEPTION: The area separation wall may terminate at the sheathing of the lower roof provided the roof is of at least one-hour fire-resistive construction for a width of ten feet (10′) without openings measured from the wall.

See Chapters 6 to 16 inclusive for special occupancy provisions. (See U.B.C. Standard No. 30-1-67 for fire dampers in air ducts piercing area separations.)

Allowable Area Increases

Sec. 506. (a) **General.** The floor areas specified in Section 505 may be increased by one of the following:

1. **Separation on two sides.** Where public space, streets, or yards more than twenty feet (20′) in width extend along and adjoin two sides of the building, floor areas may be increased at a rate of one and one-fourth per cent for each foot by which the minimum width exceeds twenty feet (20′), but the increase shall not exceed 50 per cent.

2. **Separation on three sides.** Where public space, streets, or yards more than twenty feet (20′) in width extend along and adjoin three sides of the building, floor areas may be increased at a rate of two and one-half per cent for each foot by which the minimum width exceeds twenty feet (20′), but the increase shall not exceed 100 per cent.

3. **Separation on all sides.** Where public space, streets or yards, more than twenty feet (20′) in width extend on all sides of a building and adjoin the entire perimeter, floor areas may be increased at a rate of five per cent for each foot by which the minimum width exceeds twenty feet (20′). Such increases shall not exceed 100 per cent, except for buildings not exceeding two stories in height of Group G Occupancy and one-story buildings housing aircraft storage hangars and as further limited in Section 1002 (b) for aircraft repair hangars.

(b) **Unlimited Area.** The area of any one- or two-story building of Group F, Group G and Division 5 of Group E Occupancies shall not be limited, if the building is provided with an approved automatic fire-extinguishing system throughout, as specified in Chapter 38, and entirely surrounded and adjoined by public space, streets or yards not less than sixty feet (60′) in width.

The area of a one-story Type II, Type III, Heavy-Timber or Type III, One-hour, or Type IV building of Group G Occupancy shall not be limited if the building is entirely surrounded and adjoined by public space, streets, or yards not less than sixty feet (60′) in width.

(c) **Automatic Fire-extinguishing Systems.** The area specified in Section 505 may be tripled in one-story buildings and doubled in buildings of more than one story if the building is provided with an approved automatic fire-extinguishing system throughout as specified in Chapter 38. The area increases permitted in this Subsection may be compounded with that specified in paragraph numbered 1, 2, or 3, of Subsection (a) of this Section. Where other provisions of this Code require approved automatic fire-extinguishing systems throughout the increases permitted in this Section shall not apply.

Allowable Area Increases (Continued)

Maximum Height of Buildings and Increases

Sec. 507. The maximum height and number of stories of every building shall be dependent upon the character of the occupancy and the type of construction, and shall not exceed the limits set forth in Table No. 5-D, except as provided in this Section. The height shall be measured from the highest adjoining sidewalk or ground surface, provided that the height measured from the lowest adjoining surface shall not exceed such maximum height by more than ten feet (10').

The limits set forth in Table No. 5-D may be increased by one story if the building is provided with an automatic fire-extinguishing system throughout installed in accordance with the provisions of Chapter 38. The increase in height for sprinklers shall not apply when other provisions of this Code require automatic fire-extinguishing systems throughout or when the increases under Section 506 (c) are used.

EXCEPTIONS: 1. Towers, spires, and steeples, erected as a part of a building and not used for habitation or storage, are limited as to height only by structural design if completely of incombustible materials, or may extend not to exceed twenty feet (20') above the height limit in Table No. 5-D if of combustible materials.

2. The height of one-story aircraft hangars shall not be limited if the building is provided with automatic fire-extinguishing systems throughout as specified in Chapter 38 and is entirely surrounded by public space, streets, or yards not less in width than one and one-half times the height of the building.

See Chapters 6 to 16 inclusive for special occupancy provisions.

Fire-Resistive Substitution

Sec. 508. Where one-hour fire-resistive construction throughout is required by this Code, an approved automatic fire-extinguishing system, as specified in Chapter 38, may be substituted, provided such system is not otherwise required.

(Continued on page 56)

TABLE NO. 5-A—WALL AND OPENING PROTECTION OF OCCUPANCIES BASED ON LOCATION ON PROPERTY

TYPES IV AND V CONSTRUCTION: For exterior wall and opening protection of Types IV and V buildings see table below. Type V construction is not permitted within Fire Zone No. 1. Exceptions to limitation for Type IV and Type V construction, as provided in Sections 1109, 2103 and 2203 apply.

(TYPES I, II, AND III CONSTRUCTION: Exterior walls and protection of openings shall be as specified in Sections 1803, 1903, and 2003.)

GROUP	DESCRIPTION OF OCCUPANCY	FIRE ZONE	FIRE RESISTANCE OF EXTERIOR WALLS	OPENINGS IN EXTERIOR WALLS
A	Any assembly building with a stage and an occupant load of 1000 or more in the building		Permitted in Type I Buildings only [See Section 602 (a)]	
B See also Section 702	1—Any assembly building with a stage and an occupant load of less than 1000 in the building	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 20 feet
	2—Any assembly building without a stage and having an occupant load of 300 or more in the building	2 and 3	2 hour less than 10 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 10 feet
	3—Any assembly building without a stage and having an occupant load of less than 300 in the building, including such buildings used for school purposes less than eight hours per week	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 20 feet
		2	2 hour less than 5 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 10 feet
		3	2 hour less than 5 feet 1 hour less than 10 feet	
	4—Stadiums, reviewing stands, and amusement park structures not included within Group A nor Divisions 1, 2 and 3, Group B, Occupancies	1	2 hour less than 20 feet 1 hour elsewhere	Protected less than 20 feet
		2	1 hour	Protected less than 10 feet
		3	1 hour less than 10 feet	
C See also Section 802	Any building used for school or day-care purposes more than eight hours per week, involving assemblage for instruction, education, or recreation, and not classified in Group A or Divisions 1 and 2, Group B, Occupancies.	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 20 feet
		2	2 hour less than 10 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 10 feet
		3	2 hour less than 5 feet 1 hour less than 10 feet	Not permitted less than 5 feet

NOTES: (1) See Section 504 for type of walls affected and requirements covering percentage of openings permitted in exterior walls.
(2) For additional restrictions see Chapters under Occupancy, Fire Zones, and Types of Construction.
(3) For walls facing streets, yards and public ways see Part V.
(4) Openings shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating.

TABLE NO. 5-A—Continued

D See also Section 902	1—Mental hospitals, mental sanitariums, jails, prisons, reformatories, houses of correction, and buildings where personal liberties of inmates are similarly restrained		Permitted in Type I and II Buildings only [See Section 902 (b)]	
	2—Nurseries for full-time care of children under kindergarten age. Hospitals, sanitariums, nursing homes with nonambulatory patients, and similar buildings (each accommodating more than five persons)	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 20 feet
		2 and 3	2 hour less than 5 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 10 feet
	3—Nursing homes for ambulatory patients, homes for children of kindergarten age or over (each accommodating more than five persons)	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 3 feet Protected less than 20 feet
		2 and 3	1 hour	Not permitted less than 3 feet Protected less than 10 feet
E See also Section 1002	1—Storage and handling of hazardous and highly inflammable or explosive materials other than flammable liquids		Not permitted in Fire Zones Nos. 1 and 2	
		3	4 hour less than 5 feet 2 hour less than 10 feet 1 hour less than 20 feet	Not permitted less than 5 feet Protected less than 20 feet
	2—Storage and handling of Class I, II and III flammable liquids, as specified in U.B.C. Standard No. 9-1-67; dry cleaning plants using flammable liquids, paint stores with bulk handling; paint shops and spray painting rooms and shops 3—Woodworking establishments, planing mills and box factories; shops, factories where loose, combustible fibers or dust are manufactured, processed, or generated; warehouses where highly combustible material is stored 4—Repair garages	1	4 hour less than 20 feet 1 hour elsewhere	
		2	4 hour less than 5 feet 2 hour less than 10 feet 1 hour elsewhere	
		3	4 hour less than 5 feet 2 hour less than 10 feet 1 hour less than 20 feet	
	5—Aircraft repair hangars		Not permitted in Fire Zones Nos. 1 and 2 except as set forth in Sections 1602 (c) and 1603 (c).	
		3	1 hour less than 60 feet	Protected less than 60 feet
F See also Section 1102	1—Gasoline and service stations, storage garages where no repair work is done except exchange of parts and maintenance requiring no open flame, welding, or the use of highly flammable liquids	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 20 feet
	2—Wholesale and retail stores, office buildings, drinking and dining establishments having an occupant load of less than 100, printing plants, municipal police and fire stations, factories and workshops using material not highly flammable or combustible, storage and sales rooms for combustible goods, paint stores without bulk handling See Section 402 for definition of Assembly Buildings	2	1 hour	Not permitted less than 5 feet Protected less than 10 feet
		3	1 hour less than 10 feet	
	3—Aircraft hangars where no repair work is done except exchange of parts and maintenance requiring no open flame, welding, or the use of highly flammable liquids Open parking garages. (For requirements, see Section 1109.)	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 5 feet Protected less than 20 feet
		2	1 hour	
		3	1 hour less than 20 feet	

See Notes, page 50.

TABLE NO. 5-A—Continued

GROUP	DESCRIPTION OF OCCUPANCY	FIRE ZONE	FIRE RESISTANCE OF EXTERIOR WALLS	OPENINGS IN EXTERIOR WALLS
G	Ice plants, power plants, pumping plants, cold storage, and creameries, factories and workshops using incombustible and nonexplosive materials. Storage and sales rooms of incombustible and nonexplosive materials	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 3 feet Protected less than 20 feet
		2	1 hour	Not permitted less than 3 feet Protected less than 10 feet
		3	1 hour less than 3 feet	Not permitted less than 3 feet
H See also Section 1302	Hotels and apartment houses Convents, monasteries (each accommodating more than 10 persons)	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 3 feet Protected less than 20 feet
		2	1 hour	Not permitted less than 3 feet Protected less than 10 feet
		3	1 hour less than 5 feet	Not permitted less than 3 feet
I	Dwellings and lodging houses	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 3 feet Protected less than 20 feet
		2	1 hour	Not permitted less than 3 feet Protected less than 10 feet
		3	1 hour less than 3 feet	Not permitted less than 3 feet
J	1—Private garages, carports, sheds and agricultural buildings used as accessories only when not over 1000 square feet in area	1	2 hour less than 20 feet 1 hour elsewhere	Not permitted less than 3 feet Protected less than 20 feet
		2	1 hour	Not permitted less than 3 feet Protected less than 10 feet
		3	1 hour less than 3 feet (Or may be protected on the exterior with materials approved for 1 hour fire-resistive construction)	Not permitted less than 3 feet
	2—Fences over 6 feet high, tanks and towers	1	Incombustible construction not regulated Combustible construction not permitted	
		2	Incombustible construction not regulated Combustible construction to be 1-hour fire-resistive	
		3	Not regulated	

See Notes, page 50.

TABLE NO. 5-B—REQUIRED SEPARATIONS IN BUILDINGS OF MIXED OCCUPANCY

(In Hours)

GROUP	A	B	C	D	E-1	E-2[1]	E-3	E-4-5	F-1	F-2	F-3	G	H	I	J
A	N	N	N	3	4	4	4	4	4	3	3	3	1	1	1
B		N	N	3	4	4	4	4	3	1	1	1	1	1	1
C			N	1	4	4	4	4	4	1	1	1	1	1	1
D				N	4	4	4	4	4[2]	2	4	4	1	1	3
E-1					N	1	1	1	2	2	2	2	4	4	1
E-2						N	1	1	1	1	1	1	3	3	1
E-3							N	1	1	1	1	1	3	3	1
E-4-5								N	1	1	1	1	3	3	1
F-1									N	1	1	1	3[3]	1	1
F-2										N	1	1	1	N	1
F-3											N	1	1	N	1
G												N	1	N	N
H													N	N	1
I														N	1[4]
J															N

[1]Where an approved spray booth, constructed in accordance with Chapter 53, is installed, such booth need not be separated from other Group E Occupancies or from Groups F and G Occupancies.

[2]A three-hour occupancy separation is permitted provided the Group F, Division 1 Occupancy is a garage used only for the parking of passenger motor vehicles having a capacity of not more than nine persons per vehicle and no repair work or fueling is done.

[3]A one-hour occupancy separation is permitted provided the Group F, Division 1 Occupancy is a garage used only for the parking of passenger motor vehicles having a capacity of not more than nine persons per vehicle, no repair work or fueling is done and the area does not exceed three thousand square feet (3000 sq. ft.) in a building.

[4]Provided that materials as approved for one-hour fire-resistive construction on the garage side and a self-closing, tight-fitting solid wood door one and three-eighths inches (1⅜") in thickness, shall be permitted. Fire dampers shall not be required in ducts which pierce this separation provided such ducts are constructed of not less than No. 26 gauge galvanized iron or steel.

TABLE NO. 5-C—BASIC ALLOWABLE FLOOR AREA FOR BUILDINGS ONE STORY IN HEIGHT IN FIRE ZONES NO. 1 AND NO. 2. FOR BUILDINGS LOCATED IN FIRE ZONE NO. 3 THE BASIC AREA MAY BE INCREASED 33⅓ PER CENT

(In Square Feet)

OCCUPANCY	TYPES OF CONSTRUCTION							
	I	II	III		IV		V	
			1-Hour or H.T.	N	1-Hour	N	1-Hour	N
A	Unlimited	Not Permitted						
B) 1-2	Unlimited	13,500	10,100	Not Permitted	10,100	Not Permitted	7900	Not Permitted
B) 3-4	Unlimited	13,500	10,100	6800	10,100	6800	7900	4500
C	Unlimited	20,300	15,200	10,100	15,200	10,100	11,800	6800
D) 1	Unlimited	6800	Not Permitted[1]					
D) 2-3	Unlimited	6800	5100	Not Permitted	5100	Not Permitted	3900	Not Permitted
E) 1-2[2]	11,250	5600	4200	2800	4200	2800	3300	1900
E) 3-4-5[2]	Unlimited	11,300	8400	5600	8400	5600	6600	3800
F) 1-2-3	Unlimited	18,000	13,500	9000	13,500	9000	10,500	6000
G	Unlimited	27,000	20,300	13,500	20,300	13,500	15,800	9000
H	Unlimited	13,500	10,100	6800[3]	10,100	6800[3]	7900	4500[3]
I	Unlimited							
J	See Chapter 15							

N.—No general requirements for fire resistance.
H.T.—Heavy Timber.
[1]See Section 902 (b).
[2]For additional limitations in Fire Zones No. 1 and No. 2 see Sections 1602 and 1603.
[3]Areas above the first floor shall not exceed three thousand square feet (3000 sq. ft.).

TABLE NO. 5-D—MAXIMUM HEIGHT OF BUILDINGS

OCCUPANCY	TYPES OF CONSTRUCTION							
	I	II	III		IV		V	
			1-Hr. or H.T.	N	1-Hour	N	1-Hour	N
	MAXIMUM HEIGHT IN FEET							
	Unlimited	95	65	55	65	55	50	40
	MAXIMUM HEIGHT IN STORIES							
A	Unlimited	Not Permitted						
B) 1-2	Unlimited	4	2	Not Permitted	2	Not Permitted	2	Not Permitted
B) 3-4	Unlimited	4	2	1	2	1	2	1
C[1]	Unlimited	4[1]	2[1]	1	2[1]	1	2[1]	1
D) 1	Unlimited	2	Not Permitted[2]					
D) 2	Unlimited	3	1	Not Permitted	1	Not Permitted	1	Not Permitted
D) 3	Unlimited	3	2	Not Permitted	2	Not Permitted	2	Not Permitted
E) 1	Unlimited	2	1	1	1	1	1	1
E) 2-3-4-5	Unlimited	2	2	1	2	1	2	1
F) 1-2-3	Unlimited	6	4	2	4	2	3	2
G	Unlimited	6	4	2	4	2	3	2
H	Unlimited	5	4	2[3]	4	2[3]	3	2[3]
I	Unlimited	3	3	3	3	3	3	3
J	See Chapter 15							

[1]See Section 802 (b).
[2]See Section 902 (b).
[3]Areas above the first floor shall not exceed three thousand square feet (3000 sq. ft.). [See Section 1302 (b).]

N.—No general requirements for fire resistance.
H. T.—Heavy Timber.

Arcades

Sec. 509. Arcades connecting buildings and used exclusively as passageways need not be considered as adjacent buildings for the provisions of this Chapter, provided that the walls of the building adjoining the arcades are finished with the same construction as required for the exterior walls of the building, with no communicating openings between the arcades and the building, except doors; and provided that the arcades are of not less than one-hour fire-resistive construction or entirely of incombustible materials, or of heavy timber construction with two-inch (2") nominal sheathing.

CHAPTER 6—REQUIREMENTS FOR GROUP A OCCUPANCIES

Group A Occupancies Defined

Sec. 601. Group A Occupancies shall be:

Any assembly building with a stage and an occupant load of 1000 or more in the building.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 602. (a) **General.** Buildings or parts of buildings classed in Group A because of the use or character of the occupancy shall be of Type I construction and shall not be limited as to location in fire zones, occupant load, height, or area.

(b) **Special Provisions.** Stages and enclosed platforms as defined in Sections 417 and 420 shall be constructed in accordance with Chapter 39.

The slope of the main floor of the assembly room shall not exceed one in five.

Location on Property

Sec. 603. Buildings housing Group A Occupancies shall front directly upon or have access to a public street not less than twenty feet (20′) in width. The access to the public street shall be a minimum twenty-foot (20′) wide right-of-way unobstructed and maintained only as access to the public street. The main entrance to the building shall be located on the public street or on the access way. The main assembly floor shall be located at or near the adjacent ground level.

For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 1803.

Exit Facilities

Sec. 604. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3315.)

Light, Ventilation, and Sanitation

Sec. 605. All portions of Group A Occupancies customarily used by human beings and all dressing rooms shall be provided with light and ventilation by means of windows or skylights with an area not less than one-eighth of the total floor area, one-half of which shall be openable, or shall be provided with artificial light and a mechanically operated ventilating system. The mechanically operated ventilating system shall supply a minimum of five cubic feet per minute of outside air with a total circulated of not less than 15 cubic feet per minute per occupant in all portions of the building and such system shall be kept continuously in operation during such time as the building is occupied. If the velocity of the air at the register exceeds 10 feet per second, the register shall be placed more than eight feet (8′) above the floor directly beneath.

Lights in all parts of the building customarily used by human beings shall be on a separate circuit from that of the

Light, Ventilation, and Sanitation (Continued)

stage and shall be controlled from the box office. All lights in corridors, exit courts and exit passageways shall be protected by a wire cage.

All registers or vents supplying air backstage shall be equipped with automatic closing devices with fusible links. Such closing devices shall be located where the vents or ducts pass through the proscenium walls and shall be operated by fusible links located on both sides of the proscenium wall and both inside of and outside of the vent or duct.

There shall be provided in an approved location at least one lavatory for each two toilets for each sex, and at least one drinking fountain for each floor level.

For requirements for floors and walls of toilet compartments, see Section 1711.

Enclosure of Vertical Openings

Sec. 606. Exits shall be enclosed as specified in Chapter 33. (For specific requirements see Section 3315.)

Elevator shafts, vent shafts, and other vertical openings shall be enclosed and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 607. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 608. Stages shall be equipped with automatic ventilators as required in Section 3901.

Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

Motion picture machine booths shall conform to the requirements of Chapter 40.

Proscenium curtains shall conform to the requirements set forth in U.B.C. Standard No. 6-1-67.

Flammable liquids shall not be placed or stored in any Group A Occupancy.

Every gas service to the stage portion of the building shall be separated from any other service to the building and each building shall be provided with an approved shutoff valve at a convenient and conspicuous place outside the building and adequately marked.

All exterior openings in a boiler room or room containing central heating equipment if located below openings in another story or if less than ten feet (10′) from other doors or windows of the same building shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating. Such fire assemblies shall be fixed, automatic, or self-closing.

Every room containing a boiler or a central heating plant shall be separated from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5 with all openings protected as set forth in Table No. 33-B.

Special Hazards (Continued)

Sec. 609. Gymnasiums and similar occupancies may have running tracks constructed of wood or unprotected steel or iron.

Exceptions and Deviations

CHAPTER 7—REQUIREMENTS FOR GROUP B OCCUPANCIES

Group B Occupancies Defined

Sec. 701. Group B Occupancies shall be:

Division 1. Any assembly building with a stage and an occupant load of less than 1000 in the building.

Division 2. Any assembly building without a stage and having an occupant load of 300 or more in the building.

Division 3. Any assembly building without a stage and having an occupant load of less than 300 in the building, including such buildings used for school purposes less than eight hours per week.

Division 4. Stadiums, reviewing stands, and amusement park structures not included within Group A nor Divisions 1, 2, and 3, Group B Occupancies. Specific and general requirements for grandstands, bleachers and reviewing stands are to be found in Chapter 33.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 702. (a) **General.** Buildings or parts of buildings classed in Group B because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

> EXCEPTION: Division 4 structures of open skeleton frame type without roof, cover, or enclosed usable spaces, shall not be limited in area or height.

(b) **Special Provisions.** Stages and enclosed platforms as defined in Sections 417 and 420 shall be constructed in accordance with Chapter 39.

A fire-resistive ceiling shall not be required in one-story buildings of Type III, IV, or V construction having an open frame roof. Division 2 Occupancies with an occupant load of 1000 or more shall be of Type I, II, or III construction.

> EXCEPTION: Gymnasiums which have not more than two balconies, each with an occupant load not to exceed 300, and which are not located over usable spaces, need not have one-hour fire-resistive protection.

Division 3 Occupancies located in a basement or above the first story shall be of not less than one-hour fire-resistive construction.

Group B assembly rooms having an occupant load of 1000 or more shall not be located in the basement.

Division 3 Occupancies with an occupant load of 50 or more, which are located over usable space, shall be separated from such space by not less than one-hour fire-resistive construction.

Construction, Height, and Area Allowable (Continued)

For attic space partitions and draft stops see Section 3205.

(c) **Division 4 Provisions.** Erection and structural maintenance of structures housing Division 4 Occupancies shall conform to the requirements of this Code, and where there are no such specific requirements, shall provide adequate safety for the loads to which they may be subjected.

Structures housing Division 4 Occupancies, other than those of open skeleton frame type, when more than one story in height or four hundred square feet (400 sq. ft.) in area, shall be of not less than one-hour fire-resistive construction.

When the space under a Division 4 Occupancy is used for any purpose, it shall be separated from all parts of such Division 4 Occupancy, including exits, by walls, floors, and ceilings of not less than one-hour fire-resistive construction.

> EXCEPTION: The underside of continuous steel deck grandstands when erected outdoors need not be fire-protected when occupied for public toilets.

The Building Official may cause all Division 4 structures to be re-inspected at least once every six months.

Location on Property

Sec. 703. All buildings housing Group B Occupancies shall front directly upon or have access to a public street not less than twenty feet (20′) in width. The access to the public street shall be a minimum twenty-foot (20′) wide right-of-way unobstructed and maintained only as access to the public street. The main entrance to the building shall be located on the public street or on the access way.

For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Exit Facilities

Sec. 704. (a) **General.** Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3316.)

(b) **Amusement Structures.** Stairs and exits for Division 4 amusement structures shall be provided as specified in Chapter 33, subject to the approval of the Building Official. Exit signs shall be installed as specified in Section 3312 and where required by the Building Official.

Light, Ventilation, and Sanitation

Sec. 705. All portions of Group B Occupancies customarily used by human beings and all dressing rooms shall be provided with natural or artificial light, ventilation, and sanitary facilities as specified in Sections 605 and 1711.

Enclosure of Vertical Openings

Sec. 706. Exits shall be enclosed as specified in Chapter 33. (For specific requirements see Section 3316.)

Elevator shafts, vent shafts, and other vertical openings shall be enclosed, and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 707. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 708. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

Motion picture machine booths shall conform to the requirements of Chapter 40.

Proscenium curtains shall conform to the requirements set forth in U.B.C. Standard No. 6-1-67.

Flammable liquids shall not be placed or stored in a Group B Occupancy.

Each building shall be provided with an approved outside gas shutoff valve conspicuously marked.

All exterior openings in a boiler room or rooms containing central heating equipment if located below openings in another story or if less than ten feet (10′) from other doors or windows of the same building shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating. Such fire assemblies shall be fixed, automatic, or self-closing.

Every room containing a boiler or a central heating plant shall be separated from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation, as defined in Chapter 5, with all openings protected as set forth in Table No. 33-B.

Exceptions and Deviations

Sec. 709. Gymnasiums and similar occupancies may have running tracks constructed of wood or unprotected steel or iron.

In gymnasiums and in multipurpose schoolrooms having an area not greater than thirty-two hundred square feet (3200 sq. ft.), one-inch (1″) nominal tight tongue-and-grooved or three-fourths-inch (¾″) plywood wall covering may be used on the inner side in lieu of fire-resistive plaster.

CHAPTER 8—REQUIREMENTS FOR GROUP C OCCUPANCIES

Group C Occupancies Defined

Sec. 801. Group C Occupancies shall be:

Any building used for school or day-care purposes more than eight hours per week, involving assemblage for instruction, education, or recreation, and not classed in Group A Occupancies or in Divisions 1 and 2 of Group B Occupancies.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 802. (a) **General.** Buildings or parts of buildings classed in Group C because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

(b) **Special Provisions.** Rooms having an occupant load of more than 100, and rooms used for kindergarten, first- or second-grade pupils, shall not be located above the first story above grade except in buildings of Type I construction.

Laboratories, woodworking and metalworking shops, machine shops, paint shops, storage rooms, and similar areas shall be separated from each other and from classrooms by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5.

Where there is usable space under the first floor of two-story Types III, IV, and V buildings, the construction up to and including the first floor shall be of Type I construction, and the first floor shall be unpierced for human access.

Balconies and bleachers over usable space and all janitor closets shall be protected with materials approved for one-hour fire-resistive construction.

All curtains, drops, and drapes shall be flame-proofed.

Stages and enclosed platforms shall be constructed in accordance with Chapter 39.

The provisions of Section 1803 (b) shall not apply to openings in buildings not more than three stories high when such openings are not less than thirty feet (30′) from adjacent property lines and not less than thirty feet (30′) from buildings on the same property.

For attic space partitions and draft stops, see Section 3205.

Location on Property

Sec. 803. (a) **General.** All buildings housing Group C Occupancies shall front directly upon or have access to a public street not less than twenty feet (20′) in width. The access to the public street shall be a minimum twenty-foot (20′) wide right-of-way unobstructed and maintained only as access to the public street. At least one required exit shall be located on the public street or on the access way.

For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Location on Property (Continued)

(b) **Special Provision.** Exterior walls or parts of walls of Group C Occupancies having an occupant load of less than 100 persons, when within ten feet (10′) of adjacent property lines, may be of one-hour fire-resistive construction.

Exit Facilities

Sec. 804. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3317.)

Light, Ventilation, and Sanitation

Sec. 805. All portions of Group C Occupancies shall be provided with light and ventilation, either natural or artificial, as specified in Section 605.

Toilets shall be provided on the basis of the following ratios of toilets to the number of students:

	Boys	Girls
Elementary Schools	1:100	1:35
Secondary Schools	1:100	1:45
Colleges and Universities	1:100	1:60

In addition, urinals shall be provided for boys on the basis of 1:30 in elementary and secondary schools and 1:110 in colleges and universities.

There shall be provided at least one lavatory for each two toilets or urinals for each sex, and at least one drinking fountain on each floor for elementary and secondary schools. The ratio for lavatories in colleges and universities shall be 1:100 for girls, 1:150 for boys.

For requirements for floors and walls of toilet compartments, see Section 1711.

Enclosure of Vertical Openings

Sec. 806. Exits shall be enclosed as specified in Chapter 33. (For specific requirements see Section 3317.)

Elevator shafts, vent shafts, and other vertical openings shall be enclosed, and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 807. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 808. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

Motion picture machine booths shall conform to the requirements of Chapter 40.

Each building shall be provided with an approved outside gas shutoff valve conspicuously marked.

All exterior openings in a boiler room or rooms containing central heating equipment if located below openings in another story or if less than ten feet (10′) from other doors or windows of the same building shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating. Such fire assemblies shall be fixed, automatic, or self-closing.

Special Hazards (Continued)

Every room containing a boiler or a central heating plant shall be separated from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5 with all openings protected as set forth in Table No. 33-B.

When the opening for a heater or equipment room is protected by a pair of fire doors, the inactive leaf shall be normally secured in the closed position and shall be openable only by the use of a tool. An astragal shall be provided and the active leaf shall be self-closing.

No flammable liquids shall be placed, stored, or used in any Group C Occupancies, except in approved quantities as necessary in laboratories and approved utility rooms, and such liquids shall be kept in tight or sealed containers when not in actual use.

Exceptions and Deviations

Sec. 809. For requirements for gymnasiums and similar buildings, see Section 709.

Roof covering shall be a "fire-retardant" roofing as specified in Section 3203.

A building which will have only the first floor accessible to not more than 20 pupils at any time, may be used for school purposes with the following exceptions to Code requirements:

1. Exterior walls or parts of walls which are less than three feet (3') from adjacent property lines shall have no openings therein and shall be of not less than one-hour fire-resistive construction as specified in Chapter 43.

2. Classrooms may have only one exit not less than three feet (3') wide.

CHAPTER 9—REQUIREMENTS FOR GROUP D OCCUPANCIES

Group D Occupancies Defined

Sec. 901. Group D Occupancies shall be:

Division 1. Mental hospitals, mental sanitariums, jails, prisons, reformatories, and buildings where personal liberties of inmates are similarly restrained.

Division 2. Nurseries for the full-time care of children under kindergarten age (each accommodating more than five persons).

Hospitals, sanitariums, nursing homes with nonambulatory patients and similar buildings (each accommodating more than five persons).

Division 3. Nursing homes for ambulatory patients, homes for children of kindergarten age or over (each accommodating more than five persons).

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

> EXCEPTION: Group D Occupancies shall not include buildings used only for private residential purposes or for a family group .

Construction, Height, and Area Allowable

Sec. 902. (a) **General.** Buildings or parts of buildings classed in Group D because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

(b) **Special Provisions.** Division 1 Occupancies shall be housed in buildings of Type I or Type II construction.

> EXCEPTION: One-story buildings of Type III-one hour, IV-one hour or V-one hour construction may be permitted provided the floor area does not exceed thirty-nine hundred square feet (3900 sq. ft.) between separation walls of two-hour fire-resistive construction with openings protected by fire assemblies having one and one-half-hour fire-resistive ratings. See Subsection 3318 (g) for limitation on locking devices.

Occupancies in which the personal liberties of inmates or patients are restrained within the building shall have floors of incombustible construction.

For attic space partitions and draft stops, see Section 3205.

Location on Property

Sec. 903. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Exit Facilities

Sec. 904. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3318.)

Light, Ventilation, and Sanitation

Sec. 905. All portions of Group D Occupancies customarily used by human beings shall be provided with light and ventilation by means of windows or skylights with an area equal to one-eighth of the total floor area, one-half of which shall be openable, or shall be provided with artificial light and a mechanically operated ventilating system as specified in Section 605.

For requirements for floors and walls of toilet compartments see Section 1711.

Enclosure of Vertical Openings

Sec. 906. Exits shall be enclosed as specified in Chapter 33. (For specific requirements see Section 3318.)

Elevator shafts, vent shafts, and other vertical openings shall be enclosed, and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 907. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 908. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

Motion picture machine booths shall conform to the requirements of Chapter 40.

Storage of volatile flammable liquids shall not be allowed in Group D Occupancies and the handling of such liquid shall not be permitted in any Group D Occupancies in quantities of more than one gallon unless such handling complies with U.B.C. Standard No. 9-1-67.

Each building shall be provided with an approved outside gas shutoff valve conspicuously marked.

All exterior openings in a boiler room or room containing central heating equipment if located below openings in another story, or if less than ten feet (10′) from other doors or windows of the same building, shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating. Such fire assemblies shall be fixed, automatic, or self-closing.

Every room containing a boiler or a central heating plant shall be separated from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5 with all openings protected as set forth in Table No. 33-B.

> **EXCEPTION:** When the opening for a heater or equipment room is protected by a pair of fire doors, the inactive leaf shall be normally secured in the closed position and shall be openable only by the use of a tool. An astragal shall be provided and the active leaf shall be self-closing.

CHAPTER 10—REQUIREMENTS FOR GROUP E OCCUPANCIES

Group E Occupancies Defined

Sec. 1001. Group E Occupancies shall be:

Division 1. Storage and handling of hazardous and highly flammable or explosive materials other than flammable liquids.

Division 2. Storage and handling of Class I, II, and III flammable liquids, as set forth in U.B.C. Standard No. 9-1-67; dry cleaning plants using flammable liquids, paint stores with bulk handling; paint shops and spray painting rooms and shops.

Division 3. Woodworking establishments, planing mills and box factories; shops, factories where loose, combustible fibers or dust are manufactured, processed or generated; warehouses where highly combustible material is stored.

Division 4. Repair garages.

Division 5. Aircraft repair hangars.

For occupancy separations see Table No. 5-B. Where an approved spray booth constructed as specified in Chapter 53 is installed, such booth need not be separated from other Group E or Groups F and G Occupancies.

For occupant load see Section 3301.

Note: Highly flammable liquids shall be deemed to be those with a flash point below 190°F. as determined by the closed cup tester, provided that liquids with a flash point above 138.5°F. shall not be deemed to be highly flammable when used in a closed safety cleaning system meeting the requirements of U.B.C. Standard No. 10-1-67 for a Class III rating.

Construction, Height, and Area Allowable

Sec. 1002. (a) **General.** Buildings or parts of buildings classed in Group E because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

(b) **Special Provisions.** Division 5 occupancies shall have exterior walls of not less than one-hour fire-resistive construction or shall be surrounded by public space, streets, or yards, not less than sixty feet (60') in width.

The area increases allowed by Section 506 (a) shall not exceed 500 per cent for aircraft repair hangars.

In public garages and where flammable or explosive liquids are used or stored floors shall be entirely protected with incombustible materials against saturation.

In buildings over ninety-five feet (95') in height, the structural frame shall be protected with not less than four-hour fire-resistive protection and the floors shall be of not less than three-hour fire-resistive construction.

Construction, Height, and Area Allowable (Continued)

For attic space partitions and draft stops see Section 3205.

A Division 4 occupancy having a floor area not exceeding twenty-five hundred square feet (2500 sq. ft.) shall have exterior walls of not less than two-hour fire-resistive construction when less than five feet (5′) from a property line and of not less than one-hour fire-resistive construction when more than five feet (5′) but less than ten feet (10′) from a property line, when located in Fire Zone No. 3.

Location on Property

Sec. 1003. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Exit Facilities

Sec. 1004. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3319.)

Where ramps are used for the transfer of automobiles from one floor to another such ramps shall meet the ground floor level at a point not less than twenty feet (20′) from the exit from such building.

Light, Ventilation, and Sanitation

Sec. 1005. All portions of Group E Occupancies customarily used by human beings shall be provided with light and ventilation by means of windows or skylights with an area equal to one-eighth of the total floor area, one-half of which shall be openable, or shall be provided with artificial light and a mechanically operated ventilating system as specified in Section 605.

In all buildings used for the storing or handling of automobiles operated under their own power, and in all buildings where flammable liquids are used, exhaust ventilation shall be provided sufficient to produce one complete change of air every 15 minutes. Such exhaust ventilation shall be taken from a point at or near the floor level.

> EXCEPTION: In public garages and aircraft hangars not exceeding an area of five thousand square feet (5000 sq. ft.), the Building Official may authorize the omission of such ventilating equipment where, in his opinion, the building is supplied with unobstructed openings to the outer air which are sufficient to provide the necessary ventilation.

Every building or portion thereof where persons are employed shall be provided with at least one toilet. Every building and each subdivision thereof where both sexes are employed shall be provided with access to at least two toilets located either in such building or conveniently in a building adjacent thereto on the same property. All toilet rooms shall be provided with an exterior window at least three square feet (3 sq. ft.) in area, fully openable; or a vertical duct not less

Light, Ventilation, and Sanitation (Continued)

than one hundred square inches (100 sq. in.) in area for the first toilet facility with an additional fifty square inches (50 sq. in.) for each additional toilet facility; or a mechanically operated exhaust system which is connected to the light switch, capable of providing a complete change of air every 15 minutes. Such systems shall be vented to the outside air and at the point of discharge shall be at least five feet (5′) from any openable window.

For requirements for floors and walls of toilet compartments, see Section 1711.

Enclosure of Vertical Openings

Sec. 1006. Exits shall be enclosed as specified in Chapter 33. (For specific requirements see Section 3319.)

Elevator shafts, vent shafts, and other vertical openings shall be enclosed, and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Doors which are part of an automobile ramp enclosure may be kept normally open but shall be equipped with fusible links and so arranged as to be self-closing when released.

Fire-Extinguishing Systems

Sec. 1007. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 1008. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

Each building shall be provided with an approved outside gas shutoff valve conspicuously marked.

Every boiler room or room containing a heating plant shall be separated from the rest of the building by a Four-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5.

> **EXCEPTION:** In Divisions 4 and 5, unit heaters may be installed provided they are at least seven feet (7′) above the floor.

In any room in which volatile flammable liquids are used or stored no device generating a glow or flame capable of igniting gasoline vapor shall be installed or used within twenty-four inches (24″) of the floor.

The use, handling, storage, and sale of gasoline, fuel oil, and other flammable liquids shall not be permitted in any Group E Occupancy unless such use, handling, storage, and sale comply with U.B.C. Standard No. 9-1-67.

Dry cleaning plants in which highly flammable solvents are used or stored shall be of Type I construction and shall not exceed one story in height. All partitions shall be of four-hour fire-resistive construction, except for the necessary openings

Special Hazards (Continued)

for the vent ducts, piping, and shafting. All openings in exterior walls except wall vents shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating. Such fire assemblies shall be fixed, automatic, or self-closing. Wall vents having an area of not less than sixteen square inches (16 sq. in.) each, shall be placed in the exterior walls near the floor line, not more than six feet (6′) apart horizontally. Each building shall be provided with a power-driven fan exhaust system of ventilation which shall be arranged and operated so as to produce a complete change of air in each room every three minutes.

Each machine in dry cleaning establishments which uses a volatile flammable liquid shall have an adequate steam line directly connected to it, so arranged as to have the steam automatically released to the inside of such machine should an explosion occur in the machine.

Equipment or machinery which generates or emits combustible or explosive dust or fibers shall be provided with an adequate dust collecting and exhaust system installed in conformance with U.B.C. Standard No. 10-2-67, unless the building or portion thereof housing such machinery is provided with an automatic fire-extinguishing system conforming to the provisions of Chapter 38. The fire-extinguishing system for such occupancies having a floor area of less than three thousand square feet (3000 sq. ft.) may be a type conforming to the provisions of Exception 2, Section 3802.

CHAPTER 11—REQUIREMENTS FOR GROUP F OCCUPANCIES

Group F Occupancies Defined

Sec. 1101. Group F Occupancies shall be:

Division 1. Gasoline service stations, storage garages where no repair work is done except exchange of parts and maintenance requiring no open flame, welding, or the use of highly flammable liquids.

Division 2. Wholesale and retail stores, office buildings, drinking and dining establishments having an occupant load of less than 100, printing plants, municipal police and fire stations, factories and workshops using materials not highly flammable or combustible, storage and sales rooms for combustible goods, paint stores without bulk handling. (See Section 402, for definition of Assembly Buildings.)

Division 3. Aircraft hangars where no repair work is done except exchange of parts and maintenance requiring no open flame, welding, or the use of highly flammable liquids.

Open parking garages.

Heliports.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 1102. (a) **General.** Buildings or parts of buildings classed in Group F because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

(b) **Special Provisions.** Motor vehicle service stations including canopies and supports over pumps shall be incombustible or of one-hour fire-resistive construction.

> EXCEPTION: Roofs of one-story service stations may be of heavy-timber construction.

In storage garages and motor vehicle service stations, floors shall be entirely protected against saturation.

Storage areas in excess of one thousand square feet (1000 sq. ft.), in connection with wholesale or retail sales, shall be separated from the public areas by a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5. Such areas may be increased to three thousand square feet (3000 sq. ft.) when sprinklers, not otherwise required, are installed in the storage area.

> EXCEPTION: A One-Hour Fire-Resistive Occupancy Separation is not required where an approved automatic fire-extinguishing system is installed throughout the building. Area increases also shall be permitted as specified in Section 506 (c).

For attic space partitions and draft stops see Section 3205.

Sec. 1103. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V. **Location on Property**

Sec. 1104. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. **Exit Facilities**

Sec. 1105. All portions of Group F Occupancies customarily used by human beings shall be provided with light and ventilation by means of windows or skylights with an area not less than one-eighth of the total floor area, one-half of which shall be openable, or shall be provided with artificial light and a mechanically operated ventilating system. In no case shall less than two changes of air per hour be provided. **Light, Ventilation, and Sanitation**

In all buildings used for the storing or handling of automobiles operated under their own power, and in all buildings where flammable liquids are used, exhaust ventilation shall be provided sufficient to produce one complete change of air every 15 minutes. Such exhaust ventilation shall be taken from a point at or near the floor level.

> EXCEPTION: In storage garages and aircraft hangars not exceeding an area of five thousand square feet (5000 sq. ft.), the Building Official may authorize the omission of such ventilating equipment where, in his opinion, the building is supplied with unobstructed openings to the outer air which are sufficient to provide the necessary ventilation.

Every building or portion thereof where persons are employed shall be provided with at least one toilet. Every building and each subdivision thereof where both sexes are employed shall be provided with access to at least two toilets located either in such building or conveniently in a building adjacent thereto on the same property.

Such toilet rooms in connection with food establishments where food is prepared, stored, or served, shall have a nonabsorbent interior finish on floors, walls, and ceilings, shall be separated from such food establishments with close-fitting, tight doors and shall have hand washing facilities therein or adjacent thereto.

All toilet rooms shall be provided with an exterior window at least three square feet (3 sq. ft.) in area, fully openable or a vertical duct not less than one hundred square inches (100 sq. in.) in area for the first toilet facility with an additional fifty square inches (50 sq. in.) for each additional toilet facility; or a mechanically operated exhaust system, which is connected to the light switch, capable of providing a complete change of air every 15 minutes. Such systems shall be vented to the outside air and at the point of discharge shall be at least five feet (5′) from any openable window.

For requirements for floors and walls of toilet compartments, see Section 1711.

Enclosure of Vertical Openings

Sec. 1106. Exits shall be enclosed as specified in Chapter 33.

Elevator shafts, vent shafts, and other vertical openings shall be enclosed, and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 1107. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 1108. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

No storage of volatile flammable liquids shall be allowed in Group F Occupancies and the handling and use of gasoline, fuel oil and other flammable liquids shall not be permitted in any Group F Occupancy unless such use and handling comply with U.B.C. Standard No. 9-1-67.

Devices generating a glow or flame capable of igniting gasoline vapor shall not be installed or used within twenty-four inches (24") of the floor in any room in which volatile flammable liquids are used or stored.

Every boiler room or room containing a central heating plant shall be separated from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5 with all openings protected as set forth in Table No. 33-B.

Open Parking Garages

Sec. 1109. (a) **Scope.** Except where specific provisions are made in the following Subsections, other requirements of this Code shall apply.

(b) **Definition.** For the purpose of this Section, an open parking garage is a structure of Type I, II, or IV construction more than one tier in height which is at least 50 per cent open on two or more sides and is used exclusively for the parking or storage of passenger motor vehicles having a capacity of not more than nine persons per vehicle.

Open parking garages are further classified as either ramp-access or mechanical-access. Ramp-access open parking garages are those employing a series of continuously rising floors or a series of interconnecting ramps between floors permitting the movement of vehicles under their own power from and to the street level. Mechanical-access parking garages are those employing parking machines, lifts, elevators, or other mechanical devices for vehicles moving from and to street level and in which public occupancy is prohibited above the street level.

(c) **Construction.** Construction shall be of incombustible materials. Open parking garages shall meet the design requirements of Chapter 23. Adequate curbs and railings shall be provided at every opening.

Open Parking Garages (Continued)

(d) **Area and Height.** Area and height of open parking garages in Fire Zones No. 1, No. 2, and No. 3 shall be limited as set forth in Table No. 11-A except for increases allowed by Subsection (e).

In structures having a spiral or sloping floor, the horizontal projection of the structure at any cross section shall not exceed the allowable area per parking tier. In the case of a structure having a continuous spiral floor, each nine feet six inches (9′6″) of height or portion thereof shall be considered as a tier.

The clear height of a parking tier shall be not less than six feet six inches (6′6″) except that a lesser clear height may be permitted in mechanical-access open parking garages when approved by the Building Official.

(e) **Area and Height Increases.** Area of structures open on three sides may be increased 25 per cent and one tier in height. Areas of structures open on four sides may be increased 50 per cent and one tier in height.

(f) **Location on Property.** When located adjacent to interior property lines, exterior walls shall be of the degree of fire resistance set forth in Table No. 11-B and such walls shall be without openings.

TABLE NO. 11-A—OPEN PARKING GARAGES AREA AND HEIGHT

TYPE OF CONSTRUCTION	AREA PER TIER (Square Feet)	HEIGHT	
		Ramp-Access	Mechanical-Access
I	Unlimited	Unlimited	Unlimited
II	75,000	10 Tiers	12 Tiers
IV—1-hour	50,000	8 Tiers	10 Tiers
IV—N	30,000	6 Tiers	8 Tiers

TABLE NO. 11-B—OPEN PARKING GARAGES EXTERIOR WALLS

DISTANCE FROM PROPERTY LINE TO BUILDING	FIRE ZONE NO. 1	FIRE ZONE NO. 2	FIRE ZONE NO. 3
0′-10′	2-hour	2-hour	1-hour
10′-20′	1-hour	1-hour	None

Open Parking Garages (Continued)

(g) **Stairs and Exits.** Where persons other than parking attendants are permitted, stairs and exits shall meet the requirements of Chapter 33, based on an occupant load of two hundred square feet (200 sq. ft.) per occupant. Where no persons other than parking attendants are permitted there shall be not less than two stairs three feet (3′) wide. Lifts may be installed for use of employees only, provided they are completely enclosed by incombustible materials.

(h) **Standpipes.** Standpipes shall be installed when required by the provisions of Chapter 38.

(i) **Occupancy Separations.** Occupancy separations shall be installed as required in Chapter 5 between open parking garages and other occupancy such as sale of gasoline or oil.

(j) **Fire-extinguishing Apparatus.** Automatic fire-extinguishing systems shall be installed as specified in Chapter 38.

(k) **Enclosure of Vertical Openings.** Enclosure shall not be required for vertical openings except as specified in Subsection (g) for stairs, exits, and lifts.

(l) **Ventilation.** Ventilation, other than the percentage of openings specified in Subsection (b), shall not be required.

(m) **Prohibitions.** The following uses and alterations are not permitted:

1. Automobile repair work.
2. Parking of busses, trucks, and similar vehicles.
3. Partial or complete closing of required openings in exterior walls by tarpaulins or any other means.

CHAPTER 12—REQUIREMENTS FOR GROUP G OCCUPANCIES

Group G Occupancies Defined

Sec. 1201. Group G Occupancies shall be:

Ice plants, power plants, pumping plants, cold storage, creameries.

Factories and workshops using incombustible and nonexplosive materials.

Storage and sales rooms of incombustible and nonexplosive materials.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 1202. (a) **General.** Buildings or parts of buildings classed in Group G because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

(b) **Special Provisions.** Fire protection of the underside of roof framing may be omitted in all Types of Construction.

For attic space partitions and draft stops see Section 3205.

Location on Property

Sec. 1203. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Exit Facilities

Sec. 1204. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33.

Light, Ventilation, and Sanitation

Sec. 1205. All portions of Group G Occupancies customarily used by human beings shall be provided with light and ventilation as specified in Section 1105.

Every building or portion thereof where persons are employed shall be provided with at least one toilet. Every building and each subdivision thereof where both sexes are employed shall be provided with access to at least two toilets located either in such building or conveniently in a building adjacent thereto on the same property.

For requirements for floors and walls of toilet compartments, see Section 1711.

Enclosure of Vertical Openings

Sec. 1206. Interior stairways, ramps and escalators shall be enclosed as specified in Chapter 33. Other vertical openings are not required to be enclosed.

Fire-Extinguishing Systems

Sec. 1207. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Special Hazards

Sec. 1208. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

In any room in which volatile flammable liquids are used or stored, no device generating a glow or flame capable of igniting gasoline vapor shall be installed or used within twenty-four inches (24") of the floor.

The storage, use, and handling of gasoline, fuel oil, and other flammable liquids shall not be permitted in any Group G Occupancy unless such storage, use, and handling comply with U.B.C. Standard No. 9-1-67.

Every boiler room or room below the first floor containing a heating plant shall be separated from the rest of the building by a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5 with all openings protected as set forth in Table No. 33-B.

CHAPTER 13—REQUIREMENTS FOR GROUP H OCCUPANCIES

Group H Occupancies Defined

Sec. 1301. Group H Occupancies shall be:

Hotels and apartment houses.

Convents and monasteries (each accommodating more than 10 persons).

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 1302. (a) **General.** Buildings or parts of buildings classed in Group H because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

(b) **Special Provisions.** Group H Occupancies more than two stories in height or having more than three thousand square feet (3000 sq. ft.) of floor area above the first floor shall be of not less than one-hour fire-resistive construction throughout.

The story height limits set forth in Table No. 5-D may be increased by one story in Group H Occupancies provided:

1. The first story is of Type I construction with no basement or cellar below and is limited in area to that of the floor immediately above, except where approved access to the stories above is provided for fire-fighting purposes; and

2. The first story is used for nothing more hazardous than the parking of passenger motor vehicles having a capacity of not more than nine persons per vehicle with no repair work or fueling; and

3. There is a three-hour incombustible occupancy separation between the first and second stories; and

4. The maximum building height in feet shall not exceed the limits set forth in Table No. 5-D; and

5. For the purposes of area limitation, construction other than the Type I portion shall be classed as a separate and distinct building.

For attic space partitions and draft stops see Section 3205.

Location on Property

Sec. 1303. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Exit Facilities

Sec. 1304. Stairs, exits, and smokeproof enclosures shall be as specified in Chapter 33.

All stairs and exits in Group H Occupancies shall open directly upon a street or alley or upon a yard or court not less

Exit Facilities (Continued)

than four feet (4') in width directly connected to a street or alley by means of a passageway not less in width than the stairway opening into such passageway and not less than seven feet (7') in height.

Buildings more than one story in height shall have no transoms or ventilating openings from guest rooms to public corridors.

Door openings from guest rooms to public corridors shall be protected with a fire-resistive assembly as set forth in Table No. 33-B.

Light, Ventilation, and Sanitation

Sec. 1305. (a) **Windows.** All living rooms, kitchens, and other rooms used for living, dining, or sleeping purposes shall be provided with windows with an area not less than twelve square feet (12 sq. ft.), nor one-eighth of the floor area of such rooms.

The window area in bathrooms, water closet compartments, and other similar rooms shall be not less than three square feet (3 sq. ft.) unless a mechanical ventilation system capable of producing a change of air every five minutes and connected directly to the outside is provided.

When such required windows are installed, not less than one-half of the required area shall be openable.

Required windows shall open directly onto a street or public alley, or a yard or court located on the same lot as the building.

EXCEPTION: Required windows may open into a roofed porch where the porch:

1. Abuts a street, yard or court; and

2. Has a ceiling height of not less than seven feet (7'); and

3. Has the longer side at least 65 per cent open and unobstructed.

(b) **Sanitation.** Every building shall be provided with at least one toilet. Every hotel and each subdivision thereof where both sexes are accommodated shall be provided with at least two toilets located in such building, which shall be conspicuously marked, one for each sex.

Additional toilets shall be provided on each floor for each sex at the rate of one for every additional 10 guests, or fractional part thereof, in excess of 10.

One toilet shall be provided for each apartment.

There shall be no opening from a room in which a water closet is located into a room in which food is prepared or stored.

A kitchen sink shall be installed in every kitchen.

For requirements for floors and walls of toilet compartments, see Section 1711.

Yards and Courts

Sec. 1306. (a) **Scope.** This Section shall apply to yards and courts having required windows opening therein.

(b) **Yards.** Every yard shall be not less than three feet (3') in width for one-story and two-story buildings. For buildings more than two stories in height the minimum width of the yard shall be increased at the rate of one foot (1') for each additional story. For buildings exceeding 14 stories in height, the required width of yard shall be computed on the basis of 14 stories.

(c) **Courts.** Every court shall be not less than three feet (3') in width. Courts having windows opening on opposite sides shall be not less than six feet (6') in width. Courts bounded on three or more sides by the walls of the building shall be not less than ten feet (10') in length unless bounded on one end by a street or yard. For buildings more than two stories in height the court shall be increased one foot (1') in width and two feet (2') in length for each additional story. For buildings exceeding 14 stories in height, the required dimensions shall be computed on the basis of 14 stories.

Adequate access shall be provided to the bottom of all courts for cleaning purposes. Every court more than two stories in height shall be provided with a horizontal air intake at the bottom not less than ten square feet (10 sq. ft.) in area and leading to the exterior of the building unless abutting a yard or public space. The construction of the air intake shall be as required for the court walls of the building, but in no case shall be less than one-hour fire-resistive.

(d) **Projection into Yards.** Eaves and cornices may project into any required yard not more than two inches (2") for each foot of yard width. Unroofed landings, porches and stairs may project into any required yard provided no portion except for guardrails extends above the floor level of a habitable room and provided further that no such projection shall obstruct a required exitway.

Room Dimensions

Sec. 1307. (a) **Ceiling Heights.** Habitable rooms, bathrooms, toilet rooms, storage rooms and laundry rooms shall have a ceiling height of not less than seven feet six inches (7'6"). Hallways and corridors shall have a ceiling height of not less than seven feet (7') measured to the lowest projection from the ceiling.

If any room in a building has a sloping ceiling, the prescribed ceiling height for the room is required in only one-half the area thereof. No portion of the room measuring less than five feet (5') from the finished floor to the finished ceiling shall be included in any computation of the minimum area thereof.

If any room has a furred ceiling, the prescribed ceiling height is required in two-thirds the area thereof, but in no case shall the height of the furred ceiling be less than seven feet (7').

Room Dimensions (Continued)

Any portion of a garage shall have an unobstructed headroom clearance of not less than six feet six inches (6′6″) above the finish floor to any ceiling, beam, pipe, or similar construction except for wall-mounted shelves, storage surfaces, racks, or cabinets.

(b) **Superficial Floor Area.** Every dwelling unit shall have at least one room which shall have not less than one hundred and twenty square feet (120 sq. ft.) of superficial floor area. Every room which is used for both cooking and living or both living and sleeping purposes shall have not less than one hundred and fifty square feet (150 sq. ft.) of superficial floor area. Other habitable rooms shall have an area of not less than ninety square feet (90 sq. ft.). Where more than two persons occupy a room used for sleeping purposes, the required superficial floor area shall be increased at the rate of fifty square feet (50 sq. ft.) for each occupant in excess of two. Every kitchen shall have not less than fifty square feet (50 sq. ft.) of superficial floor area. Superficial floor area is herein defined as clear floor space, exclusive of fixed or built-in cabinets or appliances.

(c) **Width.** No habitable room other than a kitchen shall be less than seven feet (7′) in any dimension.

Efficiency Dwelling Units

Sec. 1308. An efficiency dwelling unit shall conform to the requirements of the Code except as herein provided:

1. The unit shall have a living room of not less than two hundred and twenty square feet (220 sq. ft.) of superficial floor area. An additional one hundred square feet (100 sq. ft.) of superficial floor area shall be provided for each occupant of such unit in excess of two.
2. The unit shall be provided with a separate closet.
3. The unit shall be provided with a kitchen sink, cooking appliance and refrigeration facilities each having a clear working space of not less than thirty inches (30″) in front. Light and ventilation conforming to this Code shall be provided.
4. The unit shall be provided with a separate bathroom containing a toilet, lavatory, and bathtub or shower.

Enclosure of Vertical Openings

Sec. 1309. Exits shall be enclosed as specified in Chapter 33.

Elevator shafts, vent shafts, and other vertical openings shall be enclosed and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 1310. When required by other provisions of this Code, automatic fire-extinguishing systems, standpipes, and basement pipe inlets shall be installed as specified in Chapter 38.

Heating

Sec. 1311. Every dwelling unit and guest room shall be provided with heating facilities capable of maintaining a room temperature of 70°F. at a point three feet (3′) above the floor in all habitable rooms.

Special Hazards

Sec. 1312. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

The storage and handling of gasoline, fuel oil, and other flammable liquids shall not be permitted in any Group H Occupancy unless such storage and handling comply with U.B.C. Standard No. 9-1-67.

Doors leading into rooms in which volatile flammable liquids are stored or used shall be protected by a fire assembly having a one-hour fire-resistive rating. Such fire assembly shall be self-closing and shall be posted with a sign on each side of the door in one-inch (1") block letters stating: "FIRE DOOR—KEEP CLOSED."

Every boiler room or room containing a central heating plant shall be separated from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5 with all openings protected as set forth in Table No. 33-B.

> EXCEPTION: A separation shall not be required for such rooms with equipment serving only one dwelling unit.

Existing Buildings

Sec. 1313. For existing buildings see Appendix Section 1313.

CHAPTER 14—REQUIREMENTS FOR GROUP I OCCUPANCIES

Group I Occupancies Defined

Sec. 1401. Group I Ocupancies shall be:

Dwellings and lodging houses.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 1402. Buildings or parts of buildings classed in Group I because of the use or character of the occupancy shall be limited to the types of construction set forth in Tables No. 5-C and No. 5-D and shall not exceed, in area or height, the limits specified in Sections 505, 506, and 507.

Location on Property

Sec. 1403. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Exit Facilities

Sec. 1404. Stairs and exits shall be provided as specified in Chapter 33.

Light, Ventilation, and Sanitation

Sec. 1405. (a) **Windows.** All living rooms, kitchens, and other rooms used for living, dining, or sleeping purposes shall be provided with windows with an area not less than twelve square feet (12 sq. ft.) nor one-eighth of the floor area of such rooms.

The window area in bathrooms, water-closet compartments, and other similar rooms shall be not less than three square feet (3 sq. ft.), unless a mechanical ventilation system capable of producing a change of air every five minutes and connected directly to the outside is provided.

When such required windows are installed, not less than one-half the required area shall be openable.

Required windows shall open directly onto a street or public alley, or a yard or court located on the same lot as the building.

> **EXCEPTION:** Required windows may open into a roofed porch where the porch:
>
> 1. Abuts a street, yard or court; and
> 2. Has a ceiling height of not less than seven feet (7′); and
> 3. Has the longer side at least 65 per cent open and unobstructed.

(b) **Sanitation.** There shall be no opening from a room in which a water closet is located into a room in which food is prepared or stored.

A kitchen sink shall be installed in every kitchen.

(c) **Bathroom.** A minimum bathroom facility consisting of a water closet, lavatory, and bathtub or shower shall be provided in every dwelling unit.

Room Dimensions

Sec. 1406. (a) **Ceiling Heights.** Habitable rooms, bathrooms, toilet rooms, storage rooms and laundry rooms shall have a ceiling height of not less than seven feet six inches (7′6″). Connecting corridors shall have a ceiling height of not less than seven feet (7′).

If any room in a building has a sloping ceiling, the prescribed ceiling height for the room is required in only one-half the area thereof. No portion of the room measuring less than five feet (5′) from the finished floor to the finished ceiling shall be included in any computation of the minimum area thereof.

If any room has a furred ceiling, the prescribed ceiling height is required in two-thirds the area thereof, but in no case shall the height of the furred ceiling be less than seven feet (7′).

(b) **Superficial Floor Area.** Every dwelling unit shall have at least one room which shall have not less than one hundred and twenty square feet (120 sq. ft.) of superficial floor area. Every room which is used for both cooking and living or both living and sleeping purposes shall have not less than one hundred and fifty square feet (150 sq. ft.) of superficial floor area. Other habitable rooms shall have an area of not less than ninety square feet (90 sq. ft.). Where more than two persons occupy a room used for sleeping purposes the required superficial floor area shall be increased at the rate of fifty square feet (50 sq. ft.) for each occupant in excess of two. Every kitchen shall have not less than fifty square feet (50 sq. ft.) of superficial floor area. Superficial floor area is herein defined as clear floor space, exclusive of fixed or built-in cabinets or appliances.

(c) **Width.** No habitable room other than a kitchen shall be less than seven feet (7′) in any dimension.

Enclosure of Vertical Openings

Sec. 1407. Dumbwaiter shafts, clothes chutes, and other vertical openings shall be enclosed and the enclosure shall be as set forth in Table No. 17-A. (See also Chapter 30.)

Fire-Extinguishing Systems

Sec. 1408. Fire-extinguishing systems when installed shall conform to the requirements of Chapter 38.

Heating

Sec. 1409. Every dwelling unit and guest room shall be provided with heating facilities capable of maintaining a room temperature of 70°F. at a point three feet (3′) above the floor in all habitable rooms.

Special Hazards

Sec. 1410. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

Exceptions and Deviations

Sec. 1411. A one-story carport entirely open on two or more sides need not have a fire separation between the carport and the dwelling.

Windows between the carport and the dwelling shall not be openable. Doors may be of any type, provided that any sash used in a door be fixed; doors between a dwelling and a carport shall be self-closing.

CHAPTER 15—REQUIREMENTS FOR GROUP J OCCUPANCIES

Group J Occupancies Defined

Sec. 1501. Group J Occupancies shall be:

Division 1. Private garages, carports, sheds, and agricultural buildings.

Division 2. Fences over six feet (6′) high, tanks, and towers.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

Construction, Height, and Area Allowable

Sec. 1502. Buildings or parts of buildings classed in Group J, Division 1 because of the use or character of the occupancy shall not exceed one thousand square feet (1000 sq. ft.) in area or one story in height except as provided in this Section. Any building or portion thereof that exceeds the limit specified in this Chapter shall be classed in the occupancy group other than Group J, Division 1 that it most nearly resembles.

For a mixed occupancy building, the total area of private garages used exclusively for the parking of passenger motor vehicles having a capacity of not more than nine persons per vehicle may be three thousand square feet (3000 sq. ft.) providing the exterior wall and opening protection are as required for the major occupancy of the building. The allowable floor area of the building shall be as permitted for the major occupancy of the building. Each portion of a building separated as specified in Section 505 may be considered a separate building. Such increase in area may apply to a single occupancy building providing the use of the building is as specified and the exterior wall and opening protection are as required for a Group H Occupancy building.

Location on Property

Sec. 1503. For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

Light and Ventilation

Sec. 1504. Private garages which are constructed in conjunction with any Group H or I Occupancy and which have openings into such buildings shall be equipped with fixed louvered or screened openings or exhaust ventilation to the outside with exhaust openings located within six inches (6″) of the floor. The clear area of the louvered opening or of the openings into the exhaust ducts shall be not less than sixty square inches (60 sq. in.) per car stored in such private garage. Under no circumstances shall a private garage have any opening directly into a room used for sleeping purposes.

Private garage floor surfaces shall be of approved incombustible material.

Special Hazards

Sec. 1505. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 and Uniform Building Code, Volume II, Mechanical.

Flammable liquids shall not be stored, handled, or used in Group J Occupancies unless such storage or handling shall comply with U.B.C. Standard No. 9-1-67.

PART IV

REQUIREMENTS BASED ON LOCATION IN FIRE ZONES

CHAPTER 16—RESTRICTIONS IN FIRE ZONES

General

Sec. 1601. (a) **Fire Zones Defined.** For the purpose of this Code, the entire city is hereby declared to be and is hereby established a Fire District and said Fire District shall be known and designated as Fire Zones One, Two, and Three, and shall include such territory or portions of said City as outlined in an ordinance of said City, entitled: "An Ordinance Creating and Establishing Fire Zones." Whenever in this Code reference is made to any fire zone, it shall be construed to mean one of the fire zones created by said ordinance.

(b) **Buildings Located in More than One Fire Zone.** A building or structure which is located partly in one fire zone and partly in another shall be considered to be in the more highly restricted fire zone when more than one-third of its total floor area is located in such zone.

(c) **Moved Buildings.** Any building or structure moved within or into any fire zone shall be made to comply with all the requirements for new buildings in that fire zone.

(d) **Temporary Buildings.** Temporary buildings such as reviewing stands and other miscellaneous structures conforming to the requirements of this Code, and sheds, canopies, or fences used for the protection of the public around and in conjunction with construction work may be erected in Fire Zone No. 1 or No. 2 by special permit from the Building Official for a limited period of time, and such building or structure shall be completely removed upon the expiration of the time limit stated in such permit.

(e) **Center Lines of Streets.** For the purpose of this Chapter, the center line of an adjoining street or alley may be considered an adjacent property line. Distance shall be measured at right angles to the street or alley.

Restrictions in Fire Zone No. 1

Sec. 1602. (a) **General.** Buildings or structures hereafter erected, constructed, moved within or into Fire Zone No. 1 shall be only of Type I, II, III-H.T., III-one-hour, or IV-one-hour construction and shall meet the requirements of this Section. For Exceptions covering Type IV construction, see Sections 1109 and 2103 (a).

(b) **Alterations.** No building of Type IV construction in excess of one thousand square feet (1000 sq. ft.) in floor area nor any building of Type V construction already erected in Fire Zone No. 1 shall hereafter be altered, raised, enlarged, added to, or moved, except as follows:

Restrictions in Fire Zone No. 1 (Continued)

1. Such Type IV building may be made to conform to all the provisions of Sections 1602 (a) and 2103.

2. Changes, alterations, and repairs to the interior of such building or to the front thereof facing a public street may be made, provided such changes do not, in the opinion of the Building Official, increase the fire hazard of such building.

3. Roofs of such buildings may be covered only with a fire-retardant roofing as specified in Section 3203. See Section 104 (f) for repairs.

4. Such building may be moved entirely outside the limits of Fire Zone No. 1.

5. Such building may be demolished.

(c) **Occupancies Prohibited.** No Group E, Division 2 Occupancy having a floor area exceeding fifteen hundred square feet (1500 sq. ft.) shall be permitted in Fire Zone No. 1.

No Group E, Division 1 or 5 Occupancies shall be permitted in Fire Zone No. 1.

> EXCEPTION: This shall not apply to dry cleaning plants not using highly flammable liquids.

Restrictions in Fire Zone No. 2

Sec. **1603.** (a) **General.** Buildings or structures hereafter erected, constructed, moved within or into Fire Zone No. 2 shall be one of the Types of Construction as defined in this Code and shall meet the requirements of this Section.

For fire-resistive protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V. (For regulations covering open parking garages see Section 1109.)

Roof covering shall be fire-retardant roofing as specified in Section 3203 (e). See Section 104 (f) for repairs.

(b) **Alterations.** No building of Type IV construction in excess of one thousand square feet (1000 sq. ft.) in floor area nor any building of Type V construction already erected in Fire Zone No. 2, shall hereafter be altered, raised, enlarged, added to or moved except as follows:

1. Such building may be made to conform to the provisions of Section 2103 for Type IV and Section 2203 for Type V construction.

2. Changes, alterations, and repairs to the interior of such building or to the front thereof facing a public street may be made provided such changes do not, in the opinion of the Building Official, increase the fire hazard of such building.

3. Roofs of such buildings may be covered only with a fire-retardant roofing as specified in Section 3203. See Section 104 (f) for repairs.

4. Such building may be moved entirely outside the limits of Fire Zone No. 2.

Restrictions in Fire Zone No. 2 (Continued)

5. Such building may be demolished.

6. Combustible finish on the outside of walls may be replaced by or covered with exterior plaster as specified in Chapter 47.

(c) **Occupancies Prohibited.** No Group E, Division 2 Occupancy having a floor area exceeding fifteen hundred square feet (1500 sq. ft.) shall be permitted in Fire Zone No. 2.

No Group E, Division 1 or 5 Occupancies shall be permitted in Fire Zone No. 2.

> EXCEPTION: This shall not apply to dry cleaning plants not using highly flammable liquids.

Restrictions in Fire Zone No. 3

Sec. 1604. Any building or structure complying with the requirements of this Code may be erected, constructed, moved within or into Fire Zone No. 3.

PART V

REQUIREMENTS BASED ON TYPES OF CONSTRUCTION

CHAPTER 17—CLASSIFICATION OF ALL BUILDINGS BY TYPES OF CONSTRUCTION AND GENERAL REQUIREMENTS

General

Sec. 1701. The requirements of Part V are for the various Types of Construction and represent varying degrees of public safety and resistance to fire. Every building shall be classified by the Building Official into one of the Types of Construction set forth in Table No. 17-A. Any building which does not entirely conform to a Type of Construction set forth in Table No. 17-A shall be classified by the Building Official into a type having an equal or lesser degree of fire resistance.

No building or portion thereof shall be required to conform to the details of a Type of Construction higher than that type which meets the minimum requirements based on Occupancy (Part III) or Location in Fire Zone (Part IV) even though certain features of such building actually conform to a higher Type of Construction.

Where specific materials, types of construction, or fire-resistive protection are required, such requirements shall be the minimum requirements and any materials, types of construction, or fire-resistive protection which will afford equal or greater public safety or resistance to fire, as specified in this Code, may be used.

Portions of buildings separated as specified in Section 505 (c) may be considered a separate building for classification of types of construction. When there is no such separation, the area of the entire building shall not exceed the least area permitted for the types of construction involved.

Structural Frame

Sec. 1702. The structural frame shall be considered to be the columns and the girders, beams, trusses, and spandrels having direct connections to the columns and all other members which are essential to the stability of the building as a whole. The members of floor or roof panels which have no connection to the columns shall be considered secondary members and not a part of the structural frame.

Usable Space Under Floors

Sec. 1703. Usable space under the first floor shall be enclosed except in Groups I and J Occupancies and such enclosure when constructed of metal or wood shall be protected on the side of the usable space as required for one-hour fire-resistive construction. Doors shall be self-closing, of incombustible construction or solid wood core, not less than one and three-fourths inches (1¾") in thickness.

Roof Coverings

Sec. 1704. Roof covering shall be fire-retardant except in Type V buildings housing Groups H, I, or J Occupancies, where it may be as specified in Section 3203 (f).

EXCEPTION: Roofs of cedar or redwood shakes having a nominal thickness of one inch (1") at the butt may be used in buildings of Group F, Division 2, Occupancies of Type V-N construction, provided that the horizontal clearance between cornice and property line, except street fronts, is not less than ten feet (10'). This provision shall be applicable only in Fire Zone No. 3.

Roof Coverings (Continued)

Skylights shall be constructed as required in Chapter 34.

Penthouses shall be constructed as required in Chapter 36.

For use of plastics in roofs see Chapter 52.

For Attics; Access and Area, see Section 3205. For Roof Drainage, see Section 3206.

Unprotected Materials Allowed

Sec. 1705. (a) **Fixed Partitions.** Regardless of the fire-resistive requirements for permanent partitions, partitions dividing portions of stores, offices, or similar places occupied by one tenant only, and which do not establish a corridor serving an occupant load of 30 or more, may be constructed of:

1. Incombustible materials.
2. Fire-retardant treated wood.
3. One-hour fire-resistive construction.
4. Wood panels or similar light construction up to three-fourths the height of the room in which placed; when more than three-fourths the height of the room, such partitions shall have not less than the upper one-fourth of the partition constructed of glass.

For use of plastics in partitions see Section 5208.

(b) **Walls Fronting on Public Ways.** Regardless of fire-resistive requirements for exterior walls certain elements of the walls fronting on public ways may be constructed as follows:

1. Show-window frames, aprons and showcases located in the first story may be of combustible or incombustible materials, provided the height of such construction does not exceed fifteen feet (15') above grade.
2. In Fire Zones No. 2 and No. 3 wood veneer of not less than one-inch (1") nominal thickness or Exterior type plywood not less than three-eighths inch (⅜") nominal thickness may be applied to walls provided the veneer does not exceed one story in height and further provided such wood shall be placed either directly against incombustible surfaces or furred out from such surfaces not to exceed one and five-eighths inches (1⅝") with all concealed spaces firestopped as provided in Section 2508.

(c) **Trim.** Trim, picture molds, chair rails, baseboards, handrails, show-window backing may be of wood. Unprotected wood doors and windows may be used except where openings are required to be fire protected.

TABLE NO. 17-A—TYPES OF CONSTRUCTION—FIRE-RESISTIVE REQUIREMENTS
(In Hours)
(For Details see Chapters under Occupancy and Types of Construction)

MATERIALS OF CONSTRUCTION	I	II	III		IV		V	
	Incom-bustible	Incom-bustible	1-Hr. or H.T.	N	1-Hour	N	1-Hour	N
			Combustible		Incombustible		Combustible	
Exterior Bearing Walls	4 Sec. 1803 (a)	4 Sec. 1903 (a)	4 Sec. 2003 (a)	4 Sec. 2003 (a)	1	N	1	N
Interior Bearing Walls	3	1	1	N	1	N	1	N
Exterior Non-bearing Walls	4 Sec. 1803 (a)	4 Sec. 1903 (a)	4 Sec. 2003 (a)	4 Sec. 2003 (a)	1	N	1	N
Structural Frame[1]	3	2	1 or H.T.	N	1	N	1	N
Partitions—Permanent	1[2]	1[2]	1 or H.T.	N	1[2]	N	1	N
Vertical Openings	2	2	1 or H.T.	1	1	1	1 Sec. 1706	1 Sec. 1706
Floors	2	1	1 or H.T.	N	1	N	1	N
Roofs	2 Sec. 1806	1 Sec. 1906	1 or H.T.	N	1 Sec. 2106	N	1	N
Exterior Doors and Windows	Sec. 1803 (b)	Sec. 1903 (b)	Sec. 2003 (b)	Sec. 2003 (b)	Sec. 2103 (b)	Sec. 2103 (b)	Sec. 2203 (b)	Sec. 2203 (b)

N—No general requirements for fire resistance. H.T.—Heavy Timber.

[1]Structural frame elements in the exterior wall shall be protected against external fire exposure as required for exterior bearing walls or the structural frame whichever is greater.

[2]Fire-retardant treated wood (see Section 407) may be used in the assembly provided fire resistance requirements are maintained. See Sections 1801, 1901 and 2101 respectively.

Materials used for interior finish of walls and ceilings, including wainscoting, shall be as specified in Chapter 42.

Unprotected Materials Allowed (Continued)

(d) **Loading Platforms.** Exterior loading platforms may be of incombustible construction or heavy timber construction with wood floors not less than two inches (2") nominal thickness. Such wood construction shall not be carried through the exterior walls.

(e) **Insulating Boards.** Combustible insulating boards may be used under finished flooring.

Enclosure of Vertical Openings

Sec. 1706. (a) **General.** Enclosure for elevator shafts, vent shafts and other vertical openings shall be as set forth in Table No. 17-A and all exterior openings therein shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating and all interior openings shall be protected by a fire assembly having a one-hour fire-resistive rating. (See Chapter 30.)

EXCEPTIONS: 1. In Type V buildings, chutes and dumbwaiter shafts with a cross-sectional area of not more than nine square feet (9 sq. ft.) may be lined with approved fire-resistive materials covered with not less than No. 26 galvanized sheet metal gauge with all joints in such sheet metal locklapped. All openings into any such vertical enclosure shall be protected by metal or metal-clad doors with either metal or metal-clad jambs, casings, or frames.

2. Vertical shafts for vents, ducts and piping in Groups H and I Occupancies not more than two stories in height need not be lined if the vents or ducts enclosed by the shaft are constructed of at least No. 26 galvanized sheet metal gauge and the shaft is effectively draft stopped at each floor or ceiling through which the vents or ducts pass.

(b) **Construction.** Exit enclosures shall be constructed as specified in Sections 3308 and 3309.

Weather Protection

Sec. 1707. (a) **Building Paper.** Asphalt-saturated felt free from holes and breaks and weighing not less than 14 pounds per one hundred square feet (100 sq. ft.) or approved waterproof paper, shall be applied over studs or sheathing of all exterior walls. Such felt or paper shall be applied weatherboard fashion, lapped not less than two inches (2") at horizontal joints and not less than six inches (6") at vertical joints.

Building paper may be omitted in the following cases:

1. When exterior covering is of approved weatherproof panels.
2. In back-plastered construction.
3. When there is no human occupancy.
4. Over water-repellent panel sheathing.
5. Under approved paperbacked metal or wire fabric lath.
6. Under metal lath, wire lath, or wire fabric lath on incombustible construction.

Weather Protection (Continued)

(b) **Flashing and Counterflashing.** Exterior openings exposed to the weather shall be flashed in such a manner as to make them weatherproof.

All parapets shall be provided with coping of approved materials. All flashing, counterflashing, and coping when of metal shall be of not less than No. 26 U. S. gauge corrosion-resistant metal.

Members Carrying Masonry or Concrete

Sec. 1708. All members carrying masonry or concrete walls in buildings over one story in height shall be fire-protected with not less than one-hour fire protection.

> EXCEPTION: Fire protection may be omitted from the bottom flange of lintels, shelf angles, or plates that are not a part of the structural frame.

Parapets

Sec. 1709. (a) **General.** Parapet walls shall have the same fire resistance as required for the exterior walls. [See also Subsection 505 (c).]

(b) **Fire Zone Location.** Parapet walls not less than thirty inches (30") in height shall be provided on exterior walls of buildings located in Fire Zones No. 1 and No. 2 when the walls are required to be fire-resistive due to their location on the property.

Parapet walls not less than twelve inches (12") in height shall be provided on exterior walls of buildings located in Fire Zone No. 3 when the walls are required to be fire-resistive due to their location on the property.

> EXCEPTIONS: Parapets are not required due to fire zone location on the following walls:
>
> 1. When the roof construction is entirely incombustible.
> 2. When the roof has an angle of more than 20 degrees with horizontal.
> 3. On buildings twenty feet (20') or less in height.

(c) **Climatic Location.** Parapet walls not less than twelve inches (12") in height shall be provided on exterior walls located less than five feet (5') from a public way where temperatures normally fall below freezing.

> EXCEPTION: Parapets are not required due to climatic location for Group J Occupancies accessory to single-family dwellings.

Cornices

Sec. 1710. Cornices, architectural appendages, eave overhangs and similar projections extending beyond the floor area, as defined in Section 407, shall be constructed of incombustible materials. Such projections need not be protected for fire resistance, regardless of the type of construction.

Cornices (Continued)

EXCEPTIONS: 1. For Type III construction, provided such projections do not extend nearer the property line than where unprotected, incombustible exterior nonbearing walls are first permitted in accordance with Section 2003 (a), such projections may be of combustible one-hour fire-resistive construction in Fire Zone No. 1; of combustible one-hour fire-resistive construction or heavy-timber construction in Fire Zone No. 2; or unprotected combustible construction in Fire Zone No. 3.

2. For Type V construction, such projections may be of combustible construction provided that when extending beyond walls required to be fire-resistive, such projections are of at least one-hour fire-resistive construction.

Cornices, architectural appendages, eave overhangs and similar projections extending over public property shall be constructed as specified in Chapter 45.

Toilet Compartments and Showers

Sec. 1711. (a) **Floors and Walls.** In other than dwelling units the floors and walls of toilet rooms and compartments and those within two feet (2′) of the front and sides of urinals, shall be finished with a smooth, hard nonabsorbent surface of portland cement, ceramic tile, or approved equal. Walls shall be so finished to a height of four feet (4′) above the floor. Materials other than structural elements used in such walls shall be of a type which is not adversely affected by moisture.

Each water closet compartment in all occupancies shall be not less than thirty inches (30″) in width and there shall be not less than two feet (2′) clear space in front of each water closet.

(b) **Shower Areas.** Showers shall be finished as specified in Subsection (a) to a height of not less than six feet (6′). Materials other than structural elements used in such walls shall be of a type which is not adversely affected by moisture.

(c) **Doors and Panels.** Doors and panels of shower and bathtub enclosures shall be substantially constructed from approved shatter-resistant materials. Hinged shower doors shall open outward.

(d) **Glass.** Glass used in doors and panels of shower and bathtub enclosures shall be an approved type of wire reinforced, fully tempered or laminated safety glass. Such glass shall have a thickness of not less than three-sixteenths inch ($\frac{3}{16}$″) when fully tempered, one-fourth inch (¼″) when laminated, or seven-thirty-seconds inch ($\frac{7}{32}$″) when wire reinforced.

(e) **Plastics.** Plastics used in doors and panels of shower and bathtub enclosures shall be of a shatter-resistant type.

Clearances for Electric Ranges and Hot Plates

Sec. 1712. Gas and electric ranges or hot plates shall have clearances from combustible material, and ventilation in accordance with the Uniform Building Code, Volume II, Mechanical.

Helistops

Sec. 1713. (a) **General.** Helistops may be erected on buildings or other locations if they are constructed in accordance with this Section.

(b) **Size.** The touchdown or landing area for helicopters of less than 3500 pounds shall be a minimum of twenty feet by twenty feet (20′ x 20′) in size. The touchdown area shall be surrounded on all sides by a clear area having a minimum average width at roof level of fifteen feet (15′) but with no width less than five feet (5′).

(c) **Design.** Helicopter landing areas and the supports therefor on the roof of a building shall be of incombustible construction. Landing areas shall be designed to confine any flammable liquid spillage to the landing area itself and provision shall be made to drain such spillage away from any exit or stairway serving the helicopter landing area or from a structure housing such exit or stairway.

(d) **Exits and Stairways.** Exits and stairways from helistops shall comply with the provisions of Chapter 33 of this Code, except that all landing areas located on buildings or structures shall have two or more exits. For landing platforms or roof areas less than sixty feet (60′) in length, or less than two thousand square feet (2000 sq. ft.) in area, the second exit may be a fire escape or ladder leading to the floor below.

(e) **Guardrails.** Guardrails shall be provided around all roofs or decks which are more than four feet (4′) above the adjoining ground or floor level and shall comply with the provisions of Section 1714 of this Code.

(f) **Federal Aviation Approval.** Before operating helicopters from helistops, approval must be obtained from the Federal Aviation Agency.

Guardrails

Sec. 1714. All unenclosed floor and roof openings; open and glazed sides of landings and stairs; balconies or porches which are more than thirty inches (30″) above grade; and roofs used for other than service of the building shall be protected by a guardrail. Guardrails for stairs shall be not less than thirty inches (30″) above the nosing of treads. All other guardrails shall be not less than thirty-six inches (36″) in height. Open guardrails shall have intermediate rails or an ornamental pattern such that no object nine inches (9″) in diameter can pass through the guardrail.

Grounding

Sec. 1715. Where metal siding or roofing is installed on existing or new construction, provisions shall be made to provide for the bonding and grounding of such building in accordance with the local electrical code.

CHAPTER 18—TYPE I BUILDINGS

Definition

Sec. 1801. The structural elements in Type I Buildings shall be of steel, iron, concrete, or masonry.

Walls and permanent partitions shall be of incombustible fire-resistive construction except that permanent nonbearing partitions of one-hour fire-resistive construction may use fire-retardant treated wood (see Section 407) within the assembly.

Materials of construction and fire-resistive requirements shall be as specified in Chapter 17.

Structural Framework

Sec. 1802. Structural framework shall be of structural steel or iron as specified in Chapter 27, reinforced concrete as in Chapter 26, or reinforced masonry as in Chapter 24.

For additional requirements for Group E Occupancies, see Section 1002 (b).

Exterior Walls and Openings

Sec. 1803. (a) **Exterior Walls.** Exterior walls and all structural members shall comply with the requirements specified in Section 504 and the fire-resistive provisions set forth in Table No. 17-A.

EXCEPTIONS: 1. Nonbearing walls fronting on streets or yards having a width of at least fifty feet (50') in Fire Zone No. 1 or forty feet (40') in Fire Zone No. 2 or No. 3 may be of unprotected incombustible construction.

2. In Groups F, G, and H Occupancies exterior bearing walls may be of two-hour fire-resistive incombustible construction where openings are permitted.

3. In other than Group E Occupancies exterior nonbearing walls may be of one-hour fire-resistive incombustible construction where unprotected openings are permitted and two-hour fire-resistive incombustible construction where fire protection of openings is required.

(b) **Openings in Walls.** All openings in exterior walls shall conform to the requirements of Section 504 (b) and shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating when they are less than twenty feet (20') from an adjacent property line or the center line of a street or public space.

No openings shall be permitted in exterior walls of Groups A, B, C, D, E, and F Occupancies less than five feet (5') from the property line, and no openings in Groups G, H, I, and J Occupancies less than three feet (3') from the property line.

Floors

Sec. 1804. (a) **Wood Sleepers.** Where wood sleepers are used for laying wood flooring on masonry or concrete fire-resistive floors the space between the floor slab and the underside of the wood flooring shall be filled with incombustible material or firestopped in such a manner that there will be no open spaces under the flooring which will exceed one hundred square feet (100 sq. ft.) in area and such space shall be filled

Floors (Continued)

solidly under all permanent partitions so that there is no communication under the flooring between adjoining rooms.

EXCEPTION: Gymnasium floors when wood flooring is placed on a concrete slab at or below grade level.

(b) **Mezzanine Floors.** Mezzanine floors may be of wood or unprotected steel except that in Fire Zone No. 1 they shall be of incombustible materials as approved for one-hour fire-resistive construction or of heavy timber construction as specified for floors in Subsection 2514 (e).

Not more than two mezzanine floors shall be in any room of a building.

No mezzanine floor or floors shall cover more than 33⅓ per cent of the area of any room.

Stair Construction

Sec. 1805. Stairs and stair platforms shall be constructed of reinforced concrete, iron, or steel with treads and risers of concrete, iron, or steel. Brick, marble, tile, or other hard incombustible materials may be used for the finish of such treads and risers.

Stairs shall be designed and constructed as specified in Chapter 33.

Roofs

Sec. 1806. Roofs more than twenty-five feet (25′) above any floor, balcony, or gallery may be of unprotected incombustible materials.

Where every part of the structural steel framework of the roof of a Group A, B, or C Occupancy is not less than twenty-five feet (25′) above any floor, balcony, or gallery, fire protection of all members of the roof construction may be omitted.

Where every part of the structural steel framework of the roof of a Group A, B, or C Occupancy is more than eighteen feet (18′) and less than twenty-five feet (25′) above any floor, balcony, or gallery, the roof construction shall be protected by a ceiling of not less than one-hour fire-resistive construction.

Roofs may be sheathed by wood planks of two and one-half-inch (2½″) nominal thickness when such sheathing is more than thirty feet (30′) distant from any floor, balcony, or gallery and when such plank sheathing is protected on the underside by a ceiling of not less than one-hour fire-resistive construction.

Roof covering shall be a fire-retardant roofing as specified in Section 3203.

CHAPTER 19—TYPE II BUILDINGS

Definition

Sec. 1901. The structural elements in Type II Buildings shall be of steel, iron, concrete, or masonry.

Walls and permanent partitions shall be of incombustible fire-resistive construction except that permanent nonbearing partitions of one-hour fire-resistive construction may use fire-retardant treated wood (see Section 407) within the assembly.

Materials of construction and fire-resistive requirements shall be as specified in Chapter 17.

Structural Framework

Sec. 1902. Structural framework shall be of structural steel or iron as specified in Chapter 27, reinforced concrete as in Chapter 26, or reinforced masonry as in Chapter 24.

Exterior Walls and Openings

Sec. 1903. (a) **Exterior Walls.** Exterior walls and all structural members shall comply with the requirements specified in Section 504 and the fire-resistive provisions set forth in Table No. 17-A.

> EXCEPTIONS: 1. Nonbearing walls fronting on streets or yards having a width of at least fifty feet (50′) in Fire Zone No. 1 or forty feet (40′) in Fire Zone No. 2 or No. 3 may be of unprotected incombustible construction.
>
> 2. In Groups F, G, and H Occupancies exterior bearing walls may be of two-hour fire-resistive incombustible construction where openings are permitted.
>
> 3. In other than Group E Occupancies exterior nonbearing walls may be of one-hour fire-resistive incombustible construction where unprotected openings are permitted and two-hour fire-resistive incombustible construction where fire protection of openings is required.

(b) **Openings in Walls.** All openings in exterior walls shall conform to the requirements of Section 504 (b) and shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating when they are less than twenty feet (20′) from an adjacent property line or the center line of a street or public space.

No openings shall be permitted in exterior walls of Groups A, B, C, D, E, and F Occupancies less than five feet (5′) from the property line, and no openings in Groups G, H, I, and J Occupancies less than three feet (3′) from the property line.

Floors

Sec. 1904. (a) **General.** Where wood sleepers are used for laying wood flooring on masonry or concrete fire-resistive floors, the space between the floor slab and the underside of the wood flooring shall be filled with incombustible material or firestopped in such a manner that there will be no open spaces under the flooring which will exceed one hundred square feet (100 sq. ft.) in area and such space shall be

Floors (Continued)

filled solidly under all permanent partitions so that there is no communication under the flooring between adjoining rooms.

EXCEPTION: Gymnasium floors when wood flooring is placed on a concrete slab at or below grade level.

(b) **Mezzanine Floors.** Mezzanine floors may be of wood or unprotected steel except that in Fire Zone No. 1 they shall be of incombustible materials as approved for one-hour fire-resistive construction or of heavy timber construction as specified for floors in Section 2514 (b).

Not more than two mezzanine floors shall be in any room of a building.

No mezzanine floor or floors shall cover more than 33⅓ per cent of the area of any room.

Stair Construction

Sec. 1905. Stairs and stair platforms shall be constructed of reinforced concrete, iron, or steel with treads and risers of concrete, iron, or steel. Brick, marble, tile, or other hard incombustible materials may be used for the finish of such treads and risers.

Stairs shall be designed and constructed as specified in Chapter 33.

Roofs

Sec. 1906. Roofs more than twenty-five feet (25′) above any floor, balcony, or gallery may be of unprotected incombustible materials.

Where every part of the structural steel framework of the roof of a Group A, B, or C Occupancy is not less than twenty-five feet (25′) above any floor, balcony, or gallery, fire protection of all members of the roof construction may be omitted.

Where the structural steel framework of the roof of a Group A, B, or C Occupancy is more than eighteen feet (18′) and less than twenty-five feet (25′) above any floor, balcony, or gallery, the roof construction shall be protected by a ceiling of not less than one-hour fire-resistive construction.

Roofs may be sheathed by wood planks of two and one-half-inch (2½″) nominal thickness when such sheathing is more than thirty feet (30′) distant from any floor, balcony, or gallery and when such plank sheathing is protected on the underside by a ceiling of not less than one-hour fire-resistive construction.

Roof covering shall be a fire-retardant roofing as specified in Section 3203.

CHAPTER 20—TYPE III BUILDINGS

Definition

Sec. 2001. Structural elements of Type III Buildings may be of any materials permitted by this Code.

Type III, One-Hour buildings shall be one-hour fire-resistive construction throughout.

Type III, Heavy Timber Construction, shall be in accordance with Section 2514 except that members of the structural frame may be of materials other than heavy timber provided that they have a fire resistance of not less than one hour.

Exterior walls shall be of incombustible fire-resistive construction.

Materials of construction and fire-resistive requirements shall be as specified in Chapter 17.

For requirements due to occupancy, see Chapters 6 to 15, inclusive.

For requirements in Fire Zones see Chapter 16.

Structural Framework

Sec. 2002. Structural framework shall be of steel or iron as specified in Chapter 27, concrete as in Chapter 26, masonry as in Chapter 24, or wood as in Chapter 25 and this Chapter.

Exterior Walls, Openings, and Partitions

Sec. 2003. (a) **Exterior Walls.** Exterior walls and all structural members shall comply with the requirements specified in Section 504 and the fire-resistive provisions set forth in Table No. 17-A.

EXCEPTIONS: 1. Nonbearing walls fronting on streets or yards having a width of at least fifty feet (50′) in Fire Zone No. 1 or forty feet (40′) in Fire Zone No. 2 or No. 3 may be of unprotected incombustible construction.

2. In Groups F, G, and H Occupancies exterior bearing walls may be two-hour fire-resistive incombustible construction where openings are permitted.

3. In other than Group E Occupancies exterior nonbearing walls may be of one-hour fire-resistive incombustible construction where unprotected openings are permitted and two-hour fire-resistive incombustible construction where fire protection of openings is required.

4. Bulkheads, not more than thirty inches (30″) high below show windows, need not be of incombustible or fire-resistive material.

5. Wood columns and arches conforming to heavy timber sizes may be used externally where exterior walls are permitted to be of unprotected incombustible construction or one-hour fire-resistive incombustible construction when located in Fire Zone No. 2 or No. 3.

(b) **Openings in Walls.** All openings in exterior walls shall conform to the requirements of Section 504 (b) and shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating when they are less than twenty feet (20′)

Exterior Walls, Openings, and Partitions (Continued)

from an adjacent property line or the center line of a street or public space.

No openings shall be permitted in exterior walls of Groups A, B, C, D, E and F Occupancies less than five feet (5') from the property line, and no openings in Groups G, H, I and J Occupancies less than three feet (3') from the property line.

(c) **Partitions.** Permanent partitions in Type III, One-Hour buildings shall be of one-hour fire-resistive construction. In Type III Heavy Timber buildings they shall be of solid wood construction formed by not less than two layers of one-inch (1") nominal matched boards or laminated construction of four-inch (4") nominal thickness or of one-hour fire-resistive construction. Bearing partitions when constructed of wood shall not support more than two floors and a roof. Partitions shall be constructed as specified in Section 2507 (e).

Floors

Sec. 2004. (a) **General.** Floors may be constructed as specified in Chapter 26 for concrete, Chapter 24 for masonry, Chapter 25 for wood, and Chapter 27 for steel or iron.

Wood joists, beams, and girders supported by masonry walls shall be anchored thereto as specified in Section 2313. Ventilation shall be provided between the ground and a wood floor as specified in Section 2517.

(b) **Heavy Timber Floors.** Heavy timber floors shall be constructed as specified in Section 2514.

(c) **Mezzanine Floors.** Mezzanine floors in Fire Zone No. 1 shall be constructed of not less than one-hour fire-resistive construction or of heavy timber construction, as specified for floors in Section 2514.

Not more than two mezzanine floors shall be in any room of a building.

No mezzanine floor or floors shall cover more than 33⅓ per cent of the area of any room.

Stair Construction

Sec. 2005. Stairs may be constructed with any material allowed in this Code except that in heavy timber buildings stairs shall be constructed with wood treads and risers of not less than two-inch (2") nominal thickness, except where built on laminated or plank inclines as required for floors, when they may be of one-inch (1") nominal thickness or may be constructed as required in Type I buildings.

In buildings four or more stories in height, stairs and stair construction shall be as required for Type I buildings.

Stairs and exits shall be designed and constructed as specified in Chapter 33.

Sec. 2006. Heavy timber roofs shall be constructed as specified in Section 2514. Wood joists, beams, and girders supported by masonry walls shall be anchored thereto as specified in Section 2313. **Roofs**

Roof covering shall be a fire-retardant roofing as specified in Section 3203.

CHAPTER 21—TYPE IV BUILDINGS

Definition

Sec. 2101. The structural elements of Type IV Buildings shall be of incombustible materials.

Type IV, One-Hour buildings shall be of incombustible construction and one-hour fire-resistive throughout except that permanent nonbearing partitions may use fire-retardant treated wood (see Section 407) within the assembly, provided fire-resistive requirements are maintained.

Walls and permanent partitions shall be of incombustible materials.

Materials of construction and fire-resistive requirements shall be as specified in Chapter 17.

For requirements due to occupancy, see Chapters 6 to 15, inclusive.

For requirements in Fire Zones see Chapter 16.

Structural Framework

Sec. 2102. Structural framework shall be as specified in Chapter 27 for iron and steel, Chapter 26 for concrete, and Chapter 24 for masonry.

Exterior Walls and Openings

Sec. 2103. (a) **Exterior Walls.** For fire protection of exterior walls and openings as determined by location on property, see Section 504 and Table No. 5-A.

EXCEPTIONS: 1. Nonbearing walls fronting on streets or yards having a width of at least fifty feet (50') in Fire Zone No. 1 or forty feet (40') in Fire Zone No. 2 or No. 3 may be of unprotected incombustible construction.

2. A fire-resistive time period will not be required for an exterior wall of a one-story Type IV building housing a Group F, G or J Occupancy provided the floor area of the building does not exceed twenty-five hundred square feet (2500 sq. ft.) and such wall is located not less than twenty feet (20') from a property line in Fire Zone No. 1 and ten feet (10') from a property line in Fire Zone No. 2.

3. In Fire Zone No. 2 a fire-resistive time period will not be required for an exterior wall of a Type IV building housing a Group F, G or J Occupancy provided such wall is located not less than twenty feet (20') from a property line.

4. In a Group F, G, or J Occupancy in Fire Zone No. 2 or in a Group F Occupancy in Fire Zone No. 3, a fire-resistive time period will not be required for an exterior wall of a one-story Type IV-N building provided the floor area of the building does not exceed one thousand square feet (1000 sq. ft.) and such wall is located not less than five feet (5') from a property line.

(b) **Openings in Walls.** All openings in exterior walls shall conform to the requirements specified in Section 504.

EXCEPTION: This shall not apply to openings which are more than twenty feet (20') from the center line of the street or public space.

In Fire Zone No. 1 all openings in the exterior walls within twenty feet (20') of a property line shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating.

In Fire Zone No. 2 all openings not on a street front and which are within ten feet (10′) of an adjacent property line shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating.

Exterior Walls and Openings (Continued)

Floor Construction

Sec. 2104. Floor construction shall be of incombustible material, provided, however, that a wood surface or finish may be applied over such incombustible material.

Stair Construction

Sec. 2105. Stairs shall be of any type permitted by this Code and shall comply with the requirements of Chapter 33.

Roof Construction

Sec. 2106. Roofs shall be of incombustible construction. In Type IV, One-Hour buildings, roofs may be as specified in Section 1806.

Roof covering shall be a fire-retardant roofing as specified in Section 3203.

CHAPTER 22—TYPE V BUILDINGS

Definition

Sec. 2201. Type V Buildings may be of any materials allowed by this Code.

Type V, One-Hour buildings shall be of one-hour fire-resistive construction throughout.

Materials of construction and fire-resistive requirements shall be as specified in Chapter 17.

For requirements due to occupancy, see Chapters 6 to 15, inclusive.

For requirements in Fire Zones, see Chapter 16.

Sheathing

Sec. 2202. Type V buildings three stories in height shall have all exterior walls of the first story covered with solid sheathing as specified in this Section.

Sheathing shall be one or more of the following materials:

Wood not less than five-eighths inch (⅝") thick applied diagonally.

Fiberboard not less than seven-sixteenths inch ($\frac{7}{16}$") thick complying with U.B.C. Standard No. 22-1-67.

Gypsum sheathing not less than one-half inch (½") thick complying with U.B.C. Standard No. 47-9-67.

Plywood not less than five-sixteenths inch ($\frac{5}{16}$") thick complying with U.B.C. Standard No. 25-9-67 except as required by Section 2507 (f) 3.

Exterior Walls and Openings

Sec. 2203. (a) **Exterior Walls.** For fire protection of exterior walls and openings as determined by location on property, see Section 504 and Table No. 5-A.

> EXCEPTION: In Fire Zone No. 2 exterior walls fronting on streets or yards having a width of at least forty feet (40') may be of unprotected construction.

(b) **Openings in Walls.** All openings in exterior walls shall conform to the requirements specified in Section 504. In Fire Zone No. 2 all openings not on a street front and which are within ten feet (10') of an adjacent property line shall be protected by a fire assembly having a three-fourths-hour fire-resistive rating.

For enclosure of vertical openings, see Section 1706.

Stair Construction

Sec. 2204. Stair construction may be of any type permitted in this Code and shall conform to the requirements of Chapter 33.

PART VI

ENGINEERING REGULATIONS—QUALITY AND DESIGN OF THE MATERIALS OF CONSTRUCTION

CHAPTER 23—GENERAL DESIGN REQUIREMENTS

Definitions

Sec. 2301. The following definitions give the meaning of certain terms as used in this Chapter:

DEAD LOAD. The dead load of a building shall include the weight of the walls, permanent partitions, framing, floors, roofs, and all other permanent stationary construction entering into and becoming a part of a building.

LIVE LOAD. The live load includes all loads except dead and lateral loads.

Loads

Sec. 2302. (a) **General.** Buildings and all parts thereof shall be of sufficient strength to support the estimated or actual imposed dead and live loads in addition to their own proper dead load, without exceeding the stresses noted elsewhere in this Code, provided that no building or part thereof shall be designed for live loads less than those specified in this Chapter. Impact shall be considered in the design of any structure where impact loads occur.

(b) **Special.** Provisions shall be made in designing office floors for a load of 2000 pounds placed upon any space two and one-half feet (2½′) square wherever this load upon an otherwise unloaded floor would produce stresses greater than those caused by a uniformly distributed load of 50 pounds per square foot.

In designing floors to be used for industrial or commercial purposes, the actual live load caused by the use to which the building or part of the building is to be put shall be used in the design of such building or part thereof, and special provision shall be made for machine or apparatus loads when such machine or apparatus would cause a greater load than specified for such use in Section 2304.

Floors in office buildings and in other buildings, where partition locations are subject to change, shall be designed to support, in addition to all other loads, a uniformly distributed load equal to 20 pounds per square foot.

Public garages and commercial or industrial buildings in which loaded trucks are placed, used, or stored shall have the floor systems designed to support a concentrated rear wheel load of a loaded truck placed in any possible position.

Garages for the storage of private pleasure cars shall have the floor system designed for a concentrated wheel load of not less than 2000 pounds.

Loads (Continued)

(c) **Critical Distribution of Live Loads.** Where structural members are arranged so as to create continuity, the loading conditions which would cause maximum shear and bending moments along the member shall be investigated. Where uniform floor loads are involved, consideration may be limited to full dead load on all spans in combination with full live load on adjacent spans and on alternate spans.

Where uniform roof loads are involved consideration may be limited to full dead load on all spans in combination with full live load on all spans and on alternate spans.

Method of Design

Sec. 2303. Any system or method of construction to be used shall admit of a rational analysis in accordance with well-established principles of mechanics.

All allowable stresses and soil-bearing values specified in this Code for working stress design may be increased one-third when considering wind or earthquake forces either acting alone or when combined with vertical loads. No increase will be allowed for vertical loads acting alone.

Load factors for ultimate strength design of concrete and plastic design of steel shall be as indicated in the appropriate Chapters on the materials.

Wind and earthquake loads need not be assumed to act simultaneously.

Unit Live Loads

Sec. 2304. The unit loads set forth in Table No. 23-A shall be taken as the minimum live loads in pounds per square foot of horizontal projection to be used in the design of buildings for the occupancies listed, and loads at least equal shall be assumed for uses not listed in this Section but which create or accommodate similar loadings.

All ceiling joists shall be designed for not less than 10 pounds per square foot total load.

All balcony railings, guardrails and stair handrails shall be designed to withstand a horizontal force of 20 pounds per lineal foot, applied at the top of the railing.

Roof Loads

Sec. 2305. (a) **General.** Roofs shall sustain, within the stress limitations of this Code, all "dead loads" plus unit "live loads" as set forth in Table No. 23-B. The live loads shall be assumed to act vertically upon the area projected upon a horizontal plane.

(b) **Unbalanced Loading.** Unbalanced loads shall be used where such loading will result in larger members or connections. Trusses and arches shall be designed to resist the stresses caused by unit live loads on one-half of the span if such loading results in reverse stresses, or stresses greater in any portion than the stresses produced by the required unit live load upon the entire span. For roofs whose structure is composed of a stressed shell, framed or solid, wherein stresses caused by any point loading are distributed throughout the area of the shell, the requirements for unbalanced unit live load design may be reduced 50 per cent.

Roof Loads (Continued)

(c) **Snow Loads.** Snow load, full or unbalanced, shall be considered in place of loads as set forth in Table No. 23-B where such loading will result in larger members or connections. When valleys are formed by a multiple series of roofs, special provisions shall be made for the increased load at the intersections. Where snow loads occur, the snow loads shall be determined by the Building Official.

TABLE NO. 23-A—UNIT LIVE LOADS

OCCUPANCY	LOAD IN POUNDS PER SQUARE FOOT OF HORIZONTAL PROJECTION
Apartments	40
Armories	150
Auditoriums—Fixed Seats	50
Movable Seats	100
Balconies and Galleries—Fixed Seats	50
Movable Seats	100
Cornices	60
Corridors, Public	100
Dance Halls	100
Drill Rooms	100
Dwellings	40
Exterior Balconies	100
Fire Escapes	100
Garages—Storage or Repair	100[1]
Garages—Storage Private Pleasure Cars	50[1]
Gymnasiums	100
Hospitals—Wards and Rooms	40
Hotels—Guest Rooms and Private Corridors	40
Libraries—Reading Rooms	60
Stack Rooms	125
Loft Buildings	100
Manufacturing—Light	75
Heavy	125
Marquees	60
Offices	50[1]
Printing Plants—Press Rooms	150
Composing and Linotype Rooms	100
Public Rooms	100
Rest Rooms	50
Reviewing Stands and Bleachers	100
Roof Loads	(See Section 2305)
Schools—Classrooms	40
Sidewalks	250
Skating Rinks	100
Stairways	100
Storage—Light	125
Heavy (Load to be determined from proposed use or occupancy, but never less than)	250
Stores—Retail (Light Merchandise)	75
Wholesale (Light Merchandise)	100

[1]See also Subsection 2302 (b).

Roof Loads (Continued)

(d) **Reduction of Snow Loads.** Snow loads in excess of 20 pounds per square foot may be reduced for each degree of pitch over 20 degrees by $S/40$ minus ½, where "S" is the total snow load in pounds per square foot. When the shape of roof structure as determined by actual test or experience indicates lesser or greater snow-retention value the roof load shall be modified as approved by the Building Official.

(e) **Special-purpose Roofs.** Roofs to be used for special purposes shall be designed for appropriate loads as approved by the Building Official.

Greenhouses, lath houses, residential patio structures and agricultural buildings shall be designed for a vertical live load of not less than 10 pounds per square foot.

(f) **Water Accumulation.** All roofs shall be designed with sufficient slope or camber to assure adequate drainage after the long-time deflection from dead load or shall be designed to support maximum loads including possible ponding of water due to deflection. See Section 2307 for deflection criteria.

Reduction of Live Loads

Sec. 2306. The following reductions in unit live loads as set forth in Table No. 23-A for floors shall be permitted in the designing of columns, piers, walls, foundations, trusses, beams, and flat slabs.

Except for places of public assembly, and except for live

TABLE NO. 23-B—MINIMUM ROOF LIVE LOADS (IN POUNDS PER SQUARE FOOT)[1]

ROOF SLOPE	TRIBUTARY LOADED AREA IN SQUARE FEET FOR ANY STRUCTURAL MEMBER		
	0 TO 200	201 TO 600	OVER 600
Flat or rise less than 4 inches per foot. Arch or dome with rise less than ⅛ of span.	20	16	12
Rise 4 inches per foot to less than 12 inches per foot. Arch or dome with rise ⅛ of span to less than ⅜ of span.	16	14	12
Rise 12 inches per foot and greater. Arch or dome with rise ⅜ of span or greater.	12	12	12

[1]Where snow loads occur, the roof structure shall be designed for such loads as determined by the Building Official.

loads greater than 100 pounds per square foot, the design live load on any member supporting one hundred and fifty square feet (150 sq. ft.) or more may be reduced at the rate of 0.08 per cent per square foot of area supported by the member. The reduction shall not exceed 60 per cent nor "R" as determined by the following formula:

Reduction of Live Loads (Continued)

$$R = 23.1 \left(1 + \frac{D}{L}\right)$$

WHERE:

R = Reduction in per cent

D = Dead load per square foot of area supported by the member

L = Unit live load per square foot of area supported by the member

For storage live loads exceeding 100 pounds per square foot, no reduction shall be made except that design live loads on columns may be reduced 20 per cent.

The live load reduction shall not exceed 40 per cent in garages for the storage of private pleasure cars having a capacity of not more than nine passengers per vehicle.

Deflection

Sec. 2307. The deflection of any structural member shall not exceed the values set forth in Table No. 23-C, based upon the factors set forth in Table No. 23-D. The deflection criteria representing the most restrictive condition shall apply. Deflection criteria for materials not specified shall be developed in a manner consistent with the provisions of this Section. See Section 2305 (f) for camber requirements.

Wind Pressure

Sec. 2308. (a) **General.** Buildings or structures shall be designed to withstand the minimum horizontal and uplift pressures set forth in Table No. 23-E and this Section allowing for wind from any direction. The wind pressures set forth in Table No. 23-E are minimum values and shall be adjusted by the Building Officials for areas subjected to higher wind pressures. When the form factor, as determined by wind tunnel tests or other recognized methods, indicates vertical or horizontal loads of lesser or greater severity than those produced by the loads herein specified, the structure may be designed accordingly.

(b) **Horizontal Wind Pressure.** For purposes of design, the wind pressure shall be taken upon the gross area of the vertical projection of that portion of the building or structure measured above the average level of the adjoining ground.

(c) **Uplift Wind Pressure.** Roofs of all enclosed buildings or structures shall be designed and constructed to withstand

Wind Pressure (Continued)

pressures acting upward normal to the surface equal to three-fourths of the values set forth in Table No. 23-E for the height zone under consideration. An enclosed building shall be defined as a building enclosed at the perimeter with solid exterior walls. Openings are permitted in the solid exterior wall provided they are glazed or protected with door assemblies.

Roofs of unenclosed buildings, roof overhangs, architectural projections, eaves, canopies, cornices, marquees, or similar structures unenclosed on one or more sides shall be designed and constructed to withstand upward pressures equal to one and one-fourth times those values set forth in Table No. 23-E.

The upward pressures shall be assumed to act over the entire roof area.

(d) **Roofs with Slopes Greater than 30 Degrees.** Roofs or sections of roofs with slopes greater than 30 degrees shall be designed and constructed to withstand pressures, acting inward normal to the surface, equal to those specified for the height zone in which the roof is located, and applied to the windward slope only.

(e) **Anchorage Requirements.** Adequate anchorage of the roof to walls and columns, and of walls and columns to the foundations to resist overturning, uplift, and sliding, shall be provided in all cases.

(f) **Solid Towers.** Chimneys, tanks, and solid towers shall be designed and constructed to withstand the pressures as specified by this Section, multiplied by the factors set forth in Table No. 23-F.

(g) **Open Frame Towers.** Radio towers and other towers of trussed construction shall be designed and constructed to withstand wind pressures specified in this Section, multiplied by the shape factors set forth in Table No. 23-G.

Wind pressures shall be applied to the total normal projected area of all the elements of one face (excluding ladders, conduits, lights, elevators, etc., which shall be accounted for separately by using the indicated factor for these individual members).

(h) **Miscellaneous Structures.** Greenhouses, lath houses, agricultural buildings and residential patio structures shall be designed for the horizontal wind pressures as set forth in Table No. 23-E, except that, if the height zone is ten feet (10′) or less, two-thirds of the first line of listed values may be used. The structures shall be designed to withstand an uplift wind pressure equal to three-fourths of the horizontal pressure.

(i) **Moment of Stability.** The overturning moment calculated from the wind pressure shall in no case exceed two-thirds of the dead load resisting moment.

The weight of earth superimposed over footings may be used to calculate the dead load resisting moment.

TABLE NO. 23-C—MAXIMUM ALLOWABLE DEFLECTION FOR STRUCTURAL MEMBERS[1]

TYPE OF MEMBER	MEMBER LOADED WITH LIVE LOAD ONLY (L.L.)	MEMBER LOADED WITH LIVE LOAD PLUS DEAD LOAD (L.L. + K D.L.)
Roof Member Supporting Plaster or Floor Member	$L/360$	$L/240$

[1]Sufficient slope or camber shall be provided for flat roofs in accordance with Section 2305 (*f*).

L.L. = Live load

D.L. = Dead load

K = Factor as determined by Table No. 23-D

L = Length of member in same units as deflection

TABLE NO. 23-D—VALUE OF "*K*"

WOOD		REINFORCED CONCRETE			STEEL
Unseasoned	Seasoned[1]	A's = 0	A's = 0.5 As	A's = As	
1.0	0.5	2.0	1.2	0.8	0

[1]Seasoned lumber is lumber having a moisture content of less than 16 per cent at the time of installation and used under dry conditions of use such as in most covered structures.

A's = Area of compressive reinforcing steel in flexural members.

As = Area of tensile reinforcing steel in flexural members.

TABLE NO. 23-E—WIND PRESSURES FOR VARIOUS HEIGHT ZONES ABOVE GROUND[1]

HEIGHT ZONES (in feet)	WIND-PRESSURE-MAP AREAS (pounds per square foot)						
	20	25	30	35	40	45	50
Less than 30	15	20	25	25	30	35	40
30 to 49	20	25	30	35	40	45	50
50 to 99	25	30	40	45	50	55	60
100 to 499	30	40	45	55	60	70	75
500 to 1199	35	45	55	60	70	80	90
1200 and over	40	50	60	70	80	90	100

[1]See Figure No. 1. Wind pressure column in the table should be selected which is headed by a value corresponding to the minimum permissible, resultant wind pressure indicated for the particular locality.

The figures given are recommended as minimum. These requirements do not provide for tornadoes.

TABLE NO. 23-F—MULTIPLYING FACTORS FOR WIND PRESSURES—CHIMNEYS, TANKS, AND SOLID TOWERS

HORIZONTAL CROSS SECTION	FACTOR
Square or rectangular	1.00
Hexagonal or octagonal	0.80
Round or elliptical	0.60

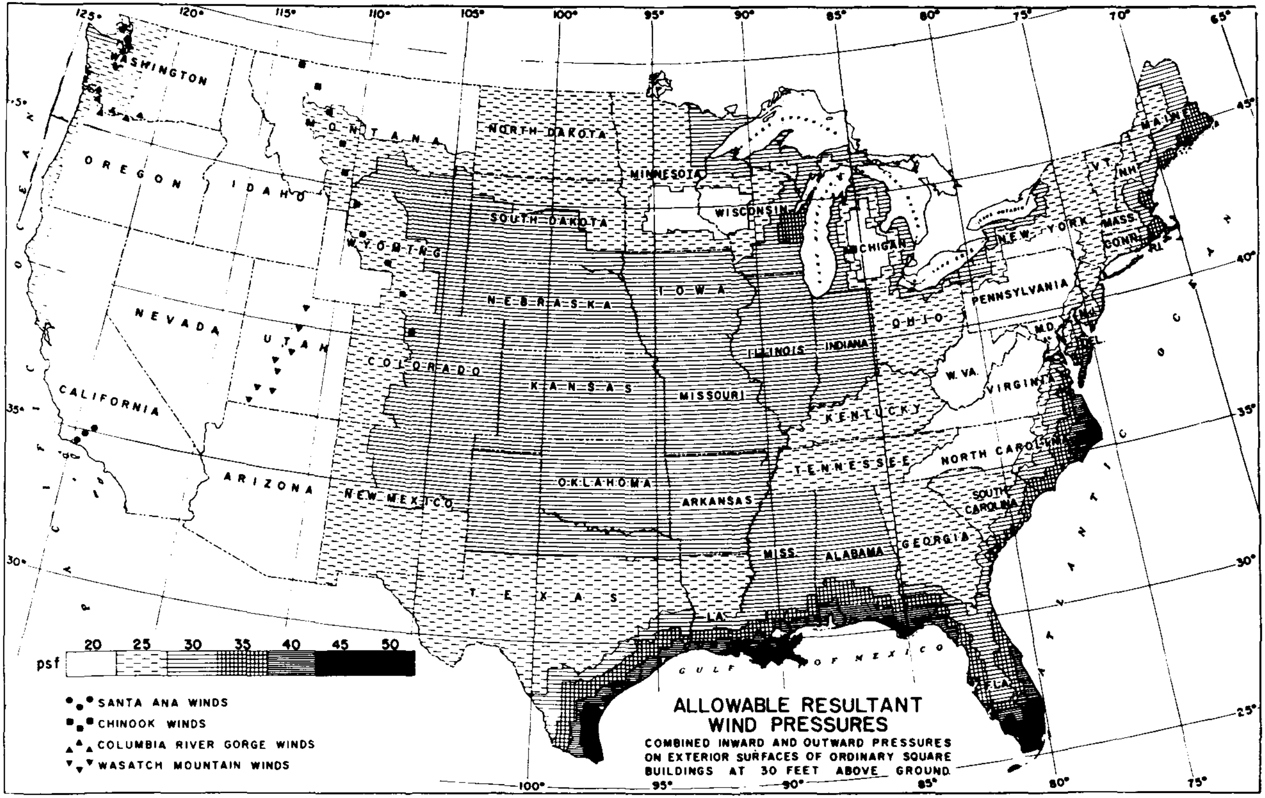
ALLOWABLE RESULTANT WIND PRESSURES
COMBINED INWARD AND OUTWARD PRESSURES ON EXTERIOR SURFACES OF ORDINARY SQUARE BUILDINGS AT 30 FEET ABOVE GROUND
psf
20
25
30
35
40
45
50
SANTA ANA WINDS
CHINOOK WINDS
COLUMBIA RIVER GORGE WINDS
WASATCH MOUNTAIN WINDS
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NEVADA
UTAH
CALIFORNIA
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LA.
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISS.
ALABAMA
GEORGIA
FLA.
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W. VA.
PENNSYLVANIA
NEW YORK
MD.
DEL.
N.J.
CONN.
R.I.
MASS.
VT.
N.H.
MAINE
GULF OF MEXICO
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°

FIGURE NO. 1

(j) **Combined Wind and Live Loads.** For the purpose of determining stresses all vertical design loads except the roof live load and crane loads shall be considered as acting simultaneously with the wind pressure.

Wind Pressure (Continued)

Live Loads Posted

Sec. 2309. The live loads for which each floor or part thereof of a commercial or industrial building is or has been designed shall have such designed live loads conspicuously posted by the owner in that part of each story in which they apply, using durable metal signs, and it shall be unlawful to remove or deface such notices. The occupant of the building shall be responsible for keeping the actual load below the allowable limits.

Retaining Walls

Sec. 2310. Retaining walls shall be designed to resist the lateral pressure of the retained material in accordance with accepted engineering practice. Walls retaining drained earth may be designed for pressure equivalent to that exerted by a fluid weighing not less than 30 pounds per cubic foot and having a depth equal to that of the retained earth. Any surcharge shall be in addition to the equivalent fluid pressure.

Footing Design

Sec. 2311. See Chapter 28.

Walls and Structural Framing

Sec. 2312. (a) **General.** Walls and structural framing shall be erected true and plumb in accordance with the design. Bracing shall be placed during erection wherever necessary to take care of all loads to which the structure may be subjected.

TABLE NO. 23-G—SHAPE FACTORS FOR RADIO TOWERS AND TRUSSED TOWERS

TYPE OF EXPOSURE	FACTOR
Wind normal to one face of tower	
Four-cornered, flat or angular sections, steel or wood	2.20
Three-cornered, flat or angular sections, steel or wood	2.00
Wind on corner, four-cornered tower, flat or angular sections	2.40
Wind parallel to one face of three-cornered tower, flat or angular sections	1.50
Factors for towers with cylindrical elements are approximately two-thirds of those for similar towers with flat or angular sections	
Wind on individual members	
Cylindrical members	
Two inches or less in diameter	1.00
Over two inches in diameter	0.80
Flat or angular sections	1.30

Walls and Structural Framing (Continued)

(b) **Interior Walls.** Interior walls, permanent partitions, and temporary partitions which exceed three-fourths of the height of the room in which they are placed shall be designed to resist all loads to which they are subjected but not less than a force of 10 pounds per square foot applied perpendicular to the walls. The deflection of such walls under a load of five pounds per square foot shall not exceed 1/240 of the span for walls with brittle finishes and 1/120 of the span for walls with flexible finishes. See Table No. 23-I for earthquake design requirements where such requirements are more restrictive.

Anchorage

Sec. 2313. Concrete or masonry walls shall be anchored to all floors and roofs which provide lateral support for the wall or are required to provide stability for the wall. Such anchorage shall be capable of resisting the horizontal forces specified in this Chapter or a minimum force of 200 pounds per linear foot of wall, whichever is the larger. Required anchors in masonry walls of hollow units or cavity walls shall enter a reinforced grouted structural element of the wall.

Earthquake Regulations

Sec. 2314. (a) **General.** Every building or structure and every portion thereof shall be designed and constructed to resist stresses produced by lateral forces as provided in this Section. Stresses shall be calculated as the effect of a force applied horizontally at each floor or roof level above the foundation. The force shall be assumed to come from any horizontal direction.

The provisions of this Section apply to the structure as a unit and also to all parts thereof, including the structural frame or walls, floor and roof systems, and other structural features.

(b) **Definitions.** The following definitions apply only to the provisions of this Section.

SPACE FRAME is a three-dimensional structural system composed of interconnected members, other than bearing walls, laterally supported so as to function as a complete self-contained unit with or without the aid of horizontal diaphragms or floor bracing systems.

SPACE FRAME-MOMENT RESISTING is a vertical load carrying space frame in which the members and joints are capable of resisting design lateral forces by bending moments.

SPACE FRAME-DUCTILE MOMENT RESISTING is a space frame-moment resisting complying with the requirements for a ductile moment resisting space frame as given in Section 2314 (j).

LATERAL FORCE RESISTING SYSTEM is that part of the structural system to which the lateral forces prescribed in Section 2314 (d) 1 are assigned.

Earthquake Regulations (Continued)

SPACE FRAME—VERTICAL LOAD-CARRYING is a space frame designed to carry all vertical loads.

BOX SYSTEM is a structural system without a complete vertical load-carrying space frame. In this system the required lateral forces are resisted by shear walls as hereinafter defined.

SHEAR WALL is a wall designed to resist lateral forces parallel to the wall. Braced frames subjected primarily to axial stresses shall be considered as shear walls for the purpose of this definition.

(c) **Symbols and Notations.** The following symbols and notations apply only to the provisions of this Section.

C = Numerical coefficient for base shear as specified in Section 2314 (d) 1.

C_p = Numerical coefficient as specified in Section 2314 (d) 2 and as set forth in Table No. 23-I.

D = The dimension of the building in feet in a direction parallel to the applied forces.

D_s = The plan dimension of the vertical lateral force resisting system in feet.

F_i, F_n, F_x = Lateral forces applied to a level "i," "n," or "x," respectively.

F_p = Lateral forces on the part of the structure and in the direction under consideration.

F_t = That portion of "V" considered concentrated at the top of the structure, at the level "n." The remaining portion of the total base shear "V" shall be distributed over the height of the structure including level "n" according to Formula (14-5).

H = The height of the main portion of the building in feet above the base.

h_i, h_n, h_x = Height in feet above the base to level "i," "n," or "x," respectively.

J = Numerical coefficient for base moment as specified in Section 2314 (h).

J_x = Numerical coefficient for overturning moment at level "x."

K = Numerical coefficient as set forth in Table No. 23-H.

Level i = Level of the structure referred to by the subscript "i."

Level n = That level which is uppermost in the main portion of the structure.

Level x = That level which is under design consideration.

M = Overturning moment at the base of the building or structure.

M_x = The overturning moment at level "x."

Earthquake Regulations (Continued)

N = Total number of stories above exterior grade.

T = Fundamental period of vibration of the building or structure in seconds in the direction under consideration.

V = Total lateral load or shear at the base.

$$V = F_t + \sum_{i=1}^{n} F_i$$

where $i = 1$ designates first level above the base.

W = Total dead load including partitions using the actual weight of the partitions or the partition loading specified in Section 2302 (b).

$$W = \sum_{i=1}^{n} w_i$$

EXCEPTION: "W" shall be equal to the total dead load plus 25 per cent of the floor live load in storage and warehouse occupancies.

w_i, w_x = That portion of "W" which is located at or is assigned to level "i" or "x" respectively.

W_p = The weight of a part or portion of a structure.

Z = Numerical coefficient dependent upon the zone as determined by the map on the inside back cover. For locations in Zone No. 1 "Z" shall be equal to one-fourth. For locations in Zone No. 2 "Z" shall be equal to one-half. For locations in Zone No. 3 "Z" shall be equal to one.

(d) **Minimum Earthquake Forces for Structures. 1. Total lateral force and distribution of lateral force.** Every structure shall be designed and constructed to withstand minimum total lateral seismic forces assumed to act nonconcurrently in the direction of each of the main axes of the structure in accordance with the following formula (for forces on parts or portions of buildings and for forces on structures other than buildings, see paragraph 2 of this Subsection):

$$V = ZKCW \tag{14-1}$$

The value of "K" shall be not less than that set forth in Table No. 23-H. The value of "C" shall be determined in accordance with the following formula:

$$C = \frac{0.05}{\sqrt[3]{T}} \tag{14-2}$$

Except as provided in Table No. 23-I, the maximum value of "C" need not exceed 0.10. For all one- and two-story buildings the value of "C" shall be considered as 0.10.

"T" is the fundamental period of vibration of the structure in seconds in the direction under consideration. Properly substantiated technical data for establishing the period "T" may be submitted. In the absence of such data, the value of "T" for buildings shall be determined by the following formula:

Earthquake Regulations (Continued)

$$T = \frac{0.05h_n}{\sqrt{D}} \qquad (14\text{-}3)$$

TABLE NO. 23-H—HORIZONTAL FORCE FACTOR "K" FOR BUILDINGS OR OTHER STRUCTURES[1]

TYPE OR ARRANGEMENT OF RESISTING ELEMENTS	VALUE[2] OF K
All building framing systems except as hereinafter classified	1.00
Buildings with a box system as specified in Section 2314 (b)	1.33
Buildings with a dual bracing system consisting of a ductile moment resisting space frame and shear walls using the following design criteria: (1) The frames and shear walls shall resist the total lateral force in accordance with their relative rigidities considering the interaction of the shear walls and frames (2) The shear walls acting independently of the ductile moment resisting portions of the space frame shall resist the total required lateral forces (3) The ductile moment resisting space frame shall have the capacity to resist not less than 25 per cent of the required lateral force	0.80
Buildings with a ductile moment resisting space frame designed in accordance with the following criteria: The ductile moment resisting space frame shall have the capacity to resist the total required lateral force	0.67
Elevated tanks plus full contents, on four or more cross-braced legs and not supported by a building[3,4]	3.00[5]
Structures other than buildings and other than those set forth in Table No. 23-I	2.00

[1]Where wind load as specified in Section 2307 would produce higher stresses, this load shall be used in lieu of the loads resulting from earthquake forces.

[2]See map on inside back cover for seismic probability zones and definition of "Z" as specified in Subsection (c).

[3]The minimum value of "KC" shall be 0.12 and the maximum value of "KC" need not exceed 0.25.

[4]For overturning, the factor "J" as specified in Section 2314 (h) shall be 1.00.

[5]The tower shall be designed for an accidental torsion of five per cent as specified in Section 2314 (g). Elevated tanks which are supported by buildings or do not conform to type or arrangement of supporting elements as described above shall be designed in accordance with Section 2314 (d) 2 using "C_p" = .2.

Earthquake Regulations (Continued)

EXCEPTION: In all buildings in which the lateral resisting system consists of a moment-resisting space frame which resists 100 per cent of the required lateral forces and which frame is not enclosed by or adjoined by more rigid elements which would tend to prevent the frame from resisting lateral forces:

$$T = 0.10N \qquad (14\text{-}3A)$$

The total lateral force "V" shall be distributed in the height of the structure in the following manner:

$$F_t = .004V \left(\frac{h_n}{D_s}\right)^2 \qquad (14\text{-}4)$$

F_t need not exceed 0.15 "V" and may be considered as 0 for values $\left(\frac{h_n}{D_s}\right)$ of 3 or less, and

$$F_x = \frac{(V - F_t)\ w_x h_x}{\sum_{i=1}^{n} w_i h_i} \qquad (14\text{-}5)$$

EXCEPTION: One- and two-story buildings shall have uniform distribution.

At each level designated as "x," the force "F_x" shall be applied over the area of the building in accordance with the mass distribution on that level.

2. **Lateral force on parts or portions of buildings or other structures.** Parts or portions of buildings or structures and their anchorage shall be designed for lateral forces in accordance with the following formula:

$$F_p = ZC_pW_p \qquad (14\text{-}6)$$

The values of "C_p" are set forth in Table No. 23-I. The distribution of these forces shall be according to the gravity loads pertaining thereto.

3. **Pile foundations.** Individual pile or caisson footings of every building or structure shall be interconnected by ties each of which can carry by tension and compression a horizontal force equal to 10 per cent of the larger pile cap loading unless it can be demonstrated that equivalent restraint can be provided by other approved methods.

(e) **Distribution of Horizontal Shear.** Total shear in any horizontal plane shall be distributed to the various elements of the lateral force resisting system in proportion to their rigidities considering the rigidity of the horizontal bracing system or diaphragm.

Rigid elements that are assumed not to be part of the lateral force resisting system may be incorporated into buildings provided that their effect on the action of the system is considered and provided for in the design.

Earthquake Regulations (Continued)

TABLE NO. 23-I—HORIZONTAL FORCE FACTOR "C_p" FOR PARTS OR PORTIONS OF BUILDINGS OR OTHER STRUCTURES

PART OR PORTION OF BUILDINGS	DIRECTION OF FORCE	VALUE OF C_p
Exterior bearing and nonbearing walls, interior bearing walls and partitions, interior nonbearing walls and partitions over ten feet (10′) in height, masonry or concrete fences over six feet (6′) in height[1]	Normal to flat surface	0.20
Cantilever parapet and other cantilever walls, except retaining walls	Normal to flat surface	1.00
Exterior and interior ornamentations and appendages	Any direction	1.00
When connected to or a part of a building: towers, tanks, towers and tanks plus contents, chimneys, smokestacks, and penthouses	Any direction	0.20[2]
When resting on the ground, tank plus effective mass of its contents	Any direction	0.10
Floors and roofs acting as diaphragms[3]	Any direction	0.10
Connections for exterior panels or for elements complying with Section 2314 (k) 5	Any direction	2.00
Connections for prefabricated structural elements other than walls, with force applied at center of gravity of assembly[4]	Any horizontal direction	0.30

[1]See also Section 2312 (b) for minimum load on deflection criteria for interior partitions.

[2]When "h_n/D" of any building is equal to or greater than five to one increase value by 50 per cent.

[3]Floors and roofs acting as diaphragms shall be designed for a minimum value of "C_p" of 10 per cent applied to loads tributary from that story unless a greater value of "C_p" is required by the basic seismic formula $V = ZKCW$.

[4]The "W_p" shall be equal to the total load plus 25 per cent of the floor live load in storage and warehouse occupancies.

Earthquake Regulations (Continued)

(f) **Drift.** Lateral deflections or drift of a story relative to its adjacent stories shall be considered in accordance with accepted engineering practice.

(g) **Horizontal Torsional Moments.** Provisions shall be made for the increase in shear resulting from the horizontal torsion due to an eccentricity between the center of mass and the center of rigidity. Negative torsional shears shall be neglected. Where the vertical resisting elements depend on diaphragm action for shear distribution at any level, the shear-resisting elements shall be capable of resisting a torsional moment assumed to be equivalent to the story shear acting with an eccentricity of not less than five per cent of the maximum building dimension at that level.

(h) **Overturning.** Every building or structure shall be designed to resist the overturning effects caused by the wind forces and related requirements specified in Section 2308, or the earthquake forces specified in this Section, whichever governs.

EXCEPTION: The axial loads from earthquake forces on vertical elements and footings in every building or structure may be modified in accordance with the following provisions:

1. The overturning moment, "M", at the base of the building or structure shall be determined in accordance with the following formula:

$$M = J(F_t h_n + \sum_{i=1}^{n} F_i h_i) \qquad (14\text{-}7)$$

WHERE:

$$J = \frac{0.5}{\sqrt[3]{T^2}} \qquad (14\text{-}8)$$

The value of "J" need not be more than 1.00.

2. The overturning moment, "M_x", at any level designated as "x" shall be determined in accordance with the following:

$$M_x = J_x\,[F_t\,(h_n - h_x) + \sum_{i=x}^{n} F_i\,(h_i - h_x)] \qquad (14\text{-}9)$$

WHERE:

$$J_x = J + (1-J)\left(\frac{h_x}{h_n}\right)^3 \qquad (14\text{-}10)$$

At any level the incremental changes of the design overturning moment, in the story under consideration, shall be distributed to the various resisting elements in the same proportion as the distribution of the shears in the resisting system. Where other vertical members are provided which are capable of partially resisting the overturning moments, a resdistribution may be made to these members if framing members of sufficient strength and stiffness to transmit the required loads are provided.

Where a vertical resisting element is discontinuous, the overturning moment carried by the lowest story of that element shall be carried down as loads to the foundation.

(i) **Set-backs.** Buildings having set-backs wherein the plan dimension of the tower in each direction is at least 75 per cent of the corresponding plan dimension of the lower part may be considered as a uniform building without set-backs for the purpose of determining seismic forces.

For other conditions of set-backs the tower shall be designed as a separate building using the larger of the seismic coefficients at the base of the tower determined by considering the tower as either a separate building for its own height or as part of the over-all structure. The resulting total shear from the tower shall be applied at the top of the lower part of the building which shall be otherwise considered separately for its own height.

(j) **Structural Systems. 1. Design requirements.** Buildings more than one hundred and sixty feet (160') in height shall have a ductile moment-resisting space frame capable of resisting not less than 25 per cent of the required seismic force for the structure as a whole. All buildings designed with a horizontal force factor "*K*" of 0.67 or 0.80 shall have a ductile moment-resisting space frame of structural steel (complying with Chapter 27) or reinforced concrete (complying with Section 2630 for buildings in Seismic Zones No. 2 and No. 3 or Section 2631 for buildings in Seismic Zone No. 1).

> **EXCEPTIONS:** 1. Buildings more than one hundred and sixty feet (160') in height in Seismic Zone No. 1 may have concrete shear walls designed in conformance with Section 2632 of this Code in lieu of a ductile moment-resisting space frame provided a "*K*" value of 1.00 or 1.33 is utilized in the design.
>
> 2. Other structural concepts may be approved by the Building Official when evidence is submitted showing that equivalent ductility and energy absorption are provided.

Moment-resisting space frames and ductile moment-resisting space frames may be enclosed by or adjoined by more rigid elements which would tend to prevent the space frame from resisting lateral forces where it can be shown that the action or failure of the more rigid elements will not impair the vertical and lateral load-resisting ability of the space frame.

2. **Construction.** The necessary ductility for a ductile moment-resisting space frame shall be provided by a frame of

Earthquake Regulations (Continued)

structural steel conforming to ASTM A7, A36 or A441 with moment-resisting connections, or by a reinforced concrete frame complying with Section 2630 of this Code for buildings in Seismic Zones No. 2 and No. 3 or Section 2631 for buildings in Seismic Zone No. 1.

Shear walls in buildings where "*K*" equals .80 shall be composed of axially loaded bracing members of ASTM A7, A36 or A441 structural steel; or reinforced concrete bracing members or walls conforming with the requirements of Section 2632 of this Code. Reinforced concrete shear walls and reinforced concrete braced frames for all buildings shall conform to the requirements of Section 2632 of this Code.

(k) **Design Requirements.** 1. **Building separations.** All portions of structures shall be designed and constructed to act as an integral unit in resisting horizontal forces unless separated structurally by a distance sufficient to avoid contact under deflection from seismic action or wind forces.

2. **Minor alterations.** Minor structural alterations may be made in existing buildings and other structures, but the resistance to lateral forces shall be not less than that before such alterations were made, unless the building as altered meets the requirements of this Section of the Code.

3. **Reinforced masonry or concrete.** All elements within the structure which are of masonry or concrete and which resist seismic forces or movement shall be reinforced so as to qualify as reinforced masonry or concrete under the provisions of Chapters 24 and 26. Principal reinforcement in masonry shall be spaced two feet (2′) maximum on center in buildings using a ductile moment-resisting space frame.

4. **Combined vertical and horizontal forces.** In computing the effect of seismic force in combination with vertical loads, gravity load stresses induced in members by dead load plus design live load, except roof live load, shall be considered.

5. **Exterior elements.** Precast, nonbearing, non-shear wall panels or other elements which are attached to, or enclose the exterior, shall accommodate movements of the structure resulting from lateral forces or temperature changes. The concrete panels or other elements shall be supported by means of poured-in-place concrete or by mechanical fasteners in accordance with the following provisions:

A. Connections and panel joints shall allow for a relative movement between stories of not less than two times story drift caused by wind or seismic forces; or one-fourth inch (¼″) whichever is greater.

B. Connections shall have sufficient ductility and rotation capacity so as to preclude fracture of the concrete or brittle failures at or near welds. Inserts in concrete shall be attached to, or hooked around reinforcing steel, or otherwise terminated so as to effectively transfer forces to the reinforcing steel.

Earthquake Regulations (Continued)

C. Connections to permit movement in the plane of the panel for story drift may be properly designed sliding connections using slotted or oversize holes or may be connections which permit movement by bending of steel.

(l) **Earthquake Recording Instrumentations.** For earthquake recording instrumentations see Appendix, Section 2314 (1).

Heliport and Helistop Landing Areas

Sec. 2315. In addition to other design requirements of this Chapter, heliport and helistop landing or touchdown areas shall be designed for the maximum stress induced by the following:

1. Dead load plus actual weight of the helicopter.
2. Dead load plus a single concentrated impact load covering one square foot (1 sq. ft.) of .75 times the fully loaded weight of the helicopter if it is equipped with hydraulic type shock absorbers, or 1.5 times the fully loaded weight of the helicopter if it is equipped with a rigid or skid type landing gear.
3. The dead load plus a uniform live load of 100 pounds per square foot. The required live load may be reduced in accordance with the formula in Section 2306.

CHAPTER 24—MASONRY

Scope

Sec. 2401. All masonry shall conform to the regulations of this Code.

Definitions

Sec. 2402. For the purpose of this Chapter certain terms are defined as follows:

DIMENSIONS. Dimensions given are nominal; actual dimensions of unit masonry may not be decreased by more than one-half inch (½").

GROSS CROSS-SECTIONAL AREA OF HOLLOW UNITS, the total area including cells of a section perpendicular to the direction of loading. Re-entrant spaces are included in the gross area, unless these spaces are to be occupied in masonry by portions of adjacent units.

MASONRY UNIT, any brick, tile, stone, or block conforming to the requirements specified in Section 2403.

Materials

Sec. 2403. (a) **General.** The quality, testing and design of masonry materials used structurally in buildings or structures shall conform to the requirements specified in this Chapter and to the following standards:

MATERIALS AND DESIGN	U.B.C. DESIGNATION
BUILDING BRICK	
Clay or Shale	24- 1-67
Sand-Lime	24- 2-67
Concrete	24- 3-67
CONCRETE MASONRY UNITS	
Hollow Load-Bearing	24- 4-67
Solid Load-Bearing	24- 5-67
Hollow Nonload-Bearing	24- 6-67
Method of Test	24- 7-67
STRUCTURAL CLAY TILE	
For Walls—Load-Bearing	24- 8-67
For Walls—Nonbearing	24- 9-67
For Floors	24-10-67
GYPSUM	
Partition Tile or Block	24-11-67
General	24-12-67
Reinforced and Precast	24-13-67
CAST STONE	24-14-67
REINFORCEMENT	
Reinforcing Steel	26- 7-67
Cold-drawn Steel Wire for Concrete Reinforcement	24-15-67
CEMENT	
Portland Cement and Air-Entraining Portland Cement	26- 1-67
Masonry Cement	24-16-67

Materials (Continued)

(b) **Brick Made from Clay or Shale.** Building brick of clay or shale shall be of a quality at least equal to the requirements set forth in U.B.C. Standard No. 24-1-67. When in contact with the ground, brick shall be of at least Grade MW. Where severe frost action occurs in the presence of moisture, brick shall be at least Grade SW.

(c) **Brick Made from Sand-Lime.** Building brick made from sand-lime shall be of a quality at least equal to the requirements set forth in U.B.C. Standard No. 24-2-67. When in contact with the ground, brick shall be of at least Grade MW. Where severe frost action occurs in the presence of moisture, brick shall be at least Grade SW.

(d) **Concrete Brick.** Building brick of concrete shall be of a quality at least equal to the requirements set forth in U.B.C. Standard No. 24-3-67.

(e) **Concrete Masonry Units.** Concrete masonry units shall be of a quality at least equal to the requirements set forth in U.B.C. Standard No. 24-4-67 or No. 24-5-67 when used for bearing walls or piers, or when in contact with ground or exposed to the weather; or equal to the requirements set forth in U.B.C. Standard No. 24-6-67 when used for nonbearing purposes and not exposed to the weather. Solid units subject to the action of weather or soil shall be Grade A. Concrete masonry units shall be tested as set forth in U.B.C. Standard No. 24-7-67.

(f) **Structural Clay Tile.** Structural clay tile shall be of a quality at least equal to the requirements set forth in U.B.C. Standard No. 24-8-67, Grade LB when used for bearing walls or piers, or Grade LBX when exposed to the weather or soil; or equal to the requirements set forth in U.B.C. Standard No. 24-9-67 when used for interior nonload-bearing purposes; or equal to the requirements set forth in U.B.C. Standard No. 24-10-67 when used for floor construction.

(g) **Gypsum Units and Gypsum.** Gypsum partition tile or block shall be of a quality at least equal to the requirements

Materials (Continued)

set forth in U.B.C. Standard No. 24-11-67. Gypsum shall conform to U.B.C. Standard No. 24-12-67. Reinforced gypsum concrete shall conform to U.B.C. Standard No. 24-13-67.

(h) **Cast Building Stones.** Cast building stone shall be equal to the requirements set forth in U.B.C. Standard No. 24-14-67. Every concrete unit more than eighteen inches (18″) in any dimension shall conform to the requirements for concrete in Chapter 26.

(i) **Unburned Clay Brick.** Unburned clay brick shall conform to the requirements specified in Section 2405.

(j) **Stone.** Natural stone shall be sound, clean, and in conformity with other provisions of this Chapter.

(k) **Structural Glass Block.** Structural glass block shall have unglazed surfaces to allow adhesion on all mortared faces.

(l) **Glazed Building Units.** Glazed brick shall conform to the structural requirements for building brick of clay or shale, and glazed structural tile shall conform to the structural requirements for structural clay tile.

(m) **Reinforcing Steel.** Reinforcing steel shall conform to the physical and chemical requirements for metal reinforcement in concrete, as specified in U.B.C. Standard No. 26-7-67.

(n) **Masonry Joint Reinforcement.** Wire reinforcement shall conform to U.B.C. Standard No. 24-15-67.

(o) **Water.** Water used in mortar, grout, or masonry work shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, or other harmful substances.

(p) **Cement.** Cement for mortar shall be Type I, II, or III portland cement as set forth in U.B.C. Standard No. 26-1-67, or Type I-A, II-A, or III-A air-entraining portland cement as set forth in U.B.C. Standard No. 26-1-67, or Type II masonry cement as set forth in U.B.C. Standard No. 24-16-67.

> **EXCEPTION:** Approved types of plasticizing agents may be added to portland cement Type I or II in the manufacturing process, but not in excess of 12 per cent of the total volume. Plastic or waterproofed cements so manufactured shall meet the requirements for portland cement as set forth in U.B.C. Standard No. 26-1-67 except in respect to the limitations on insoluble residue, air-entrainment, and additions subsequent to calcination.

(q) **Lime.** Quicklime shall conform to U.B.C. Standard No. 24-17-67. Hydrated lime shall conform to the requirements of U.B.C. Standard No. 24-18-67. Lime putty shall be made from quicklime or hydrated lime.

If made from other than processed pulverized quicklime, the lime shall be slaked and then screened through a No. 16

mesh sieve. After slaking, screening, and before using, it shall be stored and protected for not less than 10 days. The resulting lime putty shall weigh not less than 83 pounds per cubic foot.

Materials (Continued)

Processed pulverized quicklime conforming to U.B.C. Standard No. 24-19-67 shall be slaked for not less than 48 hours and shall be cool when used.

(r) **Mortar. 1. General.** Mortar other than gypsum mortar used in masonry construction shall be classified in accordance with (a) the materials and proportions set forth in Table No. 24-A, or (b) the properties as established by laboratory tests as set forth in U.B.C. Standard No. 24-20-67. Tests made to classify mortar by compressive strength shall be as set forth in U.B.C. Standard No. 24-20-67, using the proportions and materials proposed for use. Aggregates for mortar shall conform to the provisions set forth in U.B.C. Standard No. 24-21-67.

2. **Strength.** The strength of mortar using cementitious materials set forth in Table No. 24-A shall meet the minimum compressive strength shown. The Building Official may require field tests to verify compliance with this Section. Such tests shall be made in accordance with U.B.C. Standard No. 24-22-67.

(s) **Grout. 1. General.** Grout shall be proportioned by volume and shall have sufficient water added to produce consistency for pouring without segregation. Aggregate shall conform to the requirements set forth in U.B.C. Standard No. 24-23-67.

2. **Type.** Fine grout shall be composed of one part portland cement, to which may be added not more than one-tenth

TABLE NO. 24-A—MORTAR PROPORTIONS
(Parts by Volume)

MORTAR TYPE	MINIMUM COMPRESSIVE STRENGTH AT 28 DAYS (p.s.i.)	PORTLAND CEMENT	HYDRATED LIMES OR LIME PUTTY[1]		MASONRY CEMENTS TYPE II	DAMP LOOSE AGGREGATE
			MIN.	MAX.		
S	2000	1	$\frac{1}{4}$	$\frac{1}{2}$	—	Not less than $2\frac{1}{4}$ and not more than 3 times the sum of the volumes of the cement and lime used.
N	750	1	$\frac{1}{2}$	$1\frac{1}{4}$	—	
N (Masonry)	750	—	—	—	1	
O	350	1	$1\frac{1}{4}$	$2\frac{1}{2}$	—	

[1]When plastic or waterproof cement is used as specified in Section 2403 (p), hydrated lime or putty may be added but not in excess of one-tenth the volume of cement.

Materials (Continued)

part hydrated lime or lime putty, and two and one-fourth to three parts sand.

Coarse grout shall be composed of one part portland cement to which may be added not more than one-tenth part hydrated lime or lime putty, and two to three parts sand, and not more than two parts gravel.

EXCEPTION: Mortar may be used for grout in chimney and fireplace construction as specified in Section 3704.

Coarse grout may be used in grout spaces in brick masonry two inches (2″) or more in horizontal dimension and in grout spaces in filled-cell construction four inches (4″) or more in both horizontal dimensions.

3. **Strength.** Grout shall attain a minimum compressive strength of 2000 pounds per square inch at 28 days. The Building Official may require a compressive field strength test of grout made in accordance with U.B.C. Standard No. 24-22-67.

(t) **Mortar Limitations.** Masonry units used in foundation walls and footings shall be laid up in Type S mortar. Type O mortar shall be used only in interior nonstructural walls. See Sections 2413 (b), 2415 (a), and 2417 (j).

(u) **Aggregates.** Aggregates for mortar shall be of a quality at least equal to that set forth in U.B.C. Standard No. 24-21-67.

(v) **Rate of Absorption.** At the time of laying, burned clay units and sand-lime units shall have a rate of absorption not exceeding 0.025 ounces per square inch during a period of one minute. In the absorption test the surface of the unit shall be held one-eighth inch (⅛″) below the surface of the water.

(w) **Masonry Unit Surfaces.** Every masonry unit shall have all surfaces, to which mortar or grout is to be applied, capable of developing the masonry strengths required in this Chapter.

(x) **Re-use of Masonry Units.** Masonry units may be re-used when clean, whole, and conforming to the other requirements of this Section, except that the allowable working stresses shall be 50 per cent of that permitted for new masonry units.

Tests

Sec. 2404. (a) **General.** Tests of materials shall be made in accordance with the standard method prescribed for the material in question.

(b) **Load Tests.** When a load test is required, the member or portion of the structure under consideration shall be subject to a superimposed load equal to twice the design live load plus one-half of the dead 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 structure shows evidence of failure, such changes or modifications as are necessary to make the structure adequate for the rated capacity shall be made; or where lawful, a lower rating shall be established. A flexural member shall be considered to have passed the test if the maximum deflection "D" at the end of the 24-hour period neither exceeds

Tests (Continued)

$$D = \frac{L}{200} \text{ nor } D = \frac{L^2}{4000t}$$

and the beams and slabs show a recovery of at least 75 per cent of the observed deflection within 24 hours after removal of the load.

WHERE:

L = span of the member in feet.

t = thickness or depth of the member in feet.

(c) **Determination of Masonry Design Strength. 1. General.** The value of "f'_m" shall be determined by tests of masonry assemblies in accordance with the provisions of paragraph 2 of this Subsection or shall be assumed in accordance with the provisions of paragraph 3 of this Subsection.

2. **Tests. A. General.** When the strength "f'_m" is to be established by tests, they shall be made using prisms built of the same materials, under the same conditions and, insofar as possible, with the same bonding arrangements as for the structure. The moisture content of the units at time of laying, consistency of mortar, and workmanship shall be the same as will be used in the structure. The value of "f'_m" shall be the average of all specimens tested but shall be not more than 125 per cent of the minimum value determined by test, whichever is less.

Testing shall include tests in advance of beginning operations and at least one field test during construction per each five thousand square feet (5000 sq. ft.) of wall but not less than three such tests for any building.

The compressive strength "f'_m" shall be computed by dividing the ultimate load by the net area of the masonry used in the construction of the prisms. The gross area may be used in the determination of "f'_m" for solid masonry units as defined in U.B.C. Standard No. 24-1-67.

B. **Prisms.** For walls, prisms shall be sixteen inches (16") high and sixteen inches (16") long. The thickness and type of construction of the specimen shall be similar to the wall under consideration.

For columns, prisms shall be sixteen inches (16") high and not less than eight inches by eight inches (8" x 8") in plan. Cores in hollow masonry shall not be filled, except for solid filled construction.

Tests (Continued)

The symbol "f'_m" shall be taken as the compressive strength of the specimens multiplied by the following correction factor:

Ratio of "h/d"	1.5	2.0	2.5	3.0
Correction factor	.86	1.00	1.11	1.20

WHERE:

h = height of specimen in inches.

d = minimum dimension of specimen in inches.

C. **Storage of Test Prisms.** Test prisms shall be stored for seven days in air, at a temperature of 70 degrees, plus or minus 5°F., in a relative humidity exceeding 90 per cent, and then in air at a temperature of 70 degrees, plus or minus five degrees, at a relative humidity of 30 per cent to 50 per cent until tested. Prisms shall be capped and tested in compression similar to tests for molded concrete cylinders as specified in U.B.C. Standard No. 26-13-67.

D. **Sampling.** Not less than five specimens shall be made for each initial preliminary test to establish "f'_m." Not less than three shall be made for each field test to confirm that the materials are as assumed in the design. The standard age of test specimens shall be 28 days, but seven-day tests may be used, provided the relation between the seven-day and 28-day strengths of the masonry is established by adequate test data for the materials used.

3. **Assumed ultimate compressive strength.** When prism tests are not made as in paragraph 2 "f'_m" may be assumed as:

Solid Units—3000 p.s.i. gross .... $f'_m = 1800$
Solid Units—2500 p.s.i. gross .... $f'_m = 1500$
Hollow Concrete Units—Grade A .... $f'_m = 1350$
Hollow Concrete Units—Grade A
grouted solid .... $f'_m = 1500$
Hollow Clay Units—Grade LB
(1¼" minimum face shell) .... $f'_m = 1350$
Hollow Clay Units—Grade LB
(1¼" minimum face shell) grouted
solid .... $f'_m = 1500$

Unburned Clay Masonry

Sec. 2405. (a) **General.** Masonry of unburned clay units shall not be used in any building more than one story in height. The unsupported height of every wall of unburned clay units shall be not more than 10 times the thickness of such walls. Bearing walls shall in no case be less than sixteen inches (16"). Fireplaces and chimneys of unburned clay units shall be lined with firebrick not less in thickness than four inches (4"). All footing walls which support masonry of unburned clay units shall extend to an elevation not less than six inches (6") above the adjacent ground at all points.

(b) **Units.** At the time of laying, all units shall be clean and damp at the surface.

Unburned Clay Masonry (Continued)

(c) **Laying.** All joints shall be solidly filled with mortar. Bond shall be provided as specified for masonry of hollow units in Section 2411.

(d) **Stresses.** All masonry of unburned clay units shall be so constructed that the unit stresses do not exceed those set forth in Table No. 24-B. Bolt values shall not exceed those set forth in Table No. 24-C.

(e) **Soil.** The soil used shall contain not less than 25 per cent and not more than 45 per cent of material passing a No. 200 mesh sieve. The soil shall contain sufficient clay to bind the particles together but shall not contain more than 0.2 per cent of water-soluble salts.

(f) **Stabilizer.** The stabilizing agent shall be emulsified asphalt. The stabilizing agent shall be uniformly mixed with the soil in amounts sufficient to provide the required resistance to absorption.

(g) **Sampling.** Each of the tests prescribed in this Section shall be applied to five sample units selected at random from each 5000 bricks to be used.

(h) **Compressive Strength.** The units shall have an average compressive strength of 300 pounds per square inch when tested in accordance with U.B.C. Standard No. 24-24-67. One sample out of five may have a compressive strength of not less than 250 pounds per square inch.

(i) **Modulus of Rupture.** The unit shall average 50 pounds per square inch in modulus of rupture when tested according to the following procedure:

1. A cured unit shall be laid over cylindrical supports two inches (2") in diameter, located two inches (2") from each end, and extending across the full width of the unit.

2. A cylinder two inches (2") in diameter shall be laid midway between and parallel to the supports.

3. Load shall be applied to the cylinder at the rate of 500 pounds per minute until rupture occurs.

4. The modulus of rupture is equal to $\frac{3\,WL}{2\,Bd^2}$

WHERE:

W = Load of rupture
L = Distance between supports
B = Width of brick
d = Thickness of brick

(j) **Moisture Content.** The moisture content of the unit shall be not more than four per cent by weight.

Unburned Clay Masonry (Continued)

(k) **Absorption.** A dried four-inch (4″) cube cut from a sample unit shall absorb not more than two and one-half per cent moisture by weight when placed upon a constantly water-saturated porous surface for seven days.

TABLE NO. 24-B—ALLOWABLE WORKING STRESSES IN UNREINFORCED UNIT MASONRY

MATERIAL	TYPE S MORTAR					TYPE N, AND N (MASONRY)		
	Compression[1]	Shear or Tension in Flexure[2,3]		Tension in Flexure[4]		Compression[1]	Shear or Tension in Flexure[2,3]	
Special Inspection Required	No	Yes	No	Yes	No	No	Yes	No
Solid Brick Masonry								
4500 plus p.s.i.	250	20	10	40	20	200	15	7.5
2500 to 4500 p.s.i.	175	20	10	40	20	140	15	7.5
1500 to 2500 p.s.i.	125	20	10	40	20	100	15	7.5
Solid Concrete Unit Masonry								
Grade A	175	12	6	24	12	140	12	6
Grade B	125	12	6	24	12	100	12	6
Grouted Masonry								
4500 plus p.s.i.	350	25	12.5	50	25			
2500 to 4500 p.s.i.	275	25	12.5	50	25			
1500 to 2500 p.s.i.	225	25	12.5	50	25			
Hollow Unit Masonry	85	12[5]	6[5]	24[5]	12[5]	70	10[5]	5[5]
Cavity Wall Masonry Solid Units[5]								
Grade A or 2500 p.s.i. plus	140	12	6	30	15	110	10	5
Grade B or 1500 to 2500 p.s.i.	100	12	6	30	15	80	10	5
Hollow Units[5]	70	12	6	30	15	50	10	5
Stone Masonry								
Cast Stone	400	8	4	—	—	320	8	4
Natural Stone	140	8	4	—	—	100	8	4
Gypsum Masonry	20	—	—	—	—	20		
Unburned Clay Masonry	30	8	4	—	—			

[1]Allowable working stresses pounds per square inch gross cross-sectional area (except as noted). The allowable working stresses in bearing directly on concentrated loads may be 50 per cent greater than these values.

[2]This value of tension is based on tension across a bed joint, i.e., vertically in the normal masonry work.

[3]No tension allowed in stack bond across head joints.

[4]The values shown here are for tension in masonry in the direction of running bond, i.e., horizontally between supports.

[5]Net area in contact with mortar or net cross-sectional area.

(l) **Shrinkage Cracks.** No units shall contain more than three shrinkage cracks, and no shrinkage crack shall exceed three inches (3") in length or one-eighth inch (⅛") in width.

Unburned Clay Masonry (Continued)

(m) **Mortar.** All mortar used in masonry of unburned clay units shall be Type S mortar.

Gypsum Masonry

Sec. 2406. (a) **General.** Gypsum masonry is that form of construction made with gypsum block or tile in which the units are laid and set in gypsum mortar. Gypsum masonry shall not be used in any bearing wall or where exposed directly to the weather or where subject to frequent or continuous wetting.

(b) **Materials.** Gypsum masonry shall be gypsum block or tile laid up in gypsum mortar composed of one part gypsum and not more than three parts sand by weight.

(c) **Stresses.** All gypsum masonry shall be so constructed that the unit stresses do not exceed those set forth in Table No. 24-B when computed on the gross cross-sectional area.

(d) **Bond.** The bond in gypsum masonry shall conform to the requirements for bond in masonry of hollow units specified in Section 2411.

(e) **Method of Laying.** All units in gypsum masonry shall be placed in side construction with cells horizontal. The entire bearing surface of every unit shall be covered with mortar spread in an even layer, and all joints shall be filled with mortar.

Reinforced Gypsum Concrete

Sec. 2407. (a) **General.** Reinforced gypsum concrete shall consist of a mixture of gypsum with wood chips, shavings, or fiber or other approved aggregates, premixed at the mill with only water added at the job. Precast reinforced gypsum shall conform to U.B.C. Standard No. 24-13-67 and shall contain not more than three per cent, and cast-in-place reinforced gypsum concrete not more than 12½ per cent of wood chips, shavings, or fiber measured as a percentage by weight of dry mix.

TABLE NO. 24-C—ALLOWABLE SHEAR ON BOLTS
Masonry of Unburned Clay Units

DIAMETER OF BOLTS (Inches)	EMBEDMENTS (Inches)	SHEAR (Pounds)
½	—	—
⅝	12	200
¾	15	300
⅞	18	400
1	21	500
1⅛	24	600

Reinforced Gypsum Concrete (Continued)

TABLE NO. 24-D—MINIMUM ULTIMATE COMPRESSIVE STRENGTH REINFORCED GYPSUM CONCRETE

CLASS	MIXTURE	COMPRESSIVE STRENGTH (Pounds per Square Inch)
A	Not more than 12½ per cent by weight of wood chips, shavings, or fiber.	500
B	Not more than three per cent by weight of wood chips, shavings, or fiber.	1000

Reinforced gypsum concrete shall develop the minimum ultimate compressive strength in pounds per square inch set forth in Table No. 24-D when dried to constant weight, with tests made on cylinders two inches (2″) in diameter and four inches (4″) long or on two-inch (2″) cubes.

Tests when required shall follow the procedure set forth in U.B.C. Standard No. 24-25-67.

For special inspection, see Section 305 (a).

(b) **Design.** For precast slabs which cannot be analyzed in accordance with established principles of mechanics, the safe load, uniformly distributed, shall be taken as one-fifth of the total load causing failure in a full-size test panel with the load applied along two lines each distant one-fourth of the clear span from the support.

The minimum thickness of reinforced gypsum concrete shall be two inches (2″) except in the suspension system, which shall be not less than three inches (3″). Hollow precast reinforced gypsum concrete units for roof construction shall be not less than three inches (3″) thick and the shell not less than one-half inch (½″) thick.

Precast gypsum concrete units shall be reinforced and, unless the shape or marking of the unit is such as to insure its being placed right side up, the reinforcement shall be placed symmetrically so that the unit can support its load either side up.

In slabs of the suspension type, the reinforcement shall consist of wires with continuity through multiple spans and anchored at the ends. The wires shall be supported in the top of the slab by the roof or floor beams and shall be tightly drawn down as near to the bottom of the slab at mid-span as fire protection requirements will allow, but not closer than one-half inch (½″). Provisions shall be made in the framing of the end bays of this system for resisting the forces due to end anchorage of the wires. The wires shall be designed for a tension in pounds per foot width of slab equal to

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

Reinforced Gypsum Concrete (Continued)

WHERE:

w = The total load in pounds per square foot
L = The clear span in feet
d = The sag of the wires in feet

(c) **Stresses.** The maximum allowable unit working stresses in reinforced gypsum concrete shall not exceed the values set forth in Table No. 24-E except as specified in Chapter 23. Bolt values shall not exceed those set forth in Table No. 24-F.

Glass Masonry

Sec. 2408. (a) **General.** Masonry of glass blocks may be used in nonload-bearing exterior or interior walls and in openings which might otherwise be filled with windows, either isolated or in continuous bands, provided the glass block panels have a minimum thickness of three and one-half inches (3½″) at the mortar joint and the mortared surfaces of the blocks are treated for mortar bonding.

(b) **Horizontal Forces.** The panels shall be restrained laterally to resist the horizontal forces specified in Chapter 23 for bearing walls.

(c) **Size of Panels.** Glass block panels for exterior walls shall not exceed one hundred and forty-four square feet (144 sq. ft.) of unsupported wall surface nor fifteen feet (15′) in any dimension. For interior walls, glass block panels shall not exceed two hundred and fifty square feet (250 sq. ft.) of unsupported area nor twenty-five feet (25′) in any dimension.

(d) **Mortar.** Glass block shall be laid in Type S mortar. Both vertical and horizontal mortar joints shall be at least one-fourth inch (¼″) and not more than three-eighths inch (⅜″) thick and shall be completely filled.

(e) **Expansion Joints.** Every exterior glass block panel shall be provided with one-half-inch (½″) expansion joints at the sides and top. Expansion joints shall be entirely free of mortar, and shall be filled with resilient material.

Stone Masonry

Sec. 2409. (a) **General.** Stone masonry is that form of construction made with natural or cast stone in which the units are laid and set in mortar, with all joints thoroughly filled.

(b) **Construction.** In ashlar masonry, bond stones uniformly distributed shall be provided to the extent of not less than 10 per cent of the area of exposed facets.

Rubble stone masonry twenty-four inches (24″) or less in thickness shall have bond stones with a maximum spacing of three feet (3′) vertically and three feet (3′) horizontally, and if the masonry is of greater thickness than twenty-four inches (24″), shall have one bond stone for each six square feet (6 sq. ft.) of wall surface on both sides.

TABLE NO. 24-E—ALLOWABLE UNIT WORKING STRESS
REINFORCED GYPSUM CONCRETE

TYPE OF STRESS	CLASS A	CLASS B
	(Pounds per Square Inch)	
Compression—Flexural	125	220
Compression—Bearing	100	165
Bond and Shear	10	20
Modulus of Elasticity	200,000	600,000

Note: Reinforced anchored or electrically welded wire mesh reinforcement shall be considered as meeting the bond and shear requirements of this Section.

TABLE NO. 24-F—SHEAR ON ANCHOR BOLTS AND DOWELS
REINFORCED GYPSUM CONCRETE

BOLT OR DOWEL SIZE (Inches)	EMBEDMENT (Inches)	SHEAR (Pounds)
⅜ Bolt	4	250
½ Bolt	4	350
⅝ Bolt	4	500
¼ Plain dowel	6	200
⅜ Deformed dowel	6	250
½ Deformed dowel	6	350

Stone Masonry (Continued)

(c) **Minimum Thickness.** Stone masonry walls shall in no case have a minimum thickness of less than sixteen inches (16").

(d) **Stresses.** The allowable unit working stresses in stone masonry shall not exceed the values set forth in Table No. 24-B. Bolt values shall not exceed those set forth in Table No. 24-G.

Cavity Wall Masonry

Sec. 2410. (a) **General.** Cavity wall masonry is that type of construction made with brick, structural clay tile or concrete masonry units or any combination of such units in which facing and backing are completely separated except for the metal ties which serve as bonding.

(b) **Cavity Wall Construction.** In cavity walls neither the facing nor the backing shall be less than four inches (4") in thickness and the cavity shall be not less than one-inch (1") net in width nor more than four inches (4") in width. The backing shall be at least as thick as the facing.

EXCEPTION: Where both the facing and backing are constructed with clay or shale brick, the facing and backing may be three inches (3") in thickness.

The facing and backing of cavity walls shall be bonded with three-sixteenths-inch (3/16") diameter steel rods or metal ties of equivalent strength and stiffness embedded in the hori-

Cavity Wall Masonry (Continued)

zontal joints. There shall be one metal tie for not more than each four and one-half square feet (4½ sq. ft.) of wall area for cavity widths up to three and one-half-inches (3½") net in width. Where the cavity exceeds three and one-half-inches (3½") net in width, there shall be one metal tie for not more than each three square feet (3 sq. ft.) of wall area. Ties in alternate courses shall be staggered and the maximum vertical distance between ties shall not exceed twenty-four inches (24") and the maximum horizontal distance shall not exceed thirty-six inches (36"). Rods bent to rectangular shape shall be used with hollow masonry units laid with the cells vertical; in other walls the ends of ties shall be bent to 90-degree angles to provide hooks not less than two inches (2") long. Additional bonding ties shall be provided at all openings, spaced not more than three feet (3') apart around the perimeter and within twelve inches (12") of the opening. Ties shall be of corrosion-resistant metal, or shall be coated with a corrosion-resistant metal or other approved protective coating.

(c) **Maximum Height.** The maximum height of cavity walls shall be as specified in Section 2418 (e).

(d) **Stresses.** The allowable unit working stresses in cavity wall construction shall not exceed the values set forth in Table No. 24-B. Bolts fully embedded shall have values not to exceed those set forth in Table No. 24-G for solid masonry.

Hollow Unit Masonry

Sec. 2411. (a) **General.** Hollow unit masonry is that type of construction made with hollow masonry units in which the units are all laid and set in mortar.

All units shall be laid with full face shell mortar beds. All head and end joints shall be filled solidly with mortar for a distance in from the face of the unit or wall not less than the thickness of the longitudinal face shells.

(b) **Construction.** Where two or more hollow units are used to make up the thickness of a wall, the stretcher courses shall be bonded at vertical intervals not exceeding thirty-four inches (34") by lapping at least four inches (4") over the unit

TABLE NO. 24-G—ALLOWABLE SHEAR ON BOLTS FOR ALL MASONRY EXCEPT GYPSUM AND UNBURNED CLAY UNITS

DIAMETER OF BOLT (Inches)	EMBEDMENT (Inches)	SOLID MASONRY (Shear in Pounds)	GROUTED MASONRY (Shear in Pounds)
½	4	350	550
⅝	4	500	750
¾	5	750	1100
⅞	6	1000	1500
1	7	1250	1850[1]
1⅛	8	1500	2250[1]

[1]Permitted only with not less than 2500 pounds per square inch units.

Hollow Unit Masonry (Continued)

below or by lapping at vertical intervals not exceeding seventeen inches (17") with units which are at least 50 per cent greater in thickness than the units below; or by bonding with corrosion-resistant metal ties conforming to the requirements for cavity walls. There shall be one metal tie for not more than each four and one-half square feet (4½ sq. ft.) of wall area. Ties in alternate courses shall be staggered, and the maximum vertical distance between ties shall not exceed eighteen inches (18"), and the maximum horizontal distance shall not exceed thirty-six inches (36"). Walls bonded with metal ties shall conform to the requirements for allowable stress, lateral support, thickness (excluding cavity), height, and mortar for cavity walls.

(c) **Stresses.** All hollow unit masonry shall be so constructed that the unit stresses do not exceed those set forth in Table No. 24-B. Bolt values shall not exceed those set forth in Table No. 24-G.

Solid Masonry

Sec. 2412. (a) **General.** Solid masonry shall be brick, concrete brick, or solid load-bearing concrete masonry units, laid contiguously in mortar.

All units shall be laid with full shoved mortar joints, and all head, bed, and wall joints shall be solidly filled with mortar.

(b) **Construction.** In each wythe of bearing and nonbearing walls, except masonry veneer, not less than 75 per cent of the units in any transverse vertical plane shall lap the ends of the units above and below a distance not less than one and one-half inches (1½") or one-half the height of the units, whichever is greater, or the masonry shall be reinforced longitudinally as required in Section 2417 (n) for masonry laid in stack bond. Adjacent wythes in bearing and nonbearing walls shall be bonded by either of the following methods:

1. **Headers.** The facing and backing shall be bonded so that not less than four per cent of the exposed face area is composed of solid headers extending not less than four inches (4") into the backing. The distance between adjacent full-length headers shall not exceed twenty-four inches (24") vertically or horizontally. Where the backing consists of two or more wythes the headers shall extend not less than four inches (4") into the most distant wythe or the backing wythes shall be bonded together with separate headers whose area and spacing conform to the foregoing.

2. **Metal ties.** The facing and backing shall be bonded with corrosion-resistant unit metal ties or cross wires of masonry joint reinforcement conforming to the requirements of Section 2410 (b) for cavity walls. Unit ties shall be of sufficient length to engage all wythes, with ends embedded not less than one inch (1") in mortar, or shall consist of two lengths the inner embedded ends of which are hooked and lapped not less than two inches (2").

Solid Masonry (Continued)

Where the space between metal tied wythes is solidly filled with mortar the allowable stresses and other provisions for masonry bonded walls shall apply. Where the space is not filled, metal tied walls shall conform to the allowable stress, lateral support, thickness (excluding cavity), height, and mortar requirements for cavity walls.

(c) **Moisture Content.** For moisture content, see Section 2403 (v).

(d) **Stresses.** All solid masonry shall be so constructed that the unit stresses do not exceed those set forth in Table No. 24-B. Bolt values shall not exceed those set forth in Table No. 24-G.

Grouted Masonry

Sec. 2413. (a) **General.** Grouted masonry is that form of construction made with brick or solid concrete brick units in which interior joints of masonry are filled by pouring grout therein as the work progresses.

(b) **Materials.** At the time of laying, all masonry units shall be free of excessive dust and dirt. For moisture content, see Section 2403 (v). Only Type S mortar shall be used.

(c) **Low-lift Grouted Construction.** Requirements for construction shall be as follows:

1. All units in the two outer tiers shall be laid with full shoved head and bed mortar joints. Masonry headers shall not project into the grout space.

2. All longitudinal vertical joints shall be grouted and shall be not less than three-fourths inch (¾″) in thickness. In members of three or more tiers in thickness, interior bricks shall be embedded into the grout so that at least three-fourths inch (¾″) of grout surrounds the sides and ends of each unit. All grout shall be puddled with a grout stick immediately after pouring.

3. One exterior tier may be carried up sixteen inches (16″) before grouting, but the other exterior tier shall be laid up and grouted in lifts not to exceed six times the width of the grout space with a maximum of eight inches (8″).

4. If the work is stopped for one hour or longer, the horizontal construction joints shall be formed by stopping all tiers at the same elevation and with the grout one inch (1″) below the top.

(d) **High-lift Grouted Construction.** 1. All units in the two tiers shall be laid with full head and bed mortar joints.

2. The two tiers shall be bonded together with wall ties. Ties shall be not less than No. 9 wire in the form of rectangles four inches (4″) wide and two inches (2″) in length less than the over-all wall thickness. Kinks, water drips or deformations shall not be permitted in the ties. One tier of the wall shall be built up not more than sixteen inches (16″) ahead of the

Grouted Masonry (Continued)

other tier. Ties shall be laid not to exceed twenty-four inches (24″) on center horizontally and sixteen inches (16″) on center vertically for running bond and not more than twenty-four inches (24″) on center horizontally and twelve inches (12″) on center vertically for stack bond.

3. Cleanouts shall be provided for each pour by leaving out every other unit in the bottom tier of the section being poured. During the work a high pressure jet stream of water shall be used to remove mortar fins and any other foreign matter from the grout space. The cleanout shall be sealed after inspection and before grouting.

4. The grout space (longitudinal vertical joint) shall be not less than three inches (3″) in width and not less than the thickness required by the placement of steel with the required clearances and shall be poured solidly with grout. Masonry walls shall cure at least three days to gain strength before pouring grout.

EXCEPTION: If the grout space contains no horizontal steel, it may be reduced to two inches (2″).

5. Vertical grout barriers or dams shall be built of solid masonry across the grout space the entire height of the wall to control the flow of the grout horizontally. Grout barriers shall be not more than twenty-five feet (25′) apart.

6. Grout shall be a plastic mix suitable for pumping without segregation of the constituents and shall be mixed thoroughly. Grout shall be placed by pumping or by an approved alternate method and shall be placed before any initial set occurs and in no case more than one and one-half hours after water has been added.

7. Grouting shall be done in a continuous pour, in lifts not exceeding four feet (4′). It shall be consolidated by puddling or mechanical vibrating during placing and reconsolidated after excess moisture has been absorbed but before plasticity is lost. The grouting of any section of a wall between control barriers shall be completed in one day with no interruptions greater than one hour.

8. Special inspection during grouting shall be provided in accordance with Section 305; however, the work shall not qualify for the stresses entitled "Special Inspection" in Table No. 24-H unless fully inspected.

(e) **Stresses.** All grouted masonry shall be so constructed that the unit stresses do not exceed those set forth in Table No. 24-B. Bolt values shall not exceed those set forth in Table No. 24-G.

Reinforced Grouted Masonry

Sec. 2414. (a) **General.** Reinforced grouted masonry shall conform to all of the requirements for grouted masonry specified in Section 2413 and also the requirements of this Section.

Reinforced Grouted Masonry (Continued)

(b) **Construction.** The thickness of grout or mortar between masonry units and reinforcement shall be not less than one-fourth inch (¼"), except that one-fourth-inch (¼") bars may be laid in horizontal mortar joints at least one-half inch (½") thick and steel wire reinforcement may be laid in horizontal mortar joints at least twice the thickness of the wire diameter.

(c) **Stresses.** See Section 2417 (l).

Reinforced Hollow Unit Masonry

Sec. 2415. (a) **General.** Reinforced hollow unit masonry is that type of construction made with hollow masonry units in which certain cells are continuously filled with concrete or grout, and in which reinforcement is embedded. Only Type S mortar shall be used.

(b) **Construction.** Requirements for construction shall be as follows:

1. All reinforced hollow unit masonry shall be built to preserve the unobstructed vertical continuity of the cells to be filled. Walls and cross webs forming such cells to be filled shall be full-bedded in mortar to prevent leakage of grout. All head (or end) joints shall be solidly filled with mortar for a distance in from the face of the wall or unit not less than the thickness of the longitudinal face shells. Bond shall be provided by lapping units in successive vertical courses or by equivalent mechanical anchorage.

2. Vertical cells to be filled shall have vertical alignment sufficient to maintain a clear, unobstructed continuous vertical cell measuring not less than two inches by three inches (2" x 3").

3. Cleanout openings shall be provided at the bottom of all cells to be filled at each pour of grout where such grout pour is in excess of four feet (4') in height. Any overhanging mortar or other obstruction or debris shall be removed from the insides of such cell walls. The cleanouts shall be sealed before grouting, after inspection.

4. Vertical reinforcement shall be held in position at top and bottom and at intervals not exceeding 192 diameters of the reinforcement.

5. All cells containing reinforcement shall be filled solidly with grout. Grout shall be poured in lifts of eight feet (8') maximum height. All grout shall be consolidated at time of pouring by puddling or vibrating and then reconsolidated by again puddling later, before plasticity is lost.

When total grout pour exceeds eight feet (8') in height the grout shall be placed in four-foot (4') lifts and special inspection during grouting shall be required. Minimum cell dimension shall be three inches (3"). Special inspection at time of grouting shall not be considered as special inspection under Table No. 24-H.

TABLE NO. 24-H—MAXIMUM WORKING STRESSES IN POUNDS PER SQUARE INCH FOR REINFORCED SOLID AND HOLLOW UNIT MASONRY[1]

TYPE OF STRESS	SPECIAL INSPECTION REQUIRED	
	YES	NO
Compression—Axial, Walls	See Section 2418	One-half of the values permitted under Section 2418
Compression—Axial, Columns	See Section 2420	One-half of the values permitted under Section 2420
Compression—Flexural	.33 f'_m but not to exceed 900	.166 f'_m but not to exceed 450
Shear:		
No shear reinforcement[2]	50	15
Reinforcement taking entire shear:		
Flexural members	120	50
Shear Walls	75	30
Modulus of Elasticity[3]	1000 f'_m but not to exceed 3,000,000	500 f'_m but not to exceed 1,500,000
Modulus of Rigidity[3]	400 f'_m but not to exceed 1,200,000	200 f'_m but not to exceed 600,000
Bearing on full area[4]	.25 f'_m but not to exceed 900	.125 f'_m but not to exceed 450
Bearing on ⅓ or less of area[4]	.30 f'_m but not to exceed 1200	.15 f'_m but not to exceed 600
Bond—Plain bars	60	30
Bond—Deformed	140	100

[1]Stresses for hollow unit masonry are based on net section.

[2]Web reinforcement shall be provided to carry the entire shear in excess of 20 pounds per square inch whenever there is required negative reinforcement and for a distance of one-sixteenth the clear span beyond the point of inflection.

[3]Where determinations involve rigidity considerations in combination with other materials or where deflections are involved, the moduli of elasticity and rigidity under columns entitled "yes" for special inspection shall be used.

[4]This increase shall be permitted only when the least distance between the edges of the loaded and unloaded areas is a minimum of one-fourth of the parallel side dimension of the loaded area. The allowable bearing stress on a reasonably concentric area greater than one-third, but less than the full area, shall be interpolated between the values given.

Reinforced Hollow Unit Masonry (Continued)

6. When the grouting is stopped for one hour or longer, horizontal construction joints shall be formed by stopping the pour of grout one and one-half inches (1½") below the top of the uppermost unit.

(c) **Stresses.** See Section 2417 (1).

General Construction Requirements

Sec. 2416. (a) **Freezing.** All masonry shall be protected against freezing for at least 48 hours after being laid. No masonry shall be built upon frozen material.

(b) **Corbeling.** Corbels may be built only into solid masonry walls twelve inches (12") or more in thickness. The projection for each course in such corbel shall not exceed one inch (1"), and the maximum projection shall not exceed one-third the total thickness of the wall when used to support structural members, and not more than six inches (6") when used to support a chimney built into the wall. The top course of all corbels shall be a header course.

(c) **Wood.** Masonry shall not be supported by wood members except as provided for in Section 2510.

(d) **Masonry Foundations.** In one-story buildings having wood frame exterior walls, foundations not over twenty-four inches (24") high may be constructed of masonry units without mortared head joints provided the masonry units permit horizontal flow of the grout to adjacent units.

(e) **Minimum Bar Spacing.** The minimum clear distance between parallel bars, except in columns, shall be not less than the diameter of the bar except that lapped splices may be wired together. The center-to-center spacing of bars within a column shall be not less than two and one-half times the bar diameter.

(f) **Splices in Reinforcement.** Splices may be made only at such points and in such manner that the structural strength of the member will not be reduced. Lapped splices shall provide sufficient lap to transfer the working stress of the reinforcement by bond and shear, but in no case shall the lap be less than 30-bar diameters. Welded or mechanical connections shall develop the strength of the reinforcement.

(g) **Protection for Reinforcement.** All bars shall be completely embedded in mortar or grout. Joint reinforcement embedded in horizontal mortar joints shall have not less than five-eighths-inch (⅝") mortar coverage from the exposed face. All other reinforcement shall have a minimum coverage of one-bar diameter over all bars, but not less than three-fourths inch (¾") except where exposed to weather or soil in which cases the minimum coverage shall be two inches (2").

General Design

Sec. 2417. (a) **Combination of Units.** In walls or other structural members composed of different kinds or grades of units, materials, or mortars, the maximum stress shall not exceed the allowable stress for the weakest of the combinations of units, materials, and mortars of which the member is composed. The net thickness of any facing unit which is used to resist stress shall be not less than one and one-half inches (1½").

(b) **Thickness of Walls.** For thickness limitations of walls as specified in this Chapter, nominal thickness shall be used. Stresses shall be determined on the basis of the net thickness of the masonry, with consideration for reductions such as raked joints.

The thickness of masonry walls shall be designed so that allowable maximum stresses specified in this Chapter are not exceeded and so that all masonry walls shall not exceed the height or length to thickness ratio nor the minimum thickness as specified in this Chapter and as set forth in Table No. 24-I.

> EXCEPTION: The height or length to thickness ratio may be increased and the minimum thickness may be decreased when data is submitted which justifies a reduction in the requirements specified in this Section.

(c) **Piers.** Every structural pier whose width is less than three times its thickness shall be designed and constructed as required for columns.

(d) **Chases and Recesses.** Chases and recesses in masonry walls shall be designed and constructed so as not to reduce the required strength or required fire resistance of the wall.

(e) **Pipes and Conduits Embedded in Masonry.** No pipe or conduit shall be embedded in any structural masonry necessary for structural stability or required fire protection.

> EXCEPTIONS: 1. Rigid electric conduits may be embedded in structural masonry when their location has been detailed on the approved plans.
>
> 2. Any pipe or conduit may pass vertically or horizontally through any masonry by means of a sleeve at least large enough to pass any hub or coupling on the pipe line. Such sleeves shall be placed not closer than three diameters, center-to-center, nor shall they unduly impair the strength of construction.
>
> 3. Placement of pipes or conduits in unfilled cores of hollow unit masonry shall not be considered as embedment.

(f) **Arches and Lintels.** Members supporting masonry shall be of incombustible materials.

(g) **Anchorage.** Masonry walls that meet or intersect shall be bonded or anchored as required in Section 2313.

Structural members framing into or supported by walls or columns shall be anchored.

General Design (Continued)

(h) **Combined Axial and Flexural Stresses.** Members subject to combined axial and flexural stresses shall be so proportioned that the quantity

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \text{ shall not exceed 1}$$

WHERE:

f_a = Computed axial unit stress, determined from total axial load and effective area.

F_a = Axial unit stress permitted by this Code at the point under consideration, if member were carrying axial load only, including any increase in stress allowed by this Section.

f_b = Computed flexural unit stress.

F_b = Flexural unit stress permitted by this Code, if member were carrying bending load only, including any increase in stress allowed by this Section.

(i) **Allowable Reduction of Bending Stress by Vertical Load.** In calculating maximum tensile fiber stress due to lateral forces other than earthquake forces, the maximum tensile fiber stress may be reduced by the direct stress due to vertical dead loads. In calculating maximum tensile fiber stress due to earthquake forces, the maximum tensile fiber stress may be reduced by not more than 50 per cent of the direct stress due to vertical dead loads.

(j) **Unreinforced Masonry.** Design and construction of elements of plain masonry shall be such that unit stresses do not exceed those set forth in tables in this Chapter for the various masonry units.

(k) **Partially Reinforced Masonry.** Partially reinforced masonry shall be designed as unreinforced masonry, except that

TABLE NO. 24-I—MINIMUM THICKNESS OF MASONRY WALLS

TYPE OF MASONRY	MAXIMUM RATIO UNSUPPORTED HEIGHT OR LENGTH TO THICKNESS	NOMINAL MINIMUM THICKNESS (Inches)
BEARING WALLS:		
Unburned Clay Masonry	10	16
Stone Masonry	14	16
Cavity Wall Masonry	18	8
Hollow Unit Masonry	18	8
Solid Masonry	20	8
Grouted Masonry	20	7
Reinforced Grouted Masonry	25	6
Reinforced Hollow Unit Masonry	25	6
NONBEARING WALLS:		
Exterior Unreinforced Walls	20	2
Exterior Reinforced Walls	30	2
Interior Partitions Unreinforced	36	2
Interior Partitions Reinforced	48	2

General Design (Continued)

reinforced areas or elements may be considered as resisting stresses in accordance with the design criteria specified in Section 2418 provided such elements fully comply with the design and construction requirements for reinforced masonry except as herein noted. Only Type S mortar shall be used.

The minimum area of reinforcement required in Section 2418 (f) 3 shall not apply to partially reinforced masonry walls. Maximum spacing of vertical reinforcement in exterior partially reinforced masonry walls shall be eight feet (8′). Reinforcement shall be provided each side of each opening and at each corner of all walls. Horizontal reinforcement not less than 0.2 square inches in area shall be provided at the top of footings, at the bottom and top of wall openings, near roof and floor levels and at the top of parapet walls.

(l) **Reinforced Masonry.** All reinforced masonry shall be so designed and constructed that the unit stresses do not exceed those set forth in Table No. 24-H.

All plans submitted for approval shall clearly show the assumed strength of masonry for which all parts of the structure were designed.

(m) **Allowable Steel Stresses.** Stresses in reinforcement shall not exceed the following:

TENSILE STRESS:	POUNDS PER SQUARE INCH
For billet-steel or axle steel reinforcing bars of structural grade	18,000
For deformed bars with a yield strength of 60,000 pounds per square inch or more and in sizes No. 11 and smaller	24,000
Joint reinforcement, 50 per cent of the minimum yield point specified in U.B.C. Standards for the particular kind and grade of steel used, but in no case to exceed	30,000
For all other reinforcement	20,000
COMPRESSIVE STRESS IN COLUMN VERTICALS:	
40 per cent of the minimum yield strength, but not to exceed	24,000

COMPRESSIVE STRESS IN FLEXURAL MEMBERS:

For compression reinforcement in flexural members, the allowable stress shall not be taken as greater than the allowable tensile stress shown above.

The modulus of elasticity of steel reinforcement may be taken as 30,000,000 pounds per square inch.

(n) **Bolt Values.** The allowable loads on bolts shall not exceed the values set forth in Table No. 24-G.

(o) **Stack Bond.** Where masonry units are laid in stack bond in plain masonry mechanical bond shall be provided by placing one continuous No. 9 gauge wire or its equivalent in the horizontal bed joint for each four-inch (4″) thickness of the masonry unit and spaced not more than sixteen inches (16″) on centers vertically.

General Design (Continued)

(p) **Symbols and Notations.** The symbols and notations used in this Section are defined as follows:

α = Angle between inclined web bars and axis of beam.
A_v = Total area of web reinforcement in tension within a distance of "s", or the total area of all bars bent up in any one plane.
b = Width of rectangular section or width of flange of I- or T-sections.
d = Depth from compression face of beam or slab to centroid of longitudinal tensile reinforcement.
E_m = Modulus of elasticity of masonry in compression.
E_s = Modulus of elasticity of steel in tension or compression (30,000,000 pounds per square inch).
f_m = Allowable compressive unit stress in extreme fiber in flexure.
f'_m = Ultimate compressive strength, usually at age of 28 days, as specified in Section 2404 (c).
f_v = Allowable tensile unit stress in web reinforcement.
j = Ratio of distance between centroid of compression and centroid of tension to the depth "d".
n = Ratio of modulus of elasticity of steel to that of masonry $= \frac{E_s}{E_m}$
Σo = Sum of perimeters of bars in one set.
s = Spacing of stirrups or of bent bars in a direction parallel to that of the main reinforcement.
u = Bond stress per unit of surface area of bar.
v = Shearing unit stress.
v_m = Allowable unit shearing stress in the masonry.
V = Total shear.

(q) **Reinforced Masonry Flexural Design.** The design of reinforced masonry shall be in accordance with the following principal assumptions:

1. A section that is plane before bending remains plane after bending.
2. Moduli of elasticity of the masonry and of the reinforcement remain constant.
3. Tensile forces are resisted only by the tensile reinforcement.
4. Reinforcement is completey surrounded by and bonded to masonry material so that they will work together as a homogeneous material within the range of working stresses.

(r) **Flexural Computations.** 1. **General.** All members shall be designed to resist at all sections the maximum bending moment and shears produced by dead load, live load, and

General Design (Continued)

other forces, as determined by the principle of continuity and relative rigidity.

2. **Distance between lateral supports.** The clear distance between lateral supports of a beam shall not exceed 32 times the least width of the compression flange or face.

(s) **Shear and Diagonal Tension.** 1. **Shearing unit stress.** The shearing unit stress "v" in reinforced masonry flexural members shall be computed by

$$v = \frac{V}{bjd} \qquad (1)$$

Where the value of the shearing unit stress computed by Formula (1) exceeds the shearing unit stress "v_m" permitted on masonry, web reinforcement shall be provided to carry the entire stress.

2. **Types of web reinforcement.** Web reinforcement may consist of:

A. Stirrups or web reinforcement bars perpendicular to the longitudinal steel.

B. Stirrups or web reinforcement bars welded or otherwise rigidly attached to the longitudinal steel and making an angle of 30 degrees or more thereto.

C. Longitudinal bars bent so that the axis of the inclined portion of the bar makes an angle of 15 degrees or more with the axis of the longitudinal portion of the bar.

D. Special arrangements of bars with adequate provisions to prevent slip of bars or splitting of masonry by the reinforcement.

Stirrups or other bars to be considered effective as web reinforcement shall be anchored at both ends.

3. **Stirrups.** The area of steel required in stirrups placed perpendicular to the longitudinal reinforcement shall be computed by Formula (2):

$$A_v = \frac{Vs}{f_v jd} \qquad (2)$$

Inclined stirrups shall be proportioned in accordance with the provisions of paragraph 4 of this Subsection.

4. **Bent bars.** Only the center three-fourths of the inclined portion of any longitudinal bar that is bent up for web reinforcement shall be considered effective for that purpose, and such bars shall be bent around a pin having a diameter not less than six times the bar size.

When the web reinforcement consists of a single bent bar or of a single group of parallel bars all bent up at the same distance from the support, the required area of such bars shall be computed by Formula (3):

$$A_v = \frac{V}{f_v \sin \alpha} \quad \text{.................................} (3)$$

General Design (Continued)

Where there is a series of parallel bars or groups of bars bent up at different distances from the support, the required area shall be determined by Formula (4):

$$A_v = \frac{Vs}{f_v jd\ (\sin \alpha + \cos \alpha)} \quad \text{.......................} (4)$$

5. **Spacing of web reinforcement.** Where web reinforcement is required it shall be so spaced that every 45-degree line (representing a potential crack) extending from the mid-depth of the beam to the longitudinal tension bars shall be crossed by at least one line of web reinforcement.

(t) **Bond and Anchorage. 1. Computation of bond stress in beams.** In flexural members in which the tensile reinforcement is parallel to the compression face, the bond stress at any cross section shall be computed by Formula (5):

$$u = \frac{V}{\Sigma ojd} \quad \text{....................................} (5)$$

in which "V" is the shear at that section and "Σo" is taken as the perimeter of all effective bars crossing the section on the tension side. To be effective the bars must be properly developed by hooks, lap, or embedment on each side of the section. Bent-up bars that are not more than $d/3$ from the level of the main longitudinal reinforcement may be included. Critical sections occur at the face of the support, at each point where tension bars terminate within a span, and at the point of inflection.

Bond shall be similarly computed on compressive reinforcement, but the shear used in computing the bond shall be reduced in the ratio of the compressive force assumed in the bars to the total compressive force at the section. Anchorage shall be provided by embedment past the section to develop the assumed compressive force in the bars at the bond stress in Table No. 24-H.

2. **Anchorage requirements.** Tensile negative reinforcement in any span of a continuous, restrained, or cantilever beam, or in any member of a rigid frame shall be adequately anchored by bond, hooks, or mechanical anchors in or through the supporting member. Within any such span every reinforcing bar except in a lapped splice whether required for positive or negative moment shall be extended at least 12 diameters beyond the point at which it is no longer needed to resist stress.

General Design (Continued)

At least one-third of the total reinforcement provided for negative moment at the support shall be extended beyond the extreme position of the point of inflection a distance sufficient to develop by bond one-half the allowable stress in such bars, not less than one-sixteenth of the clear span length, or not less than the depth of the member, whichever is greater. The maximum tension in any bar must be developed by bond on a sufficient straight or bent embedment or by other anchorage.

The bar may be bent across the web at an angle of not less than 15 degrees with the longitudinal portion of the bar and be made continuous with the reinforcement which resists moment of opposite sign.

Of the positive reinforcement in continuous beams not less than one-fourth the area shall extend along the same face of the beam into the end support a distance of six inches (6″).

In simple beams, or at the freely supported end of continuous beams, at least one-third the required positive reinforcement shall extend along the same face of the beam into the support a distance of six inches (6″).

Compression steel in beams and girders shall be anchored by ties or stirrups not less than one-fourth inch (¼″) in diameter, spaced not farther apart than 16 bar diameters or 48 tie diameters. Such ties or stirrups shall be used throughout the distance where compression steel is required.

3. **Plain bars in tension.** Plain bars in tension shall terminate in standard hooks except that hooks shall not be required on the positive reinforcement at interior supports of continuous members.

4. **Anchorage of web reinforcement.** Single separate bars used as web reinforcement shall be anchored at each end by one of the following methods:

A. Welding to longitudinal reinforcement.

B. Hooking tightly around the longitudinal reinforcement through at least 180 degrees.

C. Embedment above or below the mid-depth of the beam on the compression side, a distance sufficient to develop the stress to which the bar will be subject at a bond stress of not to exceed the bond stresses permitted in Table No. 24-H.

D. By a standard hook, considered as developing 7500 pounds per square inch plus embedment sufficient to develop by bond the remaining stress in the bar at the unit stress set forth in Table No. 24-H. The effective embedded length shall not be assumed to exceed the distance between the mid-depth of the beam and the tangent of the hook.

The extreme ends of bars forming a simple U- or multiple-stirrups shall be anchored by one of the methods of this Subsection or shall be bent through an angle of at least 90 degrees tightly around a longitudinal reinforcing bar not less in diameter than the stirrup bar, and shall project beyond the bend at least 12 diameters of the stirrup bar.

General Design (Continued)

The loops or closed ends of such stirrups shall be anchored by bending around the longitudinal reinforcement through an angle of at least 90 degrees, or by being welded or otherwise rigidly attached thereto.

Between the anchored ends, each bend in the continuous portion of a U- or multiple U-stirrup shall be made around a longitudinal bar. Hooking or bending stirrups around the longitudinal reinforcement shall be considered effective only when these bars are perpendicular to the longitudinal reinforcement.

Longitudinal bars bent to act as web reinforcement shall, in a region of tension, be continuous with the longitudinal reinforcement. The tensile stress in each bar shall be fully developed in both the upper and the lower half of the beam by adequate anchorage through bond or hooks.

5. **Hooks.** The terms "hook" or "standard hook" as used herein shall mean either:

A. A complete semicircular turn with a radius of bend on the axis of the bar of not less than three and not more than six bar diameters, plus an extension of at least four bar diameters at the free end of the bar.

B. A 90-degree bend having a radius of not less than four bar diameters plus an extension of 12 bar diameters.

C. For stirrup anchorage only, a 135-degree turn with a radius on the axis of the bar of three diameters, plus an extension of at least six bar diameters at the free end of the bar.

Hooks having a radius of bend of more than six bar diameters shall be considered merely as extensions to the bars.

In general, hooks shall not be permitted in the tension portion of any beam except at the ends of simple or cantilever beams or at the freely supported ends of continuous or restrained beams.

No hook shall be assumed to carry a load which would produce a tensile stress in the bar greater than 7500 pounds per square inch.

Hooks shall not be considered effective in adding to the compressive resistance of bars.

Any mechanical device capable of developing the strength of the bar without damage to the masonry may be used in lieu of a hook. Tests must be presented to show the adequacy of such devices.

Bearing Walls

Sec. 2418. (a) **General.** Masonry walls shall be designed as specified in Section 2417 and to withstand all vertical and horizontal loads as specified in Chapter 23, and with due allowance for the effect of eccentric loads.

(b) **End Support.** Beams, girders, or other concentrated loads supported by a wall or pier shall have bearing at least three inches (3") in length upon solid masonry not less than four inches (4") thick or upon a metal bearing plate of ade-

Bearing Walls (Continued)

quate design and dimensions to distribute the loads safely on the wall or pier, or upon a continuous reinforced masonry member projecting not less than three inches (3″) from the face of the wall, or by other approved methods.

Joists shall have bearing at least three inches (3″) in length upon solid masonry at least two and one-fourth inches (2¼″) thick; or other provisions shall be made to distribute safely the loads on the wall or pier.

(c) **Width in Flexural Computation.** In computing flexural stresses for masonry where reinforcement occurs the effective width "*b*" shall not be greater than six times the wall thickness in running bond, nor more than three times the wall thickness in stacked bond.

(d) **Distribution of Concentrated Loads.** In calculating wall stresses, concentrated loads may be distributed over a maximum length of wall not exceeding the center-to-center distance between loads.

Where the concentrated loads are not distributed through a structural element, the length of wall considered shall not exceed the width of the bearing plus four times the wall thickness.

Concentrated loads shall not be considered as distributed by metal ties, nor distributed across continuous vertical joints.

(e) **Plain Masonry Walls. 1. Ratio of height or length to thickness.** The ratio of unsupported height to thickness or the ratio of unsupported length to thickness (one or the other but not both) for solid masonry walls or bearing partitions shall not exceed 20, and shall not exceed 18 for walls of hollow masonry or cavity walls. In computing the ratio for cavity walls, the value for thickness shall be the sum of the nominal thicknesses of the inner and outer widths of the masonry. In walls composed of different kinds or classes of units or mortars, the ratio of height or length to thickness shall not exceed that allowed for the weakest of the combination of units and mortars of which the member is composed.

2. **Minimum thickness.** The minimum thickness of bearing walls of plain masonry shall be twelve inches (12″) for the uppermost thirty-five feet (35′) of their height, and shall be increased four inches (4″) in thickness for each successive thirty-five feet (35′) or fraction thereof measured downward from the top of the wall.

> **EXCEPTIONS:** 1. The top story walls of a building not exceeding three stories or thirty-five feet (35′) in height, or the walls of a one-story building, may have a wall thickness equal to eight inches (8″).
>
> 2. The thickness of unreinforced grouted brick masonry walls may be two inches (2″) less than required by this Subsection, but in no case less than seven inches (7″) except in one-story dwellings.

Bearing Walls (Continued)

3. In Group I Occupancies not more than three stories in height, masonry walls may be of eight inches (8") nominal thickness when not over thirty-five feet (35') in height. Solid masonry walls in one-story single-family and one-story multiple-family dwellings, one-story motels and one-story garages may be of six-inch (6") nominal thickness when not over nine feet (9') in height, provided that when gable construction is used an additional six feet (6') is permitted to the peak of the gable.

When a change in thickness due to minimum thickness requirements occurs between floor levels, the greater thickness shall be carried to the higher floor level.

3. **Stresses.** The axial stress in unreinforced bearing walls, or portions thereof, shall not exceed the values set forth in Table No. 24-B. Bolt values shall not exceed those set forth in Table No. 24-G.

(f) **Reinforced Masonry Walls.** 1. **Minimum thickness.** The minimum nominal thickness of reinforced masonry bearing walls shall be six inches (6"), and the ratio of height or length to thickness shall not exceed 25, except as specified in Section 2417 (b).

2. **Stresses.** The axial stress in reinforced masonry bearing walls shall not exceed the value determined by the following formula:

$$f_m = 0.20\, f'_m \left[1 - \left(\frac{h}{30t}\right)^3\right]$$

WHERE:

f_m = Compressive unit axial stress in masonry wall.

f'_m = Ultimate compressive masonry stress as determined by Section 2404 (c). The value of "f'_m" shall not exceed 3500 pounds per square inch.

t = Thickness of wall in inches.

h = Clear height in inches.

3. **Reinforcement.** All walls using stress permitted for reinforced masonry shall be reinforced with both vertical and horizontal bars.

The minimum area of reinforcement in either direction shall be not less than .0007 (0.07 per cent) times the gross cross-sectional area of the wall taken perpendicular to the steel considered. The sum of the ratios of horizontal and vertical steel shall be at least .002 (0.2 per cent). Principal wall steel shall be limited to a maximum spacing of four feet (4') on center. The minimum diameter shall be three-eighths inch (⅜") except that wire reinforcement used as a temperature steel or to replace running bond may be used as part of the required reinforcement where special inspection is provided.

Reinforcing perpendicular to the principal wall steel shall be limited to a maximum spacing of four feet (4') on center.

Bearing Walls (Continued)

Horizontal reinforcement shall be provided in the top of footings, at the top of wall openings, at roof and floor levels, and at the top of parapet walls. Only horizontal reinforcement which is continuous in the wall shall be considered in computing the minimum area of reinforcement.

If the wall is constructed of more than two units in thickness, the minimum area of required reinforcement shall be equally divided into two layers, except where designed as retaining walls. Where reinforcement is added above the minimum requirements such additional reinforcement need not be so divided.

In bearing walls of every type of reinforced masonry there shall be not less than one one-half-inch (½") bar or two three-eighths-inch (⅜") bars on all sides of, and adjacent to, every opening which exceeds twenty-four inches (24") in either direction, and such bars shall extend not less than 40 diameters, but in no case less than twenty-four inches (24") beyond the corners of the opening. The bars required by this paragraph shall be in addition to the minimum reinforcement elsewhere required.

Nonbearing Walls

Sec. 2419. (a) **General.** Nonbearing walls may be constructed of any masonry as specified in this Chapter.

(b) **Thickness.** Every nonbearing masonry wall shall be so constructed and have a sufficient thickness to withstand all vertical loads and horizontal loads, where specifically required by Chapter 23, but in no case shall the thickness of such walls (including plaster when applied) be less than the values set forth in Table No. 24-I.

(c) **Wire-mesh Reinforcement.** Wire-mesh reinforcement may be used to resist tensile stresses when embedded in plaster applied to the surface of any nonbearing wall.

Wire-mesh reinforcement shall conform to the requirements for welded steel wire fabric as specified in U.B.C. Standard No. 26-11-67 and plaster shall conform to the requirements of Chapter 47.

(d) **Anchorage.** All nonbearing partitions shall be anchored along the top edge to a structural member or a suspended ceiling, or shall be provided with equivalent anchorage along the sides.

All exterior nonbearing walls shall be anchored along all edges to structural members.

Columns

Sec. 2420. (a) **General.** Masonry columns shall be constructed of reinforced masonry and as required by this Section.

(b) **Limiting Dimensions.** The least dimension of every masonry column shall be not less than twelve inches (12"), unless designed for one-half the allowable stresses, in which case the minimum least dimensions shall be eight inches (8"). No masonry column shall have an unsupported length greater than 20 times its least dimension.

Columns (Continued)

(c) **Allowable Loads.** The axial load on columns shall not exceed:

$$P = A_g\ (.18\,f'_m + 0.65\,P_g\,f_s)\ \left[1 - \left(\frac{h}{30t}\right)^3\right]$$

WHERE:

P = Maximum concentric column axial load.

A_g = The gross area of the column.

f'_m = Ultimate compressive masonry strength as determined by Section 2404 (c). The value of "f'_m" shall not exceed 3500 pounds per square inch.

P_g = Ratio of the effective cross-sectional area of vertical reinforcement to "A_g."

f_s = Allowable stress in reinforcement [see Section 2417 (l)].

t = Least thickness of column in inches.

h = Clear height in inches.

(d) **Reinforcement. 1. Vertical reinforcement.** The ratio "P_g" shall be not less than 0.5 per cent nor more than four per cent. The number of bars shall be not less than four, nor the diameter less than three-eighths inch (⅜").

Where lapped splices are used, the amount of lap shall be sufficient to transfer the working stress by bond, but in no case shall the length of lapped splice be less than 30 bar diameters, and welded splices shall be full butt welded.

2. **Ties.** Lateral ties shall be at least one-fourth inch (¼") in diameter and shall be spaced apart not over 16 bar diameters, 48 tie diameters, or the least dimension of the column. Lateral ties shall be placed not less than one and one-half inches (1½") and not more than five inches (5") from the surface of the column, and may be against the vertical bars, or placed in the horizontal bed joints.

CHAPTER 25—WOOD

General

Sec. 2501. (a) **Quality and Design.** The quality and design of wood members and their fastenings used for load-supporting purposes shall conform to the provisions of this Chapter, and to the following standards:

MATERIALS AND DESIGN	U.B.C. DESIGNATION
GRADING—LIGHT FRAMING, JOISTS AND PLANKS, DECKING, BEAMS AND STRINGERS, POSTS AND TIMBERS	
All Species of Lumber	25- 1-67
Cedar, Incense and Western Red	25- 3-67 25- 4-67
Cypress–Tidewater Red	25- 2-67
Douglas Fir, Coast Region	25- 3-67
Douglas Fir	25- 4-67
Fir, White	25- 3-67 25- 4-67
Fir, Balsam	25- 8-67
Hemlock, Eastern	25- 5-67
Hemlock, West Coast	25- 3-67
Hemlock, Western	25- 4-67
Larch	25 -4-67
Pine (Idaho White, Lodgepole, Ponderosa and Sugar)	25- 4-67
Pine, Norway	25- 5-67
Pine, Southern	25- 6-67
Redwood	25- 7-67
Spruce, Eastern	25- 8-67
Spruce, Engelmann	25- 4-67
Spruce, Sitka	25- 3-67
PLYWOOD—CONSTRUCTION AND INDUSTRIAL SOFTWOOD	25- 9-67
STRUCTURAL GLUED-LAMINATED TIMBER	
All Species of Lumber	25-10-67
Douglas Fir	25-11-67
Pine, Southern	25-11-67
Hardwood	25-11-67
Hemlock, West Coast	25-11-67
Larch	25-11-67
PRESERVATIVE TREATMENT BY PRESSURE PROCESSES	25-12-67
WOOD POLES	25-13-67
ROUND TIMBER PILES	25-14-67
SPACED COLUMNS	25-15-67
FLEXURAL AND AXIAL LOADING	25-16-67
JOINTS	
Timber Connector Joints	25-17-67
Bolted Joints	25-17-67
Drift Bolts and Wood Screws	25-17-67
Lag Screws	25-17-67
STRUCTURAL GLUED BUILT-UP MEMBERS PLYWOOD COMPONENTS	25-18-67

General (Continued)

(b) **Workmanship.** All members shall be framed, anchored, tied, and braced so as to develop the strength and rigidity necessary for the purposes for which they are used.

(c) **Fabrication.** Preparation, fabrication, and installation of wood members, and glues and mechanical devices for the fastening thereof, shall conform to good engineering practices and to the requirements of this Code.

(d) **Rejection.** The Building Official may deny permission for the use of a wood member where permissible grade characteristics or defects are present in any wood member in such a combination that they affect the serviceability of the member.

Definitions and Notations

Sec. 2502. Except where otherwise provided, the following terms and symbols used in this Chapter have the meaning indicated in this Section:

GLUED-LAMINATED LUMBER, lumber composed of an assembly of wood laminations bonded with adhesives in which the laminations are too thick to be classed as veneers. See definition of Structural Glued-laminated Lumber.

GLUED BUILT-UP MEMBERS, structural members, the sections of which are composed of built-up sawn lumber alone, plywood alone, or plywood in combination with sawn or glued-laminated lumber; all parts bonded together with adhesives.

GRADE (Lumber), the classification of lumber in regard to strength and utility in accordance with U.B.C. Standards No. 25-1-67 to No. 25-8-67.

GRADE—STRESS (Lumber), a lumber grade defined in such terms that a definite working stress may be assigned to it as set forth in U.B.C. Standard No. 25-1-67.

MACHINE STRESS-RATED LUMBER, is lumber which has been individually pretested by an approved nondestructive mechanical means supplemented by visual grading as required in U.B.C. Standard No. 25-1-67, Section 25.113, in order to establish unit working stresses.

NOMINAL SIZE (Lumber), the commercial size designation of width, and depth, in standard sawn lumber and glued-laminated lumber grades; somewhat larger than the standard net size of dressed lumber, in accordance with U.B.C Standard No. 25-1-67 for sawn lumber and U.B.C. Standard No. 25-10-67 or No. 25-11-67 for glued-laminated lumber.

Definitions and Notations (Continued)

NORMAL LOADING, a design load that stresses a member or fastening to the full allowable stress tabulated in this Chapter. This loading may be applied for approximately 10 years, either continuously or cumulatively, and 90 per cent of this full maximum design load may be applied for the remainder of the life of the structure. See U.B.C. Standard No. 25-1-67.

PLYWOOD — CONSTRUCTION AND INDUSTRIAL SOFTWOOD is a built-up panel of laminated veneers conforming to U.B.C. Standard No. 25-9-67.

STRUCTURAL GLUED-LAMINATED LUMBER, any member comprising an assembly of laminations of lumber in which the grain of all laminations is approximately parallel longitudinally; in which the laminations are bonded with adhesives; and which is fabricated in accordance with U.B.C. Standard No. 25-10-67 or No. 25-11-67.

SYMBOLS AND NOTATIONS, as used in these regulations, are defined as follows:

A = area in square inches of net cross section.

b = breadth of beam or of cross section in inches.

c = compression parallel to grain, allowable unit stress in pounds per square inch.

d = least dimension of column, in inches.

E = modulus of elasticity.

f = extreme fiber in bending, allowable unit stress in pounds per square inch.

h = depth of section, in inches.

H = horizontal shear, allowable unit stress in pounds per square inch.

I = moment of inertia of member.

l = span in inches or laterally unsupported length of a column in inches.

N = allowable unit stress on inclined surface in pounds per square inch.

P = total load in pounds.

q = compression perpendicular to grain, allowable unit stress in pounds per square inch.

R = reaction, in pounds.

t = tension parallel to grain, allowable unit stress in pounds per square inch.

V = vertical shear at section under consideration.

l/d = ratio of length to least dimension.

P/A = compressive strength or maximum axial load, in pounds per square inch.

θ = angle between direction of load and the direction of grain, in degrees.

Definitions and Notations (Continued)

TREATED WOOD. Pressure treatment or the term "pressure impregnated with an approved preservative" is that treatment of wood which is in accordance with U.B.C. Standard No. 25-12-67.

Size of Structural Members

Sec. 2503. (a) **Required Sizes.** Wood members shall be of sufficient size to carry the dead and required live loads without exceeding the allowable unit stresses as hereinafter specified.

(b) **Size Determination.** Minimum sizes of lumber and glued-laminated members required by this Code refer to nominal sizes. U.B.C. Standards No. 25-1-67 for lumber, and No. 25-10-67 or No. 25-11-67 for glued-laminated dressed sizes shall be accepted as the minimum net sizes conforming to nominal sizes. Nominal sizes may be shown on the plans. Computations to determine the required sizes of members shall be based on the net dimensions (actual sizes) and not the nominal sizes. If rough sizes or sizes or shapes other than U.B.C. Standard No. 25-1-67 or No. 25-11-67 dressed sizes are to be used, the actual net sizes shall be specified on the plans.

Allowable Unit Stresses

Sec. 2504. (a) **Allowable Unit Stress on Plans.** Where structures are designed for use of stress grade lumber, structural glued-laminated lumber, for plywood used structurally, the allowable unit stresses for the species and the grade shall be shown on the plans filed with the Building Department.

(b) **Stresses.** 1. **General.** Except as hereinafter provided, stresses shall not exceed the allowable unit stresses in pounds per square inch for the respective species and grades and grade combinations as set forth in Table No. 25-A and Table No. 25-B for solid sawn stress grade lumber; and Table No. 25-C for softwood plywood; and Tables No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H for structural glued-laminated lumber.

For modification of allowable unit stresses for structural glued-laminated lumber, see also Section 2513.

The allowable unit stresses in extreme fiber in bending "f" as set forth in Tables No. 25-D, No. 25-F, No. 25-G and No. 25-H apply to members with the wide face of the lamination perpendicular to the direction of the load. When the wide face of the lamination is parallel to the direction of the load and the beam is composed of not less than three laminations, 115 per cent of the bending stresses as set forth in Table No. 25-A shall apply, except as provided in Tables No. 25-E and No. 25-G.

The allowable unit stresses as set forth in Tables No. 25-A, No. 25-B, No. 25-D, No. 25-E, No. 25-F, No. 25-G and No.

Allowable Unit Stresses (Continued)

25-H and adjustments thereof, and stresses as set forth in Table No. 25-C apply also to lumber, to structural glued-laminated lumber and to exterior type plywood that have been pressure impregnated by an approved preservative.

Studs, joists, rafters, foundation plates or sills, planking two inches (2") or more in depth, beams, stringers, posts, structural sheathing and similar load-bearing members shall be of at least the minimum grades set forth in Table No. 25-A or No. 25-B and in Groups I, II, and III set forth in Table No. 25-I. Lumber set forth in Group IV of Table No. 25-I may be used only under conditions specifically approved by the Building Official.

Stresses for grade and species other than those tabulated shall be established by the Building Official in accordance with U.B.C. Standard No. 25-1-67 and in accordance with U.B.C. Standard No. 25-10-67 for species and grade combinations used in structural glued-laminated lumber.

Allowable unit stresses of plywood other than as provided in Table No. 25-C shall be determined according to species.

2. **Stresses in poles or piles used as structural members.** Induced stresses in pounds per square inch for normal loading of round poles or piles when used as structural members, except modulus of elasticity which shall be the same as for sawn lumber, shall not exceed 60 per cent of the basic unit working stresses for clear lumber for the species as set forth in U.B.C. Standard No. 25-1-67, and the pieces shall meet the requirements of U.B.C. Standard No. 25-13-67 for poles or U.B.C. Standard No. 25-14-67 for piles.

(c) **Identification.** All species set forth in Tables No. 25-A, No. 25-B and No. 25-I shall be used only when identified by a grade mark of, or certificate of inspection issued by, an approved lumber grading or inspection bureau or agency.

All plywood used structurally, including applications such as siding, roof and wall sheathing, subflooring, diaphragms, and built-up members, shall conform to performance standards set forth in U.B.C. Standard No. 25-9-67; it shall be properly identified and grade marked by an approved agency. In addition to the above requirements, all plywood when permanently exposed in outdoor applications shall be of exterior type.

The allowable unit stresses for structural glued-laminated lumber as set forth in U.B.C. Standard No. 25-10-67 and in Tables No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H shall be used only when the material and workmanship are in accordance with U.B.C. Standard No. 25-10-67 or No. 25-11-67, respectively, and are inspected and identified in a manner meeting the approval of the Building Official.

(Continued on page 193)

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER*

Normal Loading—See also Section 2504 (d) and (e)

†ABBREVIATIONS: J.&P.: Joists and Planks; B.&S.: Beams and Stringers; P.&T.: Posts and Timbers; L.F.: Light Framing; K.D.: Kiln Dried; S.R.: Stress Rated.

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f^1)	H	q	c	E[4]	
DOUGLAS FIR, COAST REGION							
Dense Select Structural	L.F.	2050	120[2-3-5]	455	1500		
Select Structural	L.F.	1900	120[2-3-5]	415	1400		
1750f.-Industrial	L.F.	1750	120	455	1400		
1500f.-Industrial	L.F.	1500	120	390	1200		
1200f.-Industrial	L.F.	1200	95	390	1000		
Dense Select Structural	J. & P.	2050	120[2-3-5]	455	1650		
Select Structural	J. & P.	1900	120[2-3-5]	415	1500		
Dense Construction	J. & P.	1750	120[2-4-5]	455	1400		
Construction	J. & P.	1500	120[2-4-5]	390	1200	(All) 1,600,000	U.B.C. Standard No. 25-3-67
Standard	J. & P.	1200	95[2-4-5]	390	1000		
Dense Select Structural	B. & S.	2050	120[7]	455	1500		
Select Structural	B. & S.	1900	120[7]	415	1400		
Dense Construction	B. & S.	1750	120[7]	455	1200		
Construction	B. & S.	1500	120[7]	390	1000		
Dense Select Structural	P. & T.	1900	120[7]	455	1650		
Select Structural	P. & T.	1750	120[7]	415	1500		
Dense Construction	P. & T.	1500	120[7]	455	1400		
Construction	P. & T.	1200	120[7]	390	1200		

*For explanatory footnotes see pages 174-175.

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f^1)	H	q	c	E[6]	
HEMLOCK, WEST COAST							
Select Structural	L.F.	1600	100[2-3-9]	365	1100		
1500f. Industrial	L.F.	1500	100	365	1000		
1200f. Industrial	L.F.	1200	80	365	900		
Select Structural	J. & P.	1600	100[2-3-9]	365	1200	(All) 1,400,000	U.B.C. Standard No. 25-3-67
Construction	J. & P.	1500	100[2-8-9]	365	1100		
Standard	J. & P.	1200	80[2-8-9]	365	1000		
Construction	B. & S.	1500	100[10]	365	1000		
Construction	P. & T.	1200	100[10]	365	1100		
DOUGLAS FIR, COAST REGION							U.B.C. Standard No. 25-3-67
Select Dex	Decking	1500	—	390	—	1,600,000	
Commercial Dex	Decking	1200	—	390	—	1,600,000	
HEMLOCK, WEST COAST							U.B.C. Standard No. 25-3-67
Select Dex	Decking	1300	—	365	—	1,400,000	
Commercial Dex	Decking	1000	—	365	—	1,400,000	
SPRUCE, SITKA							U.B.C. Standard No. 25-3-67
Select Dex	Decking	1100	—	305	—	1,200,000	
Commercial Dex	Decking	850	—	305	—	1,200,000	
CEDAR, INCENSE							U.B.C. Standard No. 25-3-67
Select Dex	Decking	1100	—	305	—	900,000	
Commercial Dex	Decking	850	—	305	—	900,000	

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f[1])	H	q	c	E[6]	
CEDAR, WESTERN RED							U.B.C. Standard No. 25-3-67
Select Dex	Decking	900	—	240	—	1,000,000	
Commercial Dex	Decking	700	—	240	—	1,000,000	
FIR, WHITE							U.B.C. Standard No. 25-3-67
Select Dex	Decking	1100	—	365	—	1,100,000	
Commercial Dex	Decking	850	—	365	—	1,100,000	
DOUGLAS FIR AND LARCH[17]						(All) 1,600,000	U.B.C. Standard No. 25-4-67
Dense Select Structural MC15**	L.F.[16]	2300	135[2-3-5]	455	1700		
Dense Select Structural DRY***	L.F.	2150	130	455	1500		
Select Structural MC15	L.F.[16]	2100	135[2-3-5]	415	1550		
Dense Select Structural	L.F.	2050	120[2-3-5]	455	1500		
Select Structural DRY	L.F.	1950	130	415	1400		
Select Structural	L.F.	1900	120[2-3-5]	415	1400		
1750f. Industrial MC15	L.F.	2050	135	455	1600		
1750f. Industrial DRY	L.F.	1850	130	455	1450		
1750f. Industrial	L.F.	1750	120	455	1400		
1500f. Industrial MC15	L.F.[16]	1750	135	390	1400		
1500f. Industrial DRY	L.F.	1600	130	390	1200		
1500f. Indstrial	L.F.	1500	120	390	1200		
1200f. Industrial MC15	L.F.[16]	1500	110	390	1200		
1200f. Industrial DRY	L.F.	1350	115	390	1050		
1200f. Industrial	L.F.	1200	95	390	1000		
Dense Select Structural MC15	J. & P.[16]	2300	135[2-3-5]	455	1850		

**Grades designated as MC-15 are required to have a maximum moisture content of 15 per cent. The modulus of elasticity for such grades may be increased 20 per cent, however such increase shall not be cumulative with that specified in footnote No. 6.

***Grades designated as DRY are required to have a maximum moisture content of 19 per cent. The modulus of elasticity, "E", for such grades may be increased 14 per cent, however, such increase shall not be cumulative with that specified in footnote No. 6.

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f[1])	H	q	c	E[6]	
DOUGLAS FIR AND LARCH[17]							
Dense Select Structural DRY	J. & P.	2150	130	455	1750		
Select Structural MC15	J. & P.[16]	2100	135[2-3-5]	415	1650		
Dense Select Structural	J. & P.	2050	120[2-3-5]	455	1650		
Dense Construction MC15	J. & P.[16]	2050	135[2-4-5]	455	1600		
Select Structural DRY	J. & P.	2000	130	415	1600		
Select Structural	J. & P.	1900	120[2-3-5]	415	1500		
Dense Construction DRY	J. & P.	1850	130	455	1450		
Dense Construction	J. & P.	1750	120[2-4-5]	455	1400		
Construction MC15	J. & P.[16]	1750	135[2-4-5]	390	1400		
Construction DRY	J. & P.	1600	130	390	1200	(All)	U.B.C.
Construction	J. & P.	1500	120[2-4-5]	390	1200	1,600,000	Standard
Standard MC15	J. & P.[16]	1500	110[2-4-5]	390	1200		No. 25-4-67
Standard DRY	J. & P.	1350	105	390	1100		
Standard	J. & P.	1200	95[2-4-5]	390	1000		
Dense Select Structural	B. & S.	2050	120[7]	455	1500		
Select Structural	B. & S.	1900	120[7]	415	1400		
Dense Construction	B. & S.	1750	120[7]	455	1200		
Construction	B. & S.	1500	120[7]	390	1000		
Dense Select Structural	P. & T.	1900	120[7]	455	1650		
Select Structural	P. & T.	1750	120[7]	415	1500		
Dense Construction	P. & T.	1500	120[7]	455	1400		
Construction	P. & T.	1200	120[7]	390	1200		

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f[1])	H	q	c	E[6]	
HEMLOCK, WESTERN							
Select Structural MC15	L.F.[16]	1800	115[2-3-9]	365	1200		
Select Structural DRY	L.F.	1600	110	365	1100		
Select Structural	L.F.	1600	100[2-3-9]	365	1100		
1500f. Industrial MC15	L.F.[16]	1650	115	365	1150		
1500f. Industrial DRY	L.F.	1550	110	365	1100		
1500f. Industrial	L.F.	1500	100	365	1000		
1200f. Industrial MC15	L.F.[16]	1450	90	365	1050		
1200f. Industrial DRY	L.F.	1300	100	365	900		
1200f. Industrial	L.F.	1200	80	365	900		
Select Structural MC15	J. & P.[16]	1800	115[2-3-9]	365	1300	(All) 1,400,000	U.B.C. Standard No. 25-4-67
Select Structural DRY	J. & P.	1650	110	365	1250		
Select Structural	J. & P.	1600	100[2-3-9]	365	1200		
Construction MC15	J. & P.[16]	1650	115[2-8-9]	365	1250		
Construction DRY	J. & P.	1550	110	365	1150		
Construction	J. & P.	1500	100[2-8-9]	365	1100		
Standard MC15	J. & P.[16]	1450	90[2-8-9]	365	1150		
Standard DRY	J. & P.	1300	85	365	1000		
Standard	J. & P.	1200	80[2-8-9]	365	1000		
Construction	B. & S.	1500	100[10]	365	1000		
Construction	P. & T.	1200	100[10]	365	1100		

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE	SYMBOL:†	ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH — Extreme Fiber in Bending (and Tension Parallel to Grain) f (or f[1])	Maximum Horizontal Shear H	Compression Perpendicular to Grain q	Compression Parallel to Grain c	Modulus of Elasticity E[6]	RULES UNDER WHICH GRADED
DOUGLAS FIR AND LARCH							U.B.C. Standard No. 25-4-67
Selected Decking	Decking	1500	—	390	—	1,600,000	
Commercial Decking	Decking	1200	—	390	—	1,600,000	
WHITE FIR							U.B.C. Standard No. 25-4-67
Selected Decking	Decking	1100	—	365	—	1,100,000	
Commercial Decking	Decking	850	—	365	—	1,100,000	
PINE, NORWAY							U.B.C. Standard No. 25-5-67
Prime Structural	J. & P.[15,16]	1200	75	360	900	1,200,000	
Common Structural	J. & P.[15,16]	1100	75	360	775	1,200,000	
Utility Structural	J. & P.[15,16]	950	75	360	650	1,200,000	
PINE (IDAHO WHITE, LODGEPOLE, PONDEROSA AND SUGAR)							U.B.C. Standard No. 25-4-67
Selected Decking	Decking	900	—	305	—	1,000,000	
Commercial Decking	Decking	700	—	305	—	1,000,000	
CEDAR, INCENSE AND WESTERN RED							U.B.C. Standard No. 25-4-67
Selected Decking	Decking	900	—	240	—	1,000,000	
Commercial Decking	Decking	700	—	240	—	1,000,000	
SPRUCE, ENGELMANN							U.B.C. Standard No. 25-4-67
Selected Decking	Decking	750	—	215	—	1,000,000	
Commercial Decking	Decking	600	—	215	—	1,000,000	

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f[1])	H	q	c	E[4]	
HEMLOCK, WESTERN							U.B.C. Standard No. 25-4-67
Selected Decking	Decking	1300	—	365	—	1,400,000	
Commercial Decking	Decking	1000	—	365	—	1,400,000	
HEMLOCK, EASTERN						(All) 1,100,000	U.B.C. Standard No. 25-5-67
Select Structural	J. & P.[15]-B. & S.[15]	1300	85	360	850		
Prime Structural	J. & P.[15-16]	1200	60	360	775		
Common Structural	J. & P.[15-16]	1100	60	360	650		
Utility Structural	J. & P.[15-16]	950	60	360	600		
Select Structural	P. & T.	—	—	360	850		
PINE, SOUTHERN						(All) 1,600,000	U.B.C. Standard No. 25-6-67
Select	Decking	1500	105	390	1250		
Select No. 1	Decking	1200	105	390	900		
No. 2	Decking	1200	105	390	900		
PINE, SOUTHERN[11]						(All) 1,600,000	U.B.C. Standard No. 25-6-67
Dense Structural 86 KD[13-14]	2″ thick only	3000	165	455	2250		
Dense Structural 72 KD[13-14]		2500	150	455	1950		
Dense Structural 65 KD[13-14]		2250	135	455	1800		
Dense Structural 58 KD[13-14]		2050	120	455	1650		
No. 1 Dense KD[13-14]		2050	135	455	1750		
No. 1 KD[13]		1750	135	390	1500		
No. 2 Dense KD[13-14]		1750	120	455	1300		
No. 2 KD[13]		1500	120	390	1100		

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f^1)	H	q	c	E^6	
PINE, SOUTHERN[11]							
Dense Structural 86[14]	2″ thick only	2900	150	455	2200		
Dense Structural 72[14]		2350	135	455	1800		
Dense Structural 65[14]		2050	120	455	1600		
Dense Structural 58[14]		1750	105	455	1450		
No. 1 Dense[14]		1750	120	455	1550		
No. 1		1500	120	390	1350		
No. 2 Dense[14]		1400	105	455	1050		
No. 2		1200	105	390	900		
Dense Structural 86[14]	3″ and 4″ thick	2900	150	455	2200		
Dense Structural 72[14]		2350	135	455	1800		
Dense Structural 65[14]		2050	120	455	1600		
Dense Structural 58[14]		1750	105	455	1450		
No. 1 Dense SR[14]		1750	120	455	1750	(All) 1,600,000	U.B.C. Standard No. 25-6-67
No. 1 SR		1500	120	390	1500		
No. 2 Dense SR[14]		1400	105	455	1050		
No. 2 SR		1200	105	390	900		
Dense Structural 86[14]	5″ thick and up	2400[12]	150	455	1800		
Dense Structural 72[14]		2000[12]	135	455	1550		
Dense Structural 65[14]		1800[12]	120	455	1400		
Dense Structural 58[14]		1600[12]	105	455	1300		
No. 1 Dense SR[14]		1600[12]	120	455	1500		
No. 1 SR		1400[12]	120	390	1300		
No. 2 Dense SR[14]		1400[12]	105	455	1050		
No. 2 SR		1200[12]	105	390	900		

TABLE NO. 25-A—ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-GRADED LUMBER (Continued)

SPECIES AND COMMERCIAL GRADE		ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH					RULES UNDER WHICH GRADED
		Extreme Fiber in Bending (and Tension Parallel to Grain)	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity	
	SYMBOL:†	f (or f[1])	H	q	c	E[4]	
PINE, SOUTHERN[11]							
Industrial 86 KD[13]	1″, 1¼″ and 1½″ thick	2600	165	390	1950	(All) 1,600,000	U.B.C. Standard No. 25-6-67
Industrial 72 KD[13]		2200	150	390	1650		
Industrial 65 KD[13]		2000	135	390	1550		
Industrial 58 KD[13]		1750	120	390	1400		
Industrial 50 KD[13]		1500	120	390	1100		
Industrial 86	1″, 1¼″ and 1½″ thick	2500	150	390	1900		
Industrial 72		2000	135	390	1550		
Industrial 65		1750	120	390	1350		
Industrial 58		1500	105	390	1250		
Industrial 50		1200	105	390	900		
SPRUCE, EASTERN							
1450f. Structural Grade	J. & P.[15]	1450	110	300	1050	(All) 1,200,000	U.B.C. Standard No. 25-8-67
1300f. Structural Grade	J. & P.[15]	1300	95	300	975		
1200f. Structural Grade	J. & P.[15]	1200	95	300	900		
REDWOOD							
Dense Structural	J. & P.[15]-B. & S.[15]	1700	110	320	1450	(All) 1,200,000	U.B.C. Standard No. 25-7-67
Heart Structural	J. & P.[15]-B. & S.[15]	1300	95	320	1100		
Dense Structural	P. & T.	—	—	320	1450		
Heart Structural	P. & T.	—	—	320	1100		
SPRUCE (White and Western White)							U.B.C. Standard No. 25-4-67[18]
Selected Decking	Decking	1100	—	305	—	1,200,000	
Commercial Decking	Decking	850	—	305	—	1,200,000	

[1]In tension members the slope of grain limitations applicable to the middle portion of the length of the joist and plank and beam and stringer grades used shall apply throughout the length of the piece. For exception see footnote No. 11.

[2]Value applies to pieces used as planks.

[3]Value applies to two-inch (2″) thick pieces of Select Structural Grade used as joists.

[4]**For two-inch (2″) thick pieces of Construction and Standard Grades used as joists:**

H = 120 when length of split is approximately equal to one-half the width of piece.

H = 100 when length of split is approximately equal to the width of piece.

H = 70 when length of split is approximately equal to one and one-half times width of piece.

[5]**For three-inch (3″) thick pieces of Select Structural, Construction and Standard Grades used as joists:**

H = 120 when length of split is approximately two and one-fourth inches (2¼″).

H = 80 when length of split is approximately four and one-half inches (4½″), and

For four-inch (4″) thick pieces of Select Structural, Construction and Standard Grades used as joists:

H = 120 when length of split is approximately three inches (3″).

H = 80 when length of split is approximately six inches (6″).

[6]**The value of "E" may be increased 10 per cent where the lumber is surface seasoned before being fully loaded.**

[7]**For Beams and Stringers and for Posts and Timbers:**

H = 120 when length of split is equal to one-half the nominal narrow face dimension.

H = 100 when length of split is equal to the nominal narrow face dimension.

H = 80 when length of split is equal to one and one-half times the nominal narrow face dimension.

NOTE: Values for lengths of split other than those given in Notes 4, 5 and 7 are proportionate.

[8]**For two-inch (2″) thick pieces of Construction and Standard Grades used as joists:**

H = 100 when length of split is approximately equal to one-half the width of piece.

H = 80 when length of split is approximately equal to the width of piece.

H = 60 when length of split is approximately equal to one and one-half times width of piece.

[9]**For three-inch (3″) thick pieces of Select Structural, Construction and Standard Grades used as joists:**

H = 100 when length of split is approximately two and one-fourth inches (2¼″).

H = 70 when length of split is approximately four and one-half inches (4½″) and

For four-inch (4″) thick pieces of Select Structural, Construction and Standard Grades used as joists:

H = 100 when length of split is approximately three inches (3″).

H = 70 when length of split is approximately six inches (6″).

[10]**For Beams and Stringers and for Posts and Timbers:**

H = 100 when length of split is equal to three-fourths the nominal narrow face dimension.

H = 90 when length of split is equal to the nominal narrow face dimension.

H = 70 when length of split is equal to one and one-half times the nominal narrow face dimension.

NOTE: Values for lengths of splits other than those given in Notes 8, 9 and 10 are proportionate.

[11]All stress-grades under U.B.C. Standard No. 25-6-67 are all-purpose grades and apply to all sizes. Pieces so graded may be cut to shorter lengths without impairment of the stress rating of the shorter pieces.

Grade restrictions provided by U.B.C. Standard No. 25-6-67 apply to the entire length of the piece, and each piece is suitable for use in continuous spans, over double spans, or under concentrated loads without regrading for special shear or other special stress requirements.

The following variations apply to the provisions of U.B.C. Standard No. 25-6-67 for lumber in service under wet conditions or where the moisture content is at or above fiber saturation point, as when continuously submerged: (a) the allowable unit stresses in bending, tension parallel to grain and horizontal shear shall be limited in all thicknesses to the stresses indicated for thicknesses of five inches (5″) and up; (b) the allowable unit stresses for compression parallel to grain shall be limited to the stresses indicated for thicknesses of five inches (5″) and up reduced by 10 per cent; (c) the allowable unit stresses for compression perpendicular to grain shall be reduced one-third.

[12]These stresses apply for loading either on narrow face or on wide face, which is an exception to U.B.C. Standard No. 25-6-67.

[13]KD = Kiln dried in accordance with the provisions of U.B.C. Standard No. 25-6-67.

[14]Longleaf may be specified by substituting "Longleaf" for "Dense" in the grade name, and when so specified the same allowable stresses shall apply.

[15]The allowable unit stresses for tension parallel to grain "*t*" and compression parallel to grain "*c*" are applicable when the following additional provisions are applied to the grades:

The sum of the sizes of all knots in any six inches (6″) of the length of the piece shall not exceed twice the maximum permissible size of knot. Two knots of maximum permissible size shall not be within the same six inches (6″) of length of any face.

[16]These grades applicable to two-inch (2″) thickness only.

[17]Working stresses for Douglas Fir (Western Pine Region) shall be adjusted in accordance with basic stresses as set forth in U.B.C. Standard No. 25-1-67.

[18]Spruce (White and Western White) decking is graded under the requirements of Section 25.406 of U.B.C. Standard No. 25-4-67.

TABLE NO. 25-B—ALLOWABLE UNIT STRESSES FOR MACHINE STRESS-RATED LUMBER NORMAL LOADING[1]

EXTREME FIBER IN BENDING "f"[2] (in p.s.i.)	MODULUS OF ELASTICITY "E" (in p.s.i.)	TENSION AND COMPRESSION PARALLEL TO GRAIN "T" AND "c" (in p.s.i.)	COMPRESSION PERPENDICULAR TO GRAIN (in p.s.i.)[3]				HORIZONTAL SHEAR "H" (in p.s.i.)			
			Douglas Fir and Larch	Western Hemlock and White Fir	Ponderosa Pine	Engelmann Spruce	Douglas Fir and Larch	Western Hemlock	White Fir and Engelmann Spruce	Ponderosa Pine
900	1,000,000	725	390	365	310	215	75	65	60	70
1200	1,200,000	950	390	365	310	215	75	65	60	70
1500	1,400,000	1200	390	365	310	215	105	85	80	90
1800	1,600,000	1450	390	365	310	215	105	85	80	90
2100	1,800,000	1700	415	365	310	215	105	85	80	90
2400	2,000,000	1925	455	365	310	215	105	85	80	90

[1]For visual grading rules which also apply, see U.B.C. Standard No. 25-1-67, Section 25.113.

[2]The above stresses are for lumber used on edge. When loaded flatwise "f" may be increased 18 per cent.

[3]The values for compression perpendicular and parallel to the grain are for lumber that will be continuously dry in use as in most covered structures. For wet conditions of use reduce the values 33⅓ per cent for compression perpendicular to the grain and 10 per cent for compression parallel to the grain.

TABLE NO. 25-C—ALLOWABLE UNIT STRESSES FOR CONSTRUCTION AND INDUSTRIAL SOFTWOOD PLYWOOD
(In Pounds per Square Inch)

(To be used with section properties in Plywood-Design Specification—See U.B.C. Standard No. 25-9-67)

TYPE OF STRESS	SPECIES[1] GROUP	EXTERIOR A-A, A-C, C-C[2] STRUCTURAL I A-C, C-C (Use Group 1 Stresses)	EXTERIOR A-B, B-B, B-C, C-C (PLUGGED) STRUCTURAL I C-D (Use Group 1 Stresses) STRUCTURAL II C-D (Use Group 3 Stresses) STANDARD SHEATHING (Exterior Glue)[2] ALL INTERIOR GRADES WITH EXTERIOR GLUE	ALL OTHER GRADES OF INTERIOR INCLUDING STANDARD SHEATHING[2]
Extreme fiber in bending Tension Face grain parallel or perpendicular to span (at 45° to face grain use 1/6)	1 2, 3 4	2000 1400 1200	1650 1200 1000	1650 1200 1000
Compression Parallel or perpendicular to face grain (at 45° to face grain use 1/3)	1 2, 3 4	1650 1200 1000	1550 1100 950	1550 1100 950
Bearing (on face)	1 2, 3 4	340 220 160		
Shear in plane perpendicular to plies[3] Parallel or perpendicular to face grain (at 45° increase 100 per cent)	1 2, 3 4	250 185 175	250 185 175	230 170 160

(Continued)

TABLE NO. 25-C—ALLOWABLE UNIT STRESSES FOR CONSTRUCTION AND INDUSTRIAL SOFTWOOD PLYWOOD

(In Pounds per Square Inch)

(To be used with section properties in Plywood-Design Specification—See U.B.C. Standard No. 25-9-67)

TYPE OF STRESS	SPECIES[1] GROUP	EXTERIOR A-A, A-C, C-C[2] STRUCTURAL I A-C, C-C (Use Group 1 Stresses)	EXTERIOR A-B, B-B, B-C, C-C (PLUGGED) STRUCTURAL I C-D (Use Group 1 Stresses) STRUCTURAL II C-D (Use Group 3 Stresses) STANDARD SHEATHING (Exterior Glue)[2] ALL INTERIOR GRADES WITH EXTERIOR GLUE	ALL OTHER GRADES OF INTERIOR INCLUDING STANDARD SHEATHING[2]
Shear, rolling in plane of plies, parallel or perpendicular to face grain (at 45° increase 1/3)[4]	All	53	53	48
Modulus of Elasticity in bending. Face grain parallel or perpendicular to span	1 2 3 4	1,800,000 1,500,000 1,200,000 900,000		

[1]See U.B.C. Standard No. 25-9-67 for plywood species groups.

[2]Exterior C-C and Standard Sheathing: The combination of Identification-Index designation and panel thickness determines the minimum species group and, therefore, the stress permitted, as follows:

5/16 - 20/0, 3/8 - 24/0, 1/2 - 32/16, 5/8 - 42/20, 3/4 - 48/24—use Group 2 working stresses.

All other combinations—use Group 4 working stresses.

[3]Shear through the thickness stresses are based on the most common structural applications where the plywood is attached to framing around its boundary. Where the plywood is attached to framing at only two sides, such as in the heel joint of a truss, reduce the allowable shear through the thickness values by 11 per cent where framing is parallel to face grain and 25 per cent where it is perpendicular.

[4]For Structural I and Structural II use 75 pounds per square inch and 56 pounds per square inch respectively.

WET OR DAMP LOCATION:

Where moisture content is 16 per cent or more, decrease the dry location values as follows: All grades of Exterior and Interior plywood with Exterior glue: Extreme fiber in bending, 25 per cent; Tension, 31 per cent; Compression, 39 per cent; Bearing, 33 per cent; Shear, 16 per cent; Modulus of Elasticity, 11 per cent. For all other grades of Interior: Extreme fiber in bending, 31 per cent; Tension, 31 per cent; Compression, 39 per cent; Bearing, 33 per cent; Shear, 16 per cent; Modulus of Elasticity, 20 per cent.

TABLE NO. 25-D—ALLOWABLE UNIT STRESSES—STRUCTURAL GLUED-LAMINATED LARCH, AND WEST COAST HEMLOCK LUMBER—DRY CONDITIONS OF USE[1]

Allowable unit stresses are for normal conditions of loading, pounds per square inch.

COMBINATION NUMBER	SPECIES AND COMMERCIAL GRADE COMBINATION			EXTREME FIBER IN BENDING "f"		TENSION PARALLEL TO GRAIN "t"		COMPRESSION PARALLEL TO GRAIN "c"		HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "q"
	1	2	3	4	5	6	7	8	9	10	11
	Grade of Laminations at Top and Bottom	Number at Top and Bottom	Grade of Inner Laminations	From 4 to 14 Laminations	15 or More Laminations	From 4 to 14 Laminations	15 or More Laminations	From 4 to 14 Laminations	15 or More Laminations		
LARCH—2" THICKNESS											
L-1	D Select (Dense)	One	Dense Construction	3000	3000	3000	3000	2400	2400	200	450
L-2	D Select	One	Select Structural	2600	2600	2600	2600	2200	2200	200	415
L-3	D Select	One	Construction or Standard	2500	2500	2600	2600	2100	2100	200	390
L-4	Dense Select Structural	Two	Construction or Standard	2400	2600	3000	3000	2300	2300	200	450
L-5	Select Structural	All	Select Structural	2300	2600	2700	2700	2200	2200	200	415
L-6	Select Structural	One	Construction or Standard	2200	2400	2700	2700	2200	2200	200	415
L-7	Dense Construction	1/14	Construction or Standard	2200[2]	2600	2800	2800	2300	2300	200	450
L-8	Construction or Standard	All	Construction or Standard	1900[2]	2200	2600	2600	2000	2000	200	390
LARCH—1" THICKNESS											
L-9	D Select	One	No. 2 Common	2600	2600			2100	2100	200	
L-10	D Select	One	No. 3 or 4 Common	2500	2500	All	All	2100	2100	200	All
L-11	No. 2 Common	All	No. 2 Common	2100[2]	2400	2600	2600	2100	2100	200	390
L-12	No. 2 Common	One	No. 3 or 4 Common	2000[2]	2200			2000	2000	200	
L-13	No. 3 or 4 Common	All	No. 3 or 4 Common	1700[2]	2100			2000	2000	200	

TABLE NO. 25-D—ALLOWABLE UNIT STRESSES—STRUCTURAL GLUED-LAMINATED LARCH, AND WEST COAST HEMLOCK LUMBER—DRY CONDITIONS OF USE[1]—Continued

Allowable unit stresses are for normal conditions of loading, pounds per square inch.

COMBINATION NUMBER	SPECIES AND COMMERCIAL GRADE COMBINATION			EXTREME FIBER IN BENDING "f"		TENSION PARALLEL TO GRAIN "t"		COMPRESSION PARALLEL TO GRAIN "c"		HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "q"
	1	2	3	4	5	6	7	8	9	10	11
	Grade of Laminations at Top and Bottom	Number at Top and Bottom	Grade of Inner Laminations	From 4 to 14 Laminations	15 or More Laminations	From 4 to 14 Laminations	15 or More Laminations	From 4 to 14 Laminations	15 or More Laminations		
WEST COAST HEMLOCK											
1	Clear	One	Select Structural	2200	2200	2200	2200	1700	1700	140	365
2	Clear	One	Construction	2200	2200	2200	2200	1600	1700	140	365
3	Select Structural	All	Select Structural	2200	2200	2200	2200	1700	1700	140	365
4	Select Structural	One	Construction	2000	2200	2000	2200	1600	1700	140	365
5	Select Structural	Two	Construction	2000	2200	2200	2200	1700	1700	140	365
6	Select Structural	Two	Standard	2000	2200	2200	2200	1600	1600	140	365
7	Construction	All	Construction	1800	2000	2000	2200	1600	1700	140	365
8	Clear	One	Standard	2000	2000	1800	2000	1500	1600	140	365
9	Select Structural	One	Standard	2000	2000	1800	2000	1500	1600	140	365
10	Construction	One	Standard	1800	2000	1800	2000	1500	1600	140	365
11	Standard	All	Standard	1600	1800	1800	2000	1500	1600	140	365

[1]Modulus of elasticity, "E," dry conditions of use for larch, 1,800,000; for West Coast Hemlock, 1,540,000.

Allowable stress values for dry conditions of use shall be applicable for normal loading when the moisture content in service is less than 16 per cent as in most covered structures.

For wet conditions of use, the following maximum percentages of Dry Use Stresses shall be permitted:

"f" (bending) and "t" (tension) 80 per cent.

"H" (horizontal shear) and "M" (modulus of elasticity) 90 per cent. "H" for all combinations of Larch shall not exceed 165 pounds per square inch.

"c" and "q" (compression parallel and perpendicular) 70 per cent

[2]Values are for combinations having 6-14 laminations.

TABLE NO. 25-E—STRUCTURAL GLUED-LAMINATED DOUGLAS FIR (COAST REGION) TIMBER

PART A—MEMBERS STRESSED PRINCIPALLY IN BENDING—LOADED PERPENDICULAR TO WIDE FACE OF LAMINATIONS

DRY CONDITIONS OF USE

COMBINATION	EXTREME FIBER IN BENDING "f"	TENSION PARALLEL TO GRAIN		COMPRESSION PARALLED TO GRAIN		HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
		"t"	"t" Special[2]	"c"	"c" Special[2]		
A	2600	1600	2200	1500	1900	165	450
B	2400	1600	2000	1500	1800	165	450
C	2200	1600	1800	1500	1800	165	450

Modulus of Elasticity "*E*" Dry Conditions of Use, 1,800,000.

WET CONDITIONS OF USE[1]

COMBINATION	EXTREME FIBER IN BENDING "f"	"t"	"t" Special[2]	"c"	"c" Special[2]	HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
A	2000	1300	1800	1100	1400	145	305
B	1800	1300	1600	1100	1300	145	305
C	1600	1300	1400	1100	1300	145	305

Modulus of Elasticity "*E*" Wet Conditions of Use, 1,600,000.

[1]Allowable unit stresses for normal conditions of loading. Pounds per square inch.

[2]For the Special values for tension parallel to grain, "*t*," and for compression parallel to grain, "*c*," the slope of grain of all laminations in the member must not be steeper than that required in the outer 10 per cent of laminations.

(Continued)

TABLE NO. 25-E (Continued)

PART B—MEMBERS STRESSED PRINCIPALLY IN AXIAL COMPRESSION, AXIAL TENSION, OR LOADED PARALLEL OR PERPENDICULAR TO WIDE FACE OF LAMINATIONS

DRY CONDITIONS OF USE[1]

COMBINATION	COMPRESSION PARALLEL TO GRAIN "c"	TENSION PARALLEL TO GRAIN "t" AND EXTREME FIBER IN BENDING "f" WHEN LOADED PARALLEL OR PERPENDICULAR TO WIDE FACE OF LAMINATIONS	HORIZONTAL SHEAR "H" Loaded Perpendicular to Wide Face of Laminations	HORIZONTAL SHEAR "H" Loaded Parallel to Wide Face of Laminations	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
E	2200	2600	165	145	450
F	2100	2200	165	145	450
G	1800	1800	165	145	385
H	1500	1200	165	145	385

Modulus of Elasticity "*E*" Dry Conditions of Use, 1,800,000.

WET CONDITIONS OF USE[1]

COMBINATION	COMPRESSION PARALLEL TO GRAIN "c"	TENSION PARALLEL TO GRAIN "t" AND EXTREME FIBER IN BENDING "f" WHEN LOADED PARALLEL OR PERPENDICULAR TO WIDE FACE OF LAMINATIONS	HORIZONTAL SHEAR "H" Loaded Perpendicular to Wide Face of Laminations	HORIZONTAL SHEAR "H" Loaded Parallel to Wide Face of Laminations	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
E	1600	2000	145	120	305
F	1500	1800	145	120	305
G	1300	1400	145	120	260
H	1100	950	145	120	260

Modulus of Elasticity "*E*" Wet Conditions of Use, 1,600,000.

[1]Allowable unit stresses for normal conditions of loading. Pounds per square inch.

TABLE NO. 25-E (Continued)

PART C—GRADE REQUIREMENTS FOR THE TABULATED ALLOWABLE UNIT STRESSES

COMBINATION	NUMBER OF LAMINATIONS	MINIMUM GRADE OF LAMINATIONS[1]					SLOPE OF GRAIN	
		Top and Bottom Zone		Intermediate Zone		Inner Zone		
		Grade	Number	Grade	Number	Grade	Outer 10 per Cent of Laminations	Next Inner 10 per Cent of Laminations
A	4 to 8 9 to 20 21 or more	L 1 L 1 L 1	2 2 3	L 3 L 2 L 2	— 2 2	L 3 L 3 L 3	1:14	1:12
B	4 to 8 9 or more	L 1 L 1	1 1	L 2 L 2-D	1 2	L 3 L 3	1:12	1:10
C	4 or more	L 2-D	2	L 3	—	L 3	1:12	1:10
E	All			L 1			1:14 All	
F	All			L 2-D			1:12 All	
G	All			L 2			1:12 All	
H	All			L 3			1:8 All	

[1]See Section 25.312 of U.B.C. Standard No. 25-3-67 for the characteristics and limiting provisions of the laminating grades.

TABLE NO. 25-F—PART A—ALLOWABLE UNIT STRESSES FOR GLUED HARDWOOD LAMINATED LUMBER[1] FOR NORMAL LOADING DURATION—DRY CONDITIONS OF USE[2]

SPECIES	MULTIPLY THE APPROPRIATE STRESS MODULE IN PART B BY THE FACTORS BELOW TO DETERMINE ALLOWABLE STRESS FOR		ALLOWABLE UNIT STRESS (Pounds per Square Inch)		
	Extreme Fiber in Bending "f" or Tension Parallel to Grain "t"	Compression Parallel to Grain "c"	Horizontal Shear "H"	Compression Perpendicular to Grain "q"	Modulus of Elasticity "E"
Hickory, true and pecan	3.90	3.05	260	730	2,000,000
Beech, American	3.05	2.45	230	610	1,800,000
Birch, sweet and yellow	3.05	2.45	230	610	1,800,000
Elm, rock	3.05	2.45	230	610	1,400,000
Maple, black and sugar (hard maple)	3.05	2.45	230	610	1,800,000
Ash, commercial white	2.85	2.20	230	610	1,600,000
Oak, commercial red and white	2.85	2.05	230	610	1,600,000
Elm, American and slippery (white or soft elm)	2.20	1.60	190	310	1,300,000
Sweet gum (red or sap gum)	2.20	1.60	190	370	1,300,000
Tupelo, black (black gum)	2.20	1.60	190	370	1,300,000
Tupelo, water	2.20	1.60	190	370	1,300,000
Ash, black	2.00	1.30	170	370	1,200,000
Poplar, yellow	1.80	1.45	150	270	1,200,000
Cottonwood, Eastern	1.55	1.20	110	180	1,100,000

TABLE NO. 25-F—PART B—VALUES FOR USE IN COMPUTING WORKING STRESSES WITH FACTORS OF PART A TOGETHER WITH LIMITATIONS REQUIRED TO PERMIT THE USE OF SUCH STRESSES[3]

RATIO OF SIZE OF MAXIMUM PERMITTED KNOT TO FINISHED WIDTH OF LAMINATION[4]	NUMBER OF LAMINATIONS	EXTREME FIBER IN BENDING			TENSION PARALLEL TO GRAIN			COMPRESSION PARALLEL TO GRAIN	
		Stress Module	Steepest Grain Slope	Steepest Scarf Slope	Stress Module	Steepest Grain Slope	Steepest Scarf Slope	Stress Module	Steepest Grain Slope
0.1	4 to 14	800	1:16	1:10	800	1:16	1:10	970	1:15
.1	15 or more	800	1:16	1:10	800	1:16	1:10	980	1:15
.2	4 to 14	800	1:16	1:10	800	1:16	1:10	930	1:15
.2	15 or more	800	1:16	1:10	800	1:16	1:10	950	1:15
.3	4 to 14	670	1:12	1:8	800	1:16	1:10	870	1:15
.3	15 or more	770	1:16	1:10	800	1:16	1:10	900	1:15
.4	4 to 14	520	1:8	1:5	640	1:12	1:8	810	1:12
.4	15 or more	660	1:12	1:8	750	1:15	1:8	860	1:14
.5	4 to 14	390	1:8	1:5	480	1:8	1:5	730	1:10
.5	15 or more	550	1:10	1:15	630	1:12	1:8	800	1:12

[1]The allowable unit stresses in bending obtained from Table No. 25-F apply when the wide faces of the lamination are normal to the direction of the load.

[2]Allowable stresses for dry conditions of use shall be applicable when the moisture content in service is 16 per cent or less as in most covered structures. For wet conditions of use the following maximum percentage of the dry use stresses shall be permitted:

"f" (bending) and "t" (tension) 80 per cent
"H" (horizontal shear) and "E" (modulus of elasticity) 90 per cent
"c" (compression parallel to grain) 70 per cent
"q" (compression perpendicular to grain) 67 per cent

[3]For modification of allowable unit stresses for structural glued-laminated lumber see Section 2504.

[4]Factors for knot sizes of 0.1 and 0.2 are identical in case of extreme fiber in bending and in tension parallel to grain because a slope of grain of 1:16 is a greater limitation than knot size. The smaller knot size may be specified for reasons other than strength.

TABLE NO. 25-G—STRUCTURAL GLUED-LAMINATED CALIFORNIA REDWOOD TIMBER

PART A—MEMBERS STRESSED PRINCIPALLY IN BENDING—LOADED PERPENDICULAR TO WIDE FACE OF LAMINATIONS[1]

DRY CONDITIONS OF USE[2]

COMBINATION	EXTREME FIBER IN BENDING "f"	TENSION PARALLEL TO GRAIN "t"	COMPRESSION PARALLEL TO GRAIN "c"	HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
A	2200	2000[3]	2200	125	325
B	2200	2000[3]	2000	125	325
C	2200	2000	2000	125	325

Modulus of Elasticity "*E*" Dry Conditions of Use, 1,300,000.

WET CONDITIONS OF USE[2]

COMBINATION	EXTREME FIBER IN BENDING "f"	TENSION PARALLEL TO GRAIN "t"	COMPRESSION PARALLEL TO GRAIN "c"	HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
A	1800	1600[3]	1600	110	215
B	1800	1600[3]	1500	110	215
C	1800	1600	1500	110	215

Modulus of Elasticity "*E*" Wet Conditions of Use, 1,200,000.

[1]When a load that produces bending stress is parallel to the wide faces for members of combinations A, B, and C in Part A, the allowable bending stress and compression parallel to grain value shall be the computed weighted average for the number of pieces of each grade in the member. The allowable in bending stress, horizontal shear, and compression parallel to grain value for each grade are those shown in Part B.

[2]Allowable unit stresses are for normal conditions of loading, pounds per square inch.

[3]If slope of grain in all laminations is no steeper than one in 20, the tension stress of combinations A and B can be increased to 2200 pounds per square inch for dry conditions of use, and 1800 pounds per square inch for wet conditions of use.

TABLE NO. 25-G (Continued)

PART B—MEMBERS STRESSED PRINCIPALLY IN AXIAL COMPRESSION, AXIAL TENSION, OR LOADED IN BENDING PARALLEL AND PERPENDICULAR TO WIDE FACE OF LAMINATIONS

COMBINATION	COMPRESSION PARALLEL TO GRAIN "c"	TENSION PARALLEL TO GRAIN "t"	EXTREME FIBER IN BENDING "f" WHEN LOADED PERPENDICULAR TO WIDE FACE OF LAMINATION "f"	EXTREME FIBER IN BENDING "f" WHEN LOADED PARALLEL TO WIDE FACE OF LAMINATION "f"	HORIZONTAL SHEAR "H" WHEN LOADED PERPENDICULAR TO WIDE FACE OF LAMINATION "H"	COMPRESSION PERPENDICULAR TO GRAIN "c ⊥"
DRY CONDITIONS OF USE[1]						
D	2200	2200	2200	2200	125	325
E	2000	2000	2000	1400	125	325
F	1800	1800	1400	1000	125	325
Modulus of Elasticity "E" Dry Conditions of Use, 1,300,000.						
WET CONDITIONS OF USE[1]						
D	1600	1800	1800	1800	110	215
E	1500	1600	1600	1100	110	215
F	1300	1500	1100	800	110	215

Modulus of Elasticity "*E*" Wet Conditions of Use, 1,200,000.

[1]Allowable unit stresses are for normal conditions of loading, pounds per square inch.

(Continued)

TABLE NO. 25-G (Continued)

PART C—GRADE REQUIREMENTS FOR TABULATED ALLOWABLE UNIT STRESSES

COMBINATION	NUMBER OF LAMINATIONS	MINIMUM GRADE OF LAMINATIONS			SLOPE OF GRAIN	
		Top and Bottom		Inner Grade	Outer 10 Per Cent of Laminations	Remainder of Laminations
		Grade	Number			
A	4 or more	L 1 or L 2	—	L 1 or L 2	1 : 20	1 : 15
A–All Heart	4 or more	L 1	—	L 1	1 : 20	1 : 15
B	4 or more	L 1 or L 2	1	L 3	1 : 20	1 : 15
B–All Heart	4 or more	L 1	1	L 3	1 : 20	1 : 15
C	4 or more	L 1 or L 2	2	L 4 or L 5	1 : 20	1 : 15
C–All Heart	4 or more	L 1	2	L 4	1 : 20	1 : 15
D	ALL	L 1 or L 2	—	L 1 or L 2	1 : 20 ALL	
D–All Heart	ALL	L 1	—	L 1	1 : 20 ALL	
E–All Heart	ALL	L 3	—	L 3	1 : 15 ALL	
F	ALL	L 4 or L 5	—	L 4 or L 5	1 : 15 ALL	
F–All Heart	ALL	L 4	—	L 4	1 : 15 ALL	

TABLE NO. 25-H—STRUCTURAL GLUED-LAMINATED SOUTHERN PINE TIMBER

PART A—ALLOWABLE UNIT STRESSES[1]

Dry Conditions of Use

COMBINATION NUMBER		NUMBER OF LAMINATIONS	EXTREME FIBER IN BENDING "f"	TENSION PARALLEL TO GRAIN "t"[2]	COMPRESSION PARALLEL TO GRAIN "c"[2]	HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "q"
A	1	9 or more[3]	2600	2600	2000	200	385
	2	14 or 21		2600			450
	3	22 or more		2600			450
	4	13 or more		2400			450
B	1	4 or more	2400	2600			385
	2	12 or more		2600			450
	3	25 or more		2600			385
	4	9 or more		2400			385
C	1	6 or more[4]	2200	2400	1900		450
	2	14 or more		2600	2000		385
	3	18 or more		2400	1900		385
D	1	10 or more[4]	2000	2400	1900		385
	2	10 or more		2200			
E	1	4 or more	1800	2200	1900		
	2	12 or more			1800		

Modulus of Elasticity "E" Dry Conditions of Use – 1,800,000

(Continued)

TABLE NO. 25-H—STRUCTURAL GLUED-LAMINATED SOUTHERN PINE TIMBER—Continued

PART A—ALLOWABLE UNIT STRESSES[1]

Wet Conditions of Use

COMBINATION NUMBER		NUMBER OF LAMINATIONS	EXTREME FIBER IN BENDING "f"	TENSION PARALLEL TO GRAIN "t"[2]	COMPRESSION PARALLEL TO GRAIN "c"[2]	HORIZONTAL SHEAR "H"	COMPRESSION PERPENDICULAR TO GRAIN "q"
A	1	9 or more[3]	2000	2000	1500	175	260
	2	14 to 21	2000		1400		300
	3	22 or more	2000		1400		300
	4	13 or more	2100		1400		300
B	1	4 or more	1900		1400		260
	2	12 or more	2000				300
	3	25 or more	1900				260
	4	9 or more	1900				260
C	1	6 or more[4]	1800	1800			300
	2	14 or more	1800	2000			260
	3	18 or more	1700	1800			260
D	1	10 or more[4]	1600	2000			260
	2	10 or more	1600	1800			
E	1	4 or more	1400	1800	1400		
	2	12 or more			1300		

Modulus of Elasticity "E" Wet Conditions of Use – 1,600,000

[1]Allowable unit stresses for normal conditions of loading, pounds per square inch.

[2]Where slope of grain is limited to that required for bending members, the allowable unit stresses in tension and compression parallel to grain shall not exceed the following:

	Dry Conditions of Use	Wet Conditions of Use
Tension parallel to grain	1600	1300
Compression parallel to grain	1500	1100

[3]For fewer than nine laminations add one No. 1 lamination to each outer zone.

[4]Where fewer laminations are required a combination with a higher allowable stress can be selected.

TABLE NO. 25-H—STRUCTURAL GLUED-LAMINATED SOUTHERN PINE TIMBER—Continued

PART B—GRADE REQUIREMENTS FOR THE TABULATED ALLOWABLE UNIT STRESSES

Dry Conditions of Use

COMBINATION NUMBER		NUMBER OF LAMINATIONS	GRADE OF LAMINATIONS[1]			BENDING MEMBERS Slope of Grain			TENSION MEMBERS STEEPEST GRAIN SLOPE	COMPRESSION MEMBERS STEEPEST GRAIN SLOPE
			Outer Zone	Intermediate Zone	Inner Zone	Outer 10 Per Cent	Next 10 Per Cent	Balance		
A	1	9 or more	2 No. 1	No. 2	No. 2	1:18	1:12	1:8	1:18	1:15
	2	14 to 21	2 No. 2 Dense	No. 2	No. 2	1:14			1:18	
	3	22 or more	1 No. 2 Dense	No. 2	No. 2	1:14			1:18	
	4	13 or more	2 No. 1 Dense	4 No. 2	No. 3	1:14			1:16	
B	1	4 or more	1 No. 1	No. 2	No. 2	1:16			1:18	
	2	12 or more	1 No. 2 Dense	No. 2	No. 2	1:12			1:18	
	3	25 or more	No. 2	No. 2	No. 2	1:16			1:18	
	4	9 or more	1 No. 1	3 No. 2	No. 3	1:16			1:16	
C	1	6 or more	1 No. 2 Dense	No. 2	No. 2	1:12	1:10		1:16	1:14
	2	14 or more	No. 2	No. 2	No. 2	1:14			1:18	1:15
	3	18 or more	1 No. 1	1 No. 2	No. 3	1:14			1:16	1:14
D	1	10 or more	No. 2	No. 2	No. 2	1:12	1:8		1:16	1:14
	2		2 No. 2	No. 3	No. 3				1:14	
E	1	4 or more	No. 2	No. 2	No. 2	1:10			1:14	1:14
	2	12 or more	1 No. 2	No. 3	No. 3					1:12

[1]No. 3 refers to medium grain boards and to No. 3 MG dimension.

(Continued)

TABLE NO. 25-H—STRUCTURAL GLUED-LAMINATED SOUTHERN PINE TIMBER—Continued

PART B—GRADE REQUIREMENTS FOR THE TABULATED ALLOWABLE UNIT STRESSES

Wet Conditions of Use

COMBINATION NUMBER		NUMBER OF LAMINATIONS	GRADE OF LAMINATIONS[1]			BENDING MEMBERS Slope of Grain			TENSION MEMBERS STEEPEST GRAIN SLOPE	COMPRESSION MEMBERS STEEPEST GRAIN SLOPE
			Outer Zone	Intermediate Zone	Inner Zone	Outer 10 Per Cent	Next 10 Per Cent	Balance		
A	1	9 or more	2 No. 1	No. 2	No. 2	1:18	1:12	1:8	1:18	1:15
	2	14 to 21	2 No. 2 Dense	No. 2	No. 2	1:14				
	3	22 or more	1 No. 2 Dense	No. 2	No. 2	1:14				
	4	13 or more	2 No. 1 Dense	4 No. 2	No. 3	1:15				
B	1	4 or more	1 No. 1	No. 2	No. 2	1:16				
	2	12 or more	1 No. 2 Dense	No. 2	No. 2	1:12				
	3	25 or more	No. 2	No. 2	No. 2	1:16				
	4	9 or more	1 No. 1	3 No. 2	No. 3	1:16				
C	1	6 or more	1 No. 2 Dense	No. 2	No. 2	1:12	1:10		1:14	
	2	14 or more	No. 2	No. 2	No. 2	1:14			1:18	
	3	18 or more	1 No. 1	1 No. 2	No. 3	1:16			1:14	
D	1	10 or more	No. 2	No. 2	No. 2	1:12	1:8		1:18	
	2	10 or more	2 No. 2	No. 3	No. 3				1:14	
E	1	4 or more	No. 2	No. 2	No. 2	1:10			1:14	1:15
	2	12 or more	1 No. 2	No. 3	No. 3					1:12

(*Continued from page 164*)

Allowable Unit Stresses (Continued)

(d) **Conditions of Service.** The allowable unit stresses as set forth in Table No. 25-A for visually graded lumber, and adjustments thereof apply to lumber used under conditions continuously dry, such as in most covered structures. Under such conditions of use the modulus of elasticity may be increased 10 per cent for lumber that is surface seasoned before loading to the maximum allowable load. Except for compression parallel and compression perpendicular to the grain, they also apply to lumber used under conditions where the moisture content of the wood is permanently at or above the fiber saturation point, as when continuously submerged.

When used under continuously wet conditions, the allowable unit stresses as set forth in Table No. 25-A for compression parallel to grain shall be reduced 10 per cent and for compression perpendicular to grain shall be reduced one-third.

The allowable unit stresses set forth in Table No. 25-B for machine stress-rated lumber shall be adjusted for conditions of use as specified in the footnote to the Table.

The allowable unit stresses as set forth in Tables No. 25-A, No. 25-B, No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H and adjustments thereof, and stresses as set forth in Table No. 25-C apply also to lumber, to structural glued-laminated lumber and to exterior type plywood that has been pressure-impregnated by an approved process and to the heartwood of durable species under dry or other conditions of use.

The allowable unit stresses for structural glued-laminated lumber as set forth in Tables No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H shall be for dry conditions of use where the moisture content in service is 16 per cent or less, as in most covered structures. For wet conditions of use, the maximum percentage of the dry-use stress permitted shall be as specified in the footnotes applicable to the respective tables.

(e) **Adjustment of Allowable Unit Stresses for Duration of Load.** The allowable unit stresses as set forth in Tables No. 25-A and No. 25-B for sawn lumber, Table No. 25-C for plywood and Tables No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H for structural glued-laminated lumber, and the values for mechanical fastenings as hereinafter established, shall be applicable as follows for the various durations of loading:

1. Where a member is fully stressed to the maximum allowable stress, either continuously or cumulatively for more than 10 years under the condition of maximum design load, the allowable unit stresses used in the design shall not exceed 90 per cent of those in the tables.

Allowable Unit Stresses (Continued)

2. When the duration of the full maximum load does not exceed the period indicated below, the allowable unit stresses shall be increased in the tables as follows:

15 per cent for two months duration, as for snow
25 per cent for seven days duration
33⅓ per cent for wind or earthquake
100 per cent for impact

Allowable unit stresses given in the tables for normal loading conditions may be used without regard to impact if the stress induced by impact does not exceed the allowable unit stress for normal loading.

The above increases are not cumulative. For combined durations of loading, the resulting structural members shall not be smaller than required for a longer duration of loading.

(f) **Horizontal Shear Adjustment.** The unit stress in horizontal shear in members of rectangular section stressed in flexure shall be computed by use of the following formula:

$$H = \frac{3R}{2bh}$$

WHERE:

R = reaction, pounds, under the following conditions:

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

(2) All loads uniform or concentrated, within a distance of the height of the beam from the nearest support, shall be neglected.

(3) All concentrated loads located at a distance from the support of one to three times the height of the beam shall be considered as placed at three times the height of the beam from the support.

(g) **Adjustments of Allowable Unit Stresses for Joint Details. 1. Compression.** In joists supported on a ribbon or ledger board and spiked to the studding, the allowable stress in compression perpendicular to grain may be increased 50 per cent.

Allowable unit stresses in compression perpendicular to grain as set forth in Tables No. 25-A and No. 25-B shall be increased in accordance with the following factors for bearing less than six inches (6″) in length and located three inches (3″) or more from the end of a timber.

Length of bearing (inches)	½	1	1½	2	3	4	6 or more
Factor	1.75	1.38	1.25	1.19	1.13	1.10	1.00

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

Allowable Unit Stresses (Continued)

2. **Shear.** Allowable unit stresses in shear for joint details shall be 150 per cent of the horizontal shear values as set forth in Tables No. 25-A, No. 25-B, No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H.

In computing the horizontal shear in eccentric joints the effective depth of the member shall be assumed as its actual depth less the distance from the unloaded edge to the nearest edge of the nearest connector. Where bolts alone are used, the distance from the unloaded edge to the center of the nearest bolt shall be subtracted.

(h) **Holes and Notches.** Girders, beams, or joists may be notched or bored in any part of the section within three times the beam depth from either support. Such notches or holes shall not exceed one-fifth of the depth of beam except at point of support and as hereinafter provided.

Where girders, beams, or joists are notched at points of support, they shall meet design requirements for net section in bending and in shear. The shear at such point shall not exceed the value calculated by the following formula:

$$V = \frac{2}{3}\left(\frac{bd^2 H}{h}\right)$$

WHERE:

d = actual depth of beam at the notch.

h = total depth of beam.

Where notches or holes are made in other portions of the beam, the net remaining depth of beam shall be used in determining the bending strength.

(i) **Compression on Inclined Surfaces.** The unit stress (compression) normal to a plane inclined to the fiber of a wood member shall not exceed that determined from the formula:

$$N = \frac{c\,q}{c \sin^2\theta + q \cos^2\theta}$$

Columns

Sec. 2505. (a) **General.** Columns, posts, struts, and other members in compression parallel to grain shall be designed structurally as provided in this Section.

(b) **Solid Columns.** Simple solid wood columns consist of a single piece of sawn lumber or structurally glued-laminated lumber.

The safe load in pounds per square inch of net cross-sectional area, for simple columns or other solid members stressed

Columns (Continued)

in compression parallel to grain, shall be determined by the following formula, but the maximum unit load "P/A" shall not exceed the values for compression parallel to grain "c" in Tables No. 25-A, No. 25-B, No. 25-D, No. 25-E, No. 25-F, No. 25-G and No. 25-H adjusted in accordance with the provisions of Subsection 2504 (e):

$$P/A = \frac{3.619E}{(l/r)^2}$$

For columns of square or rectangular section the following formula shall be used:

$$P/A = \frac{0.30E}{(l/d)^2}$$

WHERE:

d = least dimension of square or rectangular columns, in inches.

l = unsupported length in inches.

r = least radius of gyration of the section.

Columns shall be limited in maximum length between points of lateral support to $l = 50d$, except that the individual members of spaced columns shall be limited in maximum length to $l = 80d$.

(c) **Spaced Columns.** Spaced columns or compression members shall be based upon design principles acceptable to the Building Official, or the design principles set forth for spaced columns in U.B.C. Standard No. 25-15-67.

(d) **Axial Loading.** The allowable axial unit stresses are subject to adjustment for duration of load and conditions of service as specified in Section 2504.

(e) **Combined Flexural and Axial Loading.** Members subjected to both flexural and axial loading shall be designed in accordance with the provisions set forth in U.B.C. Standard No. 25-16-67.

Timber Connections and Fastenings

Sec. 2506. (a) **Timber Connectors.** Timber connectors may be used to transmit stress between wood members and between wood and metal members. The allowable loads and installation of timber connectors shall be as set forth in U.B.C. Standard No. 25-17-67.

Safe loads and design practices for types of connectors not mentioned or fully covered in U.B.C. Standard No. 25-17-67 may be determined in a manner approved by the Building Official.

(b) **Bolts.** Bolted joints wherein bolts are used to resist or transfer stresses in wood structures shall be designed in accordance with the provisions set forth in U.B.C. Standard No. 25-17-67. Safe loads in pounds for bolts in double shear and in seasoned lumber of the following species: Douglas fir (Coast Region) and Douglas fir; larch; pine, southern; in joints consisting of three members in which the side members are one-half the thickness of the main member, shall not exceed values set forth in Tables No. 25-J and No. 25-K. (For other species see U.B.C. Standard No. 25-17-67.)

Timber Connections and Fastenings (Continued)

(c) **Drift Bolts or Pins.** Connections of wood structural members involving the use of drift bolts or drift pins shall be designed in accordance with the provisions set forth in U.B.C. Standard No. 25-17-67.

(d) **Wood Screws.** Connections involving the use of wood screws shall be designed in accordance with the provisions set forth in U.B.C. Standard No. 25-17-67.

(e) **Lag Screws.** Connections involving the use of lag screws shall be designed in accordance with the provisions set forth in U.B.C. Standard No. 25-17-67.

(f) **Nails and Spikes. 1. Safe lateral strength.** A common wire nail driven perpendicular to grain of the wood, when used to fasten wood members together, shall not be subjected to a greater load causing shear and bending than the safe lateral strength of the wire nail or spike as set forth in Table No. 25-L.

A wire nail driven parallel to the grain of the wood or toe-nailed shall not be subjected to more than two-thirds of the lateral load allowed when driven perpendicular to grain.

2. **Safe resistance to withdrawal.** A wire nail driven perpendicular to grain of the wood shall not be subjected to a greater load, tending to cause withdrawal, than the safe resistance of the nail to withdrawal, as set forth in Table No. 25-M.

Nails driven parallel to grain of the wood shall not be allowed for resisting withdrawal forces.

TABLE NO. 25-I—GROUP CLASSIFICATION—NONSTRESS-GRADED LUMBER

SPECIES	MINIMUM GRADE	UNIFORM BUILDING CODE STANDARD NUMBER
GROUP I		
Douglas Fir (Coast Region)[1]	Construction	25-3-67
Douglas Fir[1]	Construction	25-4-67
Larch, Western[1]	Construction	25-4-67
Pine, Southern[1]	No. 3 MGKD	25-6-67
GROUP II		
Bald Cypress (Tidewater Red Cypress)	No. 2	25-2-67
Fir, White	Construction	25-3-67 25-4-67
Hemlock, Eastern	No. 1	25-5-67
Hemlock, West Coast[1]	Construction	25-3-67

TABLE NO. 25-I (Continued)

SPECIES	MINIMUM GRADE	UNIFORM BUILDING CODE STANDARD NUMBER
Hemlock, Western[1]	Construction	25-4-67
Pine, Red (Norway Pine)	No. 1	25-5-67
Pine, Southern	Special	25-6-67
Redwood, California	Select Heart	25-7-67
Spruce, Eastern	No. 1	25-8-67
Spruce, Sitka	Construction	25-3-67
Spruce, White and Western White	Construction	25-4-67[2]
GROUP III		
Cedar, Western	Construction	25-3-67
Cedar, Western Red and Incense	Construction	25-4-67
Douglas Fir (Coast Region)[1]	Standard	25-3-67
Douglas Fir[1]	Standard	25-4-67
Fir, Balsam	No. 1	25-8-67
Fir, White	Standard	25-3-67 25-4-67
Hemlock, Eastern	No. 2	25-5-67
Hemlock, West Coast[1]	Standard	25-3-67
Hemlock, Western[1]	Standard	25-4-67
Larch, Western[1]	Standard	25-4-67
Pine, Ponderosa, Lodgepole, Sugar, Idaho White	Construction	25-4-67
Pine, Southern	No. 3 MGKD	25-6-67
Pine, Southern[1]	No. 3	25-6-67
Redwood, California	Sap Common	25-7-67
Redwood, California (studs only)	Two Star	25-7-67
Spruce, Engelmann	Construction	25-4-67
Spruce, Sitka	Standard	25-3-67
Spruce, White and Western White	Standard	25-4-67[2]
GROUP IV [See Section 2504 (b) para. 5]		
Cedar, Western	Utility	25-3-67
Cedar, Western Red and Incense	Utility	25-4-67
Douglas Fir (Coast Region)	Utility	25-3-67
Douglas Fir	Utility	25-4-67
Fir, White	Utility	25-3-67 25-4-67
Hemlock, West Coast	Utility	25-3-67
Hemlock, Western	Utility	25-4-67
Larch, Western	Utility	25-4-67
Pine, Ponderosa, Lodgepole, Sugar, Idaho White	Utility	25-4-67
Pine, Southern	No. 3	25-6-67
Redwood, California	Merchantable	25-7-67
Redwood, California (studs only)	One Star	25-7-67
Spruce, Engelmann	Utility	25-4-67
Spruce, Sitka	Utility	25-3-67
Spruce, White and Western White	Utility	25-4-67[2]

[1]Two-inch by four-inch (2" x 4") only.

[2]Spruce (White and Western White) shall be graded under the requirements of Section 25.409 of U.B.C. Standard No. 25-4-67.

TABLE NO. 25-J—HOLDING POWER OF BOLTS

Loads Parallel to Grain (p)

In Double Shear in Douglas Fir (Coast Region), Douglas Fir, Larch, Southern Pine
(See U.B.C. Standard No. 25-17-67 for values in other species.)

LENGTH OF BOLT IN MAIN MEMBER[1] (Inches)	DIAMETER OF BOLT (Inches)						
	½	⅝	¾	⅞	1	1⅛	1¼
1⅝	1010	1290	1550	1810	2070		
2⅝	1280	1890	2430	2900	3340		
3⅝	1290	2010	2860	3680	4430		
4½	1290	2010	2890	3920	4980	5980	
5½		2010	2890	3940	5120	6440	
6½		2010	2890	3940	5140	6500	
7½		2010	2890	3940	5140	6500	
9½			2890	3940	5140	6500	8040
11½					5140	6500	8040

[1]This assumes dressed size lumber. Safe loads for other lengths of bolt in main member may be obtained by interpolation.

TABLE NO. 25-K—HOLDING POWER OF BOLTS

Loads Perpendicular to Grain (q)

In Double Shear in Douglas Fir (Coast Region), Douglas Fir, Larch, Southern Pine
(See U.B.C. Standard No. 25-17-67 for values in other species.)

LENGTH OF BOLT IN MAIN MEMBER[1] (Inches)	DIAMETER OF BOLT (Inches)						
	½	⅝	¾	⅞	1	1⅛	1¼
1⅝	480	540	600	670	730		
2⅝	780	880	980	1080	1170		
3⅝	1020	1210	1350	1490	1620		
4½	1020	1440	1680	1840	2010	2190	
5½		1450	1940	2250	2460	2680	
6½		1390	1940	2510	2880	3170	
7½		1300	1880	2500	3130	3610	
9½			1690	2350	3050	3830	4590
11½					2850	3660	4490

[1]This assumes dressed size lumber. Safe loads for other lengths of bolt in main member may be obtained by interpolation.

Timber Connections and Fastenings (Continued)

3. **Spacing and penetration.** Common wire nails shall have penetration into the piece receiving the point as set forth in Table No. 25-L. Nails or spikes for which the wire gauges or lengths are not set forth in Table No. 25-L shall have a required penetration of not less than 11 diameters, and allowable loads may be interpolated.

For wood to wood joints the spacing center-to-center shall be not less than the required penetration.

Edge and end distances shall be not less than one-half of the required penetration.

Holes for nails, where necessary to prevent splitting, shall be bored of a diameter smaller than that of the nails.

4. **Groups I and J Occupancies.** The number and size of nails connecting wood members of Groups I and J Occu-

Timber Connections and Fastenings (Continued)

pancies shall be not less than the amount set forth in Table No. 25-N. Other connections shall be nailed to provide equivalent strength.

Plywood subflooring and roof sheathing shall be nailed at six inches (6″) on center at panel edges and boundary members and twelve inches (12″) on center at intermediate supports. The nails shall be of sufficient size to provide the minimum penetration required in Table No. 25-L. See Section 2511 for nailing of plywood required at vertical or horizontal diaphragm.

(g) **Joist Hangers and Framing Anchors.** Connections depending upon joist hangers or framing anchors, ties, and other mechanical fastenings not otherwise covered may be used where approved.

Vertical Members or Assemblies

Sec. 2507. (a) **Columns or Posts.** All wood columns and posts shall be framed to true end bearings; shall extend down

TABLE NO. 25-L—SAFE LATERAL STRENGTH AND REQUIRED PENETRATION OF COMMON WIRE NAILS[1] DRIVEN PERPENDICULAR TO GRAIN OF WOOD

SIZE OF NAIL	STANDARD LENGTH (Inches)	WIRE GAUGE	PENETRATION REQUIRED (Inches)	LOADS (Pounds)[2] Douglas Fir Larch or Southern Pine	Other Species
6d	2	11½	1¼	63	See U.B.C. Standard No. 25-17-67
8d	2½	10¼	1½	78	
10d	3	9	1⅝	94	
12d	3¼	9	1⅝	94	
16d	3½	8	1¾	107	
20d	4	6	2⅛	139	
30d	4½	5	2¼	154	
40d	5	4	2½	176	
50d	5½	3	2¾	202	
60d	6	2	2⅞	223	

[1]The lateral strength values of box wire nails shall not exceed 75 per cent of the values for common wire nails. The safe lateral strength values may be increased 25 per cent where metal side plates are used.

[2]For wood diaphragm calculations these values may be increased 30 per cent. (See U.B.C. Standard No. 25-17-67.)

TABLE NO. 25-M—SAFE RESISTANCE TO WITHDRAWAL OF COMMON WIRE NAILS

Inserted Perpendicular to Grain of the Wood, in Pounds per Linear Inch of Penetration into the Main Member

KIND OF WOOD	SIZE OF NAIL 6d	8d	10d	12d	16d	20d	30d	40d	50d	60d
Douglas Fir, Larch or Southern Pine	33	39	44	44	48	57	61	67	72	78
Other Species	See U.B.C. Standard No. 25-17-67									

to supports of such design as to hold the column or post securely in position and to protect its base from deterioration; and shall be supported in basements or cellars by piers projecting at least two inches (2") above the finished floor and separated therefrom by an approved metal barrier, or when pressure-impregnated timber is used, it may be placed directly on concrete or masonry.

Vertical Members or Assemblies (Continued)

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

(b) **Stud Walls and Bearing Partitions. 1. Placing.** Studs in walls and partitions may be placed with their wide faces parallel to the wall or partition, provided the studs are considered as columns and are designed accordingly. Stud walls shall have top and bottom plates except that joists may be supported by a let-in ribbon as provided in Section 2509 (a).

2. **Size.** Except as otherwise provided, exterior stud walls and bearing partitions for buildings of two stories or less shall consist of not less than two-inch by four-inch (2" x 4") studs; for buildings of three stories, the studding shall be not less than three inches by four inches (3" x 4") or two inches by six inches (2" x 6") to the bottom of the second floor joists, and two inches by four inches (2" x 4") for the two upper stories.

3. **Height.** Unless supported laterally by adequate framing, the maximum allowable height shall be ten feet (10')

TABLE NO. 25-N—NUMBER OF NAILS FOR CONNECTING WOOD MEMBERS

Groups I and J Occupancies

CONNECTION	BOX OR COMMON
Joist to sill or girder—toe nail	2-16d
Bridging to joist—toe nail	2- 8d
1 x 6 subfloor to joist—face nail	2- 8d
2-inch subfloor to joist or girder	2-16d
Plate to joist or blocking	16d-16" o.c.
Stud to plate—end nail	2-16d
Stud to plate—toenail	3-16d or 4-8d
Top plates—spike together	16d-24" o.c.
—laps and intersections	2-16d
Ceiling joists—to plate—toenail	2-16d
—laps over partitions	3-16d
—to parallel alternate rafters	3-16d
Rafter to plate	3-16d
Continuous 1-inch brace to stud	2- 8d
2-inch cut-in bracing to stud	2-16d
1-inch sheathing to bearing	2- 8d
Corner studs and angles	16d-30" o.c.
Plywood roof or floor sheathing	See Section 2506 (f) 4

Vertical Members or Assemblies (Continued)

for two-inch by three-inch (2" x 3") stud framing; fourteen feet (14') for two-inch by four-inch (2" x 4") stud framing; sixteen feet (16') for three-inch by four-inch (3" x 4") stud framing; and twenty feet (20') for two-inch by six-inch (2" x 6") stud framing.

When Table No. 25-I, Group IV studs are permitted to be used by the Building Official, the maximum allowable height shall be eight feet (8') for load-bearing studs and ten feet (10') for nonload-bearing studs. When used in bearing walls, Group IV studs shall support not more than a roof and ceiling load.

4. **Spacing.** Except for one-story detached buildings of Group J Occupancy, where twenty-four-inch (24") spacing may be used, no studding shall be spaced more than sixteen inches (16") on center unless vertical supporting members in the walls are designed as columns, or such walls may be constructed of not less than four-inch by four-inch (4" x 4") posts spaced not more than five feet four inches (5'4") on center, or of larger members designed as required in this Chapter, or may be of post and beam framing with plank sheathing not less than one and one-half inches (1½") thick.

5. **Corners and bracing.** Angles or corners where stud walls or partitions meet shall be framed solid. All exterior walls and main cross stud partitions shall be effectively and thoroughly braced or sheathed with approved panels adequately nailed along all edges.

6. **Pipes in walls.** Stud partitions containing plumbing, heating, or other pipes shall be so framed and the joists underneath so spaced as to give proper clearance for the piping. Where a partition containing such piping runs parallel to the floor joists, the joists underneath such partitions shall be doubled and spaced to permit the passage of such pipes and shall be bridged. Where plumbing, heating, or other pipes are placed in or partly in a partition, necessitating the cutting of the soles or plates, a metal tie not less than one-eighth inch (⅛") thick and one and one-half inches (1½") wide shall be fastened to the plate across and to each side of the opening with not less than four 16d nails.

7. **Separations from chimneys.** For clearance space between chimneys and combustible materials, see Section 3702 (l).

8. **Top 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 plates shall be staggered not less than four feet (4').

9. **Foundation plates.** Stud walls resting on masonry or concrete shall have foundation plates or sills as provided in Sections 2806 (e) and 2517 (c).

10. **Foundation studs.** Foundation studs shall be not less in size than the studding above with a minimum of length of fourteen inches (14"). When exceeding four feet (4') in height, studs shall be of the size required for an additional story.

Vertical Members or Assemblies (Continued)

Foundation studs under bearing walls and partitions shall be thoroughly and effectively braced.

11. **Bridging.** All stud partitions or walls over ten feet (10') in height shall have bridging, not less than two inches (2") in thickness and of the same width as the stud, fitted snugly and spiked into the studs at their mid-height, or other means for giving adequate lateral support to the studs. Bridging meeting the requirements of Section 2508 may serve as required firestopping.

12. **Headers.** All openings four feet (4') wide or less in bearing walls shall be provided with headers equivalent to double headers not less than two inches (2") thick, placed on edge, securely fastened together, and all openings more than four feet (4') wide shall be trussed or provided with headers or lintels. Such headers or trusses shall have not less than two-inch (2") solid bearing at each end to the floor or bottom plate, unless other approved framing methods or joint devices are used.

(c) **Walls Without Studs.** Detached one-story buildings of Group J Occupancy may have exterior walls framed without studs when of vertical two-inch (2") or thicker planks, or when having a total floor area of not more than five hundred square feet (500 sq. ft.) may be of vertical one-inch (1") boards and battens.

(d) **Laminated Walls and Partitions.** Walls and partitions may be of laminated construction of not less than four inches (4") nominal thickness, with the structural assembly designed to support all loads.

(e) **Interior Walls and Partitions.** Interior partitions shall be constructed, framed, and firestopped as specified for exterior walls, except that interior nonbearing partitions may have a single top plate. In Group I Occupancies, nonbearing partitions constructed of two-inch by three-inch (2" x 3") studs spaced sixteen inches (16") on center may be used.

Where wood-frame walls and partitions are covered on the interior with plaster, tile, or similar materials and are subject to water splash, the framing shall be protected with 15-pound asphalt-saturated felt.

For provisions covering maximum allowable spacing of gypsum, wood, and fiber insulation lath, see Section 4703.

For provisions covering maximum allowable spacing of supports for metal and wire lath on wood studs and rafters and method of attachment, see Section 4705.

Vertical Members or Assemblies (Continued)

For provisions covering maximum allowable spacing of gypsum wallboard on wood studs and rafters and method of attachment, see Section 4710.

(f) **Exterior Wall Coverings. 1. General.** Exterior wood stud walls shall be covered on the outside with the materials and in the manner specified in this Section.

2. **Weatherboarding.** Studs or sheathing shall be covered on the outside face with one layer of building paper when required in Section 1707 (a).

Weatherboarding shall have an average thickness in place of not less than five-eighths inch (5/8") and a minimum thickness of not less than three-eighths inch (3/8"). Horizontal joints in the weatherboarding shall be tongued and grooved or shiplapped joints, or such weatherboarding shall be laid shingle fashion and lapped not less than one-half inch (1/2").

Siding patterns known as rustic, drop siding, or shiplap shall have an average thickness in place of not less than nineteen thirty-seconds inch (19/32") and shall have a minimum thickness of not less than three-eighths inch (3/8"). Bevel siding shall have a minimum thickness measured at the butt section of not less than seven-sixteenths inch (7/16") and a tip thickness of not less than three-sixteenths inch (3/16"). Siding of lesser dimensions may be used, provided such wall covering is placed over sheathing which conforms to the provisions specified in Section 2202.

All weatherboarding or siding shall be securely nailed to each stud with not less than one nail, or to solid nominal wood sheathing with not less than one line of nails spaced not more than twenty-four inches (24") on center in each piece of the weatherboarding or siding.

Nails shall be so located as to hold the bottom of the weatherboarding or siding secure and thereby to hold tight the top of the piece below. Where such nailing is not possible, two nails to each stud shall be used to hold each piece.

3. **Plywood.** Where plywood is used for covering the exterior of outside walls, it shall be of the exterior type not less than three-eighths inch (3/8") thick. Joints shall occur over framing members not less than two inches (2") thick, unless wood or plywood sheathing is used, or joints are lapped horizontally or otherwise made waterproof to the satisfaction of the Building Official.

4. **Shingles or shakes.** Wood shingles or shakes and asbestos cement shingles may be used for exterior wall covering provided the frame of the structure is covered with building paper as specified in Section 1707 (a). All shingles or shakes attached to sheathings other than wood shall be secured with approved mechanically-bonding nails or by approved corrosion-resistant nails on furring strips attached to the studs. Wood shingles or shakes may be applied over fiberboard

shingle backer and sheathing with annular grooved nails. The thickness of wood shingles or shakes between wood nailing boards shall be not less than three-eighths inch (⅜″).

Vertical Members or Assemblies (Continued)

Wood shingles or shakes and asbestos shingles or siding may be nailed directly to approved nail-base fiberboard sheathing not less than one-half-inch (½″) nominal thickness with approved corrosion-resistant annular grooved nails. Nail-base fiberboard sheathing shall comply with U.B.C. Standard No. 22-1-67.

5. **Weather-resistant metal.** Painted, treated, or noncorrosive metal may be used on stud walls. When sheathing is omitted the installation must be approved by the Building Official. Contact between dissimilar metals shall be broken by approved methods. Galvanized steel sheets formed or flat may be used.

6. **Exterior plastering.** See Chapter 47.

7. **Veneer.** See Chapter 29.

Firestops

Sec. 2508. Firestopping shall be provided to cut off all concealed draft openings (both vertical and horizontal), and form an effective barrier between stories, and between a top story and roof space. It shall be used in specific locations, as follows:

1. In exterior or interior stud walls, at ceilings and floor levels.

2. In all stud walls and partitions, including furred spaces, so placed that the maximum dimension of any concealed space is not over eight feet (8′).

3. Between stair stringers at least once in the middle portion of each run, at top and bottom, and between studs, along and in line with run of stair adjoining stud walls and partitions.

4. Around top, bottom, sides, and ends of sliding door pockets.

5. In spaces between chimneys and wood framing, loose incombustible materials shall be placed in incombustible supports, or a metal collar tightly fitted to the chimney and nailed to the wood framing may be used.

6. Any other locations not specifically mentioned above, such as holes for pipes, shafting, behind furring strips and similar places which could afford a passage for flames.

Firestops when of wood shall be two-inch (2″) nominal thickness. If width of opening is such that more than one piece of lumber is necessary, there shall be two thicknesses of one-inch (1″) material with joints broken.

Horizontal Members or Assemblies

Sec. 2509. (a) **Bearing.** Every beam, girder, and joist shall have sufficient bearing area so that the compression perpendicular to grain values set forth in Table No. 25-A,

Horizontal Members or Assemblies (Continued)

No. 25-B, No. 25-D, No. 25-E, No. 25-F, No. 25-G or No. 25-H are not exceeded.

EXCEPTIONS: 1. Two-inch (2″) joists when nailed to adjacent studs may be supported on a one-inch (1″) let-in ribbon.

2. Approved devices or other manner of support may be used in lieu of bearing.

Wood members bearing on or in contact with masonry or concrete at or below adjacent ground level shall be as specified for foundation plates in Section 2517 (c).

(b) **Built-up Members.** 1. **Beams.** Laminated built-up beams with through lamination not less than two inches (2″) in nominal thickness may be used in place of solid timbers when the laminations are parallel to applied loads. Laminated beams ten inches (10″) or less in depth may be spiked together with not less than 16d spikes at twelve-inch (12″) centers, staggered. Unless so spiked, or if the depth of beam is more than ten inches (10″), the laminations shall be connected together with bolts not smaller than one-half-inch (½″) diameter spaced not over two feet (2′) apart, staggered or equal. Fastenings shall be placed at a maximum of one-fourth the depth of the member from the top and bottom edges.

2. **Trusses.** The design, fabrication, and erection of timber trusses shall conform to the provisions of this Code.

(c) **Joist and Rafter Blocking and Bridging.** Rafters of more than eight-inch (8″) depth and joists of more than four-inch (4″) depth shall be stabilized against overturning or buckling from superimposed load as follows:

1. At ends and at each support, by solid blocking of not less than two-inch (2″) thickness and the full depth of joists, by nailing to studs when supported by ribbon boards, or by approved hangers or fastenings.

2. Between supports as required so that joists will be stabilized every eight feet (8′) and rafters every ten feet (10′) by solid blocking two inches (2″) thick and the full depth of the joist or rafter, or by wood cross bridging of not less than one inch by three inches (1″ x 3″) or metal cross bridging of equal strength. Where cross bridging is used, the lower ends of such cross bridging shall be driven up and nailed after the floor or subfloor has been nailed. Blocking and bridging of joists between supports may be eliminated for one-story Group I Occupancies where joist depth does not exceed twelve inches (12″).

(d) **Joists under Bearing Partitions.** Joists under and parallel to bearing partitions shall be doubled and well spiked, or may be separated by solid blocking spaced at no more than four-foot (4′) intervals.

Horizontal Members or Assemblies (Continued)

(e) **Headers.** Header joists over six feet (6') long and tail joists over twelve feet (12') long shall be hung in joist or beam hangers or framing anchors or secured by other devices or methods affording equivalent support. Trimmers and header joists more than four feet (4') long shall be doubled. Headers shall be not less than twenty inches (20") from face of chimney breast. Trimmers and headers shall be provided with clearance from flues, chimneys, and fireplaces as specified in Sections 3702 (l) and 3704 (g).

(f) **Wood Members Entering Masonry or Concrete.** The ends of wood members entering masonry or concrete walls from opposite sides shall be separated by not less than four inches (4") of solid masonry. Other wood members shall be set back not less than four inches (4") from the exterior face of walls, except on street fronts.

Ends of wood beams or joists entering masonry or concrete walls, unless pressure-impregnated with an approved preservative, shall be provided with a one-half-inch (½") air space on sides and end.

Ends of wood beams or joists entering masonry or concrete walls shall be beveled so that top edge does not enter more than one inch (1").

Where timbers extend into a masonry wall at a point below the level of the ground outside of the wall, metal wall boxes shall be provided or the end and all surfaces of the timber within one foot (1') of the end shall be painted with at least two coats of hot coal-tar creosote or other approved wood preservative.

(g) **Anchors and Ties.** For anchorage of wood joists or beams to masonry walls or concrete walls, see Section 2313.

(h) **Floors.** See Sections 2514 and 2515.

(i) **Roofs.** See Sections 2514 and 2515.

Wood Combined with Masonry or Concrete

Sec. 2510. (a) **Dead Load.** Wood members shall not be used to support the dead load of any masonry or concrete.

EXCEPTIONS: 1. Masonry or concrete nonstructural floor surfacing not more than four inches (4") thick may be supported by wood members.

2. Any structure may rest upon wood piles constructed in accordance with the requirements of Chapter 28.

(b) **Horizontal Force.** Wood members shall not be used to resist horizontal forces contributed by masonry or concrete construction in buildings over one story in height.

EXCEPTION: Wood floor and roof members may be used in horizontal trusses and diaphragms to resist horizontal forces imposed by wind, earthquake, or earth pressure, provided such forces are not resisted by rotation of the truss or diaphragm.

Wood Diaphragms

Sec. 2511. (a) **General.** Wood and plywood diaphragms may be used to resist horizontal forces in horizontal and vertical distributing or resisting elements, provided the deflection in the plane of the diaphragm, as determined by calculations, tests, or analogies drawn therefrom, does not exceed the permissible deflection of attached distributing or resisting elements.

Permissible deflection shall be that deflection up to which the diaphragm and any attached distributing or resisting element will maintain its structural integrity under assumed load conditions, i. e., continue to support assumed loads without danger to occupants of the structure.

Connections and anchorages capable of resisting the design forces shall be provided between the diaphragms and the resisting elements. Openings in diaphragms which materially affect their strength shall be fully detailed on the plans, and shall have their edges adequately reinforced to transfer all shearing stresses.

Size and shape of diaphragms shall be limited as set forth in Table No. 25-O.

In buildings of wood construction where rotation is provided for, transverse shear resisting elements normal to the longitudinal element shall be provided at spacings not exceeding one and one-half times the width for conventional diagonally sheathed diaphragms or two times the width for special diagonally sheathed or plywood diaphragms.

In masonry or concrete buildings wood and plywood diaphragms shall not be considered as transmitting lateral forces by rotation.

(b) **Diagonally Sheathed Diaphragms.** 1. **Conventional construction.** Such wood diaphragms shall be made up of one-inch (1″) nominal sheathing boards laid at an angle of approximately 45 degrees to supports. Sheathing boards shall be directly nailed to each intermediate bearing member with not less than two 8d nails for one-inch by six-inch (1″ x 6″) boards and three 8d nails for boards eight inches (8″) or wider, and in addition three 8d nails and four 8d nails shall be used for six-inch (6″) and eight-inch (8″) boards, respectively, at the diaphragm boundaries. End joints in adjacent boards shall be separated by at least one joist or stud space, and there shall be at least two boards between joints on the same support. Boundary members at edges of diaphragms shall be designed to resist direct tensile or compressive chord stresses and shall be adequately tied together at corners.

Conventional wood diaphragms may be used to resist shears, due to wind or seismic forces, not exceeding 300 pounds per lineal foot of width.

2. **Special construction.** Special diagonally sheathed diaphragms shall conform to conventional construction and, in

addition, shall have all elements designed in conformance with the provisions of this Code.

Wood Diaphragms (Continued)

Each chord or portion thereof may be considered as a beam, loaded with a uniform load per foot equal to 50 per cent of the unit shear due to diaphragm action. The load shall be assumed as acting normal to the chord, in the plane of the diaphragm and either toward or away from the diaphragm. The span of the chord, or portion thereof, shall be the distance between structural members of the diaphragm such as the joists, studs, and blocking, which serve to transfer the assumed load to the sheathing.

Special diagonally sheathed diaphragms shall include conventional diaphragms sheathed with two layers of diagonal sheathing at 90 degrees to each other and on the same face of the supporting members.

Special diagonally sheathed diaphragms may be used to resist shears, due to wind or seismic loads, provided such shears do not stress the nails beyond their allowable safe lateral strength and do not exceed 600 pounds per lineal foot of width.

(c) **Plywood Diaphragms.** Horizontal and vertical diaphragms sheathed with plywood may be used to resist horizontal forces not exceeding those set forth in Table No. 25-P for horizontal diaphragms, and Table No. 25-Q for vertical diaphragms, or may be calculated by principles of mechanics without limitation by using values of nail strength and plywood shear values as given elsewhere in this Code. Plywood for horizontal diaphragms shall be as set forth in Table No. 25-R for corresponding spans and loads. Maximum spans for plywood subfloor-underlayment shall be as set forth in Table No. 25-S. Plywood used for horizontal and vertical diaphragms shall conform to U.B.C. Standard No. 25-9-67.

All boundary members shall be proportioned and spliced where necessary to transmit direct stresses. Framing members shall be at least two-inch (2″) nominal in the dimension to which the plywood is attached and such members shall be

TABLE NO. 25-O—MAXIMUM DIAPHRAGM DIMENSION RATIOS

	HORIZONTAL DIAPHRAGMS	VERTICAL DIAPHRAGMS
	Maximum Span-Width Ratios	Maximum Height-Width Ratios
1. Diagonal sheathing, conventional	3:1	2:1
2. Diagonal sheathing, special	4:1	3½:1
3. Plywood, nailed all edges	4:1	3½:1
4. Plywood, blocking omitted at intermediate joints	4:1	2:1

Wood Diaphragms (Continued)

limited to a maximum spacing of sixteen inches (16″) on center for vertical diaphragms. In general, panel edges shall bear on the framing members and butt along their center lines. Nails shall be placed not less than three-eighths inch (⅜″) in from the panel edge, not more than twelve inches (12″) apart along intermediate supports and six inches (6″) along panel edge-bearings, and shall be firmly driven into the framing members. No unblocked panels less than twelve inches (12″) wide shall be used.

Design of Glued Built-up Members

Sec. 2512. Plywood components shall be designed, fabricated and identified in accordance with U.B.C. Standard No. 25-18-67.

Design of Glued-Laminated Lumber

Sec. 2513. (a) **Design and Allowable Unit Stresses.** 1. **General.** Glued-laminated and glued built-up structural members shall be designed by the applicable engineering formulas used for sawn members, and as otherwise provided without exceeding the allowable unit stresses specified in Section 2504 as modified in this Section.

2. **Curvature factor.** For the curved portion of members, the allowable stress in bending shall be modified by multiplication by the following curvature factor:

$$1 - 2000\left(\frac{t}{R}\right)^2$$

WHERE:

t = thickness of lamination in inches,

R = radius of curvature of a lamination in inches,

and "t/R" shall not exceed 1/125 for softwoods and 1/100 for hardwoods. No curvature factor shall be applied to stress in the straight portion of an assembly regardless of curvature elsewhere.

3. **Radial tension or compression.** The radial stress induced by a bending moment in a curved rectangular member shall be limited to the allowable stress "S_R" when computed by the equation

$$S_R = \frac{3M}{2R\,bh}$$

WHERE:

M = bending moment in inch pounds.

R = radius of curvature at center line of member in inches.

When "M" is in the direction tending to decrease curvature (increase the radius), the stress is in tension and shall be limited to an allowable stress equal to one-third the allowable stress in shear.

When "M" is in the direction tending to increase curvature (decrease radius), the stress is in compression and shall be limited to the allowable stress in compression perpendicular to grain.

4. **Reduction for depth.** The allowable unit flexural stresses in rectangular shaped beams over twelve inches (12") in depth shall not exceed the value established by multiplying such stress by the depth factor as determined in the following formula:

$$F_d = .81 \left(\frac{H^2 + 143}{H^2 + 88} \right)$$

WHERE:

H = Depth of beam, in inches.
F_d = Depth factor.

5. **Form factors.** The allowable unit flexural stresses in nonprismatic members shall not exceed the value established by multiplying such stress by the form factor determined as follows:

BEAM SECTION	FORM FACTOR (F_f)
Circular	1.180
Square (with diagonal vertical)	1.414
Lumber I and Box Beams	$0.81 + S\ (F_d - .81)$

WHERE:

F_f = Form factor.
F_d = Depth factor determined in accordance with Section 2513 (a) 4.
S = Support factor $= P^2\ (6 - 8P + 3P^2)\ (1 - q) + q$.
P = Ratio of depth of compression flange to full depth of beam.
q = Ratio of thickness of web or webs to the full width of beam.

6. **Tapered faces.** No taper shall be permitted on the tension side of any simple beam.

For other members subject to bending, the slope of tapered faces, measured from the tangent to the lamination of the section under consideration, shall be not steeper than 1:24 on the tension side.

> **EXCEPTIONS:** 1. This requirement shall not apply to arches.
> 2. Taper may be steeper at sections increased in size beyond design requirements for architectural projections.

7. **Width.** Allowable stresses for the various combinations are based on standard finished widths at the time of grading. Where beam widths are further reduced in finishing such reduction shall be considered in determination of allowable stresses.

TABLE NO. 25-P—ALLOWABLE SHEAR FOR WIND OR SEISMIC FORCES IN POUNDS PER FOOT FOR HORIZONTAL PLYWOOD DIAPHRAGMS[1]

PLYWOOD GRADE	COMMON NAIL SIZE	MINIMUM NAIL PENETRATION IN FRAMING (Inches)	MINIMUM NOMINAL PLYWOOD THICKNESS (Inches)	MINIMUM NOMINAL WIDTH OF FRAMING MEMBER (Inches)	BLOCKED DIAPHRAGMS				UNBLOCKED DIAPHRAGMS	
					Nail Spacing at Diaphragm Boundaries (All Cases) and Continuous Panel Edges Parallel to Load (Cases 3 and 4)[2]				Nails Spaced 6″ Maximum at Supported Edges	
					6	4	2½	2	Load Perpendicular to Unblocked Edges and Continuous Panel Joints (Case 1)	All Other Configurations (Cases 2, 3 and 4)
					Nail Spacing at Other Plywood Panel Edges					
					6	6	4	3		
STRUCTURAL I	6d	1¼	5/16	2 3	188 210	250 280	375 420	420 475	167 187	125 140
	8d	1½	⅜	2 3	270 300	360 400	530 600	600 675	240 267	180 200
	10d	1⅝	½	2 3	318 360	425 480	640 720	730 820	283 320	212 240

TABLE NO. 25-P—Continued

STRUCTURAL II, C-C Exterior, Standard Sheathing and Other grades covered in U.B.C. Standard No. 25-9-67	6d	1¼	5/16	2	125	167	250	280	111	84
				3	140	187	280	317	125	93
			⅜	2	150	201	300	336	133	101
				3	168	224	336	380	150	112
	8d	1½	⅜	2	180	240	353	400	160	120
				3	200	267	400	450	178	133
			½	2	215	288	424	480	192	144
				3	240	320	480	540	214	160
	10d	1⅝	⅝	2	255	340	512	584	227	169
				3	288	384	576	656	256	192

[1]These values are for short time loads due to wind or earthquake and must be reduced 25 per cent for normal loading.
[2]Space nails at twelve inches (12″) on center along intermediate framing members.

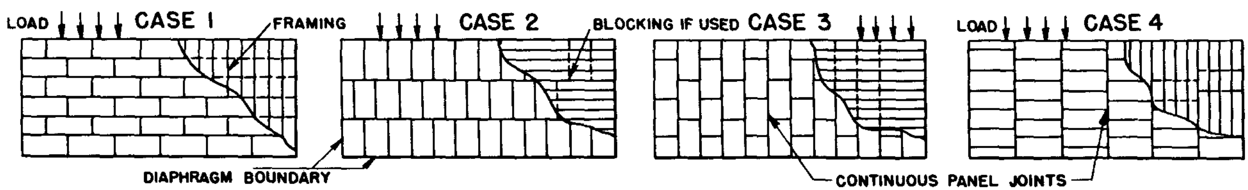

TABLE NO. 25-Q—ALLOWABLE SHEAR FOR WIND OR SEISMIC FORCES IN POUNDS PER FOOT FOR PLYWOOD SHEAR WALLS[1]

PLYWOOD GRADE	NAIL SIZE (Common or Galvanized Box)	MINIMUM NAIL PENETRATION IN FRAMING (Inches)	MINIMUM NOMINAL PLYWOOD THICKNESS (Inches)	PLYWOOD APPLIED DIRECT TO FRAMING — Nail Spacing at Plywood Panel Edges: 6	4	2½	2	NAIL SIZE (Common or Galvanized Box)	PLYWOOD APPLIED OVER ½-INCH GYPSUM SHEATHING — Nail Spacing at Plywood Panel Edges: 6	4	2½	2
STRUCTURAL I	6d 8d 10d	1¼ 1½ 1⅝	5/16 ⅜ ½	200 280 340	300 430 510	450 640 770	510 730 870	8d 10d —	200 280 —	300 430 —	450 640 —	510 730 —
STRUCTURAL II, C-C Exterior, Standard Sheathing, Panel Siding Plywood and other grades Covered in U.B.C. Standard No. 25-9-67	6d 8d 10d	1¼ 1½ 1⅝	5/16 ⅜ ½	180 260 310	270 380 460	400 570 690	450 640 770	8d 10d —	180 260 —	270 380 —	400 570 —	450 640 —
	NAIL SIZE (Galvanized Casing)							NAIL SIZE (Galvanized Casing)				
Plywood Panel Siding in Grades Covered in U.B.C. Standard No. 25-9-67	6d 8d	1¼ 1½	5/16 ⅜	140 160	210 240	320 360	360 410	8d 10d	140 160	210 240	320 360	360 410

[1]All panel edges backed with two-inch (2") nominal or wider framing. Plywood installed either horizontally or vertically. Space nails at twelve inches (12") on center along intermediate framing members. These values are for short time loads due to wind or earthquake and must be reduced 25 per cent for normal loading.

Design of Glued-Laminated Lumber (Continued)

(b) **Fastenings.** The methods of design of bolts and connectors and their allowable loads when used with glued-laminated lumber, shall be the same as provided for their use with sawn lumber.

(c) **Fabrication of Members. 1. General.** Structural glued-laminated lumber shall be fabricated in accordance with good practice and as set forth in the applicable U.B.C. Standards No. 25-10-67 and No. 25-11-67.

All work shall be under the supervision of qualified personnel.

2. **Laminations.** The individual laminations in structural glued-laminated lumber shall be not more than two inches (2") in thickness and all such laminations in the stressed portion shall be approximately parallel to the neutral plane of the member.

TABLE NO. 25-R—ALLOWABLE SPANS FOR PLYWOOD FLOOR AND ROOF SHEATHING CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PERPENDICULAR TO SUPPORTS[1]

PANEL IDENTIFICATION INDEX[3]	ROOF[2]				FLOOR
	Maximum Span (in Inches)		LOAD (IN POUNDS PER SQUARE FOOT)		Maximum Span[4] (in Inches)
	Edges Blocked	Edges Unblocked	Total Load	Live Load	
12/0	12		130	100	0
16/0	16		75	55	0
20/0	20		55	45	0
24/0	24	16	60	45	0
30/12	30	26	55	40	12[5]
32/16	32[6]	28	50[7]	40	16[8]
36/16	36	30	50[7]	35[7]	16[8]
42/20	42	32	45[7]	35[7]	20[8]
48/24	48	36	40[7]	40	24

[1]These values apply for Structural I and II, Standard Sheathing and C-C Exterior grades only. Spans shall be limited to values shown because of possible effect of concentrated loads.

[2]Uniform load deflection limitation: 1/180th of the span under live load plus dead load, 1/240th under live load only.

[3]Identification Index appears on all panels in the construction grades listed in Footnote No. 1.

[4]Plywood edges shall have approved tongue and groove joints or shall be supported with blocking, unless one-fourth-inch (1/4") minimum thickness underlayment is installed, or finish floor is twenty-five-thirty-seconds-inch (25/32") wood strip. Allowable uniform load based on deflection of 1/360 of span is 100 pounds per square foot.

[5]May be sixteen-inch (16") if twenty-five-thirty-seconds-inch (25/32") wood strip flooring is installed at right angles to joists.

[6]One-half inch (1/2") thick Structural I, when continuous over two or more spans, may be laid with face grain parallel to supports provided all panel edges are blocked or other approved type edge support is provided, the spacing of the supports does not exceed twenty-four inches (24") on center, and the live load does not exceed 30 pounds per square foot. For other grades, a thickness of five-eighths-inch (5/8") is required.

[7]For roof live load of 40 pounds per square foot or total load of 55 pounds per square foot, decrease spans by 13 per cent or use panel with next greater identification index.

[8]May be twenty-four-inch (24") if twenty-five-thirty-seconds-inch (25/32") wood strip flooring is installed at right angles to joists.

Design of Glued-Laminated Lumber (Continued)

3. **Lumber grade.** The lumber, at the time of laminating, shall conform to the grade and species specified.

4. **Moisture content.** The maximum moisture content of the wood at the time of gluing shall not exceed 16 per cent and shall be not less than seven per cent. The range of moisture content of laminations assembled into a single member shall not exceed five per cent at the time of gluing.

5. **Surfaces.** Surfaces to be glued shall be free from dust, dirt, and grease. Each lamination shall be smoothly surfaced and be of uniform thickness with a maximum allowable variation of one sixty-fourth inch (1/64") for softwoods and one one-hundredth inch (1/100") for hardwoods. Lumber surfaces shall not be sanded before gluing, except that factory-sanded plywood shall not be prohibited.

6. **Joints.** Joints in structural glued-laminated timber shall mean the contact surfaces between two adjacent pieces of wood glued together. An edge or face joint is parallel to the grain of the wood. An end joint is a joint formed by joining pieces of lumber end-to-end with adhesives.

(d) **Adhesives. 1. General.** Adhesives for structural laminating shall be in accordance with the requirements of U.B.C. Standards No. 25-10-67 and No. 25-19-67. Adhesives shall cover structural gluing exclusive of plywood. Adhesives shall provide an adequate bond, shall subject the wood to no deleterious chemical reactions, and shall withstand without deterioration the expected conditions of service.

2. **Use.** Dry-use adhesives may be used only in interior and protected locations where moisture content of the wood will not exceed 16 per cent.

TABLE NO. 25-S—ALLOWABLE SPAN FOR PLYWOOD COMBINATION SUBFLOOR-UNDERLAYMENT[1]

Plywood Continuous over Two or More Spans and Face Grain Perpendicular to Supports

SPECIES GROUPS[2]	MAXIMUM SPACING OF JOISTS		
	16"	20"	24"
1	½"	⅝"	¾"
2, 3	⅝"	¾"	⅞"
4	¾"	⅞"	1"

[1]Applicable to Underlayment Grade, C-C (plugged) and all grades of sanded Exterior type plywood. Spans limited to values shown because of possible effect of concentrated loads. Allowable uniform load based on deflection of 1/360 of span is 100 pounds per square foot. Plywood edges shall have approved tongue and groove joints or shall be supported with blocking, unless one-fourth-inch (¼") minimum thickness underlayment is installed, or finish floor is twenty-five-thirty-seconds-inch (25/32") wood strip. If wood strips are perpendicular to supports, thicknesses shown for sixteen-inch (16") and twenty-inch (20") spans may be used on twenty-four-inch (24") span.

[2]See U.B.C. Standard No. 25-9-67 for plywood species groups.

Design of Glued-Laminated Lumber (Continued)

Wet-use adhesives may be used under any conditions of exposure, but are required when the moisture content of wood exceeds 16 per cent.

3. **Tests.** Where sufficient evidence of the quality of adhesive to be used is not available, the Building Official may require tests to be made as set forth in U.B.C. Standards No. 25-19-67 and No. 25-20-67.

4. **Adhesive application.** Gluing practices shall take into consideration the characteristics and limitations of the specific adhesive used, and shall conform to good practices as to preparation of wood surfaces for gluing, control of temperature and moisture content of materials, maintenance of adequate pressures, and compatibility of the adhesive with any other wood treatments employed. Mixing, spreading, storage life, pot life, working life, and assembly-time life shall be in accordance with the recommendations of the manufacturer of the adhesive used.

(e) **Inspection. 1. Inspection agencies.** All structural glued-laminated lumber shall be inspected during lamination by an approved inspection agency.

2. **Certificate of inspection.** Each structural glued-laminated member shall be stamped with an identifying number and shall be accompanied by a certificate of inspection as required in Section 5006 (b).

Heavy Timber Construction

Sec. 2514. (a) **Columns.** Wood columns may be sawn or glued-laminated and shall be not less than eight inches (8") nominal in any dimension when supporting roof or floor loads, except as specified in Section 2514 (c).

Columns shall be continuous or superimposed by means of reinforced concrete or metal caps with brackets, or shall be connected by properly designed steel or iron caps, with pintles and base plates, or by timber splice plates affixed to the columns by means of metal connectors housed within the contact faces, or by other approved methods.

(b) **Floor Framing.** Beams and girders of wood may be sawn or glued-laminated and shall be not less than six inches (6") nominal in width and not less than ten inches (10") nominal in depth.

Framed or glued-laminated arches which spring from the floor line and support floor loads shall be not less than eight inches (8") nominal in any dimension.

Framed timber trusses supporting floor loads shall have members of not less than eight inches (8") nominal in any dimension.

(c) **Roof Framing.** Framed or glued-laminated arches for roof construction which spring from the floor line and do not support floor loads shall have members not less than six

Heavy Timber Construction (Continued)

inches (6″) nominal in width and not less than eight inches (8″) nominal in depth for the lower half of the height and not less than six inches (6″) nominal in depth for the upper half.

Framed or glued-laminated arches for roof construction which spring from the top of walls or wall abutments, framed timber trusses, and other roof framing which do not support floor loads, shall have members not less than four inches (4″) nominal in width and not less than six inches (6″) nominal in depth. Spaced members may be composed of two or more pieces not less than three inches (3″) nominal in thickness when blocked solidly throughout their intervening spaces or when such spaces are tightly closed by a continuous wood cover plate of not less than two inches (2″) nominal in thickness, secured to the underside of the members. Splice plates shall be no less than three inches (3″) nominal in thickness. When protected by approved automatic sprinklers under the roof deck, framing members shall be not less than three inches (3″) nominal in thickness.

(d) **Construction Details.** Approved wall plate boxes or hangers shall be provided where wood beams, girders or trusses rest on masonry or concrete walls. An air space of one-half inch (½″) shall be provided at the top, end and sides of the member unless approved durable or treated wood is used.

Girders and beams shall be closely fitted around columns and adjoining ends shall be cross tied to each other, or intertied by caps or ties, to transfer horizontal loads across the joint. Wood bolsters may be placed on top of columns which support roof loads only.

Where intermediate beams are used to support a floor, they shall rest on top of the girders, or shall be supported by ledgers or blocks securely fastened to the sides of the girders, or they may be supported by approved metal hangers into which the ends of the beams shall be closely fitted.

In heavy timber roof construction, every roof girder and at least every alternate roof beam shall be anchored to its supporting member; roof planking where supported by a wall shall be anchored to such wall at intervals not exceeding twenty feet (20′); every monitor and every sawtooth construction shall be anchored to the main roof construction Such anchors shall consist of steel or iron bolts of sufficient strength to resist vertical uplift of the roof.

(e) **Heavy Timber Floors.** Floors shall be without concealed spaces. Floors shall be of sawn or glued-laminated plank, splined, or tongue-and-groove, of not less than three inches (3″) nominal in thickness covered with one-inch (1″) nominal dimension tongue-and-groove flooring, laid crosswise or diagonally, or of planks not less than four inches (4") nominal in width set on edge close together and well spiked, and covered with one-inch (1") nominal dimension flooring. The planks shall be laid so that no continuous line of joints will occur except at points of support. Flooring shall not extend closer than one-half inch (½") to walls. Such one-half-inch (½") space shall be covered by a molding fastened to the wall and so arranged that it will not obstruct the swelling or shrinking movements of the floor. Corbeling of masonry walls under floor planks may be used in place of such molding.

Heavy Timber Construction (Continued)

(f) **Heavy Timber Roof Decks.** Roofs shall be without concealed spaces and roof decks shall be sawn or glued-laminated, splined or tongue-and-groove plank, not less than two inches (2") nominal in thickness or of a double thickness of one-inch (1") nominal thickness boards with tongued and grooved joints or with staggered joints, or of planks not less than three inches (3") nominal in width, set on edge close together and laid as required for floors. Other types of decking may be used when approved by the Building Official as being equal.

(g) **Mechanically Laminated Floors and Decks.** A laminated lumber floor or deck built up of wood members set on edge, when meeting the following requirements, may be designed as a solid floor or roof deck of the same thickness, and continuous spans may be designed on the basis of the full cross section using the simple span moment coefficient.

Laminations shall be driven up and spiked closely together with a row of nails near each edge at spaced intervals and staggered vertically. Nail spacing in each row shall not exceed eighteen inches (18") for two-inch by eight-inch (2" x 8") nominal width and be proportional for other plank widths. Nail length shall be not less than two and one-half times the net thickness of each lamination.

A single span deck shall have all laminations full length.

A continuous deck of two spans shall have not more than every fourth lamination spliced within quarter points adjoining supports.

A continuous deck of more than two spans shall have not more than every third lamination spliced within quarter points adjoining supports.

Joints shall be closely butted over supports or staggered across the deck but within the adjoining quarter spans.

No lamination shall be spliced more than twice in any span.

Light Frame Construction

Sec. 2515. (a) **General.** In one- and two-story buildings housing Groups H, I and J Occupancies, where engineering design is not provided, where the floor live load does not exceed 50 pounds per square foot, and where the roof live load

Light Frame Construction (Continued)

does not exceed 20 pounds per square foot, Tables Nos. 25-N, 25-R, 25-T, 25-U, 25-V, 25-W, and 25-X may be used to determine framing requirements based upon the general design requirements set forth in U.B.C. Standard No. 25-21-67. The allowable span of horizontal load-bearing members shall be taken as the clear horizontal distance between supports.

(b) **Roof Construction.** There shall be a ridge board at least one inch (1″) thick at all ridges, not less in depth than the cut end of the rafter. Where the slope of the roof is less than three in 12, the ridge member shall be designed as a vertical load-bearing member. At all valleys and hips there shall be a valley or hip rafter not less than two inches (2″) thick and not less in depth than the cut end of the rafter.

Where the ridge member is not designed as a vertical load-bearing member, rafters shall be framed directly opposite each other at the ridge and shall be nailed to adjacent ceiling joists to form a continuous tie between exterior walls. Where the ceiling joists run other than parallel to the rafters, rafters shall be tied back to the roof framework by means of cross ties spaced not more than forty-eight inches (48″) on center. Such cross ties shall be not less in size than one inch by four inches (1″ x 4″).

Purlins to support roof loads may be installed to reduce span of rafters within allowable limitations and shall be supported by struts from bearing walls or partitions. The maximum span of two-inch by four-inch (2″ x 4″) purlins is four feet (4′). The maximum span of two-inch by six-inch (2″ x 6″) purlins is six feet (6′). In no case shall the purlin be smaller than the size of rafter supported. Struts shall not be smaller than two inches by four inches (2″ x 4″). The unbraced length of struts shall not exceed eight feet (8′) and the slope of said struts shall be not less than 45 degrees from the horizontal.

(c) **Girders.** Girders supporting first floor joists shall be not less than four inches by four inches (4″ x 4″) for spans five feet (5′) or less, or not less than four inches by six inches (4″ x 6″) (placed on edge) for spans not more than seven feet (7′).

(d) **Plank and Beam Construction.** Floor and roof systems of plank and beam construction may be designed as provided in this Code, or may be as set forth in U.B.C. Standard No. 25-22-67. When used for light frame construction spans for planking may be as set forth in Table No. 25-X. Loading shall be as specified in the notes of said table.

Species of lumber are divided into groups as set forth in Table No. 25-I.

Span lengths for grades given in Table No. 25-A or No. 25-B may be based on the stresses therein.

TABLE NO. 25-T—ALLOWABLE SPANS FOR FLOOR JOISTS USING NONSTRESS-GRADED LUMBER[1]

SIZE OF FLOOR JOISTS (Inches)	SPACING OF FLOOR JOISTS (Inches)	MAXIMUM ALLOWABLE SPAN (Feet and Inches)							
		GROUP I		GROUP II		GROUP III		GROUP IV[2]	
		Plastered Ceiling Below	Without Plastered Ceiling Below	Plastered Ceiling Below	Without Plastered Ceiling Below	Plastered Ceiling Below	Without Plastered Ceiling Below	Plastered Ceiling Below	Without Plastered Ceiling Below
2 x 6	12	10-6	11-6	9-0	10-0	7-6	8-0	5-6	6-0
	16	9-6	10-0	8-0	8-6	6-6	7-0	5-0	5-0
	24	7-6	8-0	6-6	7-0	5-6	6-0	4-0	4-0
2 x 8	12	14-0	15-0	12-6	13-6	10-6	11-6	8-0	8-6
	16	12-6	13-6	11-0	11-6	9-0	10-0	7-0	7-6
	24	10-0	11-0	9-0	9-6	7-6	8-0	6-0	6-6
2 x 10	12	17-6	19-0	16-6	17-6	13-6	14-6	10-6	11-6
	16	15-6	16-6	14-6	15-6	12-0	13-0	9-6	10-0
	24	13-0	14-0	12-0	13-0	10-0	10-6	7-6	8-6
2 x 12	12	21-0	23-0	21-0	21-6	17-6	19-0	13-6	14-6
	16	18-0	20-0	18-0	19-6	15-6	16-6	12-0	13-0
	24	15-0	16-6	15-0	16-6	12-6	13-6	10-0	10-6

DESIGN LOADING AND DEFLECTION CRITERIA:

Live load—Forty pounds per square foot[3]; Dead load weight of floor—Five pounds per square foot—plus weight of joists; eight pounds per square foot—weight of lath and plaster; Deflection with or without plaster—Not to exceed 1/360th of the span with live load nor 1/240th with dead load and live load.

[1]Species of lumber are divided into groups as set forth in Table No. 25-I. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21-67. Span lengths for stress-graded lumber as set forth in Tables No. 25-A and No. 25-B may be based on the stresses therein. Spans in Group I are suitable for any species of stress-graded lumber given in Table No. 25-A or No. 25-B which has a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1100 pounds per square inch.

[2]Lumber in Group IV may be used only under conditions specifically approved by the Building Official.

[3]For live loads of 50 pounds per square foot, spans shall be reduced to 90 per cent of the tabulated values.

Light Frame Construction (Continued)

Joints in planking may be randomly spaced provided the system is applied to not less than three continuous spans, planks are center-matched and end-matched or splined, each plank bears on at least one support and joints are separated by at least twenty-four inches (24″) in adjacent pieces. One-inch (1″) nominal strip square edged flooring, one-half-inch (½″) tongue and groove flooring, or three-eighths-inch (⅜″) plywood shall be applied over random length decking used as a floor. The "strip" and tongue and groove flooring shall be applied at right angles to the span of the planks. The three-eighths-inch (⅜″) plywood shall be applied with the face grain at right angles to the span of the planks.

(e) **Plywood Subflooring.** Where used as structural subflooring, plywood shall be of the minimum thicknesses set forth in Table No. 25-R. Plywood combination subfloor-underlayment shall have maximum spans as set forth in Table No. 25-S.

(f) **Plywood Roof Sheathing.** Where used as structural roof sheathing, plywood shall be of the minimum thicknesses set forth in Table No. 25-R.

TABLE NO. 25-U—ALLOWABLE SPANS FOR CEILING JOISTS USING NONSTRESS-GRADED LUMBER[1]

Size of Ceiling Joists (Inches)	Spacing of Ceiling Joists (Inches)	MAXIMUM ALLOWABLE SPAN (Feet and Inches)			
		GROUP I	GROUP II	GROUP III	GROUP IV[2]
2 x 4	12	11-6	11-0	9-6	5-6
	16	10-6	10-0	8-6	5-0
2 x 6	12	18-0	16-6	15-6	12-6
	16	16-0	15-0	14-6	11-0
2 x 8	12	24-0	22-6	21-0	19-0
	16	21-6	20-6	19-0	16-6
DESIGN LOADING AND DEFLECTION CRITERIA:					
Live Load—None. Dead Load—Ten pounds per square foot—weight of joists and lath and plaster; Deflection—Not to exceed 1/360 of the span.					

[1]Species of lumber are divided into groups as set forth in Table No. 25-I. Span lengths for stress-graded lumber as set forth in Tables No. 25-A and No. 25-B may be based on the stresses therein. Spans in Group I are suitable for any species of stress-graded lumber given in Table No. 25-A or No. 25-B which has a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1100 pounds per square inch. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21-67.

[2]**Lumber in Group IV may be used only under conditions specifically approved by the Building Official.**

Fiberboard Sheathing Diaphragms

Sec. 2516. Wood stud walls sheathed with fiberboard sheathing complying with Section 2202 may be used to resist horizontal forces not exceeding those set forth in Table No. 25-Y. The fiberboard sheathing, four feet by eight feet (4" x 8'), shall be applied vertically to wood studs not less than one and five-eighths inches (1⅝") in width, spaced sixteen inches (16") on centers. Nailing shown in Table No. 25-Y shall be provided at the perimeter of the sheathing board, and at intermediate studs. Blocking not less than one and five-eighths inches (1⅝") in width shall be provided at horizontal joints when wall height exceeds length of sheathing panel and nail

TABLE NO. 25-V—ALLOWABLE SPANS FOR RAFTERS[1]
(Slopes 4:12 or greater)

SIZE OF RAFTER (Inches)	SPACING OF RAFTER (Inches)	MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)			
		Group I	Group II	Group III	Group IV[2]
2 x 4	12	10-0	9-0	7-0	4-0
	16	9-0	7-6	6-0	3-6
	24	7-6	6-6	5-0	3-0
	32	6-6	5-6	4-6	2-6
2 x 6	12	17-6	15-0	12-6	9-0
	16	15-6	13-0	11-0	8-0
	24	12-6	11-0	9-0	6-6
	32	11-0	9-6	8-0	5-6
2 x 8	12	23-0	20-0	17-0	13-0
	16	20-0	18-0	15-0	11-6
	24	17-0	15-0	12-6	9-6
	32	14-6	13-0	11-0	8-6
2 x 10	12	28-6	26-6	22-0	17-6
	16	25-6	23-6	19-6	15-6
	24	21-0	19-6	16-0	12-6
	32	18-6	17-0	14-0	11-0
DESIGN LOADING CRITERIA:					
Live Load—16 pounds per square foot on horizontal projection. Dead load weight of roof—seven pounds per square foot on horizontal projection plus weight of rafters.					

[1]Species of lumber are divided into groups as set forth in Table No. 25-I. Allowable stresses increased 25 per cent for roof loading [Section 2504 (e) 2]. Span length for stress-graded lumber set forth in Tables No. 25-A and No. 25-B may be based on the stresses therein. Spans in Group I are suitable for any species of stress-graded lumber given in Table No. 25-A or No. 25-B which has a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1100 pounds per square inch. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21-67.

[2]Lumber in Group IV may be used only under conditions specifically approved by the Building Official.

TABLE NO. 25-W—ALLOWABLE SPANS FOR ROOF RAFTERS USING NONSTRESS-GRADED LUMBER[1]
(Slopes less than 4:12)

SIZE OF ROOF RAFTERS (Inches)	SPACING OF ROOF RAFTERS (Inches)	MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)							
		GROUP I		GROUP II		GROUP III		GROUP IV[2]	
		Supporting Ceiling	Not Supporting Ceiling	Supporting Ceiling	Not Supporting Ceiling	Supporting Ceiling	Not Supporting Ceiling	Supporting Ceiling	Not Supporting Ceiling
2 x 4	12	8-0	9-6	7-0	8-0	5-6	6-6	3-0	4-0
	16	7-0	8-0	6-0	7-0	5-0	5-6	3-0	3-6
	24	5-6	6-6	5-0	6-0	4-0	4-6	2-6	3-0
	32	5-0	6-0	4-6	5-0	3-6	4-0	2-0	2-6
2 x 6	12	13-0	16-6	12-0	14-0	10-6	11-6	7-0	8-6
	16	11-6	14-6	10-6	12-0	8-6	10-0	6-0	7-6
	24	10-0	12-0	8-6	10-0	7-0	8-6	5-0	6-0
	32	8-6	10-6	7-6	9-0	6-0	7-6	4-6	5-6
2 x 8	12	17-0	21-6	16-0	19-0	13-6	16-0	10-6	12-6
	16	15-6	19-0	14-0	16-6	12-0	14-0	9-0	11-0
	24	13-6	15-6	11-6	13-6	10-0	11-6	7-6	9-0
	32	11-6	13-6	10-0	12-0	8-6	10-0	6-6	8-0
2 x 10	12	21-6	27-0	20-0	25-0	17-6	20-6	14-0	16-0
	16	19-6	23-6	18-6	22-0	15-6	18-0	12-0	14-0
	24	16-6	19-6	15-6	18-0	13-0	15-0	10-0	12-0
	32	14-6	17-0	13-6	16-0	11-0	13-0	9-0	10-6

TABLE NO. 25-W—ALLOWABLE SPANS FOR ROOF RAFTERS USING NONSTRESS-GRADED LUMBER[1]—Continued

SIZE OF ROOF RAFTERS (Inches)	SPACING OF ROOF RAFTERS (Inches)	MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)							
		GROUP I		GROUP II		GROUP III		GROUP IV[2]	
		Supporting Ceiling	Not Supporting Ceiling	Supporting Ceiling	Not Supporting Ceiling	Supporting Ceiling	Not Supporting Ceiling	Supporting Ceiling	Not Supporting Ceiling
2 x 12	12	25-6	32-0	24-0	31-0	22-6	26-6	17-6	20-6
	16	23-6	28-0	22-0	27-6	22-0	23-6	15-6	18-0
	24	20-0	23-6	19-6	23-0	16-6	19-6	13-0	15-0
	32	17-6	20-6	17-0	20-0	14-6	17-0	11-0	13-0

DESIGN LOADING AND DEFLECTION CRITERIA:

Live load—20 pounds per square foot on the horizontal projection. Dead load weight of roof—seven pounds per square foot on the horizontal projection—plus weight of rafters. Eleven pounds per square foot on the horizontal projection—weight of lath and plaster ceiling; Deflection—With plastered ceiling—not to exceed 1/360 of the span with live load nor 1/240 of the span with dead and live load—Without plastered ceiling—not considered.

[1]Species of lumber are divided into groups as set forth in Table No. 25-I. Allowable stresses are increased 25 per cent for roof loading [Section 2504 (e) 2]. Span lengths for stress-graded lumber set forth in Tables No. 25-A and No. 25-B may be based on the stresses therein. Spans in Group I are suitable for any species of stress-graded lumber in Table No. 25-A or No. 25-B which has a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1100 pounds per square inch. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21-67.

[2]Lumber in Group IV may be used only under conditions specifically approved by the Building Official.

Fiberboard Sheathing Diaphragms (Continued)

sheathing with nails shown in Table No. 25-Y spaced three inches (3″) on centers each side of joint. Nails shall be spaced not less than three-eighths inch (⅜″) from edges and ends of sheathing.

Marginal studs of shear walls or shear-resisting elements shall be adequately anchored at top and bottom and designed to resist all forces. The maximum height-width ratio shall be one and one-half to one.

Foundation Ventilation, Durability, and Termite Protection

Sec. 2517. (a) **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, and such openings shall be covered with a corrosion-resistant wire mesh not greater than one-half inch (½″) nor less than one-fourth inch (¼″) in any dimension. The minimum total area of ventilating openings shall be proportioned on the basis of two square feet (2 sq. ft.) for each twenty-five linear feet (25 lin. ft.) or major fraction thereof of exterior wall. One such ventilating opening shall be within three feet (3′) of each corner of said building. Such openings need not be placed in the front of the building.

Minimum clearance between bottom of floor joist or bottom of floors without joists and the ground beneath shall be eighteen inches (18″). Minimum clearance under girders shall be twelve inches (12″).

(b) **Durability.** Wood embedded in the ground for the support of permanent structures shall be approved pressure-treated wood except where it is completely below the permanent ground water line or continuously submerged in fresh water. No wood, other than Foundation Grade redwood, Foundation Grade cedar, or any species of wood, pressure-treated with an approved preservative, all marked or branded by an approved agency, shall be nearer than six inches (6″) to any earth. See Subsection 2517 (c) for plates and sills.

> EXCEPTION: Any species of untreated wood may be used in fences and similar well-ventilated and accessible nonload-bearing structures.

(c) **Termite Protection.** All foundation plates or sills and sleepers on a concrete or masonry slab which is in direct contact with earth and sills which rest on concrete or masonry foundations shall be any species or grade of wood specified in Section 2504 (b) pressure-treated with an approved preservative or Foundation redwood, all marked or branded by an approved agency. Foundation cedar or No. 2 Foundation redwood marked or branded by an approved agency may be used for sills in territories subject to moderate hazard, where termite damage is not frequent and when specifically approved by the Building Official. In territories where hazard of termite damage is slight, any species of wood specified in Section 2504 (b) may be used for sills when specifically approved by the Building Official.

Foundation Ventilation, Durability, and Termite Protection (Continued)

Before any new building is erected all stumps and roots shall be removed from the soil to a depth of at least twelve inches (12") below the surface of the ground in the area to be occupied by the building.

All wood forms which have been used in placing concrete, if within the ground or between foundation sills and the ground shall be removed before a building is occupied or used for any purpose. Before completion loose or casual wood shall be removed from direct contact with the ground under the building.

Not less than four inches (4") of solid masonry or three inches (3") of concrete shall be provided between planter boxes and wood stud walls. The masonry or concrete shall extend to a height not less than six inches (6") above the outer wall of the planter. Solid sheathing and 15-pound building paper shall be installed between the masonry or concrete and the wood stud.

TABLE NO. 25-X—ALLOWABLE SPANS FOR TWO-INCH (2") TONGUE AND GROOVE PLANKING USING NONSTRESS-GRADED LUMBER

GROUP	MAXIMUM ALLOWABLE SPAN[1,2] (Feet and Inches Measured Along the Horizontal Projection)		
	FLOOR PLANKING With or Without Finish Flooring	ROOF PLANKING Supporting Finish Ceiling	ROOF PLANKING No Finish Ceiling
I	4'6"	7'6"	9'0"
II	4'6"	7'0"	8'6"
III	4'6"	6'6"	8'0"
IV[3]	4'6"	5'6"	6'0"

DESIGN LOADING AND DEFLECTION CRITERIA:

Floor: Live Load—40 pounds per square foot. Dead Load—weight of planking and finish flooring seven pounds per square foot. Weight of lath and plaster ceiling eight pounds per square foot. The allowable spans for Groups I, II and III have been reduced to values shown based upon practical field problems and experience.

Roof: Live Load—20 pounds per square foot. Dead Load—weight of planking and roofing 10 pounds per square foot. Weight of lath and plaster ceiling eight pounds per square foot.

Deflection: See Table No. 23-D.

[1]For planking placed diagonally across supports spans shall be measured along the planking. See U.B.C. Standard No. 25-21-67 for criteria used in developing table. For live load of 50 pounds per square foot on floor planking spans shall be reduced to 90 per cent of tabulated values.

[2]Spans are based on a net thickness of one and one-half inches (1½"). Spans for planking of one and five-eighths-inch (1⅝") net thickness may be increased by six inches (6").

[3]Lumber in Group IV may be used only under conditions specifically approved by the Building Official.

TABLE NO. 25-Y—ALLOWABLE SHEARS FOR WIND OR SEISMIC LOADING ON VERTICAL DIAPHRAGMS OF FIBERBOARD SHEATHING BOARD CONSTRUCTION FOR TYPE V CONSTRUCTION ONLY[1]

SIZE AND APPLICATION	NAIL SIZE	SHEAR VALUE 3″ NAIL SPACING AROUND PERIMETER AND 6″ AT INTERMEDIATE SUPPORTS
7/16″ x 4′ x 8′	11 ga. gal. roofing nail 1½″ long, 7/16″ head	125
25/32″ x 4′ x 8′	11 ga. gal. roofing nail 1¾″ long, 7/16″ head	175

[1]Fiberboard sheathing diaphragms shall not be used to brace concrete or masonry walls.

CHAPTER 26—CONCRETE

General

Sec. 2601. The design of structures in concrete of cast-in-place or precast construction, plain, reinforced or pre-stressed shall conform to the rules and principles specified in this Chapter.

Load Tests of Structures

Sec. 2602. (a) **Notations.** The notations used in these regulations are defined as follows:

D = dead load.

L = live load.

Δ = maximum deflection, produced by a test load, of a member relative to the ends of the span, or of the free end of a cantilever relative to its support.

l = span of member under load test (the shorter span of flat slabs and of slabs supported on four sides). The span, except as provided in Section 2602 (c), is the distance between the centers of the supports or the clear distance between supports plus the depth of the member, whichever is smaller (in inches).

t = total thickness or depth of member under load test (in inches).

(b) **Static Load Tests of Structures.** The Building Official shall have the right to order the test under load of any portion of a structure when conditions are such that cause doubt about the safety of the structure.

A load test of a structure shall not be made until the portion subjected to load is at least 56 days old, unless the owner of the structure agrees to the test being made at an earlier age.

When the whole structure is not to be tested, the portion of the structure thought to provide the least margin of safety shall be selected for loading. Prior to the application of the test load, a load which simulates the effect of that portion of the service dead load which is not already present shall be applied and shall remain in place until after a decision has been made regarding the acceptability of the structure. The test load shall not be applied until the structural members to be tested have borne the full dead load for at least 48 hours.

Immediately prior to the application of the test load to flexural members (including beams, slabs, and floor and roof constructions), the necessary initial readings shall be made for the measurements of deflections (and strains, if these are considered necessary) caused by the application of the test load.

The members selected for loading shall be subjected to a superimposed test load equivalent to 0.3 times the dead load plus 1.7 times the live load (test load $= 0.3D + 1.7L$). The test load shall be applied without shock to the structure and in a manner to avoid arching of the loading materials.

Load Tests of Structures (Continued)

The test load shall be left in position for 24 hours whereupon readings of the deflections shall be taken. The test load shall be removed and additional readings of deflections shall be taken 24 hours after the removal of the test load.

(c) **Criteria for Evaluation of Load Tests.** If the structure shows evident failure or fails to meet the following criteria, the changes needed to make the structure adequate for the rated capacity shall be made or a lower rating may be established as follows:

1. If the maximum deflection, "$\triangle$", of a reinforced concrete beam, floor or roof exceeds $l^2/20{,}000t$, the recovery of deflection within 24 hours after the removal of the test load shall be at least 75 per cent of the maximum deflection.
2. If the maximum deflection, "$\triangle$", is less than $l^2/20{,}000t$, the requirement on recovery of deflection in item No. 1 may be waived.
3. In determining the limiting deflection for a cantilever, "l" shall be taken as twice the distance from the support to the end, and the deflection shall be adjusted for movement of the support.
4. Construction failing to show 75 per cent recovery of the deflection may be retested. The second test loading shall not be made until at least 72 hours after removal of the test load for the first test. The structure shall show no evidence of failure in the retest, and the recovery of deflection caused by the second test load shall be at least 75 per cent.

Definitions

Sec. 2603. The following terms are defined for general use in this Code; specialized definitions appear in individual chapters:

ADMIXTURE, a material other than portland cement, aggregate, or water added to concrete to modify its properties.

AGGREGATE, inert material which is mixed with portland cement and water to produce concrete.

AGGREGATE, LIGHTWEIGHT, aggregate having a dry, loose weight of 70 pounds per cubic foot or less.

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

COMBINATION COLUMN, a column in which a structural steel member, designed to carry the principal part of the load, is encased in concrete of such quality and in such manner that the remaining load may be allowed thereon.

COMPOSITE COLUMN, a column in which a steel or cast-iron structural member is completely encased in concrete containing spiral and longitudinal reinforcement.

COMPOSITE CONCRETE FLEXURAL CONSTRUCTION, a precast concrete member and cast-in-place reinforced concrete so interconnected that the component elements act together as a flexural unit.

Definitions (Continued)

COMPRESSIVE STRENGTH OF CONCRETE "f_c'"[1], specified compressive strength of concrete in pounds per square inch. Compressive strength shall be determined by tests of standard six-inch by twelve-inch (6" x 12") cylinders made and tested in accordance with U.B.C. specifications at 28 days or such earlier age as concrete is to receive its full service load or maximum stress.

CONCRETE, a mixture of portland cement, fine aggregate, coarse aggregate, and water.

CONCRETE, STRUCTURAL LIGHTWEIGHT, a concrete containing lightweight aggregate conforming to Section 2604 (c).

DEFORMED BAR, a reinforcing bar conforming to U.B.C. Standard No. 26-7-67. Welded wire fabric with welded intersections not farther apart than twelve inches (12") in the direction of the principal reinforcement and with cross wires not more than six gauge numbers smaller in size than the principal reinforcement may be considered equivalent to a deformed bar when used in slabs.

EFFECTIVE AREA OF CONCRETE, the area of a section which lies between the centroid of the tension reinforcement and the compression face of the flexural member.

EFFECTIVE AREA OF REINFORCEMENT, the area obtained by multiplying the right cross-sectional area of the reinforcement by the cosine of the angle between its direction and the direction for which the effectiveness is to be determined.

PEDESTAL, an upright compression member whose height does not exceed three times its average least lateral dimension.

PLAIN BAR, reinforcement that does not conform to the definition of deformed bar.

PLAIN CONCRETE, concrete that does not conform to the definition of reinforced concrete.

PRECAST CONCRETE, a plain or reinforced concrete element cast in other than its final position in the structure.

PRESTRESSED CONCRETE, reinforced concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from service loads are counteracted to a desired degree.

REINFORCED CONCRETE, concrete containing reinforcement and designed on the assumption that the two materials act together in resisting forces.

REINFORCEMENT, material that conforms to Section 2604 (e), excluding prestressing steel unless specifically included.

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[1]Wherever this quantity appears under a radical sign, the root of only the numerical value is intended; all values are in pounds per square inch.

Definitions (Continued)

SPLITTING TENSILE STRENGTH. [See Section 2605 (f).]

STRESS, intensity of force per unit area.

SURFACE WATER, water carried by an aggregate except that held by absorption within the aggregate particles themselves.

YIELD STRENGTH OR YIELD POINT "f_y", specified minimum yield strength or yield point of reinforcement in pounds per square inch. Yield strength or yield point shall be determined in tension according to applicable U.B.C. Standards.

Materials

Sec. 2604. (a) **Quality.** The quality of the materials used in concrete and the quality of concrete shall conform to the physical and chemical properties as specified in this Chapter, and to the following standards:

MATERIALS	U.B.C. DESIGNATION
PORTLAND CEMENT	
Portland Cement	26- 1-67
Portland Blast Furnace Slag Cement	26- 2-67
Portland Pozzolan Cement	26- 3-67
AGGREGATES	
Concrete	26- 4-67
Lightweight, for Structural Concrete	26- 5-67
Selecting Proportions for Concrete	26- 6-67
METAL REINFORCEMENT	
Steel Bars	26- 7-67
Prestressed Steel Strand	26- 8-67
Prestressed Steel Wire	26- 9-67
Steel Bar Mats	26-10-67
Welded Steel Wire Fabric	26-11-67
ADMIXTURES	
Admixtures	26-12-67
CONCRETE COMPRESSION AND FLEXURE TEST SPECIMENS	
Making and Curing—in the Laboratory	26-13-67
Making and Curing—in the Field	26-13-67
Test for Compressive Strength	26-13-67
Compressive Strength of Molded Concrete Cylinders	26-13-67
SPLITTING TENSILE STRENGTH	26-14-67
READY-MIXED CONCRETE	26-15-67
WELDING OF METAL REINFORCEMENT	26-16-67
DESIGN	
Design of Two Way Slabs	26-17-67

(b) **Portland Cement.** Portland cement shall conform to U.B.C. Standard No. 26-1-67.

If provisions are made for sufficient damp curing of the concrete in the structure to develop a compressive strength at least equal to that of concrete containing cement conforming to the first paragraph, portland type cements which conform to the following standards may be used: U.B.C. Standard No. 26-2-67 or No. 26-3-67. **Materials (Continued)**

(c) **Concrete Aggregates.** Concrete aggregates shall conform to U.B.C. Standard No. 26-4-67 or No. 26-5-67, except that aggregates failing to meet these specifications but which have been shown by special test or actual service to produce concrete of adequate strength and durability may be used under Section 2605 (c), Method 2, where authorized by the Building Official.

Except as permitted elsewhere in this Code, the maximum size of the aggregate shall be not larger than one-fifth of the narrowest dimension between sides of the forms of the member for which the concrete is to be used nor larger than three-fourths of the minimum clear spacing between individual reinforcing bars or bundles of bars.

(d) **Water.** Water used in mixing concrete shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or steel. Mortar cubes made with nonpotable mixing water shall have seven-day and 28-day strengths equal to at least 90 per cent of the strengths of similar specimens made with potable water.

(e) **Metal Reinforcement.** Reinforcing bars shall conform to U.B.C. Standard No. 26-7-67.

If reinforcing bars are to be welded these specifications shall be supplemented by requirements assuring satisfactory weldability.

Bar and rod mats for concrete reinforcement shall conform to U.B.C. Standard No. 26-10-67.

Wire for concrete reinforcement shall conform to U.B.C. Standard No. 26-7-67.

Welded wire fabric for concrete reinforcement shall conform to U.B.C. Standard No. 26-11-67 except that the weld shear strength requirement of those specifications shall be extended to include a wire size differential up to and including six gauges.

Wire and strands for prestressed concrete shall conform to U.B.C. Standards No. 26-8-67 and No. 26-9-67.

Structural steel shall conform to U.B.C. Standard No. 27-1-67.

Steel pipe for concrete-filled pipe columns shall conform to Grade B of U.B.C. Standard No. 27-1-67.

Cast-iron pipe for composite columns shall conform to U.B.C. Standard No. 27-1-67.

(f) **Admixtures.** Admixtures, if used, shall conform to U.B.C. Standard No. 26-12-67.

Materials (Continued)

(g) **Storage of Materials.** Cement and aggregates shall be stored in such a manner as to prevent their deterioration or the intrusion of foreign matter. Any material which has deteriorated or which has been damaged shall not be used for concrete.

Concrete Quality

Sec. 2605. (a) **Notations.** The notations used in these regulations are defined as follows:

f_c' = compressive strength of concrete (see Section 2603).
F_{sp} = ratio of splitting tensile strength to the square root of compressive strength.

(b) **Concrete Quality.** For the design of reinforced concrete structures, the value "f_c'" shall be used in determining stresses in Sections 2610 to 2614 and strengths in Sections 2615 to 2619.

All plans submitted for approval or used for any project shall clearly show the specified strength, "f_c'", of concrete at the specified age for which each part of the structure was designed.

Concrete that is to be subject to freezing temperatures while wet shall have a water-cement ratio not exceeding six gallons per bag and it shall contain entrained air.

Concrete that will be exposed to sulfate-containing or other chemically aggressive solutions shall be proportioned in accordance with U.B.C. Standard No. 26-6-67.

(c) **Methods of Determining the Proportions of Concrete.** The determination of the proportions of cement, aggregate, and water to attain the required strengths shall be made by one of the following methods, but lower water-cement ratios may be required for conformance with Section 2605 (b).

Method 1—Without preliminary tests

Where preliminary test data on the materials to be used in the concrete have not been obtained, the water-cement ratio for a given strength of concrete shall not exceed the values shown in Table No. 26-A. When strengths in excess of 4000 pounds per square inch are required or when lightweight aggregates or admixtures (other than those exclusively for the purpose of entraining air) are used, the required water-cement ratio shall be determined in accordance with Method 2.

Method 2—For combinations of materials previously evaluated or to be established by trial mixtures.

Water-cement ratios or strengths greater than shown in Table No. 26-A may be used provided that the relationship between strength and water-cement ratio for the materials to be used has been previously established by reliable test data and the resulting concrete satisfies the requirements of Section 2605 (e).

Concrete Quality (Continued)

Where previous data are not available, concrete trial mixtures having proportions and consistency suitable for the work shall be made using at least three different water-cement ratios (or cement content in the case of lightweight aggregates) which will produce a range of strengths encompassing those required for the work. For each water-cement ratio (or cement content), at least three specimens for each age to be tested shall be made, cured and tested for strength in accordance with U.B.C. Standard No. 26-13-67.

The strength tests shall be made at 28 days or the earlier age at which the concrete is to receive load, as indicated on the plans. A curve shall be established showing the relationship between water-cement ratio (or cement content) and compressive strength. The maximum permissible water-cement ratio for the concrete to be used in the structure shall be that shown by the curve to produce an average strength to satisfy the requirements of Section 2605 (e) provided that the water-cement ratio shall be no greater than that required by Section 2605 (b).

Where different materials are to be used for different portions of the work, each combination shall be evaluated separately.

(d) **Concrete Proportions and Consistency.** The proportions of aggregate to cement for any concrete 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 materials to segregate or excess free water to collect on the surface.

TABLE NO. 26-A—MAXIMUM PERMISSIBLE WATER-CEMENT RATIOS FOR CONCRETE (METHOD NO. 1)[1]

SPECIFIED COMPRESSIVE STRENGTH AT 28 DAYS, P.S.I. f_c'	MAXIMUM PERMISSIBLE WATER-CEMENT RATIO[2]			
	NONAIR-ENTRAINED CONCRETE		AIR-ENTRAINED CONCRETE	
	U.S. GAL. PER 94-LB. BAG OF CEMENT	ABSOLUTE RATIO BY WEIGHT	U.S. GAL. PER 94-LB. BAG OF CEMENT	ABSOLUTE RATIO BY WEIGHT
2000	7½	0.663	7	0.620
2500	7¼	0.642	6¼	0.554
3000	6½	0.576	5¼	0.465
3500	5¾	0.510	4½	0.399
4000	5	0.443	4	0.354

[1]The minimum cement content shall be not less than five bags per cubic yard (a bag weighing not less than 94 pounds) unless the mix is designed in accordance with the provisions of Method 2 of Section 2605 (c).

[2]Including free surface moisture on aggregates.

Concrete Quality (Continued)

The methods of measuring concrete materials shall be such that the proportions can be accurately controlled and easily checked at any time during the work.

(e) **Strength Tests of Concrete.** Tests of concrete shall be required for all concrete having an ultimate compressive strength in excess of 2000 pounds per square inch. On other concrete work, the Building Official may require tests of the concrete and other materials from time to time to determine whether such materials or methods of use are such as to produce concrete of the quality specified and used in accordance with the design of the building or structure. When tests are required, each class of concrete shall be represented by at least five tests (10 specimens). Two specimens shall be made for each test at a given age, and not less than one test shall be made for each 150 cubic yards of structural concrete, but there shall be at least one test for each day's concreting. The Building Official may modify the required number of tests for jobs involving less than 150 cubic yards. The Building Official may require a reasonable number of additional tests during the progress of the work. The tests shall be made, when ordered by the Building Official, by the owner or his authorized representative and no responsibility for the expense of these tests shall attach to the Building Department. All such tests shall be made by an approved agency, and copies of the results shall be kept on file in the office of the Building Official for a period of not less than two years after the acceptance of the structure. Specimens for concrete cylinder tests shall be taken at the place where the concrete is being deposited and shall be taken and cured in accordance with the requirements set forth in U.B.C. Standard No. 26-13-67 and tested in accordance with the requirements set forth in U.B.C. Standard No. 26-13-67. Samples from which compression test specimens are molded shall be secured in accordance with U.B.C. Standard No. 26-13-67. Specimens made to check the adequacy of the proportions for strength of concrete or as a basis for acceptance of concrete shall be made and laboratory-cured in accordance with U.B.C. Standard No. 26-13-67. Additional test specimens cured entirely under field conditions may be required by the Building Official to check the adequacy of curing and protection of the concrete. Strength tests shall be made in accordance with U.B.C. Standard No. 26-13-67.

The age for strength tests shall be 28 days or, where specified, the earlier age at which the concrete is to receive its full load or maximum stress. Additional tests may be made at earlier ages to obtain advance information on the adequacy of strength development where age-strength relationships have been established for the materials and proportions used.

To conform to the requirements of this Code:

1. For structures designed in accordance with the working stress design method of this Code, the average of any

five consecutive strength tests of the laboratory-cured specimens representing each class of concrete shall be equal to or greater than the specified strength, "f_c'", and not more than 20 per cent of the strength tests shall have values less than the specified strength.

Concrete Quality (Continued)

2. For structures designed in accordance with the ultimate strength design method of this Code, and for prestressed structures the average of any three consecutive strength tests of the laboratory-cured specimens representing each class of concrete shall be equal to or greater than the specified strength, "f_c'", and not more than 10 per cent of the strength tests shall have values less than the specified strength.

When it appears that the laboratory-cured specimens will fail to conform to the requirements for strength, the Building Official shall have the right to order changes in the concrete sufficient to increase the strength to meet these requirements. The strengths of any specimens cured on the job are intended to indicate the adequacy of protection and curing of the concrete and may be used to determine when the forms may be stripped, shoring removed, or the structure placed in service. When, in the opinion of the Building Official, the strengths of the job-cured specimens are excessively below those of the laboratory-cured specimens, the contractor may be required to improve the procedures for protecting and curing the concrete.

In addition, when concrete fails to conform to the requirements herein or when tests of field-cured cylinders indicate deficiencies in protection and curing, the Building Official may require tests in accordance with U.B.C. Standard No. 26-13-67 or order load tests as outlined in Section 2602 for that portion of the structure where the questionable concrete has been placed.

(f) **Splitting Tensile Tests of Concrete.** To determine the splitting ratio, "F_{sp}", for a particular aggregate, tests of concrete shall be made as follows:

1. Twenty-four six-inch by twelve-inch (6"x12") cylinders shall be made in accordance with U.B.C. Standard No. 26-13-67, 12 at a compressive strength level of approximately 3,000 pounds per square inch and 12 at approximately 4,000 pounds per square inch or 5,000 pounds per square inch. After seven days moist curing followed by 21 days drying at 73°F. and 50 per cent relative humidity, eight of the test cylinders at each of the two strength levels shall be tested for splitting strength and four for compressive strength.

2. The splitting tensile strength shall be determined in accordance with U.B.C. Standard No. 26-14-67, and the compressive strength in accordance with U.B.C. Standard No. 26-13-67.

Concrete Quality (Continued)

The ratio, "F_{sp}", of splitting tensile strength to the square root of compressive strength shall be obtained by using the average of all 16 splitting tensile tests and all eight compressive tests.

(g) **Minimum Strength.** Concrete, other than fill, shall have a minimum ultimate compressive strength at 28 days of 2000 pounds per square inch.

Mixing and Placing Concrete

Sec. 2606. (a) **Preparation of Equipment and Place of Deposit.** Before concrete is placed, all equipment for mixing and transporting the concrete shall be clean, all debris and ice shall be removed from the spaces to be occupied by the concrete, forms shall be thoroughly wetted or oiled, masonry filler units that will be in contact with concrete shall be well drenched, and the reinforcement shall be thoroughly clean of ice or other deleterious coatings.

Water shall be removed from the place of deposit before concrete is placed unless a tremie is to be used or unless otherwise permitted by the Building Official.

All laitance and other unsound material shall be removed from hardened concrete before additional concrete is added.

(b) **Mixing of Concrete.** All concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixer is recharged.

For job-mixed concrete, mixing shall be done in a batch mixer of approved type. The mixer shall be rotated at a speed recommended by the manufacturer and mixing shall be continued for at least one and one-half minutes after all materials are in the drum.

Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in U.B.C. Standard No. 26-15-67.

(c) **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 insure a practically continuous flow of concrete at the delivery end without separation of materials.

(d) **Depositing.** Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. The concreting shall be carried on at such a rate that the concrete is at all times plastic and flows readily into the spaces between the bars. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the structure, nor shall retempered concrete be used unless approved by the Building Official.

Mixing and Placing Concrete (Continued)

When concreting is once started, it shall be carried on as a continuous operation until the placing of the panel or section is completed. The top surface shall be generally level. When construction joints are necessary, they shall be made in accordance with Section 2607 (d).

All concrete shall be thoroughly consolidated by suitable means during placement, and shall be thoroughly worked around the reinforcement and embedded fixtures and into the corners of the forms.

Where conditions make consolidation difficult, or where reinforcement is congested, batches of mortar containing the same proportions of cement to sand as used in the concrete, shall first be deposited in the forms to a depth of at least one inch (1").

(e) **Curing.** Concrete shall be maintained above 50°F. and in a moist condition for at least the first seven days after placing, except that high-early-strength concrete shall be so maintained for at least the first three days. Other curing periods may be used if the specified strengths are obtained.

(f) **Cold Weather Requirements.** Adequate equipment shall be provided for heating the concrete materials and protecting the concrete during freezing or near-freezing weather. All concrete materials and all reinforcement, forms, fillers, and ground with which the concrete is to come in contact shall be free from frost. No frozen materials or materials containing ice shall be used.

(g) **Hot Weather Requirements.** During hot weather, steps shall be taken to reduce concrete temperature and water evaporation by proper attention to ingredients, production methods, handling, placing, protection, and curing.

Formwork, Embedded Pipes and Construction Joints

Sec. 2607. (a) **Design of Formwork.** Forms shall conform to the shape, lines, and dimensions of the member as called for on the plans and shall be substantial and sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together to maintain position and shape. If adequate foundation for shores cannot be secured, trussed supports shall be provided. Forms for prestressed concrete members shall be designed and constructed to permit movement and deflection which take place when the prestressing force is transferred to the concrete.

Temporary openings shall be provided at the base of column and wall forms, and at other points where necessary, to facilitate cleaning and inspection.

(b) **Removal of Forms.** No construction loads exceeding the structural design loads shall be supported upon any unshored portion of the structure under construction. No construction load shall be supported upon, nor any shoring

Formwork, Embedded Pipes and Construction Joints (Continued)

removed from any part of the structure under construction until that portion of the structure has attained sufficient strength to support safely its weight and the loads placed thereon. This strength may be demonstrated by job-cured test specimens and by a structural analysis considering the proposed loads in relation to these test strengths. Such analyses and test data shall be furnished by the contractor to the Building Official.

Forms shall be removed in such manner as to insure the complete safety of the structure. Where the structure as a whole is adequately supported on shores, the removable floor forms, beam and girder sides, column and similar vertical forms may be removed after 24 hours provided the concrete is sufficiently strong not to be injured thereby.

Form supports of prestressed members may be removed when sufficient prestressing has been applied to enable them to carry their dead loads and anticipated construction loads.

(c) **Conduits and Pipes Embedded in Concrete.** Electric conduits and other pipes whose embedment is allowed shall not, with their fittings, displace more than four per cent of the area of the cross section of a column on which stress is calculated or which is required for fire protection. Sleeves, conduits, or other pipes passing through floors, walls, or beams shall be of such size or in such location as not to impair unduly the strength of the construction; such sleeves, conduits, or pipes may be considered as replacing structurally in compression the displaced concrete, provided they are not exposed to rusting or other deterioration, are of uncoated or galvanized iron or steel not thinner than standard steel pipe, have a nominal inside diameter not over two inches (2") and are spaced not less than three diameters on centers. Except when plans of conduits and pipes are approved by the Building Official, embedded pipes or conduits, other than those merely passing through, shall be not larger in outside diameter than one-third the thickness of the slab, wall, or beam in which they are embedded, nor shall they be spaced closer than three diameters on center, nor so located as to impair unduly the strength of the construction. Sleeves, pipes, or conduits of any material not harmful to concrete and within the limitations of this section may be embedded in the concrete with the approval of the Building Official provided they are not considered to replace the displaced concrete. [See also Section 4303 (b) 4.]

Pipes which will contain liquid, gas, or vapor may be embedded in structural concrete under the following additional conditions:

1. The temperature of the liquid, gas, or vapor shall not exceed 150°F.

Formwork, Embedded Pipes and Construction Joints (Continued)

2. The maximum pressure to which any piping or fittings shall be subjected shall be 200 pounds per square inch above atmospheric pressure.

3. All piping and fittings shall be tested as a unit for leaks immediately prior to concreting. The testing pressure above atmospheric pressure shall be 50 per cent in excess of the pressure to which the piping and fittings may be subjected but the minimum testing pressure shall be not less than 150 pounds per square inch above atmospheric pressure. The pressure test shall be held for four hours with no drop in pressure except that which may be caused by air temperature.

> EXCEPTION: Drainpipes and other piping designed for pressures of not more than one pound per square inch above atmospheric pressure need not be pressure tested.

4. Pipes carrying liquid, gas, or vapor which is explosive or injurious to health shall again be tested as specified in point 3 after the concrete has hardened.

5. No liquid, gas or vapor, except water not exceeding 90°F. nor 20 pounds per square inch pressure, is to be placed in the pipes until the concrete has thoroughly set.

6. In solid slabs the piping, except for radiant heating and snow melting, shall be placed between the top and bottom reinforcement.

7. The concrete covering of the pipes and fittings shall be not less than one inch (1").

8. Reinforcement with an area equal to at least 0.2 per cent of the area of the concrete section shall be provided normal to the piping.

9. The piping and fittings shall be assembled by welding, brazing, solder-sweating, or other equally satisfactory method. Screw connections shall be prohibited. The piping shall be so fabricated and installed that it will not require any cutting, bending, or displacement of the reinforcement from its proper location.

10. No liquid, gas, or vapor which may be injurious or detrimental to the pipes shall be placed in them.

11. The location does not conflict with other applicable codes.

(d) **Construction Joints.** Joints not indicated on the plans shall be so made and located as not to impair the strength of the structure below that required by the design. Where a joint is to be made, the surface of the concrete shall be thoroughly cleaned and all laitance removed. In addition to the foregoing, vertical joints shall be thoroughly wetted, and slushed with a

Formwork, Embedded Pipes and Construction Joints (*Continued*)

coat of neat cement grout immediately before placing of new concrete.

A delay at least until the concrete is no longer plastic must occur in columns or walls before concreting beams, girders, or slabs supported thereon. Beams, girders, brackets, column capitals, and haunches shall be considered as part of the floor system and shall be placed monolithically therewith.

Construction joints in floors shall be located near the middle of the spans of slabs, beams, or girders, unless a beam intersects a girder at this point, in which case the joints in the girders shall be offset a distance equal to twice the width of the beam. Provision shall be made for transfer of shear and other forces through the construction joint.

Details of Reinforcement

Sec. 2608. (a) **Hooks and Bends**[1]**.**

HOOKS. The term "standard hook" as used herein shall mean:

1. A semicircular turn plus an extension of at least four bar diameters but not less than two and one-half inches (2½") at the free end of the bar, or

2. A 90-degree turn plus an extension of at least 12 bar diameters at the free end of the bar, or

3. For stirrup and tie anchorage only, either a 90-degree or a 135-degree turn plus an extension of at least six bar diameters but not less than two and one-half inches (2½") at the free end of the bar.

MINIMUM RADII. The radii of bend measured on the inside of the bar for standard hooks shall be not less than the values set forth in Table No. 26-B, except that for sizes No. 6 to No. 11, inclusive, in structural and intermediate grades of bars only, the minimum radius shall be two and one-half bar diameters.

BENDS OTHER THAN STANDARD HOOKS. Bends other than standard hooks shall mean:

1. Bends for stirrups and ties shall have radii on the inside of the bar not less than one bar diameter.

2. Bends for all other bars shall have radii on the inside of the bar not less than the values set forth in Table No. 26-B. When such bends are made at points of high stress in the bar, an adequate radius of bend shall be provided to prevent crushing of concrete.

BENDING. All bars shall be bent cold, unless otherwise permitted by the Building Official. No bars partially embedded in concrete shall be field bent except as shown on the plans or specifically permitted by the Building Official.

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[1]See also Sections 2609 (q) and (r).

Details of Reinforcement (Continued)

(b) **Cleaning Reinforcement.** Metal reinforcement, at the time concrete is placed, shall be free from loose flaky rust, mud, oil, or other coatings that will destroy or reduce the bond.

(c) **Placing Reinforcement.** 1. **Supports.** Reinforcement shall be accurately placed and adequately supported by concrete, metal, or other approved chairs; spacers; or ties and secured against displacement within tolerances permitted.

2. **Tolerances.** Unless otherwise specified by the Building Official, reinforcement shall be placed in specified positions within the following tolerances:

Depth, "*d*", in flexural members, walls, and columns where "*d*" is twenty-four inches (24") or less: plus or minus one-fourth inch (¼").

Depth, "*d*", in flexural members and columns where "*d*" is more than twenty-four inches (24"): plus or minus one-half inch (½").

Longitudinal location of bends and ends of bars: plus or minus two inches (2") except that specified concrete cover at ends of members shall not be reduced.

3. **Draped fabric.** When wire or other reinforcement, not exceeding one-fourth inch (¼") in diameter is used as reinforcement for slabs not exceeding ten feet (10') in span, the reinforcement may be curved from a point near the top of the slab over the support to a point near the bottom of the slab at midspan, provided such reinforcement is either continuous over, or securely anchored to, the support.

(d) **Spacing of Bars.** The clear distance between parallel bars (except in columns and between multiple layers of bars in beams) shall be not less than the nominal diameter of the bars, one and one-third times the maximum size of the coarse aggregate, nor one inch (1").

Where reinforcement in beams or girders is placed in two or more layers, the clear distance between layers shall be not less than one inch (1"), and the bars in the upper layers shall be placed directly above those in the bottom layer.

TABLE NO. 26-B—MINIMUM RADII OF BEND

MINIMUM RADII	BAR SIZE
No. 3, No. 4, or No. 5	2½ bar diameters
No. 6, No. 7, or No. 8	3 bar diameters
No. 9, No. 10, or No. 11	4 bar diameters
No. 14S or No. 18S[1]	5 bar diameters

[1]Special fabrication is required for bends having an internal angle less than 90 degrees for bars of these sizes and grades having a specified yield point of 50,000 pounds per square inch or more.

Details of Reinforcement (Continued)

In walls and slabs other than concrete joist construction, the principal reinforcement shall be centered not farther apart than three times the wall or slab thickness nor more than eighteen inches (18").

In spirally reinforced and in tied columns, the clear distance between longitudinal bars shall be not less than one and one-half times the bar diameter, one and one-half times the maximum size of the coarse aggregate, nor one and one-half inches (1½").

The clear distance between bars shall also apply to the clear distance between a contact splice and adjacent splices or bars.

Groups of parallel reinforcing bars bundled in contact to act as a unit must be deformed bars with not over four in any one bundle and shall be used only when stirrups or ties enclose the bundle. Bars in a bundle shall terminate at different points with at least 40 bar diameters stagger unless all of the bars end in a support. Where spacing limitations are based on bar size, a unit of bundled bars shall be treated as a single bar of equivalent area.

(e) **Splices in Reinforcement.** No splices of reinforcement shall be made except as shown on the design drawings, or as specified, or as authorized by the Building Official.

1. **Splices in reinforcement in which the critical design stress is tensile:** Lapped splices in tension shall not be used for bar sizes larger than No. 11.

Splices at points of maximum tensile stress shall be avoided wherever possible; such splices where used shall be welded, lapped, or otherwise fully developed. In any case the splice shall transfer the entire computed stress from bar to bar without exceeding three-fourths of the permissible bond values given in this Code; however, the length of lap for deformed bars shall be not less than 24, 30, and 36 bar diameters for specified yield strengths of 40,000, 50,000, and 60,000 pounds per square inch respectively, nor less than twelve inches (12"). For plain bars the minimum length of lap shall be twice that for deformed bars.

For contact splices spaced laterally closer than 12 bar diameters or located closer than six inches (6") or six bar diameters from an outside edge, the lap shall be increased by 20 per cent, or closely spaced stirrups as prescribed in Section 2609 (q) or spirals shall enclose the splice for its full length.

Where more than one-half of the bars are spliced within a length of 40 bar diameters or where splices are made at points of maximum stress, special precautions shall be taken, such as increased length of lap and the use of spirals or closely-spaced stirrups around and for the length of the splice.

2. **Splices in reinforcement in which the critical design stress is compressive:**

Details of Reinforcement (Continued)

A. Where lapped splices are used, the minimum amount of lap shall be:

For deformed bars with concrete having a strength of 3000 pounds per square inch or more, the length of lap shall be 20, 24, and 30 bar diameters for specified yield strengths of 50,000 and under, 60,000, and 75,000 pounds per square inch, respectively, nor less than twelve inches (12"). When the specified concrete strengths are less than 3000 pounds per square inch, the amount of lap shall be one-third greater than the values given above.

For plain bars, the minimum amount of lap shall be twice that specified for deformed bars.

B. Welded splices or other positive connections may be used instead of lapped splices. Where the bar size exceeds No. 11, welded splices or other positive connections shall be used. In bars required for compression only, the compressive stress may be transmitted by bearing of square-cut ends held in concentric contact by a suitably welded sleeve or mechanical device.

C. Where longitudinal bars are offset at a splice, the slope of the inclined portion of the bar with the axis of the column shall not exceed one in six, and the portions of the bar above and below the offset shall be parallel to the axis of the column. Adequate horizontal support at the offset bends shall be treated as a matter of design, and shall be provided by metal ties, spirals, or parts of the floor construction. Metal ties or spirals so designed shall be placed near (not more than eight bar diameters from) the point of bend. The horizontal thrust to be resisted shall be assumed as one and one-half times the horizontal component of the nominal stress in the inclined portion of the bar.

Offset bars shall be bent before they are placed in the forms. See Section 2608 (a).

D. Where column faces are offset three inches (3") or more, splices of vertical bars adjacent to the offset face shall be made by separate dowels overlapped as specified above.

E. In tied columns the amount of reinforcement spliced by lapping shall not exceed a steel ratio of 0.04 in any three-foot (3') length of column.

3. **Welded splices.** An approved welded splice is one in which the bars are butted and welded so that it will develop in tension at least 125 per cent of the specified yield strength of the reinforcing bar but not less than the ultimate strength. Approved positive connections for bars designed to carry critical tension or compression shall be equivalent in strength to an approved welded splice.

4. **Metal cores in composite columns.** Metal cores in composite columns shall be accurately milled at splices and positive provision shall be made for alignment of one core above

Details of Reinforcement (Continued)

another. At the column base, provision shall be made to transfer the load to the footing at safe unit stresses in accordance with Section 2610 (c). The base of the metal section shall be designed to transfer the load from the entire composite column to the footing, or it may be designed to transfer the load from the metal section only, provided it is so placed in the pier or pedestal as to leave ample section of concrete above the base for the transfer of load from the reinforced concrete section of the column by means of bond on the vertical reinforcement and by direct compression on the concrete.

5. **Splices of welded wire fabric used as reinforcement in structural slabs.**

A. Lapped splices of wires in regions of maximum stress (where they are carrying more than one-half of the permissible stress) shall be avoided wherever possible; such splices where used shall be so made that the overlap measured between outermost cross wires of each fabric sheet is not less than the spacing of the cross wires plus two inches (2").

B. Splices of wires stressed at not more than one-half the permissible stress shall be so made that the overlap measured between outermost cross wires is not less than two inches (2").

(f) **Lateral Reinforcement.** Spiral column reinforcement shall consist of evenly spaced continuous spirals held firmly in place and true to line by vertical spacers. At least two spacers shall be used for spirals twenty inches (20") or less in diameter, three for spirals twenty inches (20") to thirty inches (30") in diameter, and four for spirals more than thirty inches (30") in diameter. When spiral rods are five-eighths inch (⅝") or larger, three spacers shall be used for spirals twenty-four inches (24") or less in diameter and four for spirals more than twenty-four inches (24") in diameter. The spirals shall be of such size and so assembled as to permit handling and placing without being distorted from the designed dimensions. The material used in spirals shall have a minimum diameter of one-fourth inch (¼") for rolled bars or No. 4 A S & W gauge for drawn wire. Anchorage of spiral reinforcement shall be provided by one and one-half extra turns of spiral rod or wire at each end of the spiral unit. Splices when necessary in spiral rods or wires shall be made by welding or by a lap of one and one-half turns. The center-to-center spacing of the spirals shall not exceed one-sixth of the core diameter. The clear spacing between spirals shall not exceed three inches (3") nor be less than one and three-eighths inches (1⅜") or one and one-half times the maximum size of coarse aggregate used. The reinforcing spiral shall extend from the floor level in any story or from the top of the footing to the level of the lowest horizontal reinforcement in the slab, drop panel, or beam above. In a column with a capital, the spiral shall extend to a plane at which the diameter or width of the capital is twice that of the column.

Details of Reinforcement (Continued)

All bars for tied columns shall be enclosed by lateral ties at least one-fourth inch (¼") in diameter spaced apart not over 16 bar diameters, 48 tie diameters, or the least dimension of the column. The ties shall be so arranged that every *longitudinal* bar shall have lateral support provided by the corner of a tie having an included angle of not more than 135 degrees. Where the bars are located around the periphery of a circle, a complete circular tie may be used.

Compression reinforcement in beams or girders shall be anchored by ties or stirrups, which shall be not less than one-fourth inch (¼") in diameter spaced not farther apart than 16 bar diameters, or 48 tie diameters. The entire compression reinforcement shall be enclosed by a tie or stirrup at each spacing. Such stirrups or ties shall be used throughout the distance where the compression reinforcement is required.

(g) **Shrinkage and Temperature Reinforcement.** Reinforcement for shrinkage and temperature stresses normal to the principal reinforcement shall be provided in structural floor and roof slabs where the principal reinforcement extends in one direction only. Such reinforcement shall provide at least the following ratios of reinforcement area to gross concrete area, but in no case shall such reinforcing bars be placed farther apart than five times the slab thickness or more than eighteen inches (18").

Slabs where plain bars are used	0.0025
Slabs where deformed bars with specified yield strengths less than 60,000 pounds per square inch are used	0.0020
Slabs where deformed bars with 60,000 pounds per square inch specified yield strength or welded wire fabric having welded intersections not farther apart in the direction of stress than twelve inches (12") are used	0.0018

(h) **Concrete Protection for Reinforcement.** The reinforcement of footings and other principal structural members in which the concrete is deposited against the ground shall have not less than three inches (3") of concrete between it and the ground contact surface. If concrete surfaces after removal of the forms are to be in contact with the ground, the reinforcement shall be protected with not less than two inches (2") of concrete.

For exposed walls above grade the cover shall be not less than one and one-half inches (1½").

The concrete protective covering for any reinforcement at surfaces not exposed directly to the ground or weather shall be not less than three-fourths inch (¾") for slabs and walls, and not less than one and one-half inches (1½") for beams and girders. In concrete joist floors in which the clear distance between joists is not more than forty inches (40"), the protection of reinforcement shall be at least three-fourths inch (¾").

Details of Reinforcement (Continued)

Column spirals or ties shall be protected everywhere by a covering of concrete cast monolithically with the core, for which the thickness shall be not less than one and one-half (1½") nor less than one and one-half times the maximum size of the coarse aggregate.

Concrete protection for reinforcement shall in all cases be at least equal to the diameter of bars, except for concrete slabs and joists as in the second paragraph of this Subsection.

In extremely corrosive atmospheres or other severe exposures, the amount of protection shall be suitably increased.

Exposed reinforcing bars, inserts, and plates intended for bonding with future extensions shall be protected from corrosion by concrete or other adequate covering.

If Chapter 43 specifies, as fire-protective covering of the reinforcement, thicknesses of concrete greater than those given in this Section, then such greater thicknesses shall be used.

For special requirements for precast construction, see Section 2624 and for prestressed construction, see Section 2626.

Design—General Considerations

Sec. 2609. (a) **Notations.** The notations used in these regulations are defined as follows:

A_c = area of core of spirally reinforced column measured to the outside diameter of the spiral.
= area of concrete within the core of a composite column.

A_g = gross area of spirally reinforced or tied column.
= area of the concrete of composite columns.

A_s = area of tension reinforcement.

A_s' = area of compression reinforcement.

b = width of compression face of flexural member.

d = distance from extreme compression fiber to centroid of tension reinforcement.

E_c = modulus of elasticity of concrete [see Section 2611 (c)].

f_c' = compressive strength of concrete (see Section 2603).

f_y = yield strength of reinforcement (see Section 2603).

h = actual unsupported length of column.

h' = effective length of column.

I = moment of inertia of beam or column.

K = stiffness factor = EI/l.

l = span length of slab or beam.

l' = clear span for positive moment and shear and the average of the two adjacent clear spans for negative moment [see Section 2609 (e)].

p = ratio of area of tension reinforcement to effective area of concrete in rectangular beam or in web of flanged member.

Design—General Considerations (Continued)

p_s = ratio of volume of spiral reinforcement to total volume of core (out to out of spirals) of a spirally reinforced concrete or composite column.
r = radius of gyration of gross concrete area of a column.
r' = the ratio of "ΣK" of columns to "ΣK" of floor members in a plane at one end of a column.
R = a reduction factor for long columns as defined in Section 2609 (q).
t = thickness of flexural member.
w = total load per unit of length of beam or per unit area of slab.

(b) **Design Methods.** The design of reinforced concrete members shall be made either with reference to allowable working stresses, service loads, and the accepted straight-line theory of flexure as outlined in Sections 2610 to 2614 (Working Stress Design) or with reference to load factors and strengths as outlined in Sections 2615 to 2619 (Ultimate Strength Design).

(c) **Frame Analysis—General.** All members of frames or continuous construction shall be designed to resist at all sections the maximum effects of the prescribed loads as determined by the theory of elastic frames in which the simplifying assumptions of Section 2609 (f) may be used.

Except for prestressed concrete, in the case of two or more approximately equal spans (the larger of two adjacent spans not exceeding the shorter by more than 20 per cent) with loads uniformly distributed, where the unit live load does not exceed three times the unit dead load, the following moments and shears may be used in design in lieu of more accurate analyses.

Positive moment
End spans
If discontinuous end is unrestrained .... $1/11\ wl'^2$
If discontinuous end is integral with support ...... $1/14\ wl'^2$
Interior spans .... $1/16\ wl'^2$

Negative moment at exterior face of first interior support
Two spans .... $1/9\ wl'^2$
More than two spans .... $1/10\ wl'^2$

Negative moment at other faces of interior supports .. $1/11\ wl'^2$

Negative moment at face of all supports for, (a) slabs with spans not exceeding ten feet (10') and (b) beams and girders where ratio of sum of column stiffnesses to beam stiffness exceeds eight at each end of the span .... $1/12\ wl'^2$

Negative moment at interior faces of exterior supports for members built integrally with their supports
Where the support is a spandrel beam or girder .... $1/24\ wl'^2$

Design—General Considerations (Continued)

Where the support is a column .... $1/16\ wl'^2$

Shear in end members at first interior support .... $1.15\ \frac{wl'}{2}$

Shear at all other supports .... $\frac{wl'}{2}$

(d) **Frame Analysis—Details. 1. Arrangement of live load.** The live load may be considered to be applied only to the floor or roof under consideration, and the far ends of the columns may be assumed as fixed.

Consideration may be limited to combinations of dead load on all spans with full live load on two adjacent spans and with full live load on alternate spans.

2. **Span length.** The span length, "l", of members that are not built integrally with their supports shall be considered the clear span plus the depth of the slab or beam but shall not exceed the distance between centers of supports.

In analysis of continuous frames, center-to-center distances shall be used in the determination of moments. Moments at faces of supports may be used for design of beams and girders.

Solid or ribbed slabs with clear spans of not more than ten feet (10′) that are built integrally with their supports may be designed as continuous slabs on knife edge supports with spans equal to the clear spans of the slab and the width of beams otherwise neglected.

3. **Stiffness.** Any reasonable assumptions may be adopted for computing the relative flexural stiffness of columns, of walls, and of floor and roof systems. The assumptions made shall be consistent throughout the analysis.

In computing the value of "I" for the relative flexural stiffness of slabs, beams, girders, and columns, the reinforcement may be neglected. In T-shaped sections allowance shall be made for the effect of flange.

If the total torsional stiffness in the plane of a continuous system at a joint does not exceed 20 per cent of the flexural stiffness at the joint, the torsional stiffness need not be taken into account in the analysis.

4. **Haunched members.** The effect of haunches shall be considered both in determining bending moments and in design of members.

(e) **Requirements for T-beams.** 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 eight times the thickness of the slab nor one-half the clear distance to the next beam.

Design—General Considerations (Continued)

Isolated beams in which the T-form is used only for the purpose of providing additional compression area, shall have a flange thickness not less than one-half the width of the web and a total flange width not more than four times the width of the web.

For beams having a flange on one side only, the effective overhanging flange width shall not exceed one-twelfth of the span length of the beam, nor six times the thickness of the slab, nor one-half the clear distance to the next beam.

Where the principal reinforcement in a slab which is considered as the flange of a T-beam (not a joist in concrete joist floors) is parallel to the beam, transverse reinforcement shall be provided in the top of the slab. This reinforcement shall be designed to carry the load on the portion of the slab required for the flange of the T-beam. The flange shall be assumed to act as a cantilever. The spacing of the bars shall not exceed five times the thickness of the flange, nor in any case eighteen inches (18″).

The overhanging portion of the flange of the beam shall not be considered as effective in computing the shear and diagonal tension resistance of T-beams.

Provision shall be made for the compressive stress at the support in continuous T-beam construction, care being taken that the provisions of Section 2608 (d) relating to the spacing of bars, and of Section 2606 (d) relating to the placing of concrete shall be fully met.

(f) **Effective Depth of Beam or Slab.** The effective depth, "*d*", of a beam or slab shall be taken as the distance from the centroid of its tensile reinforcement to its compression face.

Any floor finish not placed monolithically with the floor slab shall not be included as a part of the structural member. When the top of a monolithic slab is the wearing surface and unusual wear is expected as in buildings of the warehouse or industrial class, there shall be placed an additional depth of one-half inch (½″) over that required by the design of the member.

(g) **Distance Between Lateral Supports.** The effects of lateral eccentricity of load shall be taken into account in determining the spacing of lateral supports for a beam, which shall never exceed 50 times the least width, "*b*", of compression flange or face.

(h) **Control of Deflections.** Reinforced concrete members subject to bending shall be designed to have adequate stiffness to prevent deflections or other deformations which may adversely affect the strength or serviceability of the structure.

Design—General Considerations (Continued)

The minimum thicknesses, "t", set forth in Table No. 26-C shall apply to flexural members of normal weight concrete, except when calculations of deflections prove that lesser thicknesses may be used without adverse effects.

Deflections shall be computed by the usual methods and formulas for elastic deflections, using the modulus of elasticity for concrete specified in Section 2611 (c). The moment of inertia shall be based on the gross section when "pf_y" is equal to or less than 500 and on the transformed cracked section when "pf_y" is greater. In continuous spans, the moment of inertia may be taken as the average of the values obtained for the positive and negative moment regions. Effects of creep and shrinkage shall be considered. (See Section 2307 for deflection limits.)

(i) **Deep Beams.** Beams with depth/span ratios greater than two-fifths for continuous spans, or four-fifths for simple or cantilever spans shall be designed as deep beams taking account of nonlinear distribution of stress, lateral buckling, and other pertinent effects. The minimum horizontal and vertical reinforcement in the faces shall be as specified in Section 2622 (c); the minimum tensile reinforcement as specified in Section 2609 (l).

(j) **Minimum Reinforcement of Flexural Members.** Wherever at any section of a flexural member (except slabs of uniform thickness) positive reinforcement is required by analysis, the ratio, "p", supplied shall not be less than $200/f_y$, unless the area of reinforcement provided at every section, positive or negative, is at least one-third greater than that required by analysis.

In structural slabs of uniform thickness, the minimum amount of reinforcement in the direction of the span shall be not less than that required for shrinkage and temperature reinforcement [see Section 2608 (g)].

(k) **Limiting Dimensions of Columns. 1. Minimum size.** Columns constituting the principal supports of a floor or roof shall have a diameter of at least ten inches (10″), or in the case of rectangular columns, a thickness of at least eight inches (8″), and a gross area not less than ninety-six square inches (96 sq. in.).

TABLE NO. 26-C—MINIMUM THICKNESS OR DEPTH OF FLEXURAL MEMBERS UNLESS DEFLECTIONS ARE COMPUTED

	MINIMUM THICKNESS OR DEPTH "t"			
MEMBER	SIMPLY SUPPORTED	ONE END CONTINUOUS	BOTH ENDS CONTINUOUS	CANTILEVER
One-way slabs	$l/25$	$l/30$	$l/35$	$l/12$
Beams	$l/20$	$l/23$	$l/26$	$l/10$

Design—General Considerations (Continued)

2. **Isolated column with multiple spirals.** If two or more interlocking spirals are used in a column, the outer boundary of the column shall be taken at a distance outside the extreme limits of the spiral equal to the requirements of Section 2608 (h).

3. **Limits of section of column built monolithically with wall.** For a spiral column built monolithically with a concrete wall or pier, the outer boundary of the column section shall be taken either as a circle at least one and one-half inches (1½") outside the column spiral or as a square or rectangle, the sides of which are at least one and one-half inches (1½") outside the spiral or spirals.

4. **Equivalent circular columns.** As an exception to the general procedure of utilizing the full gross area of the column section, it shall be permissible to design a circular column and to build it with a square, octagonal, or other shaped section of the same least lateral dimension. In such case, the allowable load, the gross area considered, and the required percentages of reinforcement shall be taken as those of the circular column.

5. **Limits of column section.** In a tied column which has a larger cross section than required by considerations of loading, a reduced effective area, "A_g", not less than one-half of the total area may be used for determining minimum steel area and load capacity.

(l) **Limits for Reinforcement of Columns.** The vertical reinforcement for columns shall be not less than 0.01 nor more than 0.08 times the gross cross-sectional area. The minimum size of bar shall be No. 5. The minimum number of bars shall be six for spiral columns and four for tied columns.

The ratio of spiral reinforcement, "p_s", shall be not less than the value given by

$$p_s = 0.45\,(A_g/A_c - 1)\,f_c'/f_y \quad \text{.............(9-1)}$$

WHERE:

f_y = the yield strength of spiral reinforcement but not more than 60,000 pounds per square inch.

(m) **Bending Moments in Columns.** Columns shall be designed to resist the axial forces from loads on all floors, plus the maximum bending due to loads on a single adjacent span of the floor under consideration. Account shall also be taken of the loading condition giving the maximum ratio of bending moment to axial load. In building frames, particular attention shall be given to the effect of unbalanced floor loads on both exterior and interior columns and of eccentric loading due to other causes. In computing moments in columns due to gravity loading, the far ends of columns which are monolithic with the structure may be considered fixed.

Design—General Considerations (Continued)

Resistance to bending moments at any floor level shall be provided by distributing the moment between the columns immediately above and below the given floor in proportion to their relative stiffnesses and conditions of restraint.

(n) **Length of Columns.** For purposes of determining the limiting dimensions of columns, the unsupported length of reinforced concrete columns shall be taken as the clear distance between floor slabs, except as follows:

1. In flat slab construction, it shall be the clear distance between the floor and the lower extremity of the capital, the drop panel or the slab, whichever is least.

2. In beam and slab construction, it shall be the clear distance between the floor and the underside of the deeper beam framing into the column in each direction at the next higher floor level.

3. In columns restrained laterally by struts, it shall be the clear distance between consecutive struts in each vertical plane; provided that to be an adequate support, two such struts shall meet the column at approximately the same level, and the angle between vertical planes through the struts shall vary not more than 15 degrees from a right angle. Such struts shall be of adequate dimensions and anchorage to restrain the column against lateral deflection.

4. In columns restrained laterally by struts or beams, with brackets used at the junction, it shall be the clear distance between the floor and the lower edge of the bracket, provided that the bracket width equals that of the beam or strut and is at least one-half that of the column.

For rectangular columns, that length shall be considered which produces the greatest ratio of length to radius of gyration of section.

The effective length, "h'", of columns in structures where lateral stability or resistance to lateral forces is provided by shear walls or rigid bracing, by fastening to an adjoining structure of sufficient lateral stability, or by any other means that affords adequate lateral support, shall be taken as the unbraced length, "h".

Larger effective lengths, "h'" shall be used for all columns in structures which depend upon the column stiffness for lateral stability as follows:

1. The end of a column shall be considered hinged in a plane if in that plane "r'" exceeds 25.
2. For columns restrained against rotation at one end and hinged at the other end the effective length shall be taken as:

$$h' = 2h\ (0.78 + 0.22r') \geqq 2h$$

WHERE:

r' = the value at the restrained end.

3. For columns restrained against rotation at both ends the effective length "h'" shall be taken as

Design—General Considerations (Continued)

$$h' = h\ (0.78 + 0.22r') \geqq h$$

WHERE:

r' = the average of the values at the two ends of the column.

4. For cantilever columns, that is, those fixed at one end and free at the other, the effective length "h'" shall be taken as twice the over-all length.

(o) **Strength Reductions for Length of Compression Members. 1. When compression governs.** When compression governs the design of the section, the axial load and moment computed from the analysis shall be divided by the appropriate factor "R" as given in Formula (9-2), (9-3), (9-4) or (9-5) below, and the design shall be made using the appropriate formulas for short members in Sections 2614 and 2619.

A. If relative lateral displacement of the ends of the member is prevented and the ends of the member are fixed or definitely restrained such that a point of contraflexure occurs between the ends, no correction for length shall be made unless "h/r" exceeds 60. For "h/r" between 60 and 100, the design shall be based on an analysis according to paragraph 4 of this Subsection or the following factor shall be used

$$R = 1.32 - 0.006\frac{h}{r} \leqq 1.0 \qquad (9\text{-}2)$$

If "h/r" exceeds 100, an analysis according to paragraph 4 shall be made.

B. If relative lateral displacement of the ends of the member is prevented and the member is bent in single curvature, the following factor shall be used

$$R = 1.07 - 0.008\frac{h}{r} \leqq 1.0 \qquad (9\text{-}3)$$

C. The design of restrained members for which relative lateral displacement of the ends is not prevented shall be made using the factor given in Formula (9-4); that is, with the effective length "h'" from Section 2609 (n) substituted for "h".

$$R = 1.07 - 0.008\frac{h'}{r} \leqq 1.0 \qquad (9\text{-}4)$$

When the design is governed by lateral loads of short duration, such as wind or earthquake loading, the factor "R" may be increased by 10 per cent, which is equivalent to using

Design— General Considerations (Continued)

$$R = 1.18 - 0.009\frac{h'}{r} \leqq 1.0 \qquad (9\text{-}5)$$

D. The radius of gyration, "r", may be taken equal to 0.30 times the over-all depth in the direction of bending for a rectangular column and 0.25 times the diameter of circular columns. For other shapes "r" may be computed for the gross concrete section.

2. **When tension governs.** When tension governs the design of the section, the axial load and moment computed from the analysis shall be increased as required in 1. above except that the factor "R" shall be considered to vary linearly with axial load from the values given by Formula (9-2), (9-3), (9-4) or (9-5) at the balanced condition [as defined in Section 2614 (h) or 2619] to a value of 1.0 when the axial load is zero.

3. **When minimum eccentricity governs.** When a column design is governed by the minimum eccentricities specified for ultimate strength design in Section 2619 (b) the effect of length on column strength shall be determined in one of the following ways:

A. Where the actual computed eccentricities at both ends are less than the specified minimum eccentricity, the strength reduction for length shall correspond to the actual conditions of curvature and end restraint.

B. If column moments have not been considered in the design of the column or if computations show that there is no eccentricity at one or both ends of the column, the factor from Formula (9-3) shall be used.

4. **Alternate design.** In lieu of other requirements of this Section, an analysis may be made taking into account the effect of additional deflections on moments in columns.

In such an analysis a reduced modulus of elasticity, not greater than one-third the value specified in Section 2611 (c) shall be used in calculations of deflections caused by sustained loads.

(p) **Transmission of Column Load Through Floor System.** When the specified strength of concrete in columns exceeds that specified for the floor system by more than 40 per cent, proper transmission of load through the weaker concrete shall be provided by one of the following:

1. Concrete of the strength specified for the column shall be placed in the floor for an area four times "A_g", about the column, well-integrated into floor concrete, and placed in accordance with Section 2607 (d).

2. The capacity of the column through the floor system shall be computed using the weaker concrete strength and adding vertical dowels and spirals as required.

Design—General Considerations (Continued)

3. For columns laterally supported on four sides by beams of approximately equal depth or by slabs, the capacity may be computed by using an assumed concrete strength in the column formulas equal to 75 per cent of the column concrete strength plus 35 per cent of the floor concrete strength.

(q) **Anchorage Requirements—General.** The calculated tension or compression in any bar at any section must be developed on each side of that section by proper embedment length, end anchorage, or hooks. A tension bar may be anchored by bending it across the web at an angle of not less than 15 degrees with the longitudinal portion of the bar and making it continuous with the reinforcement on the opposite face of the member.

Except at supports, every reinforcing bar shall be extended beyond the point at which it is no longer needed to resist flexural stress, for a distance equal to the effective depth of the member or 12 bar diameters, whichever is greater.

No flexural bar shall be terminated in a tension zone unless one of the following conditions is satisfied:

1. The shear is not over one-half that normally permitted, including allowance for shear reinforcement, if any.

2. Stirrups in excess of those normally required are provided each way from the cutoff a distance equal to three-fourths of the depth of the beam. The excess stirrups shall be at least the minimum specified in Section 2612 (g) or 2617 (g). The stirrup spacing shall not exceed $d/8r_b$ where "r_b" is the ratio of the area of bars cut off to the total area of bars at the section.

3. The continuing bars provide double the area required for flexure at that point or double the perimeter required for flexural bond.

Tensile negative reinforcement in any span of a continuous, restrained or cantilever beam, or in any member of a rigid frame shall be adequately anchored by bond, hooks, or mechanical anchors in or through the supporting member.

At least one-third of the total reinforcement provided for negative moment at the support shall be extended beyond the extreme position of the point of inflection a distance not less than one-sixteenth of the clear span, or the effective depth of the member, whichever is greater.

At least one-third the positive moment reinforcement in simple beams and one-fourth the positive moment reinforcement in continuous beams shall extend along the same face of the beam into the support at least six inches (6").

Plain bars (as defined in Section 2603) in tension, except bars for shrinkage and temperature reinforcement, shall terminate in standard hooks except that hooks shall not be required on the positive reinforcement at interior supports of continuous members.

Design—General Considerations (Continued)

Standard hooks [Section 2608 (a)] in tension may be considered as developing 10,000 pounds per square inch in Sections 2610 and 2614 or 19,000 pounds per square inch in Sections 2615 to 2619 in the bars or may be considered as extensions of the bars at appropriate bond stresses.

Hooks shall not be considered effective in adding to the compressive resistance of bars.

Any mechanical device capable of developing the strength of the bar without damage to the concrete may be used in lieu of a hook. Test results showing the adequacy of such devices must be presented.

(r) **Anchorage of Web Reinforcement.** The ends of bars forming simple U- or multiple U-stirrups shall be anchored by one of the following methods:

1. By a standard hook, considered as developing 50 per cent of the allowable stress in the bar, plus embedment sufficient to develop by bond the remaining stress in the bar, in conformance with Sections 2613 and 2618. The effective embedment of a stirrup leg shall be taken as the distance between the mid-depth of the member, $d/2$, and the center of radius of bend of the hook.
2. Welding to longitudinal reinforcement.
3. Bending tightly around the longitudinal reinforcement through at least 180 degrees.
4. Embedment above or below the mid-depth, $d/2$, of the beam on the compression side, a distance sufficient to develop by bond the stress to which the bar will be subjected, at the bond stresses permitted by Sections 2613 (b) and 2618 (b) but, in any case, a minimum of 24 bar diameters.

Between the anchored ends, each bend in the continuous portion of a simple U- or multiple U-stirrup shall be made around a longitudinal bar.

Hooking or bending stirrups around the longitudinal reinforcement shall be considered effective only when these bars are perpendicular to the longitudinal reinforcement or make an angle of at least 45 degrees with deformed longitudinal bars.

Longitudinal bars bent to act as web reinforcement shall, in a region of tension, be continuous with the longitudinal reinforcement and in a compression zone shall be anchored as specified above in Item 1 or 4.

In all cases web reinforcement shall be carried as close to the compression surface of the beam as fireproofing regulations and the proximity of other steel will permit.

(s) **Transfer of Moments and Effect of Openings in Slabs and Footings.** When unbalanced gravity load, wind or earthquake cause transfer of bending moment between column and slab, the additional shears on the critical section shall be investigated by a rational analysis.

Design—General Considerations (Continued)

When openings in slabs are located at a distance less than 10 times the thickness of the slab from a concentrated load or reaction or when openings in flat slabs are located within the column strips as defined in Section 2621 (b), that part of the periphery of the critical section for shear which is covered by radial projections of the openings to the centroid of the loaded area shall be considered ineffective.

(t) **Torsion.** In edge or spandrel beams, the stirrups provided shall be closed and at least one longitudinal bar shall be placed in each corner of the beam section, the bar to be at least the diameter of the stirrup or one-half inch (½"), whichever is larger.

Allowable Stresses—Working Stress Design

Sec. 2610. (a) **Notations.** The notations used in these regulations are defined as follows:

f_c = compressive stress in concrete.
f_c' = compressive strength of concrete (see Section 2603).
n = ratio of modulus of elasticity of steel to that of concrete.
v = shear stress.
v_c = shear stress carried by the concrete.
w = weight of concrete, pounds per cubic foot.

(b) **General.** For structures to be designed with reference to allowable stresses, service loads, and the accepted straight-line theory of stress and strain in flexure, the allowable stresses of this Chapter shall be used, and designs shall conform to all provisions of this Code except Sections 2615 to 2619.

(c) **Allowable Stresses in Concrete.** The stresses for flexure and bearing on all concrete designed in accordance with Sections 2610 to 2614 shall not exceed the values set forth in Table No. 26-D.

The stresses for shear shall not exceed those set forth in Table No. 26-D except as specified in Section 2612.

The allowable stresses for bond shall not exceed those specified in Section 2613.

(d) **Allowable Stresses in Reinforcement.** Unless otherwise provided in this Code, steel for concrete reinforcement shall not be stressed in excess of the following limits:

In tension:

For billet-steel or axle-steel concrete reinforcing bars of structural grade........................18,000 p.s.i.

For main reinforcement, three-eighths inch (⅜") or less diameter, in one-way slabs of not more than twelve-foot (12') span, 50 per cent of the minimum yield strength specified in the U.B.C. Standards for the

TABLE NO. 26-D—ALLOWABLE STRESSES IN CONCRETE

DESCRIPTION		ALLOWABLE STRESSES					
		FOR ANY STRENGTH OF CONCRETE IN ACCORDANCE WITH SECTION 2605 (c)	FOR STRENGTH OF CONCRETE SHOWN BELOW				
			$f_c' =$ 2000 P.S.I.	$f_c' =$ 2500 P.S.I.	$f_c' =$ 3000 P.S.I.	$f_c' =$ 4000 P.S.I.	$f_c' =$ 5000 P.S.I.
Modulus of elasticity ratio: n		$\frac{29{,}000{,}000}{w^{1.5}33\sqrt{f_c'}}$					
For concrete weighing 145 lb. per cu. ft. [See Section 2611 (c)]	n		11	10	9	8	7
Flexure: f_c							
Extreme fiber stress in compression	f_c	$0.45f_c'$	900	1125	1350	1800	2250
Extreme fiber stress in tension in plain concrete footings and walls	f_c	$1.6\sqrt{f_c'}$	71	80	88	102	113

Shear: v (as a measure of diagonal tension at a distance "d" from the face of the support)							
Beams with no web reinforcement[1]	v_c	$1.1\sqrt{f_c'}$	49[1]	55[1]	60[1]	70[1]	78[1]
Joists with no web reinforcement	v_c	$1.2\sqrt{f_c'}$	54	61	66	77	86
Members with vertical or inclined web reinforcement or properly combined bent bars and vertical stirrups	v	$5\sqrt{f_c'}$	223	250	274	316	354
Slabs and footings [peripheral shear, Section 2612 (h)][1]	v_c	$2\sqrt{f_c'}$	89[1]	100[1]	110[1]	126[1]	141[1]
Shear in Walls:[2]							
Shear carried by concrete[3]							
$H/D \leq 1$	v_c	$3\sqrt{f_c'}$	134	150	164	190	212
$H/D \geq 2.7$	v_c	$1.1\sqrt{f_c'}$	49	55	60	70	78
Shear carried by concrete and reinforcement[4]							
$H/D \leq 1$	v	$3\sqrt{f_c'}$	134	150	164	190	212
$H/D \geq 2$	v	$5\sqrt{f_c'}$	223	250	274	316	354
Bearing: f_c							
On full area		$0.25f_c'$	500	625	750	1000	1250
On one-third area or less[5]		$0.375f_c'$	750	938	1125	1500	1875

[1]For shear values for lightweight aggregate concrete see Section 2612 (i).
[2]For earthquake resisting shear walls these values must be modified in accordance with Section 2632.
[3]For values between "H/D" of 1.0 and 2.7, the allowable shear varies linearly. For lightweight concrete multiply tabulated values by .15 F_{sp}.
[4]For values between "H/D" of 1.0 and 2.0, the allowable shear varies linearly.
[5]This increase shall be permitted only when the least distance between the edges of the loaded and unloaded areas is a minimum of one-fourth of the parallel side dimension of the loaded area. The allowable bearing stress on a reasonably concentric area greater than one-third but less than the full area shall be interpolated between the values given.

Allowable Stresses—Working Stress Design (Continued)

particular kind and grade of steel used, but not to exceed .... 30,000 p.s.i.
For deformed bars with a yield strength of 60,000 p.s.i. or more and in sizes No. 11 and smaller .... 24,000 p.s.i.
Cold drawn steel wire in welded wire fabric reinforcement .... 30,000 p.s.i.
For all other reinforcement .... 20,000 p.s.i.

In compression, vertical column reinforcement
Spiral columns, 40 per cent of the minimum yield strength, but not to exceed .... 30,000 p.s.i.
Tied columns, 85 per cent of the value for spiral columns, but not to exceed .... 25,500 p.s.i.
Composite and combination columns:
Structural steel sections
Steel with minimum yield strength of 36,000 p.s.i. .... 18,000 p.s.i.
Steel with minimum yield strength of 33,000 p.s.i. .... 16,000 p.s.i.
Cast iron sections .... 10,000 p.s.i.
Steel pipe .... see limitations of Section 2614 (g)

In compression, flexural members
For compression in flexural members see Section 2611 (c).

Spirals [yield strength for use in Formula (9-1)]
Hot rolled rods, intermediate grade .... 40,000 p.s.i.
Hot rolled rods, hard grade .... 50,000 p.s.i.
Hot rolled rods of minimum yield strength of 60,000 p.s.i., and cold-drawn wire .... 60,000 p.s.i.

Flexural Computations—Working Stress—Design

Sec. 2611. (a) **Notations.** The notations used in these regulations are defined as follows:

E_c = modulus of elasticity of concrete [see Section 2611 (c)].

E_s = modulus of elasticity of steel.

f_c' = compressive strength of concrete (see Section 2603).

n = ratio of modulus of elasticity of steel to that of concrete.

w = weight of concrete, pounds per cubic foot.

(b) **Design Assumptions.** In the design of reinforced concrete structures by the working stress design method, the following assumptions shall be made:

1. A section plane before bending remains plane after bending; stains vary as the distance from the neutral axis.

2. The stress-strain relation for concrete is a straight line under service loads within the allowable working stresses. Stresses vary as the distance from the neutral axis except for deep beams [Section 2609 (k)].

3. The steel takes all the tension due to flexure.
4. The tension reinforcement is replaced in design computations with a concrete tension area equal to "n" times that of the reinforcing steel.

Flexural Computations—Working Stress—Design (Continued)

(c) **Modulus of Elasticity of Concrete.** The modulus of elasticity, "E_c", for concrete may be taken as $w^{1.5}33\sqrt{f_c'}$, in pounds per square inch, for values of "w" between 90 and 155 pounds per cubic foot. For normal weight concrete, "w" may be considered as 145 pounds per cubic foot.

The modular ratio:

$$n = E_s/E_c$$

may be taken as the nearest whole number (but not less than six). Except in calculations for deflections, the value of "n" for lightweight concrete shall be assumed to be the same for normal weight concrete of the same strength.

In beams and slabs with compressive reinforcement an effective modular ratio of $2n$ shall be used to transform the compression reinforcement and compute its stress, which shall not be taken as greater than the allowable tensile stress.

(d) **Modulus of Elasticity of Steel.** The modulus of elasticity of steel reinforcement may be taken as 29,000,000 pounds per square inch.

Shear and Diagonal Tension—Working Stress Design

Section 2612. (a) **Notations.** The notations used in these regulations are defined as follows:

A_g = gross area of section.
A_s = area of tension reinforcement.
A_v = total area of web reinforcement in tension within a distance, "s", measured in a direction parallel to the longitudinal reinforcement.
a = angle between inclined web bars and logitudinal axis of member.
b = width of compression face of flexural member.
b' = width of web in I- and T-sections.
b_o = periphery of critical section for slabs and footings.
d = distance from extreme compression fiber to centroid of tension reinforcement.
f_c' = compressive strength of concrete (see Section 2603).
f_v = tensile stress in web reinforcement.
F_{sp} = ratio of splitting tensile strength to the square root of compressive strength [see Section 2605 (f)].
M = bending moment.
M' = modified bending moment.
N = load normal to the cross section, to be taken as positive for compression, negative for tension, and to include the effects of tension due to shrinkage and creep.
p_w = $A_s/b'd$.

Shear and Diagonal Tension—Working Stress Design (Continued)

s = spacing of stirrups or bent bars in a direction parallel to the logitudinal reinforcement.
t = total depth of section.
v = shear stress.
v_c = shear stress carried by concrete.
V = total shear.
V' = shear carried by web reinforcement.

(b) **Shear Stress**[1]. The nominal shear stress, as a measure of diagonal tension, in reinforced concrete members shall be computed by:

$$v = V/bd \qquad \text{(12-1)}$$

For design, the maximum shear shall be considered as that at the section a distance, "*d*" from the face of the support.[2] Wherever applicable, effects of torsion shall be added and effects of inclined flexural compression in variable-depth members shall be included.

For beams of I- or T-section, "*b*'" shall be substituted for "*b*" in Formula (12-1).

The shear stress, "v_c", permitted on an unreinforced web shall not exceed $1.1\sqrt{f_c'}$ at a distance "*d*" from the face of the support unless a more detailed analysis is made in accordance with this Subsection. The shear stresses at sections between the face of the support and the section a distance "*d*" therefrom shall not be considered critical[2]. For members with axial tension, "v_c" shall not exceed the value given in the fifth paragraph of this Subsection.

The shear stress permitted on an unreinforced web shall not exceed that given by:

$$v_c = \sqrt{f_c'} + 1300 \frac{p_w V d}{M} \qquad \text{(12-2)}$$

but not to exceed $1.75\sqrt{f_c'}$. The shear stresses at sections between the face of the support and the section a distance "*d*" therefrom shall not be considered critical[2]. "*V*" and "*M*" are the shear and bending moment at the section considered, but "*M*" shall be not less than "*Vd*".

For members subjected to axial load in addition to shear and flexure, Formula (12-2) shall apply except that "*M*'" shall be substituted for "*M*"

WHERE:

$$M' = M - N \frac{(4t - d)}{8} \qquad \text{(12-3)}$$

and "v_c" shall not exceed

$$v_c = 1.75 \sqrt{f_c' (1 + 0.004\, N/A_g)} \qquad \text{(12-4)}$$

[1]Special provisions for lightweight aggregate concretes are given in Section 2612 (i).
[2]This provision does not apply to brackets and other short cantilevers.

When all longitudinal reinforcement at a section acts in compression, use Formula (12-4). [See Section 2612 (i) for Lightweight Aggregate Concretes.]

Shear and Diagonal Tension—Working Stress Design (Continued)

(c) **Web Reinforcement.** Wherever the value of the shear stress, "v", computed by Formula (12-1), plus effects of torsion, exceeds the shear stress, "v_c", permitted for the concrete of an unreinforced web by Section 2612 (b), web reinforcement shall be provided to carry the excess. Such web reinforcement shall also be provided for a distance equal to the depth, "d", of the member beyond the point theoretically required. Web reinforcement between the face of the support and the section at a distance "d" therefrom shall be the same as required at that section.

Web reinforcement may consist of the following:

1. Stirrups perpendicular to the longitudinal reinforcement.
2. Stirrups making an angle of 45 degrees or more with the longitudinal tension reinforcement.
3. Longitudinal bars bent so that the axis of the bent bar makes on angle of 30 degrees or more with the axis of the longitudinal portion of the bar.
4. Combinations of (1) or (2) with (3).

Stirrups or other bars to be considered effective as web reinforcement shall be anchored at both ends according to the provisions of Section 2609 (t).

(d) **Stirrups.** The area of steel required in stirrups placed perpendicular to the longitudinal reinforcement shall be computed by:

$$A_v = V's/f_v d \quad \text{.........................} (12\text{-}5)$$

The area of inclined stirrups shall be computed by Formula (12-7).

(e) **Bent Bars.** Only the center three-fourths of the inclined portion of any longitudinal bar that is bent up for web reinforcement shall be considered effective for that purpose.

When the web reinforcement consists of a single bent bar or of a single group of parallel bars all bent up at the same distance from the support, the required area shall be computed by:

$$A_v = \frac{V'}{f_v \sin \alpha} \quad \text{.......................} (12\text{-}6)$$

WHERE:

V' shall not exceed $1.5\, bd \sqrt{f_c'}$.

Where there is a series of parallel bars or groups of bars bent up at different distances from the support, the required area shall be computed by:

$$A_v = \frac{V's}{f_v d\, (\sin \alpha + \cos \alpha)} \quad \text{.............} (12\text{-}7)$$

Shear and Diagonal Tension—Working *Stress Design* (Continued)

Bent bars used alone as web reinforcement shall be so spaced that the effective inclined portion defined in this Subsection meets the requirements of Section 2612 (g).

Where more than one type of web reinforcement is used to reinforce the same portion of the web, the total shear resistance shall be computed as the sum of the resistances computed for the various types separately. In such computations, the resistance of the concrete, "v_c", shall be included only once, and no one type of reinforcement shall be assumed to resist more than $2V'/3$.

(f) **Stress Restrictions.** The tensile stress in web reinforcement, "f_v", shall not exceed the values given in Section 2610 (d).

The shear stress, "v", shall not exceed $5\sqrt{f_c'}$ in sections with web reinforcement.

(g) **Web Reinforcement Restrictions.** Where web reinforcement is required, it shall be so spaced that every 45-degree line, representing a potential diagonal crack and extending from mid-depth, $d/2$, of the member to the longitudinal tension bars, shall be crossed by at least one line of web reinforcement. When the shear stress exceeds $3\sqrt{f_c'}$, every such 45-degree line shall be crossed by at least two lines of web reinforcement.

Where web reinforcement is required, its area shall be not less than 0.15 per cent of the area, "bs", computed as the product of the width of the web and the spacing of the web reinforcement along the longitudinal axis of the member.

(h) **Shear Stress in Slabs and Footings**[1]. The shear capacity of slabs and footings in the vicinity of concentrated loads or concentrated reactions shall be governed by the more severe of the two following conditions:

1. The slab or footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width. This case shall be considered in accordance with Section 2612 (b).

2. Two-way action existing for the slab or footing, with potential diagonal cracking along the surface of a truncated cone or pyramid around the concentrated load or reaction. The slab or footing in this case shall be designed as required in the remainder of this Section.

The critical section for shear to be used as a measure of diagonal tension shall be perpendicular to the plane of the slab and located at a distance $d/2$ out from the periphery of the concentrated load or reaction area.

The nominal shear stress shall be computed by formula:

$$v = V/b_o d \quad \text{.................} (12\text{-}8)$$

[1]For transfer of moments and effects of openings see Section 2609 (s).

where "V" and "b_o" are taken at the critical section specified in this Subsection. The shear stress, "v", so computed shall not exceed $2\sqrt{f_c'}$, unless shear reinforcement is provided in accordance with the following paragraph, in which case "v" *shall not* exceed $3\sqrt{f_c'}$.

Shear and Diagonal Tension—Working Stress Design (Continued)

When "v" exceeds $2\sqrt{f_c'}$, shear reinforcement shall be provided in accordance with Sections 2612 (c) to 2612 (g), except that the allowable stress in shear reinforcement shall be 50 per cent of that prescribed in Section 2610 (d). Shear reinforcement consisting of bars, rods or wire shall not be considered effective in members with a total thickness of less than ten inches (10″).

(i) **Lightweight Aggregate Concretes.** When structural lightweight aggregate concretes are used, the provisions of this Chapter shall apply with the following modifications:

1. The shear stress "v_c", permitted on an unreinforced web in Section 2612 (b) shall be

$$0.17\, F_{sp} \sqrt{f_c'} \quad \text{(12-9)}$$

2. Formula (12-2) shall be replaced by:

$$v_c = 0.15\, F_{sp} \sqrt{f_c'} + 1300 \frac{p_w V d}{M} \quad \text{(12-10)}$$

3. The limiting value for shear stress in slabs and footings, "v_c", in Section 2612 (h) shall be:

$$0.3 F_{sp} \sqrt{f_c'} \quad \text{(12-11)}$$

The value of "F_{sp}" shall be 4.0 unless determined in accordance with Section 2605 (f) for the particular aggregate to be used.

(j) **Shear Walls.** Shear stresses in shear walls shall be limited in accordance with the following:

1. The shear stress carried by the concrete in a shear wall shall not exceed

$$v_c = \left(3.7 - \frac{H}{D}\right) 1.1 \sqrt{f'_c} \quad \text{(12-12)}$$

where "H" is the total height to which the shear wall extends in the structure, and "D" is the width of the wall in the direction of the shear force.

2. The maximum value for "v_c" shall not exceed $3\sqrt{f'_c}$ for "H/D" ratios less than one and the minimum value shall be not less than $1.1\sqrt{f'_c}$ for "H/D" ratios greater than 2.7.

3. The area of reinforcement required in the horizontal direction shall be computed by

Shear and Diagonal Tension—Working Stress Design (Continued)

$$A_v = \frac{V'_s}{f_v d\left(\frac{H}{D} - 1\right)} \qquad \text{(12-13)}$$

but in no case shall the reinforcement be less than required in Section 2622 or Formula (12-5).

4. The shear stress "v" shall not exceed

$$v = \left(1 + 2\frac{H}{D}\right)\sqrt{f'_c} \qquad \text{(12-14)}$$

5. The maximum value for "v" shall not exceed $5\sqrt{f'_c}$ for "H/D" ratios greater than two and the minimum value shall be not less than $3\sqrt{f'_c}$ for "H/D" ratios less than one.

6. When structural lightweight concretes are used, the limiting value of "v_c" shall be 0.15 F_{sp} times the values in Section 2612 (j) 1 and 2.

Bond and Anchorage—Working Stress Design

Sec. 2613. (a) **Notations.** The notations used in these regulations are defined as follows:

d = distance from extreme compression fiber to centroid of tension reinforcement.

D = nominal diameter of bar, inches.

f_c' = compressive strength of concrete (see Section 2603).

j = ratio of distance between centroid of compression and controid of tension to the depth, "d".

Σo = sum of perimeters of all effective bars crossing the section on the tension side if of uniform size; for mixed sizes, substitute $4A_s/D$, where "A_s" is the total steel area and "D" is the largest bar diameter.

= For bundled bars use the sum of the exposed portions of the perimeters.

u = bond stress.

V = total sheer.

(b) **Computation of Bond Stress in Flexural Members.** In flexural members in which the tension reinforcement is parallel to the compression face, the flexural bond stress at any cross section shall be computed by

$$u = \frac{V}{\Sigma o j d} \qquad \text{(13-1)}$$

Bent-up bars that are not more than $d/3$ from the level of the main longitudinal reinforcement may be included. Critical sections occur at the face of the support, at each point where tension bars terminate within a span, and at the point of inflection.

To prevent bond failure or splitting, the calculated tension or compression in any bar at any section must be developed on each side of that section by proper embedment length,

Bond and Anchorage—Working Stress Design (Continued)

end anchorage, or, for tension only, hooks. Anchorage or development bond stress, "u", shall be computed as the bar forces divided by the product of "Σo" times the embedment length.

The bond stress, "u", computed as in the preceding paragraphs shall not exceed the limits given below, except that flexural bond stress need not be considered in compression, nor in those cases of tension where anchorage bond is less than 0.8 of the permissible.

1. For tension bars with sizes and deformations conforming to U.B.C. Standard No. 26-7-67, Section 26.703 (a), except for those designated as Special Large Size Deformed Reinforcing Bars:

Top bars[1] $\dfrac{3.4\sqrt{f_c'}}{D}$ nor 350 p.s.i.

Bars other than top bars $\dfrac{4.8\sqrt{f_c'}}{D}$ nor 500 p.s.i.

2. For tension bars designated as Special Large Size Deformed Reinforcing Bars in U.B.C. Standard No. 26-7-67:

Top bars[1] $2.1\sqrt{f_c'}$

Bars other than top bars $3\sqrt{f_c'}$

3. For all deformed compression bars:

$6.5\sqrt{f_c'}$ nor 400 p.s.i.

4. For plain bars with allowable bond stresses shall be one-half of those permitted for bars conforming to U.B.C. Standard No. 26-7-67, Section 26.703 but not more than 160 pounds per square inch.

Adequate anchorage shall be provided for the tension reinforcement in all flexural members to which Formula (13-1) does not apply, such as sloped, stepped or tapered footings, brackets, or beams in which the tension reinforcement is not parallel to the compression face.

Reinforced Concrete Columns—Working Stress Design

Sec. 2614. (a) **Notations.** The notations used in these regulations are defined as follows:

A_c = area of concrete within a pipe column.

A_g = gross area of spirally reinforced or tied column.
= the total area of the concrete encasement of combination column.
= area of concrete of a composite column.

A_r = area of steel or cast-iron core of a composite, combination, or pipe column.

A_s = area of tension reinforcement.

A_{st} = total area of longitudinal reinforcement.

b = width of compression face of flexural member.

d = distance from extreme compression fiber to centroid of tension reinforcement.

[1]Top bars, in reference to bond, are horizontal bars so placed that more than twelve inches (12") of concrete is cast in the member below the bar.

Reinforced Concrete Columns—Working Stress Design (Continued)

d' = distance from extreme compression fiber to centroid of compression reinforcement.
D_s = diameter of circle through centers of the longitudinal reinforcement in spiral columns.
e = eccentricity of the resultant load on a column, measured from the gravity axis.
e_b = maximum permissible eccentricity of "N_b".
F_b = allowable bending stress that would be permitted for bending alone.
f_a = axial load divided by area of member, "A_g".
f_c' = compressive strength of concrete (see Section 2603).
f_r = allowable stress in the metal core of a composite column.
f_r' = allowable stress on unencased metal columns and pipe columns.
f_s = allowable stress in column vertical reinforcement.
f_y = yield strength of reinforcement (see Section 2603).
h = unsupported length of column.
j = ratio of distance between centroid of compression and centroid of tension to the depth, "d".
K_c = radius of gyration of concrete in pipe columns.
K_s = radius of gyration of metal pipe in pipe columns.
m = $f_y / 0.85 f_c'$.
n = ratio of modulus of elasticity of steel to that of concrete.
N = eccentric load normal to the cross section of a column.
N_b = the value of "N" below which the allowable eccentricity is controlled by tension, and above which by compression.
p = ratio of area of tension reinforcement to effective area of concrete.
p' = ratio of area of compression reinforcement to effective area of concrete.
p_g = ratio of area of vertical reinforcement to the gross area, "A_g".
P = allowable axial load on a reinforced concrete column without reduction for length or eccentricity.
= allowable axial load on combination, composite, or pipe column without reduction for eccentricity.
t = over-all depth of rectangular column or the diameter of a round column.

(b) **Limiting Dimensions.** The loads determined by the provisions of this Chapter apply only when unsupported length reductions are not required by the provision of Sections 2609 (n) and 2609 (o). [See Section 2609 (k) for minimum size.]

Reinforced Concrete Columns—Working Stress Design (Continued)

(c) **Spirally Reinforced Columns.** The maximum allowable axial load, "P", on columns with closely spaced spirals [see Section 2609 (l)] enclosing a circular core reinforced with vertical bars shall be that given by

$$P = A_g\ (0.25\, f_c' + f_s p_g) \qquad \text{(14-1)}$$

where "f_s" equals allowable stress in vertical column reinforcement, to be taken at 40 per cent of the minimum specification value of the yield strength, but not to exceed 30,000 pounds per square inch.

(d) **Tied Columns.** The maximum allowable axial load on columns reinforced with longitudinal bars and separate lateral ties shall be 85 per cent of that given by Formula (14-1).

(e) **Composite Columns.** The allowable load on a composite column, consisting of a structural steel or cast-iron column thoroughly encased in concrete reinforced with both longitudinal and spiral reinforcement, shall not exceed that given by

$$P = 0.225\, A_g f_c' + f_s A_{st} + f_r A_r \qquad \text{(14-2)}$$

where "f_r" equals allowable unit stress in metal core, not to exceed 18,000 pounds per square inch for steel with a minimum yield strength of 36,000 pounds per square inch, 16,000 for steel with a minimum yield strength of 33,000 pounds per square inch, or 10,000 pounds per square inch for a cast-iron core.

The column as a whole shall satisfy the requirements of Formula (14-2) at any point. The reinforced concrete portion shall be designed to carry all loads imposed between metal core brackets or connections at a stress of not more than 0.35 "f_c'" based on an area of "A_g".

Metal core and reinforcement. The cross-sectional area of the metal core shall not exceed 20 per cent of the gross area of the column. If a hollow metal core is used it shall be filled with concrete. The amounts of longitudinal reinforcement and the requirements as to spacing of bars, details of splices and thickness of protective shell outside the spiral shall conform to the limiting values specified for a spiral column of the same over-all dimensions. Spiral reinforcement shall conform to Formula (9-1). A clearance of at least three inches (3″) shall be maintained between the spiral and the metal core at all points except that when the core consists of a structural steel H-column, the minimum clearance may be reduced to two inches (2″).

Transfer of loads to the metal core shall be provided for by the use of bearing members such as billets, brackets, or other positive connections; these shall be provided at the top of the metal core and at intermediate floor levels where required.

Reinforced Concrete Columns—Working Stress Design (Continued)

The metal cores shall be designed to carry safely any construction or other loads to be placed upon them prior to their encasement in concrete.

(f) **Combination Columns. Steel Columns Encased in Concrete.** The allowable load on a structural steel column which is encased in concrete at least two and one-half inches (2½") thick over all metal (except rivet heads), reinforced as hereinafter specified, shall be computed by.

$$P = A_r f_r' \left[1 + \frac{A_g}{100 A_r} \right] \text{..................} (14\text{-}3)$$

The concrete used shall develop a compressive strength, "f_c'", of at least 2500 pounds per square inch at 28 days. The concrete shall be reinforced by the equivalent of welded wire fabric having wires of No. 10 A S & W gauge, the wires encircling the column being spaced not more than four inches (4") apart and those parallel to the column axis not more than eight inches (8") apart. This fabric shall extend entirely around the column at a distance of one inch (1") inside the outer concrete surface and shall be lap-spliced at least 40 wire diameters and wired at the splice. Special brackets shall be used to receive the entire floor load at each floor level. The steel column shall be designed to carry safely any construction or other loads to be placed upon it prior to its encasement in concrete.

(g) **Concrete-filled Pipe Columns.** The allowable load on columns consisting of steel pipe filled with concrete shall be determined by

$$P = 0.25 f_c' \left(1 - 0.000025 \frac{h^2}{K_c^2} \right) A_c + f_r' A_r \text{......} (14\text{-}4)$$

The value of "f_r'" shall be given by Formula (14-5) when the pipe has a yield strength of at least 33,000 pounds per square inch, and an "h/K_s" ratio equal to or less than 120

$$f_r' = 17{,}000 - 0.485 \frac{h^2}{K_s^2} \text{..............} (14\text{-}5)$$

(h) **Columns Subjected to Axial Load and Bending.** The strength of the column is controlled by compression if the load, "N", has an eccentricity, "e", in each principal direction, no greater than that given by Formula (14-6), (14-7), or (14-8) and by tension if "e" exceeds these values in either principal direction.

For symmetrical spiral columns:

$$e_b = 0.43\, p_g m D_s + 0.14\, t \text{..............} (14\text{-}6)$$

For symmetrical tied columns:

$$e_b = (0.67\, p_g m + 0.17)\, d \text{.............} (14\text{-}7)$$

Reinforced Concrete Columns—Working Stress Design (Continued)

For unsymmetrical tied columns:

$$e_b = \frac{p'm\,(d - d') + 0.1\,d}{(p' - p)m + 0.6} \qquad (14\text{-}8)$$

Columns controlled by compression shall be proportioned by Formula (14-9) except that the allowable load "N" shall not exceed the load, "P", permitted when the column supports axial load only.

$$f_a/F_a + f_{bx}/F_b + f_{by}/F_b \text{ not greater than unity} \qquad (14\text{-}9)$$

where "f_{bx}" and "f_{by}" are the bending moment components about the "x" and "y" principal axes divided by the section modulus of the respective transformed uncracked section, $2n$ being assumed as the modular ratio for all vertical reinforcement, and

$$F_a = 0.34\,(1 + p_g m)\,f_c' \qquad (14\text{-}10)$$

The allowable bending moment "M" on columns controlled by tension shall be considered to vary linearly with axial load, from "M_o" when the section is in pure flexure, to "M_b" when the axial load is equal to "N_b"; "M_b" and "N_b" shall be determined from "e_b" and Formula (14-9); "M_o" from Formula (14-11), (14-12), or (14-13).

For spiral columns:

$$M_o = 0.12\,A_{st} f_y D_s \qquad (14\text{-}11)$$

For symmetrical tied columns:

$$M_o = 0.40\,A_s f_y\,(d - d') \qquad (14\text{-}12)$$

For unsymmetrical tied columns:

$$M_o = 0.40\,A_s f_y jd \qquad (14\text{-}13)$$

For bending about two axes

$$\frac{M_x}{M_{ox}} + \frac{M_y}{M_{oy}} \text{ not greater than unity} \qquad (14\text{-}14)$$

where "M_x" and "M_y" are bending moments about the "X" and "Y" principal axes, and "M_{ox}" and "M_{oy}" are the values of "M_o" for bending about these axes.

General Requirements—Ultimate Strength Design

Sec. 2615. (a) **Notations.** The notations used in these regulations shall be defined as follows:

A_s = area of tension reinforcement.
A_s' = area of compression reinforcement.
A_{sf} = area of reinforcement to develop compressive strength of overhanging flanges in I- and T-sections.
a = depth of equivalent rectangular stress block = $k_1 c$.
b = width of compression face of flexural member.
b' = width of web in I- and T-sections.
c = distance from extreme compression fiber to neutral axis at ultimate strength.

General Requirements—Ultimate Strength Design (Continued)

D = dead load.
d = distance from extreme compression fiber to centroid of tension reinforcement.
E = earthquake load.
f_c' = compressive strength of concrete (see Section 2603).
f_y = yield strength of reinforcement (see Section 2603).
k_1 = a factor defined in Section 2615 (d) 6.
L = specified live load plus impact.
p = A_s/bd.
p' = A_s'/bd.
p_f = $A_{sf}/b'd$.
p_w = $A_s/b'd$.
U = required ultimate load capacity of section.
W = wind load.
ϕ = capacity reduction factor [see Section 2615 (e)].

(b) **Definition.** Ultimate strength design is a method of proportioning reinforced concrete members based on calculations of their ultimate strength. To ensure serviceability, consideration also is given to control of deflection and cracking under loads.

(c) **General Requirements.** The general requirements for ultimate strength design are as follows:

1. All provisions of this Code, except those of Sections 2610 to 2614, shall apply to the design of members by ultimate strength method, unless otherwise specifically provided in Sections 2615 to 2619.

2. Bending moments in an axially loaded member shall be taken into account in the calculation of the strength required of the member.

3. Except as provided in 4, analysis of indeterminate structures, such as continuous beams, frames, and arches, shall be based on the assumption of elastic behavior. For buildings of usual type of construction, spans, and story heights, approximate methods as provided in Section 2609 are acceptable for determination of moments and shears.

4. Except where approximate values for bending moments are used, the negative moments calculated by elastic theory, for any assumed loading arrangement, at the supports of continuous flexural members may each be increased or decreased by not more than 10 per cent, provided that these modified negative moments are also used for final calculations of the moments at other sections in the spans corresponding to the same loading condition. Such an adjustment shall only be made when the section at which the moment is reduced is so designed that "p", "$p - p'$", or "$p_w - p_f$", whichever is applicable, is equal to or less than 0.50 times the reinforcement ratio "p_b", producing balanced conditions at ultimate strength as calculated by Formula (16-2).

General Requirements—Ultimate Strength Design (Continued)

(d) **Assumptions.** Ultimate strength design of members for bending and axial load shall be based on the assumptions given in this Section, and on satisfaction of the applicable conditions of equilibrium and compatibility of strains. The *simplified* design formulas given in Sections 2616 and 2619 are satisfactory.

Strain in the concrete shall be assumed directly proportional to the distance from the neutral axis. Except in anchorage regions, strain in reinforcing bars shall be assumed equal to the strain in the concrete at the same position.

The maximum strain at the extreme compression fiber at ultimate strength shall be assumed equal to 0.003.

Stress in reinforcing bars below the yield strength, "f_y", for the grade of steel used shall be taken as 29,000,000 pounds per square inch times the steel strain. For strain greater than that corresponding to the design yield strength, "f_y", the reinforcement stress shall be considered independent of strain and equal to the design yield strength, "f_y".

Tensile strength of the concrete shall be neglected in flexural calculations.

At ultimate strength, concrete stress is not proportional to strain. The diagram of compressive concrete stress distribution may be assumed to be a rectangle, trapezoid, parabola, or any other shape which results in predictions of ultimate strength in reasonable agreement with the results of comprehensive tests.

The requirements of the preceding paragraph may be considered satisfied by the equivalent rectangular concrete stress distribution which is defined as follows: At ultimate strength, a concrete stress intensity of 0.85 f_c' shall be assumed uniformly distributed over an equivalent compression zone bounded by the edges of the cross section and a straight line located parallel to the neutral axis at a distance $a = k_1c$ from the fiber of maximum compressive strain. The distance "c" from the fiber of maximum strain to the neutral axis is measured in a direction perpendicular to that axis. The fraction "k_1" shall be taken as 0.85 for strengths, "f_c'" up to 4000 pounds per square inch and shall be reduced continuously at a rate of 0.05 for each 1000 pounds per square inch of strength in excess of 4000 pounds per square inch.

(e) **Safety Provisions.** Strengths shall be computed in accordance with the provisions of Sections 2615 to 2619.

The coefficient "ϕ" shall be 0.90 for flexure; 0.85 for diagonal tension, bond, and anchorage; 0.75 for spirally reinforced compression members; and 0.70 for tied compression members.

Strength capacities of members so computed shall be at least equal to the total effects of the design loads required by Section 2615 (g).

General Requirements—Ultimate Strength Design (Continued)

(f) **Design Strengths for Reinforcement.** When reinforcement is used that has a yield strength, "f_y", in excess of 60,000 pounds per square inch, the yield strength to be used in design shall be reduced by 0.85 f_y or 60,000 pounds per square inch, whichever is greater, unless it is shown by tension tests that at a proof stress equal to the specified yield strength, "f_y", the strain does not exceed 0.003.

Designs shall not be based on a yield strength, "f_y", in excess of 75,000 pounds per square inch. Design of tension reinforcement shall not be based on a yield strength, "f_y", in excess of 60,000 pounds per square inch unless tests are made in compliance with Section 2615 (i).

(g) **Design Loads.** The design loads shall be computed as follows:

1. For structures in such locations and of such proportions that the effects of wind and earthquake may be neglected the design capacity shall be

$$U = 1.5D + 1.8L \quad \text{.................. (15-1)}$$

The loads "D", "L", "W", and "E" are the loads specified in Section 2615 (a).

2. For structures in the design of which wind loading must be included, the design capacity shall be

$$U = 1.25\ (D + L + W) \quad \text{............... (15-2)}$$

OR

$$U = 0.9D + 1.1W \quad \text{................... (15-3)}$$

whichever is greater, provided that no member shall have a capacity less than required by Formula (15-1).

3. For those structures in which earthquake loading must be considered, "E" shall be substituted for "W" in Formula (15-2).

4. In considering the combination of dead, live, and wind loads, the maximum and minimum effects of live loads shall be taken into account.

5. In structures in which it is normal practice to take into account creep, elastic deformation, shrinkage, and temperature, the effects of such items shall be considered on the same basis as the effects of dead load.

(h) **Control of Deflections.** The computed deflection of members at the load level of "$D + L$" shall conform to the provisions of Section 2609 (h), and deflections shall always be checked whenever the required net reinforcement ratio "p", "$p - p'$" or "$p_w - p_f$" in any section of a flexural member exceeds $0.18f_c'/f_y$, or whenever the specified yield strength, "f_y", exceeds 40,000 pounds per square inch.

(i) **Control of Cracking.** Only deformed bars shall be used, except that plain bars may be used as temperature bars

General Requirements—Ultimate Strength Design (Continued)

and column spirals and No. 2 plain bars may be used as stirrups and column ties. Tension reinforcement shall be well distributed in the zones of maximum concrete tension and in the flange of T-beams.

The design yield strength, "f_y", for tension reinforcement shall not exceed 60,000 pounds per square inch, unless it is shown by full-scale tests of typical members that the average crack width at service load at the concrete surface of the extreme tension edge, does not exceed .015 inch for interior members and .010 inch for exterior members. These requirements shall not apply to compression reinforcement.

Flexural Computations—Ultimate Strength Design

Sec. 2616. (a) **Notations.** The notations used in these regulations shall be defined as follows:

A_s = area of tension reinforcement.
A_s' = area of compression reinforcement.
A_{sf} = area of reinforcement to develop compressive strength of overhanging flanges in I- and T-sections.
a = depth of rectangular stress block.
b = width of compression face of flexural member.
b' = width of web in I- and T-sections.
d = distance from extreme compression fiber to centroid of tension reinforcement.
d' = distance from extreme compression fiber to centroid of compression reinforcement.
f_c' = compressive strength of concrete (see Sections 2603).
f_y = yield strength of reinforcement (see Section 2603).
k_1 = a factor defined in Section 2615 (d).
M_u = ultimate resisting moment.
p = A_s/bd.
p' = A_s'/bd.
p_b = reinforcement ratio producing balanced conditions at ultimate strength as defined by Formula (16-2).
p_f = $A_{sf}/b'd$.
p_w = $A_s/b'd$.
q = $A_sf_y/bd\,f_c'$.
t = flange thickness in I- and T-sections.
ϕ = capacity reduction factor [see Section 2615 (e)].

(b) **Rectangular Beams with Tension Reinforcement Only.** The ultimate design resisting moment of rectangular beams with tension reinforcement only shall be calculated by:

$$M_u = \phi\,[bd^2 f_c'\,q\,(1-0.59q)] = \phi\left[A_sf_y\left(d-\frac{a}{2}\right)\right] \qquad (16\text{-}1)$$

WHERE:

$q = pf_y/f_c'$.
$a = A_sf_y/0.85f_c'b$.

Flexural Computations—Ultimate Strength Design (Continued)

The reinforcement ratio, "p", shall not exceed 0.75 of the ratio, "p_b", which produces balanced conditions at ultimate strength given by:

$$p_b = \frac{0.85\, k_1 f_c'}{f_y} \quad \frac{87{,}000}{87{,}000 + f_y} \quad \ldots\ldots (16\text{-}2)$$

(c) **Rectangular Beams with Compression Reinforcement.** The ultimate design resisting moment in rectangular beams with compression reinforcement shall be calculated by:

$$M_u = \phi \left[(A_s - A_s')\, f_y \left(d - \frac{a}{2} \right) + A_s' f_y\, (d - d') \right] \ldots (16\text{-}3)$$

WHERE:

$a = (A_s - A_s') f_y \,/\, 0.85\, f_c' b.$

Formula (16-3) is only valid when the compression steel reaches the yield strength, "f_y", at ultimate strength. This is satisfied when:

$$p - p' \geqq 0.85\, k_1 \quad \frac{f_c' d'}{f_y d} \quad \frac{87{,}000}{87{,}000 - f_y} \quad \ldots\ldots (16\text{-}4)$$

When "$p - p'$" is less than the value given by Formula (16-4), so that the compression steel stress is less than the yield strength, "f_y", or when effects of compression steel are neglected, the calculated ultimate moment shall not exceed that given by Formula (16-1), except when a general analysis is made on the basis of the assumptions given in Section 2615 (d).

The quantity "$p - p'$" shall not exceed 0.75 of the value "p_b" given by Formula (16-2). When the compression steel does not yield at ultimate strength, or when effects of compression steel are neglected, "p" shall not exceed 0.75 p_b, except when it is shown by a general analysis that the tension steel ratio, "p", does not exceed 75 per cent of that corresponding to balanced conditions.

Balanced conditions exist when, at ultimate strength of a member, the tension reinforcement reaches its yield strength, "f_y", just as the concrete in compression reaches its assumed ultimate strain of 0.003.

(d) **I- and T-Sections.** When the flange thickness equals or exceeds the depth to the neutral axis, 1.18 qd / k_1, the section may be designed by Formula (16-1), with "q" computed as for a rectangular beam with a width equal to the over-all flange width given by Section 2609 (g).

When the flange thickness is less than 1.18 qd / k_1, the ultimate moment shall not exceed that given by:

Flexural Computations—Ultimate Strength Design (Continued)

$$M_u = \phi\left[(A_s - A_{sf})\, f_y \left(d - \frac{a}{2}\right) + A_{sf}\, f_y \quad (d - 0.5t)\right] \qquad \text{(16-5)}$$

in which "A_{sf}", the steel area necessary to develop the compressive strength of overhanging flanges is:

$$A_{sf} = 0.85\,(b - b')\, t\, f_c' / f_y \qquad \text{(16-6)}$$

AND $\quad a = (A_s - A_{sf})\, f_y / 0.85 f_c' b'$

The quantity "$p_w - p_f$" shall not exceed 0.75 of the value "p_b" given by Formula (16-2).

(e) **Other Cross Sections.** For other cross sections and for cases of nonsymmetrical bending, the ultimate moment shall be computed by a general analysis based on the assumptions given in Section 2615 (d).

The amount of tension reinforcement shall be so limited that the steel ratio, "p", does not exceed 75 per cent of that corresponding to balanced conditions as defined by Section 2616 (c).

Shear and Diagonal Tension—Ultimate Strength Design

Sec. 2617. (a) **Notations.** The notations used in these regulations are defined as follows:

A_g = gross area of section.
A_s = area of tension reinforcement.
A_v = total area of web reinforcement in tension within a distance, "s", measured in a direction parallel to the longitudinal reinforcement.
α = angle between inclined web bars and longitudinal axis of member.
b = width of compression face of flexural member.
b' = width of web in I- and T-sections.
b_o = periphery of critical section for slabs and footings.
d = distance from extreme compression fiber to centroid of tension reinforcement.
f_c' = compressive strength of concrete (see Section 2603).
f_y = yield strength of reinforcement (see Section 2603).
F_{sp} = ratio of splitting tensile strength to the square root of the compressive strength [see Section 2605 (f)].
M = bending moment.
M' = modified bending moment.
N = load normal to the cross section, to be taken as positive for compression, negative for tension, and to include the effects of tension due to shrinkage and creep.
p_w = $A_s / b'd$.
s = spacing of stirrups or bent bars in a direction parallel to the longitudinal reinforcement.

Shear and Diagonal Tension—Ultimate Strength Design (Continued)

t = total depth of section.
v_c = shear stress carried by concrete.
v_u = nominal ultimate shear stress as a measure of diagonal tension.
V = total shear at section.
V_u = total ultimate shear.
V_u' = ultimate shear carried by web reinforcement.
ϕ = capacity reduction factor [see Section 2615 (e)].

(b) **Ultimate Shear Strength.**[1] The nominal ultimate shear stress, as a measure of diagonal tension, in reinforced concrete members shall be computed by:

$$v_u = V_u / bd \quad \text{.......................(17-1)}$$

For design, the maximum shear shall be considered as that at the section a distance, "d", from the face of the support.[2] Wherever applicable, effects of torsion shall be added and effects of inclined flexural compression in variable-depth members shall be included.

For beams of I- or T-section, "b'" shall be substituted for "b" in Formula (17-1).

The shear stress, "v_c", carried by an unreinforced web shall not exceed $2\phi\sqrt{f_c'}$ at a distance, "d", from the face of the support unless a more detailed analysis is made in accordance with the following two paragraphs. The shear at sections between the face of the support and the section a distance, "d", therefrom shall not be considered critical.[2] For members with axial tension, "v_c" shall not exceed the value given in Section 2617 (b).

The shear stress permitted on an unreinforced web shall not exceed that given by:

$$v_c = \phi \left(1.9\sqrt{f_c'} + 2500\frac{p_w V d}{M}\right) \text{....(17-2)}$$

except that "v_c" shall not exceed $3.5\phi\sqrt{f_c'}$. The shear at sections between the face of the support and the section a distance, "d", therefrom shall, not be considered critical[2] "V" and "M" are the shear and bending moment at the section considered, but "M" shall be not less than "Vd".

For members subjected to axial load in addition to shear and flexure Formula (17-2) shall apply except that "M'" shall be substituted for "M", where

$$M' = M - N\left(\frac{4t - d}{8}\right) \text{................(17-3)}$$

[1]Special provisions for lightweight aggregate concretes are given in Section 2617 (i).
[2]This provision does not apply to brackets and other short cantilevers.

and "v_c" shall not exceed

$$3.5\phi\sqrt{f_c'}\,(1 + 0.002\,N / A_g)$$

Shear and Diagonal Tension—Ultimate Strength Design (Continued)

(c) **Web Reinforcement.** Wherever the value of the ultimate shear stress, "v_u", computed by Formula (17-1) plus effects of torsion, exceeds the shear stress, "v_c", permitted for the concrete of an unreinforced web by Section 2617 (b), web reinforcement shall be provided to carry the excess. Such web reinforcement shall also be provided for a distance equal to the depth "d", of the member beyond the point theoretically required. Web reinforcement between the face of the support and the section at a distance "d" therefrom shall be the same as required at that section.[1]

Web reinforcement may consist of the following:

1. Stirrups perpendicular to the longitudinal reinforcement.
2. Stirrups making an angle of 45 degrees or more with the longitudinal tension reinforcement.
3. Longitudinal bars bent so that the axis of the bent bar makes an angle of 30 degrees or more with the axis of the longitudinal portion of bar.
4. Combinations of 1 or 2 with 3.

Stirrups or other bars to be considered effective as web reinforcement shall be anchored at both ends according to the provisions of Section 2609 (t).

(d) **Stirrups.** The area of steel required in stirrups placed perpendicular to the longitudinal reinforcement shall be computed by:

$$A_v = V_u's / \phi f_y d \quad \text{.....................} (17\text{-}4)$$

The area of inclined stirrups shall be computed by Formula (17-6).

(e) **Bent Bars.** Only the center three-fourths of the inclined portion of any longitudinal bar that is bent up for web reinforcement shall be considered effective for that purpose.

When the web reinforcement consists of a single bent bar or a single group of parallel bars all bent up at the same distance from the support, the required area shall be computed by:

$$A_v = \frac{V_u'}{\phi\, f_y \sin\alpha} \quad \text{.....................} (17\text{-}5)$$

WHERE:

V_u' shall not exceed $3\phi bd\sqrt{f_c'}$.

Where there is a series of parallel bars or groups of bars bent up at different distances from the support, the required area shall be computed by:

[1]This provision does not apply to brackets and other short cantilevers.

Shear and Diagonal Tension—Ultimate Strength Design (Continued)

$$A_v = \frac{V_u's}{\phi f_y d\ (\sin\alpha + \cos\alpha)} \qquad \text{............(17-6)}$$

Bent bars used alone as web reinforcement shall be so spaced that the effective inclined portion defined in the first paragraph of Subsection (e) meets the requirements of Section 2617 (g).

Where more than one type of web reinforcement is used to reinforce the same portion of the web, the total shear resistance shall be computed as the sum of the resistances computed for the various types separately. In such computations, the resistance of the concrete, "v_c", shall be included only once, and no one type of reinforcement shall be assumed to resist more than $2V_u'/3$.

(f) **Stress Restrictions.** The specified yield point for stirrup reinforcement shall not exceed 60,000 pounds per square inch.

The shear stress, "v_u", shall not exceed $10\phi\sqrt{f_c'}$ in sections with web reinforcement.

(g) **Web Reinforcement Restrictions.** Where web reinforcement is required, it shall be so spaced that every 45-degree line, representing a potential diagonal crack and extending from mid-depth, $d/2$, of the member to the longitudinal tension bars, shall be crossed by at least one line of web reinforcement. When the shear stress, "v_u", exceeds $6\phi\sqrt{f_c'}$, every such line shall be crossed by at least two lines of web reinforcement.

Where web reinforcement is required, its area shall be not less than .15 per cent of the area, "bs", computed as the product of the width of the web and the spacing of the web reinforcement along the longitudinal axis of the member.

(h) **Shear Stress in Slabs and Footings.**[1] The shear strength of slabs and footings in the vicinity of concentrated loads or concentrated reactions is governed by the more severe of two conditions:

1. The slab or footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width. This case shall be considered in accordance with Section 2617 (b).

2. Two-way action existing for the slab or footing, with potential diagonal cracking along the surface of a truncated cone or pyramid around the concentrated load or reaction. The slab or footing in this case shall be designed as specified in the remainder of this Section.

The critical section for shear to be used as a measure of diagonal tension shall be perpendicular to the plane of the slab and located at a distance $d/2$ out from the periphery of the concentrated load or reaction area.

[1]For transfer of moments and effect of openings see Section 2609 (s).

Shear and Diagonal Tension—Ultimate Strength Design (Continued)

The nominal ultimate shear stress shall be computed by:

$$v_u = V_u / b_o d \qquad (17\text{-}7)$$

in which "V_u" and "b_o" are taken at the critical section specified in the preceding paragraph. The ultimate shear stress, "v_u", so computed shall not exceed $v_c = 4\phi\sqrt{f_c'}$, unless shear reinforcement is provided in accordance with the following paragraph, in which case "v_u" shall not exceed $6\phi\sqrt{f_c'}$.

When "v_u" exceeds $4\phi\sqrt{f_c}$, shear reinforcement shall be provided in accordance with Sections 2617 (c) to 2617 (g), except that the design yield strength, "f_y", for the shear reinforcement shall be 50 per cent of that prescribed in Section 2615 (f). Shear reinforcement consisting of bars, rods or wires shall not be considered effective in members with a total thickness of less than ten inches (10").

(i) **Lightweight Aggregate Concretes.** When structural lightweight aggregate concretes are used, the provisions of this Chapter shall apply with the following modifications:

1. The limiting value for "v_c" in Section 2617 (b) shall be:

$$0.3\phi F_{sp}\sqrt{f_c'} \qquad (17\text{-}8)$$

2. Formula (17-2) shall be replaced by:

$$v_c = \phi\left(0.28\,F_{sp}\sqrt{f_c'} + 2500\,\frac{p_w V d}{M}\right) \qquad (17\text{-}9)$$

3. The limiting value for shearing stress in slabs and footings, "v_u", in Section 2617 (h) shall be:

$$0.6\phi F_{sp}\sqrt{f_c'} \qquad (17\text{-}10)$$

The value of "F_{sp}" shall be 4.0 unless determined for the particular aggregate in accordance with Section 2605 (f).

(j) **Shear Walls.** Shear stresses in shear walls shall be limited in accordance with the following:

1. The shear stress carried by the concrete in a shear wall shall not exceed

$$v_c = \left(3.7 - \frac{H}{D}\right) 2\phi\sqrt{f_c} \qquad (17\text{-}11)$$

where "H" is the total height to which the shear wall extends in the structure and "D" is the width of the wall in the direction of the shear force.

2. The maximum value for "v_c" shall not exceed $5.4\,\phi\sqrt{f_c}$ for "H/D" ratios less than one and the minimum value shall not be less than two $\phi\sqrt{f_c}$ for "H/D" ratios greater than 2.7.

3. The area of reinforcement required in the horizontal direction shall be computed by

$$A_v = \frac{V'_u s}{\phi f_y d\left(\frac{H}{D} - 1\right)} \qquad (17\text{-}12)$$

Shear and Diagonal Tension—Ultimate Strength Design (Continued)

but in no case shall the reinforcement be less than required in Section 2622 or Formula (17-4).

4. The shear stress "v_u" shall not exceed

$$v_u = \left(0.8 + 4.6 \frac{H}{D}\right) \phi \sqrt{f'_c} \qquad \text{(17-13)}$$

5. The maximum value for "v_u" shall not exceed $10 \phi \sqrt{f'_c}$ for "H/D" ratios greater than two and the minimum value shall be not less than $5.4 \phi \sqrt{f'_c}$ for "H/D" ratios less than one.

6. When structural lightweight concretes are used, the limiting value of "v_c" shall be $0.15 F_{sp}$ times the values in Section 2617 (j) 1 and 2.

Bond and Anchorage—Ultimate Strength Design

Sec. 2618. (a) **Notations.** The notations used in these regulations are defined as follows:

d = distance from extreme compression fiber to centroid of tension reinforcement.

D = nominal diameter of bar, inches.

f_c' = compressive strength of concrete (see Section 2603).

Σo = sum of perimeters of all effective bars crossing the section on the tension side, if of uniform size; for mixed sizes, substitute $4A_s/D$, where "A_s" is the total steel area and "D" is the largest bar diameter. For bundled bars, use the sum of the exposed portions of the perimeters.

j = ratio of distance between centroid of compression and centroid of tension to the depth, "d".

u_u = ultimate bond stress.

V_u = total ultimate shear.

(b) **Ultimate Bond Stress.** In flexural members in which the tension reinforcement is parallel to the compression face, the ultimate flexural bond stress at any cross section shall be computed by:

$$u_u = \frac{V_u}{\phi \Sigma o j d} \qquad \text{(18-1)}$$

Bent-up bars that are not more than $d/3$ from the level of the main longitudinal reinforcement may be included. Critical sections occur at the face of the support, at each point where tension bars terminate within a span, and at the point of inflection.

To prevent bond failure or splitting, the calculated tension or compression in any bar at any section must be developed on each side of that section by proper embedment length, end anchorage or, for tension only, hooks. Anchorage or development bond stress, "u_u", shall be computed as the bar force, computed from "M/ϕ", divided by the product of "Σo" times the embedment length.

Bond and Anchorage—Ultimate Strength Design (Continued)

The bond stress "u_u", computed as in the preceding paragraphs shall not exceed the limits given below, except that flexural bond stress need not be considered in compression, nor in those cases of tension where anchorage bond is less than 0.8 of the permissible.

1. For tension bars with sizes and deformations conforming to U.B.C. Standard No. 26-7-67, except for those designated as Special Large Size Deformed Reinforcing Bars:

Top bars[1] $\dfrac{6.7\sqrt{f_c'}}{D}$ nor 560 p.s.i.

Bars other than top bars $\dfrac{9.5\sqrt{f_c'}}{D}$ nor 800 p.s.i.

2. For tension bars designated as Special Large Size Deformed Reinforcing Bars in U.B.C. Standard No. 26-7-67:

Top bars[1] $4.2\sqrt{f_c'}$

Bars other than top bars $6\sqrt{f_c'}$

3. For all deformed compression bars:

$13\sqrt{f_c'}$ nor 800 p.s.i.

4. For plain bars, the allowable bond stresses shall be one-half those permitted for bars conforming to U.B.C. Standard No. 26-7-67, Section 26.703, but not more than 250 pounds per square inch.

Adequate anchorage shall be provided for the tension reinforcement in all flexural members to which Formula (18-1) does not apply, such as sloped, stepped or tapered footings, brackets or beams in which the tension reinforcement is not parallel to the compression face.

Combined Axial Compression and Bending—Ultimate Strength Design

Sec. 2619. (a) **Notations and Definitions.** The notations used in these regulations are defined as follows:

a = depth of equivalent rectangular stress block, defined by Section 2615 (d) = "k_1c".

a_b = depth of equivalent rectangular stress block for balanced conditions = "k_1b".

A_g = gross area of section.

A_s = area of tension reinforcement.

A_s' = area of compression reinforcement.

A_{st} = total area of longitudinal reinforcement.

b = width of compression face of flexural member.

c = distance from extreme compression fiber to neutral axis.

c_b = distance from extreme compression fiber to neutral axis for balanced conditions

$$= d\,(87{,}000)\,/\,(87{,}000 + f_y).$$

d = distance from extreme compression fiber to centroid of tension reinforcement.

---

[1]Top bars, in reference to bond, are horizontal bars so placed that more than twelve inches (12") of concrete are cast in the member below the bar.

Combined Axial Compression and Bending—Ultimate Strength Design (Continued)

d' = distance from extreme compression fiber to centroid of compression reinforcement.

d'' = distance from plastic centroid to centroid of tension reinforcement.

D = over-all diameter of circular section.

D_s = diameter of the circle through centers of reinforcement arranged in a circular pattern.

e = eccentricity of axial load at end of member measured from plastic centroid of the section, calculated by conventional methods of frame analysis.

e' = eccentricity of axial load at end of member measured from the centroid of the tension reinforcement, calculated by conventional methods of frame analysis.

e_b = eccentricity of load "P_b" measured from plastic centroid of section.

f_c' = compressive strength of concrete (see Section 2603).

f_s = calculated stress in reinforcement when less than the yield strength, "f_y".

f_y = yield strength of reinforcement (see Section 2603).

k_1 = a factor defined in Section 2615 (d).

m = $f_y / 0.85 f_c'$.

m' = $m - 1$.

M_b = moment capacity at simultaneous crushing of concrete and yielding of tension steel (balanced conditions) = "$P_b e_b$".

M_u = moment capacity under combined axial load and bending.

p = A_s / bd.

p' = A_s' / bd.

p_t = A_{st} / A_g.

P_b = Axial load capacity at simultaneous crushing of concrete and yielding of tension steel (balanced conditions).

P_o = axial load capacity of actual member when concentrically loaded.

P_u = axial load capacity under combined axial load and bending.

t = over-all depth of a rectangular section or diameter of a circular section.

ϕ = capacity reduction factor [see Section 2615 (e)].

The plastic centroid of a section is the centroid of the resistance to load computed for the assumptions that the concrete is stressed uniformly to 0.85 "f_c'" and the steel is stressed uniformly to "f_y". For symmetrically reinforced members, the plastic centroid will correspond to the centroid of the cross section.

Combined Axial Compression and Bending—Ultimate Strength Design (Continued)

Balanced conditions exist when, at ultimate strength of a member, the tension reinforcement reaches its yield stress just as the concrete in compression reaches its assumed ultimate strain of 0.003.

(b) **General Requirements.** All members subjected to a compression load shall be designed for the eccentricity, "e", corresponding to the maximum moment which can accompany this loading condition, but not less than $0.05t$ for spirally reinforced columns or $0.10t$ for tied columns about either principal axis.

The maximum load capacities for members subject to axial load as determined by the requirements of this Chapter apply only to short members and shall be reduced for the effects of length according to the requirements of Section 2609 (q).

Members subjected to small compressive loads may be designed for the maximum moment, "$P_u e$", in accordance with the provisions of Section 2616, and disregarding the axial load, but the resulting section shall have a capacity, "P_b", greater than the applied compressive load.

(c) **Bending and Axial Load Capacity of Short Members —Rectangular Sections with Bars in One or Two Faces.** The ultimate strength of short members subject to combined bending and axial load shall be computed from the equations of equilibrium, which may be expressed as follows when "a" is not more than "t" and the reinforcement is in one or two faces, each parallel to the axis of bending and all the reinforcement in any one face is located at approximately the same distance from the axis of bending.

$$P_u = \phi[0.85\, f_c'\, ba + A_s' f_y - A_s f_s] \quad \text{.....(19-1)}$$

$$P_u e' = \phi \left[0.85\, f_c'\, ba \left(d - \frac{a}{2}\right) + A_s' f_y\, (d - d')\right] \text{..(19-2)}$$

Strain compatibility calculations shall be used to insure that the compression steel will actually yield at ultimate strength of a member as assumed in Formulas (19-1), (19-2), (19-3), (19-4), (19-5), (19-6), and (19-10).

The balanced load, "P_b" shall be computed using Formula (19-1) with $a = a_b = k_1 c_b$, and $f_s = f_y$. The balanced moment, "M_b", shall be computed by

$$M_b = P_b e_b = \phi \left[0.85\, f_c' b a_b \left(d - d'' - \frac{a_b}{2}\right) + A_s' f_y\, (d - d' - d'') + A_s f_y d''\right] \text{........(19-3)}$$

The ultimate capacity of a member is controlled by tension in the following paragraph, when "P_u" is less than "P_b"

Combined Axial Compression and Bending—Ultimate Strength Design (Continued)

(or "e" is greater than "e_b"). The capacity is controlled by compression in the next following paragraph, when "P_u" is greater than "P_b" (or "e" is less than "e_b").

When a section is controlled by tension, and has reinforcement in one or two faces, each parallel to the axis of bending, and all the reinforcement in any one face is located at approximately the same distance from the axis of bending, the ultimate strength shall not exceed that computed by:

$$P_u = \phi \left[0.85\, f_c' bd \left\{ p'm' - pm + (1 - e'/d) + \sqrt{(1 - e'/d)^2 + 2[(e'/d)(pm - p'm') + p'm'(1 - d'/d)]} \right\} \right] \qquad (19\text{-}4)$$

For symmetrical reinforcement in two faces, this reduces to:

$$P_u = \phi \left[0.85 f_c' bd \left\{ - p + 1 - e'/d + \sqrt{(1 - e'/d)^2 + 2p\,[m'(1 - d'/d) + e'd]} \right\} \right] \qquad (19\text{-}5)$$

With no compression reinforcement, Formula (19-4) reduces to:

$$P_u = \phi \left\{ 0.85 f_c' bd \left[- pm + 1 - e'/d + \sqrt{(1 - e'/d)^2 + 2\frac{e'pm}{d}} \right] \right\} \qquad (19\text{-}6)$$

When a section is controlled by compression, the ultimate load shall be assumed to decrease linearly from "P_o" to "P_b" as the moment is increased from zero to "M_b".

WHERE:

$$P_o = \phi[0.85 f_c' (A_g - A_{st}) + A_{st} f_y] \qquad (19\text{-}7)$$

For this assumption the ultimate strength is given by either Formula (19-8) or (19-9):

$$P_u = \frac{P_o}{1 + [\,(P_o/P_b) - 1]\, e/e_b} \qquad (19\text{-}8)$$

$$P_u = P_o - (P_o - P_b)\, M_u/M_b \qquad (19\text{-}9)$$

For symmetrical reinforcement in single layers parallel to the axis of bending, the approximate value of "P_u" given by Formula (19-10) may be used:

$$P_u = \phi \left[\frac{A_s'f_y}{\dfrac{e}{d-d'} + 0.5} + \frac{b\,t\,f_c'}{(3\,te/d^2) + 1.18} \right] \ldots (19\text{-}10)$$

Combined Axial Compression and Bending—Ultimate Strength Design (Continued)

(d) **Bending and Axial Load of Short Members—Circular Sections with Bars Circularly Arranged.** The ultimate strength of short circular members subject to combined bending and axial load shall be computed on the basis of the formulas of equilibrium taking into account inelastic deformations, or by the empirical expressions given by:

When tension controls:

$$P_u = \phi \left\{ 0.85 f_c'\, D^2 \left[\sqrt{\left(\frac{0.85e}{D} - 0.38 \right)^2 + \frac{p_t m D_s}{2.5D}} - \left(\frac{0.85e}{D} - 0.38 \right) \right] \right\} \ldots\ldots (19\text{-}11)$$

When compression controls:

$$P_u = \phi \left[\frac{A_{st} f_y}{\dfrac{3e}{D_s} + 1} + \frac{A_g f_c'}{\dfrac{9.6\,De}{(0.8D + 0.67\,D_s)^2} + 1.18} \right] \ldots\ldots (19\text{-}12)$$

(e) **Bending and Axial Load of Short Members—Square Sections with Bars Circularly Arranged.** The ultimate strength of short square members with bars circularly arranged subject to combined bending and axial load shall be computed on the basis of the formulas of equilibrium taking into account inelastic deformations, or by the empirical expressions:

When tension controls:

$$P_u = \phi \left\{ 0.85\, bt\, f_c' \left[\sqrt{\left(\frac{e}{t} - 0.5 \right)^2 + 0.67 \frac{D_s}{t} p_t m} - \left(\frac{e}{t} - 0.5 \right) \right] \right\} \ldots\ldots (19\text{-}13)$$

When compression controls:

$$P_u = \phi \left[\frac{A_{st} f_y}{\dfrac{3e}{D_s} + 1} + \frac{A_g f_c'}{\dfrac{12te}{(t + 0.67 D_s)^2} + 1.18} \right] \ldots\ldots (19\text{-}14)$$

(f) **Bending and Axial Load of Short Members—General Case.** When the reinforcement is placed in all four faces, or in faces which are not parallel to the axis of bending, the design shall be based on computations considering stress and strain compatibility and using the assumptions in Section 2615 (d).

Joists and Two-Way Slabs

Sec. 2620. (a) **Concrete Joist Floor Construction.** In concrete joist floor construction consisting of concrete joists and slabs placed monolithically with or without burned clay or concrete tile fillers, the joists shall not be farther apart than forty inches (40″) face to face. The ribs shall be straight, not less than four inches (4″) wide, and of a depth not more than three times the width.

When burned clay or concrete tile fillers of material having a unit compressive strength at least equal to that of the specified strength of the concrete in the joists are used, the vertical shells of the fillers in contact with the joists 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.

The concrete slab over the fillers shall be not less than one and one-half inches (1½″) in thickness, nor less in thickness than one-twelfth of the clear distance between joists. Shrinkage reinforcement shall be provided in the slab at right angles to the joists equal to that required in Section 2608 (g).

Where removable forms or fillers not complying with the above are used, the thickness of the concrete shall be not less than one-twelfth of the clear distance between joists and in no case less than two inches (2″). Such slab shall be reinforced at right angles to the joists with at least the amount of reinforcement required for flexure, giving due consideration to concentrations, if any, but in no case shall the reinforcement be less than that required by Section 2608 (g).

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 concrete over the fillers shall be one-half inch (½″) greater than the thickness used for design purposes.

Where the slab contains conduits or pipes as allowed in Section 2607 (c), the thickness shall be not less than one inch (1″) 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.

Shrinkage reinforcement is not required in the slab parallel to the joists.

The shear stress, "v_c", may be increased 10 per cent over those prescribed in Section 2612 (b) or 2617 (b).

(b) **Two-way Floor Systems with Supports on Four Sides.** This construction, reinforced in two directions, includes solid reinforced concrete slabs; concrete joists with fillers of hollow concrete units or clay tile, with or without concrete top

Joists and Two-Way Slabs (Continued)

slabs; and concrete joists with top slabs placed monolithically with the joists. The slab shall be supported by walls or beams on all sides and if not securely attached to supports, shall be reinforced in each direction as specified in the following paragraph.

Special reinforcement shall be provided at exterior corners in both the bottom and top of the slab. This reinforcement shall be provided for a distance in each direction from the corner equal to one-fifth the longest span. The reinforcement in the top of the slab shall be parallel to the diagonal from the corner. The reinforcement in the bottom of the slab shall be at right angles to the diagonal or may be of bars in two directions parallel to the sides of the slab. The reinforcement in each band shall be of equivalent size and spacing to that required for the maximum positive moment in the slab.

The slab shall be designed by approved methods which shall take into account the effect of continuity and fixity at supports, the ratio of length to width of slab and the effect of two-way action.[1]

The supports of two-way slabs shall be designed by accepted methods taking into account the effect of continuity. The loading on the supports may be computed from the coefficients of the approved methods.

In no case shall the slab thickness be less than three and one-half inches (3½") nor less than the perimeter of the slab divided by 180. The center-to-center spacing of reinforcement shall not be more than three times the slab thickness and the ratio of reinforcement in each direction shall be not less than required by Section 2608 (g).

Flat Slabs With Square or Rectangular Panels

Sec. 2621. (a) **Notations.** The notations used in these regulations shall be defined as follows:

A = distance in the direction of span from center of support to the intersection of the center line of the slab thickness with the extreme 45-degree diagonal line lying wholly within the concrete section of slab and column or other support, including drop panel, capital and bracket.

b_o = periphery of critical section for shear.

c = effective support size [see Section 2621 (e)].

d = distance from extreme compression fiber to centroid of tension reinforcement.

f_c' = compressive strength of concrete (see Section 2603).

h = distance from top of slab to bottom of capital.

H = story height in feet of the column or support of a flat slab center-to-center of slabs.

K = ratio of moment of inertia of column provided to "I_c" required by Formula (21-1).

[1]The requirements of this Section are satisfied by any of the methods of design shown in U.B.C. Standard No. 26-17-67.

Flat Slabs With Square or Rectangular Panels (Continued)

L = span length of a flat slab panel center-to-center of supports.

M_o = numerical sum of assumed positive and average negative moments at the critical design sections of a flat slab panel [see Section 2621 (e) 6].

R_n = factor for increasing negative moment. [Section 2621 (e), Formula (21-2)].

R_p = factor for increasing positive moment. [Section 2621 (e), Formula (21-3)].

t = thickness in inches of slab at center of panel.

t_1 = thickness in inches of slab without drop panels, or through drop panel, if any.

t_2 = thickness in inches of slab with drop panels at points beyond the drop panel.

W' = uniformly distributed unit dead and live load.

W = total dead and live load on panel.

W_D= total dead load on panel.

W_L= total live load on panel, uniformly distributed.

(b) **Definitions and Scope.** For the purpose of this Chapter, certain terms are defined as follows:

COLUMN CAPITAL is an enlargement of the end of a column designed and built to act as an integral unit with the column and flat slab. No portion of the column capital shall be considered for structural purposes which lies outside of the largest right circular cone with 90-degree vertex angle that can be included within the outlines of the column capital. Where no capital is used, the face of the column shall be considered as the edge of the capital.

DROP PANEL is the structural portion of a flat slab which is thickened throughout an area surrounding the column, column capital, or bracket.

FLAT SLAB is a concrete slab reinforced in two or more directions, generally without beams or girders to transfer the loads to supporting members. Slabs with recesses or pockets made by permanent or removable fillers between reinforcing bars may be considered flat slabs. Slabs with paneled ceilings may be considered as flat slabs provided the panel of reduced thickness lies entirely within the area of intersecting middle strips, and is at least two-thirds the thickness of the remainder of the slab, exclusive of the drop panel, and is not less than four inches (4″) thick.

PANEL STRIPS. A flat slab shall be considered as consisting of strips in each direction as follows:

A middle strip one-half panel in width, symmetrical about panel center line.

A column strip consisting of the two adjacent quarter-panels, one each side of the column center line.

ULTIMATE STRENGTH DESIGN. Flat slabs shall be proportioned by Sections 2610 to 2614 only, except that

Sections 2615 to 2619 may be used if the following modifications are made in the design:

Flat Slabs With Square or Rectangular Panels (Continued)

1. For either empirical or elastic analysis the numerical sum of the positive and negative bending moments in the direction of either side of a rectangular panel shall be assumed as not less than

$$M_o = 0.10\, WLF \left(1 - \frac{2c}{3L}\right)^2$$

in which $F = 1.15 - c/L$ but not less than 1.

2. The thickness of slab shall be not less than shown in Table No. 26-E.

(c) **Design Procedures.** 1. **Methods of analysis.** All flat slab structures shall be designed in accordance with a recognized elastic analysis subject to the limitations of Sections 2621 (c) and 2621 (d), except that the empirical method of design given in Section 2621 (e) may be used for the design of flat slabs conforming with the limitations given therein. Flat slabs within the limitations of Section 2621 (e), when designed by elastic analysis, may have resulting analytical moments reduced in such proportion that the numerical sum of the positive and average negative bending moments used in design procedure need not exceed the sum of the corresponding values as determined from Table No. 26-F.

2. **Critical sections.** The slab shall be proportioned for the bending moments prevailing at every section except that the slab need not be proportioned for a greater negative moment than that prevailing at a distance "A" from the support center line.

3. **Size and thickness of slabs and drop panels.** Subject to limitations of the following fourth paragraph, the thickness of a flat slab and the size and thickness of the drop panel, where used, shall be such that the compression due to bending at any section, and the shear about the column, column capital, and drop panel shall not exceed those permitted in Sections 2610 to 2619. When designed under Section 2621 (e), three-fourths of the width of the strip shall be used as the width of the section in computing compression due to bending, except that on a section through a drop panel, three-fourths of the width of the drop panel shall be used. Account shall be taken of any recesses which reduce the compressive area.

The shear on vertical sections which follow a periphery, "b_o", at distance, $d/2$, beyond the edges of the column, column capital, or drop panel, and concentric with them, shall be computed as required and limited in Section 2612 or 2617.

Flat Slabs With Square or Rectangular Panels (Continued)

If shear reinforcement is used, the first line shall be not further than $d/2$ from the face of the support.

Slabs with drop panels whose length is at least one-third the parallel span length and whose projection below the slab is at least one-fourth the slab thickness shall be not less than $L/40$ nor four inches (4″) in thickness.

Slabs without drop panels as described above shall be not less than $L/36$ nor five inches (5″) in thickness.

For determining reinforcement, the thickness of the drop panel below the slab shall not be assumed to be more than one-fourth of the distance from the edge of the drop panel to the edge of the column capital.

4. **Arrangement of slab reinforcement.** The spacing of the bars at critical sections shall not exceed two times the slab thickness, except for those portions of the slab area which may be of cellular or ribbed construction. In the slab over the cellular spaces, reinforcement shall be provided as required by Section 2608 (g).

In exterior panels, except for bottom bars adequately anchored in the drop panel, all positive reinforcement perpendicular to the discontinuous edge shall extend to the edge of the slab and have embedment, straight or hooked, of at least six inches (6″) in spandrel beams, walls, or columns where provided. All negative reinforcement perpendicular to the discontinuous edge shall be bent, hooked, or otherwise anchored in spandrel beams, walls, or columns.

The area of reinforcement shall be determined from the bending moments at the critical sections but shall be not less than required by Section 2608 (g).

Required splices in bars may be made wherever convenient, but preferably away from points of maximum stress. The length of any such splice shall conform to Section 2608 (e).

Bars shall be spaced approximately uniformly across each panel strip, except as follows:

(Continued on page 298)

TABLE NO. 26-E—MINIMUM SLAB THICKNESS

"f_y"	WITH DROP PANELS[1]	WITHOUT DROP PANELS
40,000	$L/40$ or 4 inches	$L/36$ or 5 inches
50,000	$L/36$ or 4 inches	$L/33$ or 5 inches
60,000	$L/33$ or 4 inches	$L/30$ or 5 inches

[1]To be considered effective, the drop panel shall have a length of at least one-third the parallel span length and a projection below the slab of at least one-fourth the slab thickness.

TABLE NO. 26-F—MOMENTS IN FLAT SLAB PANELS IN PERCENTAGES OF "M_o"

STRIP	COLUMN HEAD	SIDE SUPPORT TYPE	END SUPPORT TYPE	EXTERIOR PANEL: EXTERIOR NEGATIVE MOMENT	EXTERIOR PANEL: POSITIVE MOMENT	EXTERIOR PANEL: INTERIOR NEGATIVE MOMENT	INTERIOR PANEL: POSITIVE MOMENT	INTERIOR PANEL: NEGATIVE MOMENT
Column strip	With drop		A	44				
			B	36	24	56	20	50
			C	6	36	72		
	Without drop		A	40				
			B	32	28	50	22	46
			C	6	40	66		
Middle strip	With drop		A	10				
			B	20	20	17[1]	15	15[1]
			C	6	26	22[1]		
	Without drop		A	10				
			B	20	20	18[1]	16	16[1]
			C	6	28	24[1]		
Half column strip adjacent to marginal beam or wall	With drop	1	A	22				
			B	18	12	28	10	25
			C	3	18	36		
		2	A	17				
			B	14	9	21	8	19
			C	3	14	27		

(Continued)

TABLE NO. 26-F—MOMENTS IN FLAT SLAB PANELS IN PERCENTAGES OF "M_o" (Continued)

STRIP	COLUMN HEAD	SIDE SUPPORT TYPE	END SUPPORT TYPE	EXTERIOR PANEL			INTERIOR PANEL	
				EXTERIOR NEGATIVE MOMENT	POSITIVE MOMENT	INTERIOR NEGATIVE MOMENT	POSITIVE MOMENT	NEGATIVE MOMENT
Half column strip adjacent to marginal beam or wall	With drop	3	A	11				
			B	9	6	14	5	13
			C	3	9	18		
	Without drop	1	A	20				
			B	16	14	25	11	23
			C	3	20	33		
		2	A	15				
			B	12	11	19	9	18
			C	3	15	25		

TABLE NO. 26-F (Continued)

Half column strip adjacent to marginal beam or wall	Without drop	3	A	10	7	13	6	12
			B	8				
			C	3	10	17		

PERCENTAGE OF PANEL LOAD TO BE CARRIED BY MARGINAL BEAM OR WALL IN ADDITION TO LOADS DIRECTLY SUPERIMPOSED THEREON	TYPE OF SUPPORT LISTED IN TABLE NO. 26-F		
	SIDE SUPPORT PARALLEL TO STRIP	SIDE OR END EDGE CONDITION OF SLABS OF DEPTH "t"	END SUPPORT AT RIGHT ANGLES TO STRIP
0	1	Columns with no beams	A
20	2	Columns with beams of total depth 1 ¼t	
40	3	Columns with beams of total depth 3t or more	B
		Reinforced concrete bearing walls integral with slab	
		Masonry or other walls providing negligible restraint	C

[1]Increase negative moments 30 per cent of tabulated values when middle strip is continuous across support of Type B or C. No other values need be increased.

Note: For intermediate proportions of total beam depth to slab thicknesses, values for loads and moments may be obtained by interpolation. See also Figures No. 26-1 and No. 26-2 (pages 302, 303).

Flat Slabs With Square or Rectangular Panels (Continued)

(Continued from page 294)

A. At least 25 per cent of required negative reinforcement in the column strip shall cross the periphery located at a distance of "*d*" from the column or column capital.

B. At least 50 per cent of the required negative reinforcement in the column strip shall cross the drop panel, if any.

C. The spacing for the remainder of the column strip may vary uniformly from that required for "A" or "B" to that required for the middle strip.

5. **Openings in flat slabs.** Openings of any size may be provided in flat slabs if provision is made for the total positive and negative moments and for shear without exceeding the allowable stresses except that when design is based on Section 2621 (e), the limitations given therein shall not be exceeded.

When openings are provided within the area common to two column strips, that part of the critical section shall be considered ineffective which either passes through an opening, or is covered by a radial projection of any opening to the centroid of the support.

6. **Design of columns.** All columns supporting flat slabs shall be designed as provided in Section 2614 or 2619 with the additional requirements of this Chapter.

7. **Transfer of bending moment between column and slab.** When unbalanced gravity load, wind or earthquake causes transfer of bending moment between column and slab, the stresses on the critical section shall be investigated by a rational analysis, and the section proportioned accordingly by the requirements of Sections 2610 to 2614 or Sections 2615 to 2619. Concentration of reinforcement over the column head by additional reinforcement or closer spacing may be used to resist the moment of the section. A slab width between lines that are 1.5*t* each side of the column may be considered effective.

(d) **Design by Elastic Analysis. 1. Assumptions.** In design by elastic analysis the following assumptions may be used and all sections shall be proportioned for the moments and shears thus obtained:

> The structure may be considered divided into a number of bents, each consisting of a row of columns or supports and strips of supported slabs, each strip bounded laterally by the center line of the panel on either side of the center line of columns or supports. The bents shall be taken longitudinally and transversely of the building.
>
> Each such bent may be analyzed in its entirety or each floor thereof and the roof may be analyzed separately with its adjacent columns as they occur above and below, the columns being assumed fixed at their remote ends. Where

slabs are thus analyzed separately, it may be assumed in determining the bending at a given support that the slab is fixed at any support two panels distant therefrom provided the slab continues beyond that point.

Flat Slabs With Square or Rectangular Panels (Continued)

The joints between columns and slabs may be considered rigid, and this rigidity (infinite moment of inertia) may be assumed to extend in the slabs from the center of the column to the edge of the capital, and in the column from the top of slab to the bottom of the capital. The change in length of columns and slabs due to direct stress, and deflections due to shear, may be neglected.

Where metal column capitals are used, account may be taken of their contributions to stiffness and resistance to bending and shear.

The moment of inertia of the slab or column at any cross section may be assumed to be that of the cross section of the concrete. Variation in the moments of inertia of the slabs and columns along their axes shall be taken into account.

Where the load to be supported is definitely known, the structure shall be analyzed for that load. Where the live load is variable but does not exceed three-fourths of the dead load, or the nature of the live load is such that all panels will be loaded simultaneously, the maximum bending may be assumed to occur at all sections under full live load. For other conditions, maximum positive bending near mid-span of a panel may be assumed to occur under three-fourths of the full live load in the panel and in alternate panels; and maximum negative bending in the slab at a support may be assumed to occur under three-fourths of the full live load in the adjacent panels only. In no case, shall the design moments be taken as less than those occurring with full live load on all panels.

2. **Critical sections.** The critical section for negative bending, in both the column strip and middle strip, may be assumed as not more than the distance "*A*" from the center of the column or support and the critical negative moment shall be considered as extending over this distance.

3. **Distribution of panel moments.** Bending at critical sections across the slabs of each bent may be apportioned between the column strip and middle strip, as given in Table No. 26-G. For design purposes, any of these percentages may be varied by not more than 10 per cent of their value, but their sum for the full panel width shall not be reduced.

(e) **Empirical Method.** 1. **General limitations.** Flat slab construction may be designed by the empirical provisions of this Section when they conform to all of the limitations on continuity and dimensions given herein.

Flat Slabs With Square or Rectangular Panels (Continued)

The construction shall consist of at least three continuous panels in each direction.

The ratio of length to width of panels shall not exceed 1.33.

The grid pattern shall consist of approximately rectangular panels. The successive span lengths in each direction shall differ by not more than 20 per cent of the longer span.

Within these limitations, columns may be offset a maximum of 10 per cent of the span, in direction of the offset, from either axis between center lines of successive columns.

The calculated lateral force moments from wind or earthquake may be combined with the critical moments as determined by the empirical method, and the lateral force moments shall be distributed between the column and middle strips in the same proportions as specified for the negative moments in the strips for structures not exceeding one hundred and twenty-five feet (125′) high with maximum story height not exceeding twelve feet six inches (12′ 6″).

2. **Columns.** The minimum dimension of any column shall be as determined by the following paragraphs, but in no case less than ten inches (10″).

For columns or other supports of a flat slab, the required minimum average moment of inertia, "I_c", of the gross concrete section of the columns above and below the slab shall be determined from Formula (21-1) and shall be not less than one thousand inches^4 (1000″^{4}). If there is no column above the slab, the "I_c" of the column below shall be $(2 - 2.3h/H)$ times that given by the formula with a minimum of one thousand inches^4 (1000″^{4}).

$$I_c = \frac{t^3H}{0.5 + \dfrac{W_D}{W_L}} \qquad \text{(21-1)}$$

where "t" need not be taken greater than "t_1" or "t_2" as determined in Subsection (e) 4, "H" is the average story height of the columns above and below the slab, and "W_L" is the greater value of any two adjacent spans under consideration.

Columns smaller than required by Formula (21-1) may be used provided the bending moment coefficients given in Table No. 26-G are increased in the following ratios.

For negative moments

$$R_n = 1 + \frac{(1 - K)^2}{2.2\,(1 + 1.4W_D/W_L)} \qquad \text{(21-2)}$$

For positive moments

(Continued on page 306)

TABLE NO. 26-G—DISTRIBUTION BETWEEN COLUMN STRIPS AND MIDDLE STRIPS IN PER CENT OF TOTAL MOMENTS AT CRITICAL SECTIONS OF A PANEL

STRIP		MOMENT SECTION			
				NEGATIVE MOMENT AT EXTERIOR SUPPORT	
		NEGATIVE MOMENT AT *INTERIOR* SUPPORT	*POSITIVE* MOMENT	SLAB SUPPORTED ON COLUMNS AND ON BEAMS OF TOTAL DEPTH EQUAL *TO THE SLAB* THICKNESS[1]	SLAB SUPPORTED ON REINFORCED CONCRETE BEARING WALL OR COLUMNS WITH BEAMS OF TOTAL DEPTH EQUAL OR GREATER THAN 3 TIMES THE SLAB THICKNESS[1]
Column strip		76	60	80	60
Middle strip		24	40	20	40
Half column strip adjacent and parallel to marginal beam or wall	Total depth of beam equal to slab thickness[1]	38	30	40	30
	Total depth of beam or wall equal to or greater than 3 times slab thickness[1]	19	15	20	15

[1]Interpolate for intermediate ratios of beam depth to slab thickness.

Note: The total dead and live reaction of a panel adjacent to a marginal beam or wall may be divided between the beam or wall and the parallel half column strip in proportion to their stiffness, but the moment provided in the slab shall not be less than that given in Table No. 26-G.

FIGURE NO. 26-1

PANEL			INTERIOR		EXTERIOR						
MOMENT			SUPPORT	CENTER OF SPAN	IST. INTERIOR SUPPORT	CENTER OF SPAN	EXTERIOR SUPPORT		I ST. INTERIOR SUPPORT	CENTER OF SPAN	EXTERIOR SUPPORT
END SUPPORT							B	A			C
MARGINAL HALF COLUMN STRIP	SIDE SUPPORT	3	-12	+6	-13	+7	-8	-10	-17	+10	-3
		2	-18	+9	-19	+11	-12	-15	-25	+15	-3
		1	-23	+11	-25	+14	-16	-20	-33	+20	-3
MIDDLE STRIP			-16*	+16	-18*	+20	-20	-10	-24*	+28	-6
COLUMN STRIP			-46	+22	-50	+28	-32	-40	-66	+40	-6

DIRECTION OF ALL MOMENTS

Fig. No. 26-1—Moments in flat slab panels in percentages of M_o — Without drops

[See Table No. 26-F for notes and classification of conditions of end supports and side supports.]

*Increase negative moments 30 per cent when middle strip is continuous across a support of Type B or C; no other values need be increased.

PANEL		INTERIOR		EXTERIOR						
MOMENT		SUPPORT	CENTER OF SPAN	1 ST. INTERIOR SUPPORT	CENTER OF SPAN	EXTERIOR SUPPORT		1ST. INTERIOR SUPPORT	CENTER OF SPAN	EXTERIOR SUPPORT
END SUPPORT						B	A			C
MARGINAL HALF COLUMN STRIP — SIDE SUPPORT	3	-13	+5	-14	+6	-9	-11	-18	+9	-3
	2	-19	+8	-21	+9	-14	-17	-27	+14	-3
	1	-25	+10	-28	+12	-18	-22	-36	+18	-3
MIDDLE STRIP		-15*	+15	-17*	+20	-20	-10	-22*	+26	-6
COLUMN STRIP		-50	+20	-56	+24	-36	-44	-72	+36	-6

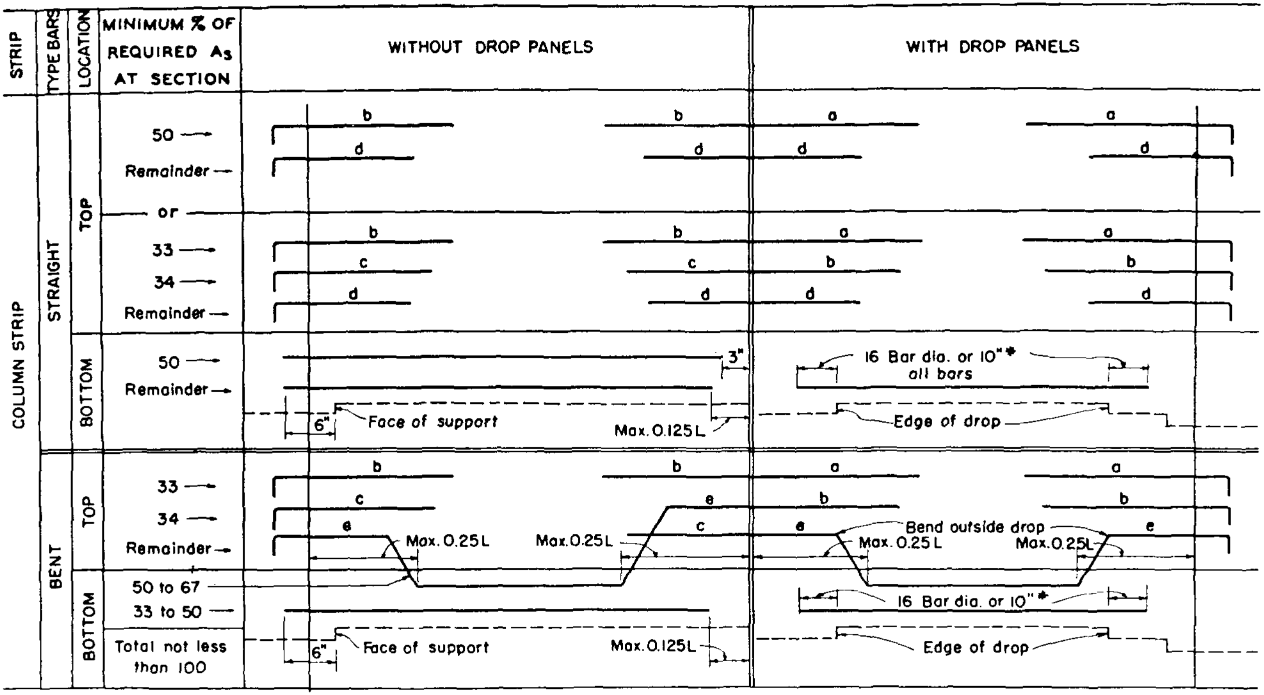
DIRECTION OF ALL MOMENTS

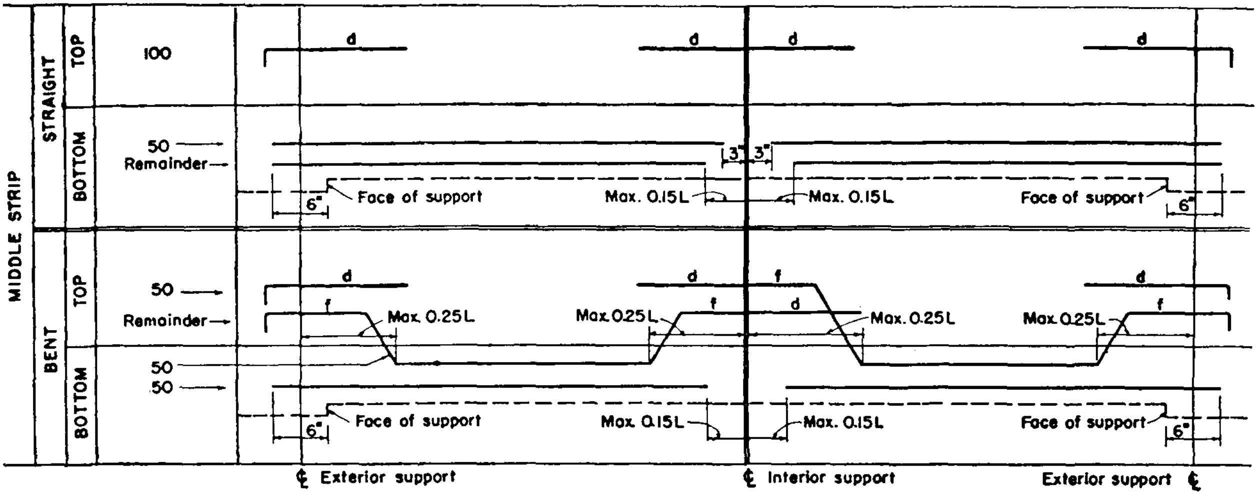
Fig. No. 26-2—Moments in flat slab panels in percentages of M_o — With drops

[See Table No. 26-F for notes and classification of conditions of end supports and side supports.]

*Increase negative moments 30 per cent when middle strip is continuous across a support of Type B or C; no other values need be increased.

FIGURE NO. 26-3





MINIMUM LENGTH OF BAR FROM ¢ SUPPORT

MARK	a	b	c	d	e	f
LENGTH	0.33L	0.30L	0.27L	0.25L	0.20L	0.15L

At interior supports, L is longer of adjacent spans.

Fig. No. 26-3—Minimum length of flat slab reinforcement

At exterior supports, where masonry walls or other construction provide only negligible restraint to the slab, the negative reinforcement need not be carried further than $0.20L$ beyond the center line of such support; any combination of straight and bent bars may be used provided minimum requirements are met.

*For bars not terminating in drop panel use lengths shown for panels without drops.

Flat Slabs With Square or Rectangular Panels (Continued)

(Continued from page 300)

$$R_p = 1 + \frac{(1-K)^2}{1.2\,(1 + 0.10W_D/W_L)} \qquad (21\text{-}3)$$

The required slab thickness shall be modified by multiplying "w" by "R_n" in Formulas (21-4) and (21-5).

Columns supporting flat slabs designed by the empirical method shall be proportioned for the bending moments developed by unequally loaded panels, or uneven spacing of columns. Such bending moment shall be the maximum value derived from

$$\frac{WL_1 - W_DL_2}{f}$$

"L_1" and "L_2" being lengths of the adjacent spans ($L_2 = 0$ when considering an exterior column) and "f" is 30 for exterior and 40 for interior columns.

This moment shall be divided between the columns immediately above and below the floor or roof line under consideration in direct proportion to their stiffness and shall be applied without further reduction to the critical sections of the columns.

3. **Determination of "c" (effective support size).** Where column capitals are used, the value of "c" shall be taken as the diameter of the cone described in Section 2621 (b) measured at the bottom of the slab or drop panel.

Where a column is without a concrete capital, the dimension "c" shall be taken as that of the column in the direction considered.

Brackets capable of transmitting the negative bending and the shear in the column strips to the columns without excessive unit stress may be substituted for column capitals at exterior columns. The value of "c" for the span where a bracket is used shall be taken as twice the distance from the center of the column to a point where the bracket is one and one-half inches (1½") thick, but not more than the thickness of the column plus twice the depth of the bracket.

Where a reinforced concrete beam frames into a column without capital or bracket on the same side with the beam, for computing bending for strips parallel to the beam, the value of "c" for the span considered may be taken as the width of the column plus twice the projection of the beam above or below the slab or drop panel.

The average of the values of "c" at the two supports at the ends of a column strip shall be used to evaluate the slab thickness "t_1" or "t_2" as prescribed in the following paragraph.

4. **Slab thickness.** The slab thickness, span "L" being the longest side of the panel, shall be at least:

Flat Slabs With Square or Rectangular Panels (Continued)

$L/36$ for slab without drop panels conforming with paragraph 5, or where a drop panel is omitted at any corner of the panel, but not less than five inches (5″) nor "t_1" as given in Formula (21-4).

$L/40$ for slabs with drop panels conforming to paragraph 5 at all supports, but not less than four inches (4″) nor "t_2" as given in Formula (21-5).

The total thickness, "t_1", in inches, of slabs without drop panels, or through the drop panel if any, shall be at least

$$t_1 = 0.028L\left(1 - \frac{2c}{3L}\right)\sqrt{\frac{w'}{f_c'/2000}} + 1\tfrac{1}{2} \quad \ldots(21\text{-}4)^1$$

The total thickness, "t_2", in inches, of slabs with drop panels, at points beyond the drop panel shall be at least

$$t_2 = 0.024L\left(1 - \frac{2c}{3L}\right)\sqrt{\frac{w'}{f_c'/2000}} + 1 \quad \ldots\ldots(21\text{-}5)^1$$

Where the exterior supports provide only negligible restraint to the slab, the values of "t_1" and "t_2" for the exterior panel shall be increased by at least 15 per cent.

5. **Drop panels.** The maximum total thickness at the drop panel used in computing the negative steel area for the column strip shall be $1.5t_2$.

The side or diameter of the drop panel shall be at least 0.33 times the span in the parallel direction.

The minimum thickness of slabs where drop panels at wall columns are omitted shall equal $(t_1 + t_2)/2$ provided the value of "c" used in the computations complies with paragraph 3.

6. **Bending moment coefficients.** The numerical sum of positive and negative bending moments in the direction of either side of a rectangular panel shall be assumed as not less than

$$M_o = 0.09\,WLF\left(1 - \frac{2c}{3L}\right)^2 \quad \ldots\ldots\ldots\ldots\ldots(21\text{-}6)$$

in which $F = 1.15 - c/L$ but not less than 1.

Unless otherwise provided, the bending moments at the critical sections of the column and middle strips shall be at least those given in Table No. 26-F.

The average of the values of "c" at the two supports at the ends of a column strip shall be used to evaluate "M_o" in determining bending in the strip. The average of the values of "M_o", as determined for the two parallel half column strips in a panel, shall be used in determining bending in the middle strip.

Bending in the middle strips parallel to a discontinuous edge shall be assumed the same as in an interior panel.

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[1]In these formulas "t_1" and "t_2" are in inches, "L" and "c" are in feet, and "w'" is in pounds per square foot.

Flat Slabs With Square or Rectangular Panels (Continued)

For design purposes, any of the moments determined from Table No. 26-F may be varied by not more than 10 per cent, but the numerical sum of the positive and negative moments in a panel shall be not less than the amount specified.

7. **Length of reinforcement.** In addition to the requirements of Section 2621 (c) 4, reinforcement shall have the minimum lengths given in Tables No. 26-H-1 and No. 26-H-2. Where adjacent spans are unequal, the tension of negative reinforcement on each side of the column center line as prescribed in Table No. 26-H-1 shall be based on the requirements of the longer span.

8. **Openings in flat slabs.** Openings of any size may be provided in a flat slab in the area common to two intersecting middle strips provided the total positive and negative steel areas required in paragraph 6 are maintained.

In the area common to two column strips, not more than one-eighth of the width of strip in any span shall be interrupted by openings. The equivalent of all bars interrupted shall be provided by extra steel on all sides of the openings. The shear stresses given in Section 2621 (c) 3 shall not be exceeded following the procedure of Section 2609 (u).

In any area common to one column strip and one middle strip, openings may interrupt one-fourth of the bars in either strip. The equivalent of the bars so interrupted shall be provided by extra steel on all sides of the opening.

Any opening larger than described above shall be analyzed by accepted engineering principles and shall be completely framed as required to carry the loads to the columns.

Reinforced Concrete Walls

Sec. 2622. (a) **Notations.** The notations used in these regulations are defined as follows:

f_c = allowable compressive stress on concrete.
f_c' = compressive strength of concrete (see Section 2603).
h = clear distance between supporting or enclosing members (vertical or horizontal stiffening elements).
t = thickness of wall.

(b) **Definitions. BEARING WALL.** For purposes of this Chapter, a bearing wall is defined as a wall which supports more than 200 pounds per foot superimposed load other than its own weight.

(c) **Lateral and Eccentric Loads.** Walls shall be designed for any lateral or other loads to which they are subjected. Proper provision shall be made for eccentric loads. In addition to the requirements of this Section, shear walls shall be designed in accordance with Section 2612 (j), Section 2617 (j) or Section 2632, whichever is applicable.

(d) **Height and Thickness.** Reinforced concrete bearing walls shall have a minimum thickness of not less than six inches (6") nor a thickness less than 1/25 of the shorter un-

(Continued on page 311)

TABLE NO. 26-H-1—MINIMUM LENGTH OF NEGATIVE REINFORCEMENT

STRIP	PERCENTAGE OF REQUIRED REINFORCING STEEL AREA TO BE EXTENDED AT LEAST AS INDICATED	MINIMUM DISTANCE BEYOND CENTER LINE OF SUPPORT TO END OF STRAIGHT BAR OR TO BEND POINT OF BENT BAR[1]			
		FLAT SLABS WITHOUT DROP PANELS		FLAT SLABS WITH DROP PANELS	
		STRAIGHT	BEND POINT WHERE BARS BEND DOWN AND CONTINUE AS POSITIVE REINFORCEMENT	STRAIGHT	BEND POINT WHERE BARS BEND DOWN AND CONTINUE AS POSITIVE REINFORCEMENT
Column strip reinforcement	Not less than 33 per cent	$0.30L^2$		$0.33L^3$	
	Not less than an additional 34 per cent	$0.27L^2$		$0.30L^3$	
	Remainder[2]	$0.25L$ or	$0.20L$	$0.25L$ or	To edge of drop but at least $0.20L$
Middle strip reinforcement	Not less than 50 per cent	$0.25L$		$0.25L$	
	Remainder[4]	$0.25L$ or	$0.15L$	$0.25L$ or	$0.15L$

[1]At exterior supports where masonry walls or other construction provide only negligible restraint to the slab, the negative reinforcement need not be carried further than $0.20L$ beyond the center line of such support.
[2]Where no bent bars are used, the $0.27L$ bars may be omitted, provided the $0.30L$ bars are at least 50 per cent of total required.
[3]Where no bent bars are used, the $0.30L$ bars may be omitted provided the $0.33L$ bars provide at least 50 per cent of the total required.
[4]Bars may be straight, bent, or any combination of straight and bent bars. All bars are to be considered straight bars for the end under consideration unless bent at that end and continued as positive reinforcement.
Note: See also Figure No. 26-3 (pages 304, 305).

TABLE NO. 26-H-2—MINIMUM LENGTH OF POSITIVE REINFORCEMENT

STRIP	PERCENTAGE OF REQUIRED REINFORCING STEEL AREA TO BE EXTENDED AT LEAST AS INDICATED	MAXIMUM DISTANCE FROM CENTER LINE OF SUPPORT TO END OF STRAIGHT BAR OR BEND POINT OF BENT BAR			
		FLAT SLABS WITHOUT DROP PANELS		FLAT SLABS WITH DROP PANELS	
		STRAIGHT	BEND POINT WHERE BARS BEND UP AND CONTINUE AS NEGATIVE REINFORCEMENT	STRAIGHT	BEND POINT WHERE BARS BEND UP AND CONTINUE AS NEGATIVE REINFORCEMENT
Column strip reinforcement	Not less than 33 per cent	$0.125L$		Minimum embedment in drop panel of 16 bar diameters but at least 10 inches	
	Not less than 50 per cent[1]	3 in. or	$0.25L$		
	Remainder[1]	$0.125L$ or	$0.25L$	Minimum embedment in drop panel of 16 bar diameters but at least 10 inches or	$0.25L$
Middle strip reinforcement	50 per cent	$0.15L$		$0.15L$	
	50 per cent[1]	3 in. or	$0.25L$	3 in. or	$0.25L$

[1]Bars may be straight, bent, or any combination of straight and bent bars. All bars are to be considered straight bars for the end under consideration unless bent at that end and continued as negative reinforcement.

(Continued from page 308)

Reinforced Concrete Walls (Continued)

supported distance between vertical or horizontal stiffening elements.

Nonbearing reinforced concrete exterior walls or nonbearing interior or exterior shear walls shall have a thickness of not less than four inches (4") nor a thickness less than 1/36 of the shorter unsupported distance between vertical or horizontal stiffening elements. Nonbearing interior partitions of reinforced concrete which do not serve as shear elements shall have a thickness of not less than two inches (2") nor a thickness less than 1/48 of the distance between supports.

> **EXCEPTION:** The provisions of this Subsection may be waived when sufficient written evidence is submitted to the Building Official by a qualified person showing that the walls meet all other requirements of this Code.

(e) **Design and Reinforcement.** The maximum allowable compressive stress for working stress design using Sections 2610 through 2614 shall not exceed

$$f_c = 0.225 f_c' \left[1 - \left(\frac{h}{40t} \right)^3 \right] \qquad (22\text{-}1)$$

For ultimate strength design by Sections 2615 to 2619 the values from Formula (22-1) shall be multiplied by 1.9.

When the reinforcement in bearing walls is designed, placed, and anchored in position as for columns, the design shall be on the basis of formulas for columns.

Concentrated loads may be assumed to be distributed over a maximum length of wall not exceeding the center-to-center distance between loads nor the width of bearing plus four times the wall thickness.

The area of the horizontal reinforcement of reinforced concrete walls shall be not less than 0.0025 and that of the vertical reinforcement not less than 0.0015 times the area of the reinforced section of the wall if of bars, and not less than three-fourths as much if of welded wire fabric. Bars, if used, shall be not less than No. 3 bars, nor shall they be spaced more than eighteen inches (18") on centers. Welded wire reinforcement for walls shall be in flat sheet form and be not less than No. 10 A.S. & W. gauge. In addition to the minimum reinforcement there shall be not less than two No. 5 bars around window or door openings. Such bars shall extend at least twenty-four inches (24") beyond the corner of the openings.

Walls more than ten inches (10") thick, except for basement walls, 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 one-half and not more than two-thirds the total required shall be placed not less than two inches (2"), specified in Section 2608 (h), nor more than one-third the thickness of the wall from the exterior surface.

Reinforced Concrete Walls (Continued)

The other layer, comprising the balance of the required reinforcement, shall be placed not less than three-fourths inch (¾") and not more than one-third the thickness of the wall from the interior surface.

Reinforced concrete walls shall be anchored as specified in Section 2313.

(f) **Precast Solid Wall Panels.** 1. **Height and thickness.** The height and thickness of precast wall panels shall be governed by the structural requirements required by this and other sections of the Code, and where applicable by the fire-resistive time-period rating set forth in Table No. 43-B.

> **EXCEPTION:** Where panels are designed to span horizontally to columns or isolated footings, the ratio of height to thickness shall not exceed 36 and the effects of deep beam action and buckling shall be provided for in the design.

2. **Reinforcement.** The provisions of Subsection (e) shall govern the minimum requirements for reinforcing steel except as specified in the following paragraph 4.

3. **Joints.** Vertical and horizontal joints shall be designed to resist all design forces, weather, and fire exposure.

4. **Anchorage.** Wall panels shall be anchored to all floors and roofs as specified in Section 2313.

5. **Stresses.** Except as otherwise provided in this Section, allowable stresses shall comply with this Chapter. The allowable unit shear stress between precast and poured elements shall not exceed that set forth in Table No. 24-B, for unit masonry laid up in cement mortar unless shear keys are provided. Where reinforcing bars are used as ties, the shear value for bolts set forth in Table No. 26-I may be used.

TABLE NO. 26-I—ALLOWABLE SHEAR ON BOLTS

DIAMETER (Inches)	EMBEDMENT (Inches)	SHEAR (Pounds)
½	4	750
⅝	4	1000
¾	5	1500
⅞	6	2000
1	7	2500
1⅛	8	3000
1¼	9	3500

Sec. 2623. (a) **Scope.** The requirements prescribed in Section 2623 (b) through (i) apply only to isolated footings. **Footings**

General procedures for the design of combined footings *are given* in Section 2623 (j).

(b) **Loads and Reactions.** Footings shall be proportioned to sustain the applied loads and induced reactions without exceeding the stresses or strengths specified in Sections 2610 to 2619, and as further provided in this Section.

In cases where the footing is concentrically loaded and the member being supported does not transmit any moment to the footing, computations for moments and shears shall be based on an upward reaction assumed to be uniformly distributed per unit area or per pile and a downward applied load assumed to be uniformly distributed over the area of the footing covered by the column, pedestal, wall, or metallic column base.

In cases where the footing is eccentrically loaded and/or the member being supported transmits a moment to the footing, proper allowance shall be made for any variation that may exist in the intensities of reaction and applied load consistent with the magnitude of the applied load and the amount of its actual or virtual eccentricity.

In the case of footings on piles, computations for moments and shears may be based on the assumption that the reaction from any pile is concentrated at the center of the pile.

(c) **Sloped or Stepped Footings.** In sloped or stepped footings, the angle of slope or depth and location of steps shall be such that the allowable stresses are not exceeded at any section.

In sloped or stepped footings, the effective cross section in compression shall be limited by the area above the neutral plane.

Sloped or stepped footings that are designed as a unit shall be cast as a unit.

(d) **Bending Moment.** 1. The external moment on any section shall be determined by passing through the section a vertical plane which extends completely across the footing, and computing the moment of the forces acting over the entire area of the footing on one side of said plane.

2. The greatest bending moment to be used in the design of an isolated footing shall be the moment computed in the manner prescribed in paragraph 1 at sections located as follows:

A. At the face of the column, pedestal or wall, for footings supporting a concrete column, pedestal or wall.

B. Halfway between the middle and the edge of the wall, for footings under masonry walls.

Footings (Continued)

C. Halfway between the face of the column or pedestal and the edge of the metallic base, for footings under metallic bases.

3. The width resisting compression at any section shall be assumed as the entire width of the top of the footing at the section under consideration.

4. In one-way reinforced footings, the total tensile reinforcement at any section shall provide a moment of resistance at least equal to the moment computed as prescribed in paragraph 1; and the reinforcement thus determined shall be distributed uniformly across the full width of the section.

5. In two-way reinforced footings, the total tension reinforcement at any section shall provide a moment of resistance at least equal to the moment computed as prescribed in paragraph 1; and the total reinforcement thus determined shall be distributed across the corresponding resisting section as prescribed for square footings in paragraph 6, and for rectangular footings in paragraph 7.

6. In two-way square footings, the reinforcement extending in each direction shall be distributed uniformly across the full width of the footing.

7. In two-way rectangular footings, the reinforcement in the long direction shall be distributed uniformly across the full width of the footing. In the case of the reinforcement in the short direction, that portion determined by Formula (23-1) shall be uniformly distributed across a band-width (B) centered with respect to the center line of the column or pedestal and having a width equal to the length of the short side of the footing. The remainder of the reinforcement shall be uniformly distributed in the outer portions of the footing.

$$\frac{\textit{Reinforcement in band-width } (B)}{\textit{Total reinforcement in short direction}} = \frac{2}{(S+1)} \quad \ldots\text{(23-1)}$$

where "S" is the ratio of the long side to the short side of the footing.

(e) **Shear and Bond.** For computation of shear in footings, see Section 2612 (h) or 2617 (h).

Critical sections for bond shall be assumed at the same planes as those prescribed for bending moment in Section 2623 (d) 2, also at all other vertical planes where changes of section or of reinforcement occur.

Computation for shear to be used as a measure of flexural bond shall be based on a vertical section which extends completely across the footing, and the shear shall be taken as the sum of all forces acting over the entire area of the footing on one side of such section.

The total tensile reinforcement at any section shall provide a bond resistance at least equal to the bond requirement as computed from the external shear at the section.

Footings (Continued)

In computing the external shear on any section through a footing supported on piles, the entire reaction from any pile whose center is located six inches (6″) or more outside the section shall be assumed as producing shear on the section; the reaction from any pile whose center is located six inches (6″) or more inside the section shall be assumed as producing no shear on the section. For intermediate positions of the pile center, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straight-line interpolation between full value at six inches (6″) outside the section and zero value at six inches (6″) inside the section.

For allowable shearing values, see Sections 2612 (h) and 2617 (h).

For allowable bond values, see Section 2613 (b) and 2618 (b).

(f) **Transfer of Stress at Base of Column.** The stress in the longitudinal reinforcement of a column or pedestal shall be transferred to its supporting pedestal or footing either by extending the longitudinal bars into the supporting member, or by dowels.

In case the transfer of stress in the reinforcement is accomplished by extension of the longitudinal bars, they shall extend into the supporting member the distance required to transfer this stress to the concrete by bond.

In cases where dowels are used, their total sectional area shall be not less than the sectional area of the longitudinal reinforcement in the member from which the stress is being transferred. In no case shall the number of dowels per member be less than four and the diameter of the dowels shall not exceed the diameter of the column bars by more than one-eighth inch (⅛″).

Dowels shall extend up into the column or pedestal a distance at least equal to that required for lap of longitudinal column bars [see Section 2608 (e)] and down into the supporting pedestal or footing the distance required to transfer to the concrete, by allowable bond stress, the full working value of the dowel [see Section 2609 (s) 9].

The compression stress in the concrete at the base of a column or pedestal shall be considered as being transferred by bearing to the top of the supporting pedestal or footing. The compression stress on the loaded area shall not exceed the bearing stress allowable for the quality of concrete in the supporting member as determined by the ratio of the loaded area to the supporting area.

Footings (Continued)

For allowable bearing stresses, design by Sections 2610 to 2614 shall conform to Table No. 26-D, and for design by Sections 2615 to 2619 to 1.9 times those values.

In sloped or stepped footings, the supporting area for bearing may be taken as the top horizontal surface of the footing, or assumed as the area of the lower base of the largest frustum of a pyramid or cone contained wholly within the footing and having for its upper base the area actually loaded, and having side slopes of one vertical to two horizontal.

(g) **Pedestals and Footings (Plain Concrete).** The allowable compression stress on the gross area of a concentrically loaded pedestal under service load shall not exceed $0.25f_c'$. Where this stress is exceeded, reinforcement shall be provided and the member designed as a reinforced concrete column.

The depth and width of a pedestal or footing of plain concrete shall be such that the tension in the concrete in flexure shall not exceed $1.6\sqrt{f_c'}$ for design by Sections 2610 to 2614 or $3.2\sqrt{f_c'}$ for design by Sections 2615 to 2619. The average shear stress shall satisfy the requirements of Section 2612 or 2617.

(h) **Footings Supporting Round Columns.** In computing the stresses in footings which support a round or octagonal concrete column or pedestal, the "face" of the column or pedestal may be taken as the side of a square having an area equal to the area enclosed within the perimeter of the column or pedestal.

(i) **Minimum Edge Thickness.** In reinforced concrete footings, the thickness above the reinforcement at the edge shall be not less than six inches (6") for footings on soil, nor less than twelve inches (12") for footings on piles.

In plain concrete footings, the thickness at the edge shall be not less than eight inches (8") for footings on soil, nor less than fourteen inches (14") above the tops of the piles for footings on piles.

(j) **Combined Footings and Mats.** The following recommendations are made for combined footings and mats—those supporting more than one column or wall:

1. Soil pressures shall be considered as acting uniformly or varying linearly, except that other assumptions may be made consistent with the properties of the soil and the structure and with established principles of soil mechanics.

2. Shear as a measure of diagonal tension shall be computed in conformance with Section 2612 (h) or 2617 (h).

Precast Concrete

Sec. 2624. (a) **Scope.** All provisions of this Code shall apply to precast concrete except for the specific variations given in Sections 2624 and 2626.

Precast Concrete (Continued)

(b) **Aggregates.** For precast concrete Section 2604 (c) shall not apply; the maximum size of aggregate shall be not larger than one-third of the least dimension of the member.

(c) **Concrete Protection for Reinforcement.** At surfaces not exposed to weather, all reinforcement shall be protected by concrete equal to the nominal diameter of bars but not less than five-eighths inch (⅝").

(d) **Details.** All details of jointing, inserts, anchors, and openings shall be shown on the drawings.

Lifting eyes or other similar devices shall be designed for 100 per cent impact. They shall be made of materials sufficiently ductile to ensure visible deformation before fracture.

(e) **Curing.** Curing by high-pressure steam, steam vapor, or other accepted processes may be employed to accelerate the hardening of the concrete and to reduce the time of curing required by Section 2606 (e) provided that the compressive strength of the concrete at the load stage considered be at least equal to the design strength required at that load stage.

(f) **Identification and Marking.** All precast concrete members shall be plainly marked to indicate the top of the member and its location and orientation in the structure. Identification marks shall be reproduced from the placing plans.

(g) **Transportation, Storage, and Erection.** Units shall be so stored, transported, and placed that they will not be overstressed or damaged.

Precast concrete units shall be adequately braced and supported during erection to insure proper alignment and safety and such bracing or support shall be maintained until there are adequate permanent connections.

Composite Concrete Flexural Construction

Sec. 2625. (a) **Notations.** The notations used in these regulations are defined as follows:

b' = width of area of contact between precast and cast-in-place concretes.

d_p = effective depth of the tension reinforcement in precast component.

I = moment of inertia of the transformed composite section neglecting area of concrete in tension.

M_D = moment due to dead load, produced prior to the time at which the cast-in-place concrete attains 75 per cent of its specified 28-day strength.

M_L = moment due to live load and superimposed dead load.

Q = statical moment of the transformed area outside of the contact surface about the neutral axis of the composite section.

V = total shear.

v_h = horizontal shear stress along contact surface.

Composite Concrete Flexural Construction (Continued)

(b) **Definition.** Composite concrete flexural construction consists of precast concrete members and cast-in-place reinforced concrete so interconnected that the component elements act together as a unit.

(c) **Special Design Considerations.** In regions of negative moment, the bending moment may be assigned to either the composite section or the precast element. When the negative moments are assigned to the composite section, adequate provision for shear transfer must be made throughout the full length of the beam.

(d) **Flexural Design—Working Stress Design (Sections 2610 to 2614).** The design of the composite reinforced concrete member shall be based on allowable stresses, working loads, and the accepted straightline theory of flexure as given in Sections 2610 to 2614. The effects of creep, shrinkage, and temperature need not be considered except in unusual cases. The effects of shoring, or lack of shoring, on deflections and stresses shall be considered.

(e) **Fexural Design—Ultimate Strength Design (Sections 2615 to 2619). Design Method.** In calculating the ultimate strength of a section, no distinction is made between shored and unshored members.

Limitations. For beams designed on the basis of ultimate strength and built without shores, the effective depth of the composite section used in the calculation of the ultimate moment shall not exceed:

$$(1.15 + 0.24\, M_L/M_D)\, d_p$$

When the specified yield point of the tension reinforcement exceeds 40,000 pounds per square inch, beams designed on the basis of ultimate strength should always be built with shores unless provisions are made to prevent excessive tensile cracking.

Construction loads. The nonprestressed precast element shall be investigated separately to assure that the loads applied before the cast-in-place concrete has attained 75 per cent of its specified 28-day strength do not cause moment in excess of 60 per cent of the ultimate moment capacity of the precast section.

(f) **Shear Connection.** 1. **Shear calculation.** The horizontal shear stress along the contact surface is given by:

$$v_h = \frac{VQ}{Ib'} \qquad \text{.........................(25-1)}$$

2. **Shear transfer.** Shear shall be transferred along the contact surface either by bond or by shear keys. The capacity of bond at ultimate load may be taken as 1.9 times the values recommended below for service loads. Except as provided in paragraph A, separation of the component elements in the

direction normal to the surface shall be prevented by steel ties or other suitable mechanical anchorages.

Composite Concrete Flexural Construction (Continued)

A. When mechanical anchorages are not provided and the contact surface is rough and clean.............................. 40 p.s.i.

B. When minimum steel tie requirements of Subsection 4 are followed and the contact surface is smooth (troweled, floated, or cast against a form).. 40 p.s.i.

C. When minimum steel tie requirements of Subsection 3 are followed and the contact surface is rough and clean..160 p.s.i.

D. When additional vertical ties are used the allowable bond stress on a rough surface may be increased at the rate of 75 pounds per square inch for each additional area of steel ties equal to one per cent of the contact area.

3. **Vertical ties.** When mechanical anchorage in the form of vertical ties is provided, spacing of such ties shall not exceed four times the thickness of the slab nor twenty-four inches (24"). A minimum cross-sectional area of ties of 0.15 per cent of the contact area shall be provided. It is preferable to provide all ties in the form of extended stirrups.

4. **Web reinforcement.** Web reinforcement for the composite section shall be designed in the same manner as for an integral beam of the same shape. All stirrups so required shall be anchored into the cast-in-place slab, where their area may also be relied upon to provide some or all of the vertical tie steel required in Subsection 3.

Sec. 2626. (a) **Notations.** The notations used in these regulations are defined as follows:

Prestressed Concrete

a $= A_s f_{su} / 0.85 f_c' b$.

A_b = bearing area of anchor plate of post-tensioning steel.

A_b' = maximum area of the portion of the anchorage surface that is geometrically similar to and concentric with the area of the anchor plate of the post-tensioning steel.

A_s = area of prestressed tendons.

A_{sf} = area of reinforcement to develop compressive strength of overhanging flanges in flanged members.

A_{sr} = area of tendon required to develop the web.

A_s' = area of unprestressed reinforcement.

A_v = area of web reinforcement placed perpendicular to the axis of the member.

b = width of compression face of flexural member.

b' = minimum width of web of a flanged member.

d = distance from extreme compression fiber to centroid of the prestressing force.

f_c' = compressive strength of concrete (see Section 2603).

f_{ci}' = compressive strength of concrete at time of initial prestress.

Prestressed Concrete (Continued)

f_{cp} = permissible compressive concrete stress on bearing area under anchor plate of post-tensioning steel.

f_d = Stress due to dead load, at the extreme fiber of a section at which tension stresses are caused by applied loads[1].

f_{pc} = compressive stress in the concrete, after all prestress losses have occurred, at the centroid of the cross section resisting the applied loads, or at the junction of the web and flange when the centroid lies in the flange. (In a composite member "f_{pc}" will be the resultant compressive stress at the centroid of the composite section, or at the junction of the web and flange when the centroid lies within the flange, due to both prestress and to the bending moments resisted by the precast member acting alone.)

f_{pe} = compressive stress in concrete due to prestress only, after all losses, at the extreme fiber of a section at which tension stresses are caused by applied loads.

f_s' = ultimate strength of prestressing steel.

f_{se} = effective steel prestress after losses.

f_{su} = calculated stress in prestressing steel at ultimate load.

f_{sy} = nominal yield strength of prestressing steel.

f_y' = strength of unprestressed reinforcement (see Section 2603).

F_{sp} = ratio of splitting tensile strength to the square root of compressive strength [see Section 2605 (f)].

h = total depth of member.

I = moment of inertia of section resisting externally applied loads[1].

K = wobble friction coefficient per foot of prestressing steel.

L = length of prestressing steel element from jacking end to any point "x".

M = bending moment due to externally applied loads[1].

M_{cr} = net flexural cracking moment.

M_u = ultimate resisting moment.

p = "A_s/bd"; ratio of prestressing steel.

p' = "A_s'/bd"; ratio of unprestressed steel.

q = "$p\, f_{su}/f_c'$"

s = longitudinal spacing of web reinforcement.

T_o = steel force at jacking end.

T_x = steel force at any point "x".

t = average thickness of the compression flange of a flanged member.

V = shear due to externally applied loads.[1]

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[1]The term "externally applied loads" shall be taken to mean the external ultimate loads acting on the member, excepting those applied to the member by the prestressing tendons.

V_c = shear carried by concrete.

V_{ci} = shear at diagonal cracking due to all loads, when such cracking is the result of combined shear and moment.

V_{cw} = shear force at diagonal cracking due to all loads, when such cracking is the result of excessive principal tension stresses in the web.

V_d = shear due to dead load.

V_p = vertical component of the effective prestress force at the section considered.

V_u = shear due to specified ultimate load.

y = distance from the centroidal axis of the section resisting the applied loads to the extreme fiber in tension.

α = total angular change of prestressing steel profile in radians from jacking end to any point "x".

ε = base of Naperian logarithms.

μ = curvature friction coefficient.

ϕ = capacity reduction factor [see Section 2615 (e)].

(b) **Definitions.** The following terms are defined for use in this Chapter:

ANCHORAGE is the means by which the prestress force is permanently delivered to the concrete.

BONDED TENDONS are tendons which are bonded to the concrete either directly or through grouting. Unbonded tendons are free to move relative to the surrounding concrete.

EFFECTIVE PRESTRESS is the stress remaining in the tendons after all losses have occurred, excluding the effects of dead load and superimposed loads.

FRICTION, CURVATURE FRICTION, is friction resulting from bends or curves in the specified cable profile.

FRICTION, WOBBLE FRICTION, is friction caused by the unintended deviation of the prestressing steel from its specified profile.

JACKING FORCE is the temporary force exerted by the device which introduces the tension into the tendons.

NOMINAL YIELD STRENGTH is the yield strength specified by appropriate U.B.C. specification or as indicated by Section 2604 (e).

POST-TENSIONING is a method of prestressing in which the tendons are tensioned after the concrete has hardened.

PRETENSIONING is a method of prestressing in which the tendons are tensioned before the concrete is placed.

TENDON is a tensioned steel element used to impart prestress to the concrete.

Prestressed Concrete (Continued)

TRANSFER is the operation of transferring the tendon force to the concrete.

(c) **Scope.** Provisions in this Chapter apply to flexural members prestressed with high-strength steel. Pavements, pipes, and circular tanks are not included.

For prestressed concrete designs or constructions in conflict with, or not encompassed by the provisions of this Chapter, see Section 106.

All provisions of this Code not specifically excluded and not in conflict with the provisions of this Chapter are to be considered applicable to prestressed concrete.

The following provisions shall not apply to prestressed concrete: Sections 2609 (g), 2609 (l), 2609 (n), 2613, 2614, 2615 (i), 2618, 2620 (a) 1, 2621, and 2625 (e) 2.

(d) **General Considerations.** Stresses and ultimate strength shall be investigated at service conditions and at all load stages that may be critical during the life of the structure from the time prestress is first applied.

Stress concentrations due to the prestressing or other causes shall be taken into account in the design.

The effects on the adjoining structure of elastic and plastic deformations, deflections, changes in length, and rotations caused by the prestressing shall be provided for. When the effect is additive to temperature and shrinkage effects, they shall be considered simultaneously.

The possibility of buckling of a member between points of contact between concrete and prestressing steel and of buckling of thin webs and flanges shall be considered.

(e) **Basic Assumptions.** The following assumptions shall be made for purposes of design:

1. Strains vary linearly with depth through the entire load range.
2. At cracked sections, the ability of the concrete to resist tension is neglected.
3. In calculations of section properties prior to bonding of tendons, areas of the open ducts shall be deducted. The transformed area of bonded tendons may be included in pretensioned members and in post-tensioned members after grouting.
4. Modulus of elasticity of concrete shall be assumed as prescribed in Section 2611 (c).
5. The modulus of elasticity of prestressing steel shall be determined by tests or supplied by the manufacturer.

(f) **Allowable Stresses in Concrete.** Temporary stresses immediately after transfer, before losses due to creep and shrinkage, shall not exceed the following:

Compression .... $0.60\ f_{ci}'$

Tension stresses in members without auxiliary reinforcement (unprestressed or prestressed) in the tension zone .... $3\sqrt{f_{ci}'}$

Where the calculated tension stress exceeds this value, reinforcement shall be provided to resist the total tension force in the concrete computed on the assumption of an uncracked section.

Prestressed Concrete (Continued)

Stresses at design loads, after allowance for all prestress losses, shall not exceed the following:

Compression .... $0.45f_c'$

Tension in the precompressed tension zone:

Members, not exposed to freezing temperatures nor to a corrosive environment, which contain bonded prestressed or unprestressed reinforcement located so as to control cracking .... $6\sqrt{f_c'}$

All other members 0

These values may be exceeded when not detrimental to proper structural behavior as provided in Section 106.

The bearing stress on the concrete created by the anchorage in post-tensioned concrete with adequate reinforcement in the end regions shall not exceed:

$$f_{cp} = 0.6f_{ci}' \sqrt[3]{A_b'/A_b} \quad \text{(26-1)}$$

but not greater than f_{ci}'.

(g) **Allowable Stresses in Steel.**

1. **Temporary stresses:**

Due to temporary jacking force .... $0.80\ f_s'$ but not greater than the maximum value recommended by the manufacturer of the steel or of the anchorages.

Pretensioning tendons immediately after transfer, or post-tensioning tendons immediately after anchoring .... $0.70\ f_s'$

2. **Effective prestress** .... $0.60\ f_s'$ or $0.80\ f_{sy}$ whichever is smaller.

(h) **Loss of Prestress.** To determine the effective prestress, allowance for the following sources of loss of prestress shall be considered:

1. Slip at anchorage.
2. Elastic shortening of concrete.
3. Creep of concrete.
4. Shrinkage of concrete.
5. Relaxation of steel stress.
6. Frictional loss due to intended or unintended curvature in the tendons.

Friction losses in post-tensioned steel shall be based on experimentally determined wobble and curvature coefficients[1], and shall be verified during stressing operations. The values of coefficients assumed for design, and the acceptable ranges of jacking forces and steel elongations shall be shown on the plans. These friction losses shall be calculated:

[1]Values of "K" (per lineal foot) and "μ" vary appreciably with duct material and method of construction.

Prestressed Concrete (Continued)

$$T_o = T_x \varepsilon^{(KL + \mu\alpha)} \qquad \text{.................(26-2)}$$

When $(KL + \mu\alpha)$ is not greater than 0.3, Formula (26-3) may be used.

$$T_o = T_x\,(1 + KL + \mu\alpha) \qquad \text{...............(26-3)}$$

When prestress in a member may be reduced through its connection with adjoining elements, such reduction shall be allowed for in the design.

(i) **Ultimate Flexural Strength.** The required ultimate load on a member, determined in accordance with Sections 2615 to 2619 shall not exceed the ultimate flexural strength computed by:

Rectangular sections, or flanged sections in which the neutral axis lies within the flange:[1]

$$M_u = \phi\left[A_s f_{su} d\,(1 - 0.59\,q)\right] = \phi\left[A_s f_{su}\left(d - \frac{a}{2}\right)\right] \qquad \text{.........(26-4)}$$

Flanged sections in which the neutral axis falls outside the flange:[2]

$$M_u = \phi\left[A_{sr} f_{su} d\left(1 - \frac{0.59\,A_{sr} f_{su}}{b'd f_c'}\right) + 0.85 f_c'\,(b - b')t\,(d - 0.5t)\right] \qquad \text{.............(26-5)}$$

WHERE:

$$A_{sr} = A_s - A_{sf}$$

AND

$$A_{sf} = 0.85 f_c'\,(b - b')t/f_{su}$$

Where information for the determination of "f_{su}" is not available, and provided that "f_{se}" is not less than 0.5 "f_s'", the following approximate values shall be used:

Bonded members

$$f_{su} = f_s'\,(1 - 0.5\,p f_s'/f_c') \qquad \text{.............(26-6)}$$

Unbonded members

$$f_{su} = f_{se} + 15{,}000 \text{ p.s.i.} \qquad \text{...............(26-7)}$$

Nonprestressed reinforcement, in combination with prestressed steel, may be considered to contribute to the tension force in a member at ultimate moment an amount equal to its area times its yield point, provided

$$\frac{p f_{su}}{f_c'} + \frac{p' f_y}{f_c'} \text{ does not exceed } 0.3$$

(j) **Limitations on Steel Percentage.** Except as provided in the following paragraph, the ratio of prestressing steel used for calculations of "M_u" shall be such that

$$p f_{su} / f_c' \text{ is not more than } 0.30$$

[1]Usually where the flange thickness is more than 1.4 "$d p f_{su}/f_c'$".
[2]Usually where the flange thickness is less than 1.4 "$d p f_{su}/f_c'$".

For flanged sections, "p" shall be taken as the steel ratio of only that portion of the total tension steel area which is required to develop the compressive strength of the web alone. **Prestressed Concrete (Continued)**

When a steel ratio in excess of that specified in the preceding paragraph is used, the ultimate moment shall be taken as not greater than the following:

Rectangular sections, or flanged sections in which the neutral axis lies within the flange

$$M_u = \phi[0.25\, f_c' b d^2] \quad \text{.................. (26-8)}$$

Flanged sections in which the neutral axis falls outside the flange

$$M_u = \phi[0.25\, f_c' b' d^2 + 0.85 f_c' \,(b - b')\, t\, (d - 0.5t)] \quad \text{.................. (26-9)}$$

The total amount of prestressed and unprestressed reinforcement shall be adequate to develop an ultimate load in flexure at least 1.2 times the cracking load calculated on the basis of a modulus of rupture of $7.5\sqrt{f_c'}$.

(k) **Shear.** 1. Except as provided in paragraph 3, the area of shear reinforcement placed perpendicular to the axis of a member shall be not less than:

$$A_v = \frac{(V_u - \phi V_c)s}{\phi\, d\, f_y} \quad \text{.................. (26-10)}$$

nor less than

$$A_v = \frac{A_s}{80} \cdot \frac{f_s'}{f_y} \cdot \frac{s}{d} \sqrt{\frac{d}{b'}} \quad \text{.................. (26-11)}$$

The effective depth, "d", used in Formulas (26-10) and (26-11) shall be as follows:

A. In members of constant over-all depth, "d", equals the effective depth at the section of maximum moment, and the length of the stirrups at the section under consideration shall be at least equal to the length of the stirrups at the section of maximum moment.

B. In members of varying depth, "d" equals "$h(d_m/h_m)$", where "d_m" and "h_m" are the effective depth and total depth respectively at the section of maximum moment, and "h" is the total depth at the section under consideration. The stirrups shall extend into the member a distance "d" from the compression face.

2. The shear, "V_c", at diagonal cracking shall be taken as the lesser of "V_{ci}" and "V_{cw}", determined from Formulas (26-12) and (26-13).

For normal weight concrete

Prestressed Concrete (Continued)

$$V_{ci} = 0.6\, b'd \sqrt{f_c'} + \frac{M_{cr}}{\dfrac{M}{V} - \dfrac{d}{2}} + V_d \quad (26\text{-}12)$$

but not less than $1.7\, b'd \sqrt{f_c'}$.

WHERE:

$$M_{cr} = \frac{I}{y} (6 \sqrt{f_c'} + f_{pe} - f_d)$$

$$V_{cw} = b'd\, (3.5 \sqrt{f_c'} + 0.3 f_{pc}) + V_p \quad (26\text{-}13)$$

For lightweight aggregate concrete

$$V_{ci} = 0.1\, F_{sp}\, b'd \sqrt{f_c'} + \frac{M_{cr}}{\dfrac{M}{V} - \dfrac{d}{2}} + V_d \quad (26\text{-}12A)$$

but not less than $0.25\, F_{sp}\, b'd \sqrt{f_c'}$.

WHERE:

$$M_{cr} = \frac{I}{y} (0.9 F_{sp} \sqrt{f_c'} + f_{pc} - f_d)$$

$$V_{cw} = b'd \left[0.5\, F_{sp} \sqrt{f_c'} + f_{pc} \left(0.2 + \frac{F_{sp}}{67} \right) \right] + V_p \quad (26\text{-}13A)$$

Alternatively "V_{cw}" may be taken as the live load plus dead load shear which corresponds to the occurrence of a principal tensile stress of $4\sqrt{f_c'}$ in normal weight concrete, or $0.6 F_{sp} \sqrt{f_c'}$ in lightweight concrete, at the centroidal axis of the section resisting the live load. In flanged members, if the centroidal axis is not in the web, the principal tensile stress should be determined at the intersection of the flange and the web.

When applying Formulas (26-12) and (26-12A), the effective depth, "d", shall be taken as the distance from the extreme compression fiber to the centroid of the prestressing tendons.

When applying Formulas (26-13) and (26-13A), the effective depth, "d", shall be taken as the distance from the extreme compression fiber to the centroid of the prestressing tendons, or as 80 per cent of the over-all depth of the member, whichever is the greater.

The value of "M/V" used in Formulas (26-12) and (26-12A) shall be that resulting from the distribution of loads causing maximum moment to occur at the section.

In a pretensioned prestressed beam in which the section distant "$d/2$" from the face of the support is closer to the end face of the beam than the transfer length of the wire or strand used, the reduced prestress in the concrete at sections falling within the transfer length should be considered when calculating the diagonal cracking shear, "V_{cw}". The prestress at the centroid of the section may be assumed to vary linearly from zero at the end face of the beam to a maximum at a distance from the end face equal to the transfer length, assumed to be 50 diameters for strand and 100 diameters for single wire.

Prestressed Concrete (Continued)

3. Web reinforcement between the face of the support and the section at a distance "$d/2$" therefrom shall be the same as that required at that section.

Shear reinforcement shall be provided for a distance equal to the effective depth, "d", of the member beyond the point theoretically required.

Web reinforcement shall be anchored at both ends in accordance with Section 2609 (t).

Shear reinforcement not less than determined from Formula (26-11) shall be provided at all sections and shall be spaced not farther apart than three-fourths the depth of the member, nor twenty-four inches (24″), whichever is the smaller, except when it is shown by tests that the required ultimate flexural and shear capacity can be developed when the web reinforcement is omitted.

A yield strength in excess of 60,000 pounds per square inch shall not be considered for shear reinforcement.

(1) **Bond.** Three or seven wire pretensioning strand shall be bonded to the concrete from the cross section under consideration for a distance in inches of not less than:

$$\left(f_{su} - \frac{2}{3} f_{se}\right) D$$

where "D", the nominal strand diameter, is in inches and "f_{su}" and "f_{se}" are expressed in kips per square inch.

Investigation may be restricted to those cross sections nearest each end of the member that are required to develop their ultimate strength under the specified ultimate load.

(m) **Repetitive Loads.** The possibility of bond failure due to repeated loads shall be investigated in regions of high bond stress and where flexural cracking is expected at design loads.

In unbonded construction subject to repetitive loads, special attention shall be given to the possibility of fatigue in the anchorages.

The possibility of inclined diagonal tension cracks forming under repetitive loading at appreciably smaller stresses than under static loading shall be taken into account in the design.

(n) **Composite Construction.** General requirements for composite construction are given in Section 2625.

Prestressed Concrete (Continued)

(o) **End Regions.** End blocks shall be provided if necessary for end bearing or for distribution of concentrated prestressing forces safely from the anchorages to the cross section of the member.

Reinforcement shall be provided in the anchorage zone to resist bursting and spalling forces induced by the concentrated loads of the prestressing steel. Points of abrupt change in section shall be adequately reinforced.

(p) **Continuity.** For continuous girders and statically indeterminate structures, moments, shears, and thrusts produced by external loads and prestressing shall be determined by elastic analysis. The effects of creep, shrinkage, axial deformation, restraint of attached structural elements, and foundation settlement shall be considered in the design.

In the application of ultimate load factors where effects of dead and live loads are of opposite sign, the case of a dead load factor of unity shall be included in the investigation.

(q) **Concrete Cover.** The following minimum thicknesses of concrete cover shall be provided for prestressing steel, ducts and nonprestressed steel.

	COVER (In Inches)
Concrete surfaces in contact with ground	2
Beams and girders	
Prestressing steel and main reinforcing bars	1½
Stirrups and ties	1
Slabs and joists exposed to weather	1
Slabs and joists not exposed to weather	¾

In extremely corrosive atmosphere or other severe exposures, the amount of protection shall be suitably increased.

(r) **Placement of Prestressing Steel.** All pretensioning steel and ducts for post-tensioning shall be accurately placed and adequately secured in position.

The minimum clear spacing between pretensioning steel at each end of the member shall be four times the diameter of individual wires or three times the diameter of strands, but at least one and one-third times the maximum size of aggregate.

Prestressing steel or ducts may be bundled together in the middle portion of the span, provided the requirements of the preceding paragraph are met.

Ducts may be arranged closely together vertically when provision is made to prevent the steel, when tensioned, from breaking through the duct. Horizontal disposition of ducts shall allow proper placement of concrete.

Where concentration of steel or ducts tends to create a weakened plane in the concrete cover, reinforcement shall be provided to control cracking.

The inside diameter of ducts shall be at least one-fourth inch (¼″) larger than the diameter of the post-tensioning bar or large enough to produce an internal area at least twice the gross area of wires, strands, or cables.

Prestressed Concrete (Continued)

(s) **Concrete.** Suitable admixtures to obtain high early strength or to increase the workability of low-slump concrete may be used if known to have no injurious effects on the steel or the concrete. Calcium chloride or an admixture containing calcium chloride shall not be used. Sea water shall not be used.

Concrete strength required at given ages shall be indicated on the plans. The strength at transfer shall be adequate for the requirements of the anchorages or of transfer through bond as well as meet camber or deflection requirements. For seven-wire strands, the minimum strength at transfer shall be 3000 pounds per square inch for three-eighths-inch (⅜") strands and smaller, and 3500 pounds per square inch for seven-sixteenths-inch ($\frac{7}{16}$") and one-half-inch (½") strands.

(t) **Grout.** Suitable admixtures, known to have no injurious effects on the steel or the concrete, may be used to increase workability and to reduce shrinkage. Calcium chloride shall not be used.

Sand, if used, shall conform to U.B.C. Standard No. 24-20-67 except that gradation may be modified as necessary to obtain proper workability.

Proportions of grouting materials shall be based on results of tests on fresh and hardened grout prior to beginning work. The water content shall be the minimum necessary for proper placement but in no case more than five and one-half gallons per sack. When permitted to stand until setting takes place, grout shall neither bleed nor segregate.

Grout shall be mixed in a high-speed mechanical mixer and then passed through a strainer into pumping equipment which provides for recirculation.

Just prior to grouting, the ducts shall be made free of water, dirt, and other foreign substances. The method of grouting shall be such as to ensure the complete filling of all voids between the prestressing steel and the duct and anchorage fittings.

Temperature of members at the time of grouting must be above 50°F. and at least this temperature shall be maintained for at least 48 hours.

(u) **Steel Tendons.** Prestressing steel shall be clean and free of excessive rust, scale, and pitting. A light oxide is permissible. Unbonded steel shall be permanently protected from corrosion.

Burning and welding operations in the vicinity of prestressing steel shall be carefully performed, so that the prestressing steel shall not be subjected to excessive temperatures, welding sparks, or ground currents.

(v) **Application and Measurement of Prestressing Force.** Prestressing force shall be determined (1) by measuring ten-

Prestressed Concrete (Continued)

don elongation and also (2) either by checking jack pressure on a recently calibrated gauge or by the use of a recently calibrated dynamometer. The cause of any discrepancy which exceeds five per cent shall be ascertained and corrected. Elongation requirements shall be taken from average load-elongation curves for the steel used.

If several wires or strands are stretched simultaneously, provision must be made to induce approximately equal stress in each.

Transfer of force from the bulkheads of the pretensioning bed to the concrete shall be carefully accomplished, by proper choice of cutting points and cutting sequence. Release of pretensioning may be effected by gradual means or by burning of tendons. Long lengths of exposed strands shall be cut near the member to minimize shock to the concrete.

The total loss of prestress due to unreplaced broken tendons shall not exceed two per cent of the total prestress.

Where there is a considerable temperature differential between the concrete and the tendons, its effect shall be taken into account.

(w) **Post-tensioning Anchorages and Couplers.** Anchorages, couplers, and splices for post-tensioned reinforcement shall develop the required ultimate capacity of the tendons without excessive slip. Couplers and splices shall be placed in areas approved by the Building Official and enclosed in housings long enough to permit the necessary movements. They shall not be used at points of sharp curvature.

Anchorage and end fittings shall be permanently protected against corrosion.

(x) **Formwork.** Forms for pretensioned members shall be constructed to permit movement of the member without damage during release of the prestressing force.

Forms for post-tensioned members shall be constructed to minimize resistance to the shortening of the member. Deflection of members due to the prestressing force and deformation of falsework shall be considered in the design.

(y) **Joints and Bearings for Precast Members.** Design and detailing of the joints and bearings shall be based on the forces to be transmitted, and on the effects of dimensional changes due to shrinkage, elastic deformation, creep and temperature. Joints shall be detailed so as to allow sufficient tolerances for manufacture and erection of the members.

Bearings shall be detailed to provide for stress concentrations, rotations, and the possible development of horizontal forces by friction or other restraints.

(z) **Lift Slab Shear.** In Seismic Zones No. 1, No. 2 and No. 3, provision shall be made for the possibility of overstress of the concrete in the vicinity of the lift collar. Deformed reinforcing bars so arranged as to support the tributary design live plus dead loads with the concrete taking no shear may be used to fulfill this requirement. Deformed reinforcing bars passing alongside of the column and passing through or attached to the lift collar and having a total area in square inches equal to 1/25 of the design live plus dead load (expressed in kips) also may be used to fulfill this requirement.

Prestressed Concrete (Continued)

Pneumatically Placed Concrete

Sec. 2627. (a) **General.** For the purpose of this Chapter all pneumatically placed concrete shall consist of a mixture of fine aggregate and cement pneumatically applied by suitable mechanism, and to which water is added immediately prior to discharge from the applicator.

Except as specified in the following Subsections of this Section, all pneumatically placed concrete shall conform to the regulations of this Chapter for concrete.

(b) **Proportions.** The proportion of cement to aggregate, in loose dry volumes, shall be not less than one to four and one-half.

(c) **Water.** The water content at the time of discharge, including any moisture in the fine aggregate, shall not exceed three and one-half gallons per sack of cement.

(d) **Mixing.** The cement and aggregate shall be thoroughly mixed prior to the addition of water. At the time of mixing the fine aggregate shall contain not less than three per cent moisture.

(e) **Rebound.** Any rebound or accumulated loose aggregate shall be removed from the surface to be covered prior to placing the initial or any succeeding layers of pneumatically placed concrete. Rebound may be reused if it conforms to the requirements for aggregate, but not in excess of 25 per cent of the total aggregate in any batch.

(f) **Joints.** Unfinished work shall not be allowed to stand for more than 30 minutes unless all abrupt edges are sloped to a thin edge. Before resuming work, this sloped portion shall be cleaned and wetted.

(g) **Damage.** Any pneumatically placed concrete which subsides after placement shall be removed.

Bolts

Sec. 2628. Bolts shall be solidly embedded in plain or reinforced concrete, and the connection shall be designed so that the shear on every bolt is not more than the values set forth in Table No. 26-I.

Minimum Slab Thickness

Sec. 2629. The minimum thickness of concrete floor slabs supported directly on the ground shall be not less than three and one-half inches (3½″).

Ductile Moment-Resisting Space Frames— Seismic Zones No. 2 and No. 3

Sec. 2630. (a) **General.** 1. Design and construction of cast-in-place, monolithic reinforced concrete framing members and their connections in ductile moment-resisting space frames shall conform to the requirements of this Code and all the requirements of this Section.

Ductile Moment-Resisting Space Frames—Seismic Zones No. 2 and No. 3 (Continued)

2. All lateral load-resisting frame members shall be designed by the ultimate strength design method except that the working stress design method may be used provided that it is shown that the factor of safety is equivalent to that achieved with the ultimate strength design method.

3. Formulas (15–2) and (15–3) of Section 2615 (g) for earthquake loading shall be modified to:

$$U = 1.40\ (D + L + E) \quad \text{.............(30-1)}$$

$$U = .90\ D + 1.25\ E \quad \text{.............(30-2)}$$

(b) **Definitions. CONFINED CONCRETE** is concrete which is confined by closely spaced special transverse reinforcement to restrain the concrete in directions perpendicular to the applied stresses.

SPECIAL TRANSVERSE REINFORCEMENT consists of spirals, stirrup ties, or hoops provided to restrain the concrete to make it qualify as confined concrete.

STIRRUP TIES OR HOOPS consist of continuous reinforcing steel of not less than a No. 3 bar bent to form a closed hoop which encloses the longitudinal reinforcing and the ends of which have a standard 135-degree bend with a 10-bar diameter extension.

(c) **Symbols and Notations.** The following symbols and notations apply only to the provisions of this Section:

A_g = gross area of column.

A_s = effective cross-sectional area of reinforcement.

d = distance from extreme compression fiber to centroid of tension reinforcement.

f'_c = compressive strength of concrete (see Section 2603).

f_y = specified yield strength of reinforcement.

P = maximum design axial load on column.

p = tension reinforcement ratio.

p' = compression reinforcement ratio.

D = nominal diameter of bar, inches.

Σo = definition given in Section 2618.

u_u = definition given in Section 2618.

V_u = total ultimate shear.

(d) **Physical Requirements for Concrete and Reinforcing Steel.** 1. **Concrete.** The minimum specified 28-day strength, "f_c'" of the concrete shall be 3000 pounds per square inch.

2. **Reinforcement.** All longitudinal reinforcing steel shall be new billet-steel bars conforming to U.B.C. Standard No. 26-7-67 and limited to grades ASTM A15, A408 or A432. For flexural members reinforcing steel complying with ASTM Standard A15 or A408 shall be either structural grade or intermediate, and the specified yield strength, "f_y", shall not exceed 40,000 pounds per square inch. A408 reinforcing bars

Ductile Moment-Resisting Space Frames—Seismic Zones No. 2 and No. 3 (Continued)

when bent more than 10 degrees shall meet the 90-degree bend test requirements for A15 reinforcing steel except that the diameter of the pin about which the specimen is bent shall have a diameter of eight times the bar diameter. For columns, the specified yield strength of the vertical reinforcing steel, "f_y", shall not exceed 60,000 pounds per square inch. Grades of steel other than those specified in the design shall not be used.

Where reinforcing steel is to be welded, a chemical analysis of the steel shall be provided. The welding procedure shall be as set forth in U.B.C. Standard No. 26-16-67.

(e) **Flexural Members. 1. General.** Flexural members shall not have a width-depth ratio of less than 0.4, nor shall the width be less than ten inches (10″) nor more than the supporting column width plus a distance on each side of the column of three-fourths the depth of the flexural member. Flexural members framing into columns shall be subject to a rational joint analysis.

2. **Reinforcement.** All flexural members shall have a minimum reinforcement ratio, for both top and bottom reinforcement, of $200/f_y$ throughout their length. At least two bars shall be provided both top and bottom. The tension reinforcement ratio, "p," shall not exceed 0.025 nor $0.46\ f'_c\ p'/f_y p$, whichever is least, for negative moment at the face of columns, and the positive moment capacity at such locations shall be not less than 50 per cent of the negative moment capacity provided. A minimum of one-fourth of the larger amount of the negative reinforcement required at either end shall continue throughout the length of the beam.

3. **Splices.** Tensile steel shall not be spliced by lapping in a region of tension or reversing stress unless the region is confined by stirrup-ties, as provided in Section 2630 (e) 5. Splices shall not be located within the column or within a distance of twice the member depth from the face of the column. At least two stirrup-ties shall be provided at all splices.

4. **Anchorage.** Flexural members framing into only one side of a column, in any vertical plane, shall have top and bottom reinforcement extending to the far face of a confined concrete region as required by Section 2630 (f) 4 terminating in a standard 90-degree hook. The length of required anchorage shall be computed beginning at the near face of the column. Length of anchorage "L" in confined regions shall be determined by:

$$L = \frac{Asfy}{1.5u_u\ \Sigma o} \qquad \text{(30-3)}$$

including hook and vertical extension, but not less than 24 inches.

Main longitudinal flexural reinforcement shall be capable of being anchored, without horizontal offsets, within the con-

Ductile Moment-Resisting Space Frames—Seismic Zones No. 2 and No. 3 *(Continued)*

fined column core when framing into only one side of a column.

5. **Web reinforcement.** Vertical web reinforcement of not less than No. 3 bars shall be provided in accordance with the requirements of Section 2617 except that:

(A) Maximum $V_u \geq \dfrac{M_u{}^A + M_u{}^B}{l} + 1.4\, V_{D+L}$ ....(30-4)

where "$M_u{}^A$" and "$M_u{}^B$" are ultimate moment capacities of opposite sense at each end of the member, and "V_{D+L}" is the simple span shear due to combined dead and live load and "l" equals the span length.

(B) Stirrups shall be spaced at not more than $d/2$ throughout the length of the member.

(C) Stirrup-ties, at a maximum spacing of not over d/4, 16 bar diameters or twelve inches (12″), whichever is least, shall be provided in the following locations:

1. At each end of all flexural members: The first stirrup-tie shall be located not more than two inches (2″) from the face of the column and the last, a distance of at least twice the member depth from the face of the column.
2. Wherever ultimate moment capacities may be developed in the flexural members under inelastic lateral displacement of the frame.
3. Wherever required compression reinforcement occurs in the flexural members.

(f) **Columns Subject to Direct Stress and Bending.** 1. **Dimensional limitations.** The ratio of minimum to maximum column thickness shall be not less than .4 nor shall any dimension be less than twelve inches (12″).

2. **Vertical reinforcement.** The reinforcement ratio, "p," in tied columns shall be not less than .01 nor greater than .06.

3. **Splices.** Lapped splices shall be made within the center half of column height and the splice length shall be not less than 30 bar diameters or sixteen inches (16″). Continuity also may be effected by welding or by approved mechanical devices provided not more than alternate bars are welded or mechanically spliced at any level and the vertical distance between these welds or splices of adjacent bars is not less than twenty-four inches (24″).

4. **Special transverse reinforcement.** Special transverse reinforcement shall be provided through the joint and in that portion of a column over a length equal to the maximum column dimension, or one-sixth the clear height of the column, but not less than eighteen inches (18″) from either face of the joint.

> **EXCEPTION:** Special transverse reinforcement of one-half the amount otherwise required by Sections 2630 (f) 4 and 2630 (f) 5 shall be required within the joint deter-

Ductile Moment-Resisting Space Frames— Seismic Zones No. 2 and No. 3 (Continued)

mined by the depth of the shallowest framing member where such members frame into all four sides of a column, and whose width is at least three-fourths the column width. When a corner, unconfined by flexural member of a tied column exceeds four inches (4"), the full special transverse reinforcement shall be provided through the joint.

Where spiral reinforcement is used to satisfy the requirement for special transverse reinforcement, it shall be not less than that required in Section 2609 (1).

The volume of transverse reinforcement provided by hoops shall be not less than two times that required for spiral reinforcement. Supplementary cross ties may be included as part of the volume of transverse reinforcement up to 25 per cent of the total volume. These supplementary ties must have the standard hook and must engage the exterior hoop and vertical bar. For hoop type reinforcement the maximum unsupported length, "h''" shall not exceed:

$$h'' = \frac{2\,A''_{sh} \quad f''_{yh}}{p''\,a\,f_y''} \qquad \text{(30-5)}$$

WHERE:

a = center-to-center spacing of hoops.

p'' = is as required for spiral reinforcement but not less than .008 for cold-drawn wire, .010 for hard-grade bars, or .012 for intermediate grade bars.

A''_{sh} = area of cross section of transverse hoop.

f_y'' = useful limit stress of transverse spiral reinforcement, to be taken as the yield stress for intermediate and hard-grade steel and as the stress corresponding to strain of .005 for cold-drawn wire or high strength steel with an indefinite yield stress.

f''_{yh} = useful limit stress of hoop reinforcement defined in the same way as "f_y''".

Where the length "h''" is less than the length of a side of a rectangular or square column, a sufficient number of overlapping hoops may be provided in order to avoid exceeding the limiting value of "h''" as given above. The center-to-center spacing of spiral or hoops shall not exceed four inches (4"). The minimum size of reinforcing steel for hoops shall be No. 3 bars. Additional ties on column bars, in addition to the perimeter hoops, may be needed to meet shear requirements.

5. **Beam-column joint analysis.** The transverse reinforcement through the joint shall be proportioned according to the requirements of Section 2630 (f) 4. The transverse reinforcement thus selected shall be checked according to the provisions specified in Section 2630 (f) 6, with the exception that the "V_u" acting on the joint shall be equal to the maximum shears in the joint computed by a rational analysis taking into account the column shear and the concentrated shears developed from the forces in the beam reinforcement at a stress assumed at "f_y".

Ductile Moment-Resisting Space Frames—Seismic Zones No. 2 and No. 3 ***(Continued)***

EXCEPTION: The provisions of this paragraph shall be modified in accordance with the provisions of Subsection (f) 4 for those cases where confinement of the joint is effected by beams framing into all four sides.

6. **Column shear.** The transverse reinforcement in columns subjected to bending and axial compression shall satisfy the following requirements:

$$A_v f_y \frac{d}{s} = V_u - V_c \quad \text{.................. (30-6)}$$

WHERE:

V_u = maximum ultimate shear on the column due to earthquake, computed as $\frac{M_u^B + \frac{1}{2} M_b}{h}$ but not more than $\frac{M_u^T + M_u^B}{h}$ where M_u^T and M_u^B are the ultimate moment capacities of the column under design earthquake axial load at the top and bottom of the column respectively, "h" is the clear height of the column and "M_b" is the maximum sum of the moment capacities of the beams framing into the top connection. This is the sum of the "negative" moment capacity of one beam and the "positive" moment capacity of the other at the faces of the column. The factor "½" shall be omitted if only one column frames into the top connection.

V_c = $v_c\, bd$ where "v_c" shall be in accordance with Section 2617 (b) except that "v_c" shall be considered zero when $P_d/A_g \leq 0.12 f'_c$.

s = spacing, $\leq$ ½ minimum column dimension.

A_v = total cross-sectional area of special transverse reinforcement in tension within a distance "s," except that two-thirds of such area shall be used in the case of circular spirals.

7. **Design limitations.** At any beam-column connection where $P_d/A_g \geq 0.12 f'_c$ the total ultimate moment capacity of the column, at the design earthquake axial load, shall be greater than the total ultimate moment capacity of the beams, along their principal planes at that joint.

EXCEPTION: Where certain beam-column connections at any level do not comply with the above limitations, the remaining columns and connected flexural members shall comply and further shall be capable of resisting the entire shear at that level accounting for the altered relative rigidities and torsion resulting from the omission of elastic action of the nonconforming beam column connections.

Where $P_d/A_g \leq 0.12 f'_c$ the column shall further conform to the requirements for flexural members.

8. **Effective column length.** All columns shall have their effective length for design determined in accordance with Section 2609 (n), with design determined in accordance with Section 2609 (o).

Ductile Moment-Resisting Space Frames—Seismic Zones No. 2 and No. 3 (Continued)

(g) **Inspection.** For buildings designed under this Section, a specially qualified inspector under the supervision of the person responsible for the structural design shall provide continuous inspection of the placement of the reinforcement and concrete, and shall submit a certificate indicating compliance with the plans and specifications.

Ductile Moment-Resisting Space Frame—Seismic Zone No. 1

Sec. 2631. (a) **General.** Compliance with the regulations of this Section, governing the design of earthquake resisting cast-in-place monolithic reinforced concrete framing members and their connections, shall be deemed to meet the requirements for a ductile moment resisting space frame of Section 2314 (j) and Table No. 23-H for buildings in Seismic Zone No. 1.

Design and construction shall conform to the requirements of this Code except Section 2630. All members assumed to be part of the earthquake resisting frame shall be subject to the limitations and requirements specified in this Section.

(b) **Flexural Members.** 1. Web reinforcement shall be required and shall be designed according to Section 2612 or 2617 except that such web reinforcement shall be not less than that prescribed in Section 2612 (g) or Section 2617 (g) throughout the length of the member. The first stirrup shall be located two inches (2″) from the column face. The next six stirrups shall be spaced at not over $d/4$.

2. Positive moment reinforcement at the supports of flexural members subject to reversal of moments shall be anchored by bond, hooks, or mechanical anchors in or through the supporting member to develop the yield strength of the bar.

3. Lapped splices located in a region of tension or reversing stress, shall be confined by at least two stirrups at each splice.

(c) **Columns.** Additional lateral reinforcement shall be provided for columns as prescribed in this Subsection. The spacing of ties at the ends of tied columns shall not exceed four inches (4″) for a distance equal to the maximum column dimension but not less than one-sixth of the clear height of the column from the face of the joint. The first such tie shall be located two inches (2″) from the face of the joint. Joints of exterior and corner columns shall be confined by lateral reinforcement through the joint. Such lateral reinforcement shall consist of spirals or ties as required at the ends of columns.

Earthquake Resisting Concrete Shear Walls and Braced Frames

Sec. 2632. (a) **General.** 1. Design and construction of earthquake resisting reinforced concrete shear walls and reinforced concrete braced frames subjected primarily to axial stresses for all buildings shall conform to the requirements of Chapter 26.

2. Shear walls and braced frames shall be designed by the ultimate strength design method except that the working stress design method may be used provided that the factor of safety in shear and diagonal tension is equivalent to that achieved with the ultimate strength design method.

3. Formulas (15-2) and (15-3) of Section 2615 (g) for earthquake loading shall be modified to:

$$U = 1.4\,(D + L + E) \quad \text{..................}(32\text{-}1)$$

$$U = 0.9\,D + 1.25\,E \quad \text{..................}(32\text{-}2)$$

provided further that twice the "U" value set forth above shall be used in calculating shear and diagonal tension in buildings without a 100 per cent moment resisting space frame.

(b) **Braced frames.** Reinforced concrete members of braced frames subjected primarily to axial stresses in buildings with a ductile moment-resisting space frame shall have special transverse reinforcing as specified in Section 2630 (f) 4 throughout the full length of the member. Tension members shall additionally meet the requirements for compression members.

(c) **Vertical Boundary Members for Shear Walls.** 1. Special vertical boundary elements shall be provided at the edges of concrete shear walls in buildings whose lateral force resisting system is as described in Table No. 23-H for a "K" of .80. These elements shall be composed of concrete encased structural steel elements of ASTM A7, A36, or A441 or shall be concrete reinforced as required for columns in Subsection 2630 (f) with special transverse reinforcement as described in paragraph 2630 (f) 4 for the full length of the element.

> EXCEPTION: The special transverse reinforcement may be omitted in Seismic Zone No. 1 when the combined dead load, live load and seismic stresses are not over one-half of those otherwise allowed.

2. The boundary vertical elements and such other similar vertical elements as may be required shall be designed to carry all the vertical stresses resulting from the wall loads in addition to tributary dead and live loads and from the horizontal forces as prescribed in Section 2314. Horizontal reinforcing in the walls shall be fully anchored to the vertical elements.

> EXCEPTION: In Seismic Zone No. 1 the vertical boundary elements may be designed to carry all vertical stresses

resulting from tributary dead and live loads not supported by the shear walls acting as bearing walls.

Earthquake Resisting Concrete Shear Walls and Braced Frames (Continued)

3. Similar confinement of horizontal and vertical boundaries at wall openings also shall be provided unless it can be demonstrated that the unit compressive stresses at the opening have a load factor two times that required by Formulas (32-1) and (32-2) above.

Plain Concrete

Sec. 2633. (a) **General.** Plain concrete, other than fill, shall have a minimum ultimate compressive strength at 28 days of 2000 pounds per square inch, and material, proportioning, and placing shall conform to the requirements of this Chapter. Concrete made with lightweight aggregates may be used with strengths less than 2000 pounds per square inch if it has been shown by tests or experience to have sufficient strength and durability.

Provisions shall be made to care for temperature and shrinkage stresses either by use of reinforcement or by means of joints.

Plain concrete construction shall conform to the detailed minimum requirements specified in this Chapter. Where Section 2314 is applicable, plain concrete also shall be designed in accordance with the allowable stresses specified in this Chapter.

(b) **Wall Thickness.** The thickness of plain concrete walls may be two inches (2″) less than required by Section 2417 (b) for plain masonry walls but in no case less than seven inches (7″), and the ratio of unsupported height or length (whichever is the lesser) to thickness shall be not greater than 22.

(c) **Design.** Plain concrete walls shall be designed to withstand all vertical and horizontal loads as specified in Chapter 23.

(d) **Stresses.** The allowable working stresses in plain concrete walls shall not exceed the following percentages of ultimate strength:

Compression	$.25\,f'_c$
Tension	$1.6\sqrt{f'_c}$
Shear	$.02\,f'_c$

CHAPTER 27—STEEL AND IRON

Material Standards and Symbols

Sec. 2701. (a) **General.** The quality and design of steel and iron used structurally in buildings or structures shall conform to the requirements specified in this Chapter and to the following standards:

MATERIAL AND DESIGN	U.B.C. DESIGNATION
STRUCTURAL STEEL	
Material Specifications	27- 1-67
Erection, Fabrication, Identification and Painting	27- 2-67
Stress Variation or Stress Reversal Design	27- 3-67
Open Web Steel Joist Design	27- 4-67
CONNECTIONS	
Rivet Steel	27- 5-67
Welding	27- 6-67
High Tensile Bolts	27- 7-67
COMPOSITE DESIGN	27- 8-67
LIGHT STEEL FOR STRUCTURAL MEMBERS	
Material Specifications	27- 9-67
Design	27-10-67

(b) **Identification.** Steel furnished for structural load-carrying purposes shall be properly identified for conformity to the ordered grade as follows:

Structural steels shall be identified in accordance with U.B.C. Standard No. 27-2-67. Where structural steel is furnished to a specified minimum yield point greater than 36,000 pounds per square inch the ASTM or other specification designation shall be marked in accordance with the requirements of U.B.C. Standard No. 27-2-67.

Light gauge steel shall be identified in accordance with U.B.C. Standard No. 27-10-67. Where light gauge steel structural members are furnished to a specified minimum yield point greater than 33,000 pounds per square inch the grade and the ASTM specification number or other specification designation shall be indicated by painting, decal, tagging or other suitable means on each lift or bundle of fabricated elements. In the case of members having a yield point of or in excess of 33,000 pounds per square inch obtained through additional treatment, the resulting minimum yield point shall be indicated in addition to the specification designation.

Each lift or bundle of open web steel joists and similar fabricated light structural load-carrying members shall be identified in accordance with U.B.C. Standard No. 27-4-67 as to type, size and manufacturer by tagging or other suitable means at the time of manufacture or fabrication and such identification shall be maintained continuously to the point of their installation in a structure.

The fabricator, in processing steel through his works, shall maintain identity of the material, and shall maintain suitable

Material Standards and Symbols (Continued)

procedures and records attesting that the specified grade has been furnished in conformity with the applicable U.B.C. Standard. Where structural steel is furnished to a specified minimum yield point greater than 36,000 pounds per square inch, the ASTM or other specification designation shall be included near the erection mark on each shipping assembly or important construction component over any shop coat of paint prior to shipment from the fabricator's plant. The fabricator's identification mark system shall be established and on record prior to fabrication.

Steel which is not readily identifiable as to grade from marking and test records shall be tested to determine conformity to such standard. The fabricator shall, when requested, furnish an affidavit of compliance with such standard.

(c) **Symbols and Notations.** The symbols and notations used in these regulations are defined as follows:

A_b = Nominal body area of a bolt.

A_c = Actual area of effective concrete flange in composite design as defined in Section 2708 (a).

A_{bc} = Planar area of web at beam to column connection.

A_f = Area of compression flange.

A_s = Area of steel beam in composite design.

A_{st} = Cross-sectional area of stiffener or pair of stiffeners.

A_w = Area of girder web.

B = Coefficient used in column formula for plastic design.

C_b = Bending coefficient dependent upon moment gradient; equal to

$$1.75 - 1.05 \left(\frac{M_1}{M_2} \right) + 0.3 \left(\frac{M_1}{M_2} \right)^2$$

C_c = Column slenderness ratio dividing elastic and inelastic buckling; equal to

$$\sqrt{\frac{2\pi^2 E}{F_y}}$$

C_m = Coefficient applied to bending term in interaction formula and dependent upon column curvature caused by applied moments.

C_v = Ratio of "critical" web stress, according to the linear buckling theory, to the shear yield point of web material; equal to

$$\frac{\pi^2 E k \sqrt{3}}{12\,(1 - v^2)\,(h/t)^2 F_y}$$

D = Factor depending upon type of transverse stiffeners.

Material Standards and Symbols (Continued)

E = Modulus of elasticity of steel (29,000,000 pounds per square inch).
E_c = Modulus of elasticity of concrete.
F_a = Axial stress permitted in the absence of bending moment.
F_{as} = Axial compressive stress, permitted in the absence of bending moment, for bracing and other secondary members.
F_b = Bending stress permitted in the absence of axial force.
F'_b = Allowable bending stress in compression flange of plate girders as reduced because of large web depth-to-thickness ratio.
F'_e = Euler stress divided by factor of safety; equal to

$$\frac{149{,}000{,}000}{\left(\frac{Kl_b}{r_b}\right)^2}$$

F_p = Allowable bearing stress.
F_t = Allowable tensile stress.
F_v = Allowable shear stress.
F_y = Specified minimum yield point of the type of steel being used.
G = Coefficient used in column formula in plastic design.
H = Coefficient used in column formula in plastic design.
I_{tr} = Moment of inertia of transformed composite section.
J = Coefficient used in column formula in plastic design.
K = Effective length factor.
L = Span length, in feet.
L_u = Maximum unbraced length of compression flange in feet for which full bending stress is permitted by Formula (5).
M = Moment.
M_1 = Smaller end moment on unbraced length of beam-column.
M_2 = Larger end moment on unbraced length of beam-column.
M_D = Moment produced by dead load.
M_L = Moment produced by live load.
M_o = Reduced plastic moment.
M_p = Plastic moment.
N = Length of bearing of applied load.
P = Applied load.
P_y = Plastic axial load; equal to profile area times specified minimum yield point.

Material Standards and Symbols (Continued)

R = Reaction or concentrated transverse load applied to beam or girder.
S_s = Section modulus of steel beam used in composite design, referred to the tension flange.
S_{tr} = Section modulus of transformed composite cross section, referred to the tension flange.
T_b = Proof load of a high strength bolt.
V = Statical shear on beam.
V_h = Total horizontal shear to be resisted by connectors.
V_u = Statical shear produced by "ultimate" load in plastic design.
Y = Ratio of yield point of web steel to yield point of stiffener steel.
a = Clear distance between transverse stiffeners.
a' = Distance required at ends of welded partial length cover plate to develop stress.
b = Effective width of concrete slab.
b_f = Flange width of rolled beam or plate girder.
c = Distance from neutral axis to extreme fiber of beam.
d = Depth of beam or girder. Also diameter of roller or rocker bearing.
e = Horizontal displacement, in the direction of the span, between top and bottom of simply supported beam at its ends.
f_a = Computed axial stress.
f_b = Computed bending stress.
f'_c = Specified compression strength of concrete at 28 days.
f_t = Computed tensile stress.
f_v = Computed shear stress, in pounds per square inch.
f_{vs} = Shear between girder web and transverse stiffeners, in pounds per linear inch of single stiffener or pair of stiffeners.
g = Transverse spacing between fastener gauge lines.
h = Clear distance between flanges of a beam or girder.
k = Coefficient relating linear buckling strength of a plate to its dimensions and condition of edge support. Also distance from outer face of flange to web toe of fillet.
l = Actual unbraced length, in inches.
l_b = Actual unbraced length in plane of bending, in inches.
l_{cr} = Critical unbraced length adjacent to plastic hinge, in inches.
n = Modular ratio; equal to "E/E_c."
q = Allowable horizontal shear to be resisted by a connector.

Material Standards and Symbols (Continued)

r = Governing radius of gyration.
r_b = Radius of gyration about axis of concurrent bending.
r_y = Lesser radius of gyration.
s = Spacing (pitch) between successive holes in line of stress.
t = Girder or beam web thickness.
t_f = Flange thickness.
t_t = Thickness of thinner part joined by partial penetration groove weld.
w = Web thickness of plastically designed rolled beams. Also length of channel shear connectors.
v = Poisson's ratio.

Allowable Unit Stresses

Sec. 2702. (a) **General.** Except as provided in Sections 2703, 2704, 2707, 2708 and 2721, all components of the structure shall be so proportioned that the unit stress, in pounds per square inch, shall not exceed the values specified in this Section.

(b) **Structural Steel.** 1. **Tension.** On the net section, except at pinholes

$$F_t = 0.60F_y$$

On the net section at pinholes in eyebars, pin-connected plates or built-up members

$$F_t = 0.45F_y$$

2. **Shear.** On the gross section (For shear calculation, the gross section of beams and girders may be taken as the product of the over-all depth and the thickness of the web.)

$$F_v = 0.40F_y$$

See Section 2707 for reduction required for thin webs.

3. **Compression.** On the gross section of axially loaded compression members when "Kl/r," the largest effective slenderness ratio of any unbraced segment as defined in Section 2705, is less than "C_c."

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right]F_y}{\text{F.S.}} \qquad \text{Formula (1)}$$

WHERE:

$$\text{F.S.} = \text{factor of safety} = \frac{5}{3} + \frac{3(Kl/r)}{8C_c} - \frac{(Kl/r)^3}{8C_c^3}$$

AND

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

Allowable Unit Stresses (Continued)

On the gross section of axially loaded columns when "Kl/r" exceeds "C_c"

$$F_a = \frac{149{,}000{,}000}{(Kl/r)^2} \qquad \text{Formula (2)}$$

On the gross section of axially loaded bracing and secondary members, when "l/r" exceeds 120 (for this case "K" is taken as unity)

$$F_{as} = \frac{F_a \text{ (by Formula 1 or 2)}}{1.6 - \dfrac{l}{200r}} \qquad \text{Formula (3)}$$

On the gross area of plate girder stiffeners

$$F_a = 0.60F_y$$

On the web of rolled shapes at the toe of the fillet for crippling.

$$F_a = 0.75F_y$$

Web stiffeners shall be provided as specified in Section 2707 (j) when the compressive stress at the web toe exceeds the allowable stress specified in the preceding paragraph.

4. **Bending.** Tension and compression on extreme fibers of laterally supported compact rolled shapes and compact builtup members having an axis of symmetry in the plane of loading.

$$F_b = 0.66F_y$$

The web depth-to-thickness ratio for a compact member subjected to bending forces shall not be greater than:

$$\frac{13{,}300}{\sqrt{F_y}} \quad \text{AND}$$

The web depth-to-thickness ratio for a compact member subjected to combined axial and bending forces shall not be greater than:

$$13{,}300 \left(\frac{1 - 1.43\, f_a/F_a}{\sqrt{F_y}} \right)$$

but need not be less than:

$$\frac{8000}{\sqrt{F_y}}$$

Allowable Unit Stresses (Continued)

The width-to-thickness ratio of projecting elements of compression flanges for rolled shapes classified as compact members shall not exceed:

$$\frac{1650}{\sqrt{F_y}} \quad \text{AND}$$

The width-to-thickness ratio of projecting elements of compression flanges for built-up shapes classified as compact members shall not exceed:

$$\frac{1600}{\sqrt{F_y}}$$

The width-to-thickness ratio measured between longitudinal lines of flange connections of flange plates in box sections classified as compact members shall not exceed

$$\frac{6000}{\sqrt{F_y}}$$

Flanges of compact built-up sections shall be continuously connected to the web or webs.

Compact members shall be assumed as laterally supported when the distance in inches between points of support of the compression flange does not exceed

$$\frac{2400\, b_f}{\sqrt{F_y}} \quad \text{OR}$$

$$\frac{20{,}000{,}000\, A_f}{dF_y}$$

Except when including the one-third stress increase allowed in designing for wind or earthquake forces, beams and girders which meet the requirements as compact members and are continuous over supports or are rigidly framed to columns by means of rivets, high strength bolts or welds, may be proportioned for nine-tenths of the negative moments produced by gravity loading which are maximum at points of support, provided that, for such members, the maximum positive moment shall be increased by one-tenth of the average negative moments. This reduction shall not apply to moments produced by loading on cantilevers. If the negative moment is resisted by a column rigidly framed to the beam or girder, the one-tenth reduction may be used in proportioning the column for the combined axial and bending loading, provided that the unit stress "f_a" due to any concurrent axial load on the member, does not exceed 0.15 "F_a."

Tension and compression on extreme fibers of unsymmetrical members, except channels, supported as specified in this Section in the region of compression stress

Allowable Unit Stresses (Continued)

$$F_b = 0.60F_y$$

Tension and compression on extreme fibers of box-type members whose proportions do not meet the provisions of a compact section, but do conform to the provisions of Section 2706

$$F_b = 0.60F_y$$

Tension on extreme fibers of rolled shapes, built-up members and plate girders not classified as compact sections

$$F_b = 0.60F_y$$

Compression on extreme fibers of rolled shapes, plate girders and built-up members not classified as compact sections and having an axis of symmetry in the plane of their web (other than box-type beams and girders) the larger value computed by Formulas (4)[1] and (5), but not more than $0.60F_y$

$$F_b = \left[1.0 - \frac{(l/r)^2}{2C_c^2C_b}\right]0.60F_y \qquad \text{Formula (4)}$$

$$F_b = \frac{12{,}000{,}000}{ld/A_f} \qquad \text{Formula (5)}$$

where "l" is the unbraced length of the compression flange; "r" is the radius of gyration of a tee section comprising the compression flange plus one-sixth of the web area, about an axis in the plane of the web; "A_f" is the area of the compression flange; "C_c" is defined in Section 2702 (b) 3 and "C_b" is equal to

$$C_b = 1.75 - 1.05\left(\frac{M_1}{M_2}\right) + 0.3\left(\frac{M_1}{M_2}\right)^2$$

but not more than 2.3 taken about the strong axis of the member, and where "M_1/M_2," the ratio of end moments, is positive when "M_1" and "M_2" have the same sign single curvature bending) and negative when they are of opposite signs (reverse curvature bending). When the bending moment at any point within an unbraced length is larger than that at both ends of this length the ratio "M_1/M_2" shall be taken as unity. See Section 2707 for further limitation in plate girder flange stress.

Compression on extreme fibers of channels, the value computed by Formula (5), but not more than

$$F_b = 0.60F_y$$

Tension and compression on extreme fibers of pins

[1]Where "l/r" is less than 40 stress reduction in Formula (4) may be neglected.

Allowable Unit Stresses (Continued)

$$F_b = 0.90F_y$$

Tension and compression on extreme fibers of rectangular bearing plates

$$F_b = 0.75F_y$$

5. **Bearing (on contact area).** Milled surfaces including bearing stiffeners and pins in reamed, drilled or bored holes, pounds per square inch[1]

$$F_p = 0.90F_y$$

Expansion rollers and rockers, pounds per linear inch[1]

$$F_p = \left(\frac{F_y - 13{,}000}{20{,}000}\right) 660d$$

where "d" is the diameter of roller or rocker in inches.

(c) **Rivets and Bolts.** 1. The allowable tension and shear stresses on rivets and bolts based on gross area shall not exceed the values set forth in Table No. 27-A.

2. Allowable bearing stress on projected area of bolts in bearing-type connections and on rivets

$$F_p = 1.35F_y$$

WHERE:

F_p = Allowable bearing stress on the projected bolt area with a maximum value not to exceed 45,000 pounds per square inch.

F_y = Yield point of the connected part.

(d) **Welds. 1. Fillet, plug, slot and partial penetration groove welds.** The allowable tensile or shear stress in the throat area of fillet, plug, slot and partial penetration groove welds shall not exceed the values specified in this Section.

Stress in fillet, plug and slot welds, tension stress transverse to the axis of partial penetration groove welds and shear in such welds, when made with A233 Class E60 series electrodes or by submerged arc welding Grade SAW-1 on all steels, or with A233 Class E70 series electrodes or by submerged arc welding Grade SAW-2 on A7 and A373 steels..............13,600

Stress in fillet, plug and slot welds, tension stress transverse to the axis of partial penetration groove welds and shear in such welds, when made with A233 Class E70 series electrodes or by submerged arc welding Grade SAW-2 on A36, A242 and A441 steels..15,800

2. **Groove welds.** The full stresses allowed by Section 2702 (b) for the connected material shall apply to complete penetration groove welds stressed in tension, compression, bending, shear and bearing and to partial penetration groove welds stressed in compression, in bearing or in tension parallel to the axis of the weld. See U.B.C. Standard No. 27-6-67 for

[1]When parts in contact have different yield points, "F_y" shall be the smaller value.

TABLE NO. 27-A—ALLOWABLE STRESSES FOR RIVETS AND BOLTS

Allowable Unit Stresses (Continued)

DESCRIPTION OF FASTENER	TENSION (F_t)	SHEAR (F_v) Friction-Type Connections	SHEAR (F_v) Bearing-Type Connections
A141 hot-driven rivets	20,000		15,000
A195 and A406 hot-driven rivets	27,000		20,000
A307 bolts and threaded parts of A7 and A373 steel	14,000		10,000
Threaded parts of other steels	$0.40F_y$		$0.30F_y$
A325 bolts when threading is *not* excluded from shear planes	40,000	15,000	15,000
A325 bolts when threading is excluded from shear planes	40,000	15,000	22,000
A354, Grade BC, bolts when threading is *not* excluded from shear planes	50,000	20,000	20,000
A354, Grade BC, when threading is excluded from shear planes	50,000	20,000	24,000

Note: There are no bearing stresses in friction-type connections.

electrodes and submerged arc welding process to be employed on various grades of steel.

3. **Effective areas of weld metal.** The effective area of butt and fillet welds shall be considered as the effective length of the weld times the effective throat thickness.

The effective shearing area of plug and slot welds shall be considered as the nominal cross-sectional area of the hole or slot, in the plane of the faying surface.

The effective area of fillet welds in holes and slots shall be computed as above specified for fillet welds, using for effective length, the length of centerline of the weld through the center of the plane through the throat. However, in the case of overlapping fillets, the effective area shall not exceed the nominal cross-sectional area of the hole or slot, in the plane of the faying surface.

The effective length of a fillet weld shall be the over-all length of full-size fillet including returns.

The effective length of a butt weld shall be the width of the part joined.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the face of the diagrammatic weld.

The effective throat thickness of a complete penetration butt weld [i.e., a butt weld conforming to the requirements of Section 2720 (f)] shall be the thickness of the thinner part joined.

The effective throat thickness of single-V or single-bevel groove welds having no root opening and having partial

Allowable Unit Stresses (Continued)

penetration into their joints shall be one-fourth inch (¼") less than the depth of the "V" or bevel groove. The effective throat thickness of single "J" or single "U" groove welds having no root opening and having partial penetration into their joints shall be the depth of the "J" or "U" groove. The effective throat thickness of any of these partial penetration groove welds shall be not less than $\sqrt{t_t/6}$, where "t_t" is the thickness of the thinner part connected by the weld.

(e) **Cast Steel and Steel Forgings.** The allowable stress for cast steel and steel forgings shall not exceed the values specified in Section 2702 (b).

Combined Stresses

Sec. 2703. (a) **Axial Compression and Bending.** Members subject to both axial compression and bending stresses shall be proportioned to satisfy the following requirements:

WHERE:

$$\frac{f_a}{F_a} \lesseqgtr 0.15$$

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \lesseqgtr 1.0 \qquad \text{Formula (6)}$$

WHERE:

$$\frac{f_a}{F_a} > 0.15$$

$$\frac{f_a}{F_a} + \frac{C_m f_b}{\left(1 - \dfrac{f_a}{F'_e}\right) F_b} \lesseqgtr 1.0 \qquad \text{Formula [7 (a)]}$$

and, in addition, at points braced in the plane of bending

$$\frac{f_a}{0.6\,F_y} + \frac{f_b}{F_b} \lesseqgtr 1.0 \qquad \text{Formula [7 (b)]}$$

C_m = A coefficient whose value shall be taken as follows:

1. For compression members in frames subject to joint translation (sidesway) "C_m" = 0.85.
2. For restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending, "C_m" = $0.6 + 0.4\,M_1/M_2$, but not less than 0.4, where "M_1/M_2" is the ratio of the smaller to the larger moments at the ends of that portion of the member, unbraced in the plane of bending, under consideration. "M_1/M_2" is positive when the member is

Combined Stresses (Continued)

bent in single curvature and negative when it is bent in reverse curvature.

3. For compression members in frames braced against joint translation in the plane of loading and subjected to transverse loading between their supports, the value of "C_m" may be determined by rational analysis. However, in lieu of such analysis, the following values may be used: (a) for members whose ends are restrained, "C_m" $= 0.85$; (b) for members whose ends are unrestrained, "C_m" $= 1$.

(b) **Axial Tension and Bending.** Members subject to both axial tension and bending stresses shall be proportioned to satisfy the requirements of Formula [7 (b)] where "f_b" and "F_b" are taken, respectively, as the computed and permitted bending tensile stress. However, the computed compressive stress, taken alone, shall not exceed the value permitted by Formula (4) and Formula (5).

(c) **Shear and Tension.** Rivets and bolts subject to combined shear and tension shall be so proportioned that the tension stress produced by the force shall not exceed the following:

For A141 rivets .... $F_t = 28{,}000 - 1.6f_v \leqq 20{,}000$

For A195 and A406 rivets.... $F_t = 38{,}000 - 1.6f_v \leqq 27{,}000$

For A307 bolts .... $F_t = 20{,}000 - 1.6f_v \leqq 14{,}000$

For A325 bolts in bearing-type joints .... $F_t = 50{,}000 - 1.6f_v \leqq 40{,}000$

For A354, Grade BC, bolts in bearing-type joints...... $F_t = 60{,}000 - 1.6f_v \leqq 50{,}000$

Where the shear stress "f_v" produced by the same force shall not exceed the allowable value for shear specified in Section 2702 (c).

For bolts used in friction-type joints, the shear stress allowed in Section 2702 (c) shall be reduced so that:

For A325 bolts .... $F_v \leqq 15{,}000\ (1 - f_tA_b/T_b)$

For A354, Grade BC, bolts.... $F_v \leqq 20{,}000\ (1 - f_tA_b/T_b)$

Where "f_t" is the tensile stress due to applied load and "T_b" is the proof load of the bolt.

Stress Reversal

Sec. 2704. Members or connections which are subjected to a variation or reversal of stress shall be designed as set forth in U.B.C. Standard No. 27-3-67.

Slenderness Ratios

Sec. 2705. (a) **Definition.** In determining the slenderness ratio of an axially loaded compression member except as provided by Formula (3) the length "l" shall be taken as its effective length "Kl" and "r" the corresponding radius of gyration.

Slenderness Ratios (Continued)

(b) **Sidesway Prevented.** In frames where lateral stability is provided, and in trusses, the effective length factor "*K*" for the compression members shall be taken as unity.

EXCEPTION: A "*K*" value of less than one may be used where substantiating data justifies such a reduction.

(c) **Sidesway Not Prevented.** The effective length of "*Kl*" compression members in a frame which depends upon its own bending stiffness for lateral stability shall be determined by a rational method and shall not be less than the actual unbraced length.

(d) **Maximum Ratios.** The slenderness ratio of compression members shall not exceed 200.

The slenderness ratio of tension members, other than rods, shall not exceed:

For main members 240
For bracing and other secondary members 300

Width-Thickness Ratios

Sec. 2706. (a) **Projecting Compression Elements.** Projecting compression elements shall have width-to-thickness ratios not greater than the following:

Single-angle struts; double-angle struts with separators	$2400/\sqrt{F_y}$
Struts comprising double angles in contact; angles or plates projecting from girders, columns or other compression members; compression flanges of beams; stiffeners on plate girders	$3000/\sqrt{F_y}$
Stems of tees	$4000/\sqrt{F_y}$

The width of plates shall be taken from the free edge to the first row of rivets, bolts or welds; the width of legs of angles, channels and zees, and of the stems of tees, shall be taken as the full nominal dimension; the width of flanges of beams and tees shall be taken as one-half the full nominal width. The thickness of a sloping flange shall be measured halfway between a free edge and the corresponding face of the web.

Projecting compression elements may be designed on assumption that a portion of the unsupported width is removed.

(b) **Compression Elements Supported Along Two Edges.** The unsupported width-to-thickness ratios of compression webs cover or diaphragm plates, between the nearest lines of fasteners or welds, or between the roots of the flanges in case of rolled sections, shall not exceed

$$\frac{8000}{\sqrt{F_y}}$$

EXCEPTIONS: 1. Compression elements supported along two edges may be designed on assumption that a portion of the unsupported width is removed.

Width-Thickness Ratios (Continued)

2. The net width-to-thickness ratios of cover plates perforated with access holes shall not exceed

$$\frac{10{,}000}{\sqrt{F_y}}$$

Plate Girders and Rolled Beams

Sec. 2707. (a) **Proportions.** Riveted and welded plate girders, cover-plated beams and rolled beams shall be proportioned by the moment of inertia of the gross section. No deduction shall be made for shop or field rivet or bolt holes in either flange, except that in cases where the reduction of the area of either flange by such holes, calculated in accordance with the provisions of Section 2711 (c), exceeds 15 per cent of the gross flange area, the excess shall be deducted.

(b) **Web.** The clear distance between flanges in inches shall not exceed

$$\frac{14{,}000{,}000\ (t)}{\sqrt{F_y(F_y + 16{,}500)}}$$

(c) **Flanges.** The thickness of outstanding parts of flanges shall conform to the requirements of Section 2706.

The ratio of unstiffened cover plate extension on riveted girders beyond the outer row of rivets or bolts to the thickness of the thinnest outside plate shall not exceed

$$\frac{3000}{\sqrt{F_y}}$$

The total cross-sectional area of cover plates of riveted girders shall not exceed 70 per cent of the total flange area. Provision shall be made for stresses resulting from abrupt changes in flange direction and other conditions that introduce stress concentration.

(d) **Flange Development.** Rivets, high strength bolts or welds connecting flange to web, or cover plate to flange, shall be proportioned to resist the total horizontal shear resulting from the bending forces on the girder. The longitudinal distribution of these rivets, bolts or of intermittent welds shall be in proportion to the intensity of the shear. But the longitudinal spacing shall not exceed the maximum permitted, respectively, for compression or tension members in Sections 2715 (c) or 2715 (d). In addition, rivets or welds connecting flange to web shall be proportioned to transmit to the web loads applied directly to the flange except where provision is made to transmit such loads by direct bearing.

Partial length cover plates shall be extended beyond the theoretical cut-off point and the extended portion shall be attached to the beam or girder by rivets, high strength bolts or fillet welds adequate to develop the cover plate's portion of the flexural stresses in the beam or girder at the theoretical

Plate Girders and Rolled Beams (Continued)

cutoff point. In addition, for welded cover plates, the welds connecting the cover plate termination to the beam or girder in the length "a'," defined below, shall be adequate to develop the cover plate's portion of the flexural stresses in the beam or girder at the distance "a'" from the end of the cover plate. The length "a'," measured from the end of the cover plate, shall be:

1. A distance equal to the width of the cover plate when there is a continuous weld equal to or larger than three-fourths of the plate thickness across the end of the plate and continued welds along both edges of the cover plate in the length "a'."
2. A distance equal to one and one-half times the width of the cover plate when there is a continuous weld smaller than three-fourths of the plate thickness across the end of the plate and continued welds along both edges of the cover plate in the length "a'."
3. A distance equal to two times the width of the cover plate when there is no weld across the end of the plate but continuous welds along both edges of the cover plate in the length "a'."

(e) **Stiffeners.** Bearing stiffeners shall be placed in pairs at unframed ends on the webs of plate girders and, where required, at points of concentrated loads. Such stiffeners shall have a close bearing against the flange, or flanges, through which they receive their loads or reactions, and shall extend approximately to the edge of the flange plates or flange angles. They shall be designed as columns subject to the provisions of Section 2702 (b) 3, assuming the column section to comprise the pair of stiffeners and a centrally located strip of the web whose width is equal to not more than 25 times its thickness at interior stiffeners or a width equal to not more than 12 times its thickness when the stiffeners are located at the end of the web. The effective length shall be taken as not less than three-fourths of the length of the stiffeners in computing the ratio "l/r." Only that portion of the stiffener outside of the angle fillet or the flange-to-web welds shall be considered effective in bearing.

The largest average web shear "f_v" in any panel between stiffeners shall not exceed the value given by Formula (8) or (9), as applicable.

WHEN: "C_v" is less than 1.0

$$F_v = \frac{F_y}{2.89}\left[C_v + \frac{1 - C_v}{1.15\sqrt{1 + (a/h)^2}}\right] \qquad \text{Formula (8)}$$

WHEN:

"C_v" is more than 1.0 or when intermediate stiffeners are omitted;

$$F_v = \frac{F_y\,(C_v)}{2.89} \qquad \text{Formula (9)}$$

but not to exceed

$$F_v = .4F_y$$

WHERE:

$$C_v = \frac{45{,}000{,}000k}{F_y(h/t)^2}, \text{ when "}C_v\text{" is less than 0.8.}$$

$$C_v = \frac{6000}{h/t}\sqrt{\frac{k}{F_y}}, \text{ when "}C_v\text{" is more than 0.8.}$$

$$k = 4.00 + \frac{5.34}{(a/h)^2}, \text{ when "}a/h\text{" is less than 1.0.}$$

$$k = 5.34 + \frac{4.00}{(a/h)^2}, \text{ when "}a/h\text{" is more than 1.0.}$$

When "a/h" is more than three, its value shall be taken as infinity. In this case Formula (8) reduces to Formula (9) and $k = 5.34$.

Intermediate stiffeners are not required when the ratio "h/t" is less than 260 and the maximum web shear stress "f_v" is less than that permitted by Formula (9).

The spacing of intermediate stiffeners, when stiffeners are required, shall be such that the web shear stress will not exceed the value for "F_v" given by Formulas (8) or (9), as applicable and the ratio "a/h" shall not exceed

$$\left(\frac{260}{h/t}\right)^2 \text{ nor } 3.0.$$

The spacing between stiffeners at end panels and panels containing large holes shall be such that the smaller panel dimension, "a" or "h," shall not exceed

$$\frac{11{,}000t}{\sqrt{f_v}}$$

The gross area, in square inches, of intermediate stiffeners spaced in accordance with Formula (8) shall be not less than that computed by Formula (10).

$$A_{st} = \frac{1 - C_v}{2}\left[\frac{a}{h} - \frac{(a/h)^2}{\sqrt{1 + (a/h)^2}}\right]YDht \qquad \text{Formula (10)}$$

WHERE:

C_v is as defined in Section 2707 (e).

Y = yield point of web steel/yield point of stiffener steel.

D = 1.0 for stiffeners furnished in pairs
= 1.8 for single angle stiffeners.
= 2.4 for single plate stiffeners.

Plate Girders and Rolled Beams (Continued)

When the greatest shear stress "f_v" in a panel is less than that permitted by Formula (8) this gross area requirement may be reduced in like proportion.

The moment of inertia of a pair of stiffeners, or a single stiffener, with reference to an axis in the plane of the web, shall not be less than

$$\left(\frac{h}{50}\right)^4$$

Intermediate stiffeners may be stopped short of the tension flange a distance not to exceed four times the web thickness, provided bearing is not needed to transmit a concentrated load or reaction. When single stiffeners are used they shall be attached to the compression flange, if it consists of a rectangular plate, to resist any uplift tendency due to torsion in the plate. When lateral bracing is attached to a stiffener, or a pair of stiffeners, these, in turn, shall be connected to the compression flange to transmit one per cent of the total flange stress, unless the flange is composed only of angles.

Intermediate stiffeners required by the provisions of Section 2707 (e) shall be connected for a shear transfer of not less than:

$$f_{vs} = h\sqrt{\left(\frac{F_y}{3400}\right)^3}$$

WHERE:

F_y = yield point of web steel.

This shear transfer may be reduced in the same proportion that the largest computed shear stress "f_v" in the adjacent panels is less than that permitted by Formula (8). However, rivets and welds in intermediate stiffeners which are required to transmit to the web an applied concentrated load or reaction shall be proportioned for not less than the applied load or reaction.

Rivets connecting stiffeners to the girder web shall be spaced not more than twelve inches (12″) on center. If intermittent fillet welds are used, the clear distance between welds shall not be more than 16 times the web thickness nor more than ten inches (10″).

(f) **Reduction in Flange Stress.** When the web depth to thickness ratio exceeds $24{,}000/\sqrt{F_b}$, the maximum stress in the compression flange shall not exceed

$$F'_b \leqq F_b\left[1.0 - 0.0005\frac{A_w}{A_f}\left(\frac{h}{t} - \frac{24{,}000}{\sqrt{F_b}}\right)\right] \quad \text{Formula (11)}$$

(g) **Combined Shear and Tension Stress.** Plate girder webs subject to a computed average shear stress in excess of that permitted by Formula (9) shall be so proportioned that the bending tensile stress, due to moment in the plane of the girder web, shall not exceed

$$0.6F_y \text{ nor} \left(0.825 - 0.375\frac{f_v}{F_v}\right)F_y \qquad \text{Formula (12)}$$

(h) **Splices.** Butt welded splices in plate girders and beams shall be complete penetration groove welds and shall develop the full strength of the smaller spliced section. Other types of splices in cross sections of plate girders and in beams, shall develop the strength required by the stresses, at the point of splice, but in no case less than 50 per cent of the effective strength of the material spliced.

(i) **Horizontal Forces.** The flanges of plate girders supporting cranes or other moving loads shall be proportioned to resist the horizontal forces produced by such loads.

The lateral force on crane runways shall be 20 per cent of the sum of the weights of the lifted load and of the crane trolley, applied at the top of rail, one-half on each side of the runway; and shall be considered as acting in either direction normal to the runway rail.

The longitudinal force shall be 10 per cent of the maximum wheel loads of the crane applied at the top of rail.

(j) **Web Crippling.** Webs of beams and welded plate girders shall be so proportioned that the compressive stress at the web toe of the fillets, resulting from concentrated loads not supported by bearing stiffeners, does not exceed the value specified in Section 2702 (b).

3. The compressive stress at the web top of the fillets shall be computed using the following formulas:

For interior loads:

$$\frac{R}{t(N+2k)} \qquad \text{Formula (13)}$$

For end-reactions:

$$\frac{R}{t(N+k)} \qquad \text{Formula (14)}$$

WHERE:

N = length of bearing in inches (not less than "k" for end reactions).

Bearing stiffeners shall be provided where the compressive stress as determined by Formulas (13) and (14) exceeds the allowable stress specified in Section 2702 (b) 3.

Webs of welded plate girders shall also be so proportioned or stiffened that the sum of the compression stresses resulting from concentrated and distributed loads, bearing directly on

Plate Girders and Rolled Beams (Continued)

or through a flange plate, upon the compression edge of the web plate, and not supported directly by bearing stiffeners do not exceed the following:

When the flange is restrained against rotation,

$$\left[5.5 + \frac{4}{(a/h)^2}\right]\frac{10{,}000{,}000}{(h/t)^2} \qquad \text{Formula (15)}$$

When the flange is not restrained against rotation,

$$\left[2 + \frac{4}{(a/h)^2}\right]\frac{10{,}000{,}000}{(h/t)^2} \qquad \text{Formula (16)}$$

These stresses shall be computed as follows: Concentrated loads and loads distributed over partial length of a panel shall be divided by the product of the web thickness and the girder depth or the length of panel in which the load is placed, whichever is the lesser panel dimension.

Any other distributed loading, in pounds per linear inch of length, shall be divided by the web thickness.

Composite Construction

Sec. 2708. (a) **Definition.** Composite construction shall consist of steel beams or girders supporting a reinforced concrete slab, so interconnected that the beam and slab act together to resist bending. When the slab extends on both sides of the beam, the effective width of the concrete flange shall be taken as not more than one-fourth of the span of the beam, and its effective projection beyond the edge of the beam shall not be taken as more than one-half the clear distance to the adjacent beam, nor more than eight times the slab thickness. When the slab is present on only one side of the beam, the effective width of the concrete flange shall be taken as not more than one-twelfth of the beam span, nor six times its thickness nor one-half the clear distance to the adjacent beam.

Beams totally encased two inches (2″) or more on their sides and soffit in concrete poured integrally with the slab may be assumed to be interconnected to the concrete by natural bond, without additional anchorage, provided the top of the beam is not less than one and one-half inches (1½″) below the top and two inches (2″) above the bottom of the slab, and provided that the encasement has adequate mesh or other reinforcing steel throughout the depth and across the soffit of the beam. When shear connectors are provided in accordance with Section 2708 (d), encasement of the beam to achieve composite action is not required.

(b) **Design Assumptions.** Encased beams shall be proportioned to support unassisted all dead loads applied prior to the hardening of the concrete except where these loads are supported temporarily on shoring. The beams acting in conjunction with the slab shall support all dead and live loads applied after hardening of the concrete, without exceeding a

Composite Construction (Continued)

computed bending stress of $0.66F_y$, where "F_y" is the yield point of the steel beam. The bending stress produced by loads after the concrete has hardened shall be computed on the basis of the moment of inertia of the composite section. Concrete tension stresses below the neutral axis of the composite section shall be neglected. Alternatively, the steel beam may be proportioned to resist unassisted the moment produced by all loads, live and dead, using a bending stress equal to $0.76F_y$, in which case temporary shoring is not required.

When shear connectors are used in accordance with Section 2708 (d) the composite section shall be proportioned to support all of the loads without exceeding the allowable stress prescribed in Section 2702 (b) 4 as applicable. The moment of inertia "I_{tr}" of the composite section shall be computed in accordance with the elastic theory. Concrete tension stresses below the neutral axis of the composite section shall be neglected. The compression area of the concrete above the neutral axis shall be treated as an equivalent area of steel by dividing it by the modular ratio "n."

For construction without temporary shoring the value of the section modulus of the transformed composite section used in stress calculations shall not exceed

$$S_{tr} = \left(1.35 + 0.35\frac{M_L}{M_D}\right) S_s \qquad \text{Formula (17)}$$

provided that the steel beam alone, supporting the loads before the concrete has hardened, is not stressed to more than the applicable bending stress given in Section 2702 (b).

(c) **End Shear.** The web and the end connections of the steel beam shall be designed to carry the total dead and live load.

(d) **Shear Connectors.** The horizontal shear between the steel beam and concrete slab shall be transferred by shear connectors welded to the beam and embedded in the concrete except as specified in Section 2708 (a). The total horizontal shear to be resisted between the point of maximum positive moment and each end of simple span steel beams and between the point of maximum positive moment and a point of contraflexure in continuous span beams shall be the smaller value obtained using the following formulas:

$$V_h = \frac{0.85f'_c A_c}{2} \qquad \text{Formula (18)}$$

AND

$$V_h = \frac{A_s F_y}{2} \qquad \text{Formula (19)}$$

Composite Construction (Continued)

The number of connectors resisting the shear obtained from Formulas (18) and (19) shall be not less than that determined by the following formula:

$$\frac{V_h}{q}$$

Shear connectors, their method of attachment and allowable shear value shall be as set forth in U.B.C. Standard No. 27-8-67. Shear connectors not provided for in U.B.C. Standard No. 27-8-67 shall be approved by the Building Official.

The required number of shear connectors may be spaced uniformly between the sections of maximum and zero moment.

Shear connectors shall have at least one inch (1″) of concrete cover in all directions.

Simple and Continuous Spans

Sec. 2709. (a) **Simple Spans.** Beams, girders and trusses shall be designed on the basis of simple spans whose effective length is equal to the distance between the centers of gravity of the members to which they deliver their end reactions.

(b) **Continuous Spans.** Beams, girders and trusses designed on the assumption of full or partial end restraint shall be designed to carry the shears and moments caused by continuity without exceeding the unit stresses prescribed in Section 2702 (b).

Deflections

Sec. 2710. Horizontal framing members shall be designed for the deflection criteria and ponding requirements specified in Section 2307 and Subsection 2305 (f).

Gross and Net Sections

Sec. 2711. (a) **General.** The gross section of a member at any point shall be determined by summing the products of the thickness and the gross width of each element as measured normal to the axis of the member. The net section shall be determined by substituting for the gross width the net width computed as specified in Section 2711 (b).

Tension members shall be designed on the basis of net section. Compression members shall be designed on the basis of gross section. Beams and girders shall be designed in accordance with Section 2707.

(b) **Net Width.** The net width of a section containing a diagonal or zigzag chain of holes shall be obtained by deducting from the gross width the sum of the diameters of all the holes in the chain, and adding, for each gauge space in the chain, the quantity

$$\frac{s^2}{4g}$$

The critical net section is obtained from that chain of holes which gives the least net width. The net section through a hole shall not exceed 85 per cent of the corresponding gross section.

Gross and Net Sections (Continued)

Weld metal in plug or slot welds shall not be considered as adding to the net area.

(c) **Angles.** The gross width of angles shall be the sum of the widths of the legs less the thickness. The gauge for holes in opposite legs shall be the sum of the gauges from back of angles less the thickness.

(d) **Size of Holes.** In computing net area the diameter of a rivet or bolt hole shall be taken as one-eighth inch (1/8") greater than the nominal diameter of the rivet or bolt.

(e) **Pin-connected Members.** Eyebars shall be of uniform thickness without reinforcement at the pinholes. They shall have "circular" heads in which the periphery of the head beyond the pinhole is concentric with the pinhole. The radius of transition between the circular head and the body of the eyebar shall be equal to or greater than the diameter of the head.

The width of the body of the eyebar shall not exceed eight times its thickness, and the thickness shall be not less than one-half inch (1/2"). The net section of the head through the pinhole transverse to the axis of the eyebar shall be not less than 1.33 nor more than 1.50 times the cross-sectional area of the body of the eyebar. The diameter of the pin shall be not less than seven-eighths the width of the body of the eyebar. The diameter of the pinhole shall be not more than one-thirty-second inch (1/32") greater than the diameter of the pin.

The minimum net section across the pinhole, transverse to the axis of the member, in pin-conected plates and built-up members shall be determined using the allowable stress specified in Section 2702 (b) 1. The net section beyond the pinhole, parallel to the axis of the member, shall be not less than two-thirds of the net section across the pinhole. The corners beyond the pinhole may be cut at 45 degrees to the axis of the member provided the net section beyond the pinhole on a plane perpendicular to the cut is not less than that required beyond the pinhole parallel to the axis of the member. The parts of members built up at the pinhole shall be attached to each other by sufficient fasteners to support the stress delivered to them by the pin.

The distance transverse to the axis of a pin-connected plate or any separated element of a built-up member from the edge of the pinhole to the edge of the member or element shall not exceed four times the thickness at the pinhole. The diameter of the pin shall be preferably not less than five times the thickness of the member or separated element at the pinhole.

Gross and Net Sections (Continued)

If a smaller size is used, the bearing stress shall not exceed the value specified in Section 2702 (b) 5. The diameter of the pinhole shall be not more than one-thirty-second inch ($\frac{1}{32}''$) greater than the diameter of the pin.

Connections

Sec. 2712. (a) **Minimum Connections.** Connections shall be designed for all tributary forces and shall be capable of supporting not less than 6000 pounds.

> EXCEPTION: Lacing, sag bars and girts may be designed only for tributary forces.

(b) **Eccentric Connections.** Members and their connections shall be designed for eccentricity where the gravity axis of the connected members do not meet at a point.

(c) **Placement of Rivets, Bolts and Welds.** Except as hereinafter provided, the rivets, bolts or welds at the ends of any member transmitting axial stress into that member shall have their centers of gravity on the gravity axis of the member unless provision is made for the effect of the resulting eccentricity. Except in members subject to repeated variation in stress as defined in U.B.C. Standard No. 27-3-67, disposition of fillet welds to balance the forces about the neutral axis or axes for end connections of single angle, double angle, and similar type members is not required. Eccentricity between the gravity axes of such members and the gauge lines for their riveted or bolted end connections may be neglected.

(d) **Unrestrained Members.** Beam, girder or truss connections may be proportioned for the reaction shears only where the connections are flexible.

Flexible connections shall permit the ends of the beam to rotate sufficiently to accommodate its deflection by providing for a horizontal displacement of the top flange determined as follows:

$e = 0.007d$, when the beam is designed for full uniform load and for live load deflection not exceeding one three-hundred-sixtieth of the span.

$= \dfrac{f_b L}{3{,}600{,}000}$, when the beam is designed for full uniform load producing the unit stress "f_b" at mid-span.

WHERE:

e = the horizontal displacement of the end of the top flange, in the direction of the span, in inches.

f_b = the flexural unit stress in the beam at mid-span, in pounds per square inch.

d = the depth of the beam, in inches.

L = the span of the beam, in feet.

(e) **Restrained Members.** Fasteners or welds for end connections of beams, girders and trusses not conforming to the requirements of Section 2712 (d) shall be designed for the combined effect of end reaction shear and tensile or compressive stresses resulting from moment induced by the rigidity of the connection when the member is fully loaded.

(f) **Fillers.** When rivets or bolts carrying computed stress pass through fillers thicker than one-fourth inch (¼″), except in friction-type connections assembled with high strength bolts, the fillers shall be extended beyond the splice material and the filler extension shall be secured by enough rivets or bolts to distribute the total stress in the member uniformly over the combined section of the member and the filler, or an equivalent number of fasteners shall be included in the connection.

In welded construction, fillers one-fourth inch (¼″) or more in thickness shall extend beyond the edges of the splice plate and shall be welded to the part on which it is fitted with sufficient weld to transmit the splice plate stress, applied at the surface of the filler as an eccentric load. The welds joining the splice plate to the filler shall be sufficient to transmit the splice plate stress and shall be long enough to avoid overstressing the filler along the toe of the weld. Fillers less than one-fourth inch (¼″) thick shall have edges flush with the edges of the splice plate and the weld size shall be the sum of the size necessary to carry the splice plate stress plus the thickness of the filler plate.

(g) **Connections of Tension and Compression Members in Trusses.** The connections at ends of tension or compression members in trusses shall develop the strength required by the stress, but not less than 50 per cent of the effective strength of the member. Groove welds at the ends of tension or compression members in trusses shall be complete penetration groove welds.

(h) **Compression Members with Bearing Joints.** Where compression members bear on bearing plates, and where tier-building columns are finished to bear, there shall be sufficient rivets, bolts or welds to hold all parts securely in place.

Where other compression members are finished to bear, the splice material and its riveting, bolting or welding shall be arranged to hold all parts in line and shall be proportioned for 50 per cent of the computed stress.

Joints shall be proportioned to resist tension that would be developed by lateral forces acting in conjunction with 75 per cent of the calculated dead load stress and no live load.

Connections (Continued)

(i) **Combination of Welds.** If two or more types of welds are combined in a joint, the effective capacity of each type weld shall be computed with reference to the axis of the group, in order to determine the allowable capacity of the combination.

(j) **Rivets and Bolts in Combination with Welds.** Welds, used in combination with rivets and bolts, shall be considered as carrying the entire load on the connection.

> **EXCEPTION:** Rivets and tightened high strength bolts (friction-type) may share stress in combination with welds for alterations to existing structures, provided the rivets or bolts carry only the existing dead load and the welds are capable of carrying all additional loads.

(k) **High Strength Bolts (in Friction-type Joints) in Combination with Rivets.** High strength bolts, installed in accordance with the provisions of Section 2713 (a) as friction-type connections, may be considered as sharing the stresses with rivets in a connection.

(l) **Field Connections.** Rivets, high strength bolts or welds shall be used for the following connections:

Column splices in all tier structures two hundred feet (200') or more in height.

Column splices in tier structures one hundred feet (100') to two hundred feet (200') in height, if the least horizontal dimension is less than 40 per cent of the height.

Column splices in tier structures less than one hundred feet (100') in height, if the least horizontal dimension is less than 25 per cent of the height.

Connections of all beams and girders to columns and of any other beams and girders on which the bracing of columns is dependent, in structures over one hundred and twenty-five feet (125') in height.

Roof-truss splices and connections of trusses to columns, column splices, column bracing, knee braces and crane supports, in all structures carrying cranes of over five-ton capacity.

Connections for supports of running machinery, or of other live loads which produce impact or reversal of stress.

For the purpose of this Section, the height of a tier structure shall be taken as the vertical distance from the curb level to the highest point of the roof beams, in the case of flat roofs, or to the mean height of the gable, in the case of roofs having a rise of more than two and two-thirds in 12. Where the curb level has not been established, or where the structure does not adjoin a street, the mean level of the adjoining land shall be used instead of curb level. Penthouses may be excluded in computing the height of structure.

Rivets and Bolts

Sec. 2713. (a) **High Strength Bolts.** Use of high strength bolts shall conform to the provisions of U.B.C. Standard No. 27-7-67.

(b) **Effective Bearing Area.** The effective bearing area of rivets and bolts shall be the diameter multiplied by the length in bearing, except that for countersunk rivets and bolts half the depth of the countersink shall be deducted.

(c) **Long Grips.** Rivets and A307 bolts which carry calculated stress, and the grip of which exceeds five diameters, shall have their number increased one per cent for each additional one-sixteenth inch (1/16") in the grip.

(d) **Minimum Pitch.** The minimum distance between centers of rivet and bolt holes shall be not less than two and two-thirds times the nominal diameter of the rivet or bolt.

(e) **Minimum Edge Distance.** The minimum distance from the center of a rivet or bolt hole to any edge shall be not less than the values set forth in Table No. 27-B.

(f) **Minimum Edge Distance in Line of Stress.** In bearing-type connections of tension members, where there are not more than two fasteners in a line parallel to the direction of stress, the distance from the center of the end fastener and that end of the connected part toward which the stress is directed for riveted connections shall be not less than the area of the fastener divided by the thickness of the connected part for fasteners in single shear, and twice this distance for fasteners in double shear.

For high strength bolted connections, the end distance shall be one and one-half times the distance specified for riveted

TABLE NO. 27-B

RIVET OR BOLT DIAMETER (Inches)	MINIMUM EDGE DISTANCE FOR PUNCHED, REAMED OR DRILLED HOLES (Inches)	
	At Sheared Edges	At Rolled Edges of Plates, Shapes or Bars or Gas Cut Edges[1]
½	⅞	¾
⅝	1⅛	⅞
¾	1¼	1
⅞	1½[2]	1⅛
1	1¾[2]	1¼
1⅛	2	1½
1¼	2¼	1⅝
Over 1¼	1¾ × Diameter	1¼ × Diameter

[1]All edge distances in this column may be reduced one-eighth inch (⅛") when the hole is at a point where stress does not exceed 25 per cent of the maximum allowed stress in the element.

[2]These may be one and one-fourth inches (1¼") at the ends of beam connection angles.

Rivets and Bolts (Continued)

connections. The end distance may be decreased proportionally if stress per fastener is less than the value specified in Section 2702 (c). The end distance shall be not less than the value specified in Section 2713 (e).

Section 2713 (e) shall govern when more than two fasteners are provided in the line of stress.

(g) **Maximum Edge Distance.** The maximum distance from the center of any rivet or bolt to the nearest edge of parts in contact with one another shall be 12 times the thickness of the plate, but shall not exceed six inches (6″).

Welds

Sec. 2714. (a) **General.** Welder qualification requirements, welding procedure and welding electrodes shall conform to U.B.C. Standard No. 27-6-67.

(b) **Maximum Effective Size of Fillet Welds.** The maximum size of a fillet weld that may be assumed in the design of a connection shall be such that the stresses in the adjacent base material do not exceed the values allowed in Section 2702 (b). The maximum size that may be used along edges of connected parts shall be:

1. Along edges of material less than one-fourth inch (¼″) thick, the maximum size may be equal to the thickness of the material.
2. Along edges of material one-fourth inch (¼″) or more in thickness, the maximum size shall be one-sixteenth inch (1/16″) less than the thickness of the material, unless the weld is especially designated on the drawings to be built out to obtain full throat thickness.

(c) **Length of Fillet Welds.** The minimum effective length of a strength fillet weld shall be not less than four times the nominal size, or else the size of the weld shall be considered not to exceed one-fourth of its effective length.

If longitudinal fillet welds are used alone in end connections of flat bar tension members, the length of each fillet weld shall be not less than the perpendicular distance between them. The transverse spacing of longitudinal fillet welds used in end connections shall not exceed eight inches (8″), except where transverse bending is provided for in the connection.

(d) **Intermittent Fillet Welds.** Intermittent fillet welds may be used to transfer calculated stress across a joint or faying surfaces when the strength required is less than that developed by a continuous fillet weld of the smallest permitted size, and to join components of built-up members. The effective length of any segment of intermittent fillet welding shall be not less than four times the weld size with a minimum of one and one-half inches (1½″).

(e) **Lap Joints.** The minimum width of laps on lap joints shall be five times the thickness of the thinner part joined and not less than one inch (1″). Lap joints joining plates or bars subjected to axial stress shall be fillet welded along the edge of both lapped parts except where the deflection of the lapped parts is sufficiently restrained to prevent opening of the joint under maximum loading.

Welds (Continued)

(f) **End Returns of Fillet Welds.** Side or end fillet welds terminating at ends or sides, respectively, of parts or members shall, wherever practicable, be returned continuously around the corners for a distance not less than twice the nominal size of the weld. This provision shall apply to side and top fillet welds connecting brackets, beam seats and similar connections, on the plane about which bending moments are computed.

(g) **Fillet Welds in Holes and Slots.** Fillet welds in holes or slots may be used to transmit shear in lap joints or to prevent the buckling or separation of lapped parts, and to join components of built-up members. Such fillet welds may overlap, subject to the provisions of Section 2711 (g). Fillet welds in holes or slots shall not be considered as plug or slot welds.

(h) **Plug and Slot Welds.** Plug or slot welds may be used to transmit shear in a lap joint or to prevent buckling of lapped parts and to join component parts of built-up members.

The diameter of the holes for a plug weld shall be not less than the thickness of the part containing it plus five-sixteenths inch (5/16″), rounded to the next greater odd one-sixteenth inch (1/16″), nor greater than two and one-fourth times the thickness of the weld metal.

The minimum center-to-center spacing of plug welds shall be four times the diameter of the hole.

The length of slot for a slot weld shall not exceed 10 times the thickness of the weld. The width of the slot shall be not less than the thickness of the part containing it, plus five-sixteenths inch (5/16″), rounded to the next greater odd one-sixteenth inch (1/16″), nor shall it be greater than two and one-fourth times the thickness of the weld. The ends of the slot shall be semicircular or shall have the corners rounded to a radius not less than the thickness of the part containing it, except those ends which extend to the edge of the part.

The minimum spacing of lines of slot welds in a direction transverse to their length shall be four times the width of the slot. The minimum center-to-center spacing in a longitudinal direction on any line shall be two times the length of the slot.

The thickness of plug or slot welds in material five-eighths inch (5/8″) or less in thickness shall be equal to the thickness of the material. In material over five-eighths inch (5/8″) in thickness, it shall be at least one-half the thickness of the material but not less than five-eighths inch (5/8″).

Sec. 2715. (a) **Open Web Steel Joists, J, H, LA and LH Series.** Open web steel joists shall be designed as set forth in U.B.C. Standard No. 27-4-67.

Built-up Members

(b) **Open Box-Type Beams and Grillages.** Where two or more rolled beams or channels are used side by side to form

Built-up Members (Continued)

a flexural member, they shall be connected together at intervals of not more than five feet (5′). Through-bolts and separators may be used, provided that in beams having a depth of twelve inches (12″) or more, no fewer than two bolts shall be used at each separator location. When concentrated loads are carried from one beam to the other, or distributed between the beams, diaphragms having sufficient stiffness to distribute the load shall be riveted, bolted or welded between the beams. Where beams are exposed, they shall be sealed against corrosion of interior surfaces, or spaced sufficiently far apart to permit cleaning and painting.

(c) **Compression Members.** All parts of built-up compression members and the transverse spacing of their lines of fasteners shall conform to the requirements of Sections 2705 and 2709.

At the ends of built-up compression members bearing on base plates or milled surfaces, all components in contact shall be connected by rivets or bolts spaced longitudinally not more than four diameters apart for a distance equal to one and one-half times the maximum width of the member, or by continuous welds having a length not less than the maximum width of the member.

The longitudinal spacing for intermediate rivets, bolts or intermittent welds in built-up members shall be adequate to provide for the transfer of calculated stress. The spacing of connectors for outside plates of built-up compression members shall not exceed the values determined by the following formulas:

When rivets or bolts are provided on all gauge lines at each section, or when intermittent welds are provided along the edges of the components

$$\frac{4000}{\sqrt{F_y}}$$

but not more than twelve inches (12″).

When rivets or bolts are staggered

$$\frac{6000t}{\sqrt{F_y}}$$

but not more than eighteen inches (18″).

WHERE:

t = thickness of thinner outside plate in inches.

The maximum longitudinal spacing of rivets, bolts or intermittent welds connecting two rolled shapes in contact with one another shall not exceed twenty-four inches (24″).

Compression members composed of two or more rolled shapes separated by intermittent fillers shall be connected at intervals such that the slenderness ratio "l/r" of either shape, between the fasteners, does not exceed the governing slender-

Built-up Members (Continued)

ness ratio of the built-up member. The least radius of gyration "*r*" shall be used in computing the slenderness ratio of each component part.

Open sides of compression members built up from plates or shapes shall be provided with lacing having tie plates at each end, and at intermediate points if the lacing is interrupted. In main members carrying calculated stress the end tie plates shall have a length of not less than the distance between the lines of rivets, bolts or welds connecting them to the components of the member. Intermediate tie plates shall have a length not less than one-half of this distance. The thickness of tie plates shall be not less than one-fiftieth of the distance between the lines of rivets, bolts or welds connecting them to the segments of the members. In riveted and bolted construction the pitch in tie plates shall be not more than six diameters and the tie plates shall be connected to each segment by at least three fasteners. In welded construction, the welding on each line connecting a tie plate shall aggregate not less than one-third the length of the plate.

Lacing, including flat bars, angles, channels or other shapes employed as lacing, shall be so spaced that the ratio "*l/r*" of the flange included between their connections shall not exceed the governing ratio for the member as a whole. Lacing shall be proportioned to resist a shearing stress normal to the axis of the member equal to two per cent of the total compressive stress in the member. The ratio "*l/r*" for lacing bars arranged in single systems shall not exceed 140. For double lacing this ratio shall not exceed 200. Double lacing bars shall be joined at their intersections. In determining the required section for lacing bars, Formula (1) or (3) shall be used, "*l*" being taken as the unsupported length of the lacing bar between rivets or welds connecting it to the components of the built-up member for single lacing and 70 per cent of that distance for double lacing. The inclination of lacing bars to the axis of the member shall be not less than 60 degrees for single lacing and 45 degrees for double lacing. When the distance between the lines of rivets or welds in the flanges is more than fifteen inches (15″), the lacing shall be double or be made of angles.

Tie plates and lacing bars are not required where the open sides of built-up compression members are enclosed with cover plates perforated with access holes. The net width of such plates across holes, as defined in Section 2706 (b), is assumed to resist axial stress, provided that: the width to thickness ratio conforms to the requirements of Section 2706 (b); the ratio of length, in direction of stress to width of hole does not exceed two; the clear distance between holes in the direction of stress is not less than the transverse distance between nearest lines of connecting rivets, bolts or welds; and the periphery of the holes at all points has a minimum radius of one and one-half inches (1½″).

Built-up Members (Continued)

(d) **Tension Members.** The longitudinal spacing of rivets, bolts and intermittent fillet welds connecting a plate and a rolled shape in a built-up tension member, or two plate components, shall not exceed 24 times the thickness of the thinner plate nor twelve inches (12″). The longitudinal spacing of rivets, bolts and intermittent welds connecting two or more shapes in a tension member shall not exceed twenty-four inches (24″). Tension members composed of two or more shapes or plates separated by intermittent fillers shall be connected at intervals such that the slenderness ratio of either component between the fasteners does not exceed 240.

Either perforated cover plates or tie plates without lacing may be used on the open sides of built-up tension members. Tie plates shall have a length not less than two-thirds the distance between the lines of rivets, bolts or welds connecting them to the components of the member. The thickness of such tie plates shall be not less than one-fiftieth of the distance between these lines. The longitudinal spacing of rivets, bolts or intermittent welds at tie plates shall not exceed six inches (6″). The spacing of tie plates shall be such that the slenderness ratio of any component in the length between tie plates will not exceed 240.

Camber

Sec. 2716. (a) **General.** Horizontal framing members shall be designed for the deflection criteria and ponding requirements specified in Section 2307 and Subsection 2305 (f).

(b) **Trusses and Girders.** Trusses of eighty feet (80′) or greater span shall be cambered for the dead load deflection. Crane girders of seventy-five feet (75′) or greater span shall be cambered for the dead plus half the live load deflection.

Expansion

Sec. 2717. Adequate provision shall be made for expansion and contraction appropriate to the service conditions of the structure.

Column Bases

Sec. 2718. (a) **Loads.** Adequate provision shall be made to transfer the column loads, and moments if any, to the footings and foundations.

(b) **Alignment.** Column bases shall be set level and to correct elevation with full bearing on the masonry.

(c) **Finishing.** Column bases shall be finished in accordance with the following requirements:

1. Rolled steel bearing plates, two inches (2″) or less in thickness, may be used without planing, provided a satisfactory contact bearing is obtained; rolled steel bearing plates over two inches (2″) but not over four inches (4″) in thickness may be straightened by pressing; or, if presses are not available, by planing for all bearing surfaces (except as noted under requirement 3 of this Section), to obtain a satisfactory contact bearing; rolled steel bearing plates over four inches

(4") in thickness shall be planed for all bearing surfaces (except as noted under requirement 3 of this Section). **Column Bases (Continued)**

2. Column bases other than rolled steel bearing plates shall be planed for all bearing surfaces (except as noted under requirement 3 of this Section).

3. The bottom surfaces of bearing plates and column bases which are grouted to insure full bearing contact on foundations need not be planed.

Anchor Bolts

Sec. 2719. Anchor bolts shall be designed to provide resistance to all conditions of tension and shear at the bases of columns, including the net tensile components of any bending moments which may result from fixation or partial fixation of columns.

Fabrication

Sec. 2720. The fabrication, erection and painting of structural steel shall conform to U.B.C. Standard No. 27-2-67.

Plastic Design

Sec. 2721. (a) **Scope.** Subject to the requirements specified in this Section, simple or continuous beams, one- and two-story rigid frames and similar portions of structures rigidly constructed so as to be continuous over at least one interior support may be proportioned on the basis of their maximum strength, otherwise known as plastic design. This strength, as determined by rational analysis, shall be not less than that required to support 1.70 times the live load plus dead load for simple and continuous beams. For continuous frames it shall be not less than 1.85 times the live load plus dead load, nor 1.40 times these loads acting in conjunction with 1.40 times the wind or earthquake forces.

Connections joining a portion of a structure designed on the basis of plastic behavior with a portion not so designed need be no more rigid than seat-and-cap angle or standard web connections.

Where plastic design is used as the basis for proportioning continuous beams and structural frames, the provisions relating to allowable stress contained in the other Sections of this Chapter are waived. The provisions of this Chapter shall apply except as modified by this Section.

Crane runways shall not be designed continuous over interior vertical supports on the basis of maximum strength. Rigid frame bents supporting crane runways may be considered as coming within the scope of this Section.

(b) **Material.** Structural steel shall conform to U.B.C. Standard No. 27-1-67.

(c) **Columns.** The slenderness ratio "l/r" shall not exceed 120 in the plane of bending for columns which develop a plastic hinge at ultimate loading. The slenderness ratio of columns regulated by Formula (21) shall not exceed 100. The maximum axial load "P" at ultimate loading shall not exceed six-tenths times the plastic axial load "P_y."

Plastic Design (Continued)

Columns in continuous frames, where sidesway is not prevented by diagonal bracing, by attachment to an adjacent structure having ample lateral stability or by floor slabs or roof decks secured horizontally by walls or bracing systems parallel to the plane of the continuous frames, shall be so proportioned that

$$\frac{2P}{P_y} + \frac{l}{70r} \lesseqgtr 1.0 \qquad \text{Formula (20)}$$

Except as otherwise provided in this Section, "M_o/M_p," the ratio of allowable end moment to the full plastic bending strength of columns and other axially loaded members, shall not exceed the value given by the following formulas:

Case I. For columns bent in double curvature by moments producing plastic hinges at both ends of the columns WHERE:

$$\frac{P}{P_y} \lesseqgtr .15$$

$$\frac{M_o}{M_p} = 1$$

WHERE:

$$\frac{P}{P_y} > .15$$

$$\frac{M_o}{M_p} \lesseqgtr 1.18\left(1 - \frac{P}{P_y}\right) \lesseqgtr 1.0 \qquad \text{Formula (21)}$$

Case II. For pin-based columns required to develop a hinge at one end only, and double curvature columns required to develop a hinge at one end when the moment at the other end would be less than the hinge value

$$\frac{M_o}{M_p} \lesseqgtr B - G\left(\frac{P}{P_y}\right) \lesseqgtr 1.0 \qquad \text{Formula (22)}$$

WHERE:

$$B^* = 1.133 + \frac{\frac{l}{r}}{3080} + \frac{\left(\frac{l}{r}\right)^2}{185{,}000}$$

$$G^* = 1.11 + \frac{\frac{l}{r}}{190} - \frac{\left(\frac{l}{r}\right)^2}{9000} + \frac{\left(\frac{l}{r}\right)^3}{720{,}000}$$

*NOTE: The formulae for computing values of B, G, H, and J consider steels with a yield strength of 33,000 p.s.i. For steels having a yield strength of 36,000 p.s.i. B, G, H, and J should be computed by adjusting the "l/r" values by the factor $\sqrt{\frac{36}{33}}$

$$\frac{l}{r} < 60 \text{ in plane of bending}$$

$$\frac{M_o}{M_p} = 1 \text{ where } \frac{P}{P_y} \leqq .15$$

Case III. For columns bent in single curvature

$$\frac{M_o}{M_p} \leqq 1.0 - H\left(\frac{P}{P_y}\right) - J\left(\frac{P}{P_y}\right)^2$$

Formula (23)

WHERE:

$$H^* = .420 + \frac{\frac{l}{r}}{70} - \frac{\left(\frac{l}{r}\right)^2}{29{,}000} + \frac{\left(\frac{l}{r}\right)^3}{1{,}160{,}000}$$

$$J^* = .770 - \frac{\frac{l}{r}}{60} + \frac{\left(\frac{l}{r}\right)^2}{8700} - \frac{\left(\frac{l}{r}\right)^3}{606{,}000}$$

In no case shall the ratio of axial load to plastic load exceed the value determined by the following formula:

$$\frac{P}{P_y} = \frac{8700}{(l/r)^2} \text{ when } \frac{l}{r} > 120 \quad \text{Formula (24)}$$

(d) **Shear.** Unreinforced webs of columns, beams, and girders shall be so proportioned that

$$V_u \leqq 0.00055 F_y w d$$

EXCEPTION: Webs subjected to shear forces may be considered adequate when

$$w > \frac{23{,}000\, M}{A_{bc}\, F_y}$$

WHERE:

M = the algebraic sum of clockwise and counter-clockwise moment (in kip-feet) applied on opposite sides of the connection web boundary.

(e) **Web Crippling.** Web stiffeners are required on a member at a point of load application where a plastic hinge would form.

Web stiffeners are required at points where concentrated compression loads are delivered by the flanges to the web when

$$w < \frac{A_f}{t_b + 5k}$$

and at points where concentrated tension loads are delivered by the flange to the web when

$$t_f < 0.4 \sqrt{A_f}$$

WHERE:

w = thickness of web to be stiffened.
k = distance from outer face of flange to web toe of fillet of member to be stiffened.
t_f = thickness of flange of member to be stiffened.
t_b = thickness of flange delivering concentrated load.
A_f = area of flange delivering concentrated load.

The area of such stiffeners, "A_{st}," shall be such that

$$A_{st} \geqq A_f - w\ (t_b + 5k)$$

Their ends shall be fully welded to the inside face of the flange opposite the concentrated tensile load. They may be fitted against the inside face of the flange opposite the concentrated compression load. When the concentrated load delivered by a beam occurs on one side only, the web stiffener need not exceed one-half the depth of the member, but the welding connecting it to the web shall be sufficient to develop "$F_y A_{st}$."

(f) **Minimum Thickness.** Projecting compression elements involving plastic hinge rotation under ultimate loading shall have width-thickness ratios no greater than eight and one-half for built-up shapes and eight and three-fourths for rolled shapes. Portions of compression elements located between rows of stiffeners on connectors shall have width-thickness ratios no greater than 32.

The depth-thickness ratio of beam and girder webs subjected to plastic bending without axial loading shall not exceed 70. Members when subjected to combined axial force and plastic bending moment at ultimate loading shall have web depth thickness ratios not to exceed the value given by the formula

$$\frac{d}{w} \lesseqgtr 70 - 100 \frac{P}{P_y} \qquad \text{Formula (25)}$$

with a minimum value of 43.

(g) **Connections.** All connections shall be capable of resisting the moments, shears and axial loads to which they would be subjected by the ultimate loading.

Haunch-type connections, tapered or curved for architectural reasons, shall be so proportioned that the full plastic bending strength of the section adjacent to the connection can be developed.

Stiffeners shall be used to preserve the flange continuity of interrupted members at their junction with other members in a continuous frame. Such stiffeners shall be placed in pairs on opposite sides of the web of the member which extends continuously through the joint.

Plastic Design (Continued)

Rivets, welds and bolts shall be proportioned to resist the forces produced at ultimate load using allowable unit stresses equal to 1.67 times those permitted in other Sections of this Chapter.

High strength bolts may be proportioned, on the basis of their minimum guaranteed proof load, to resist the tension produced by the ultimate loading. When used to transmit shear produced by the ultimate loading, one bolt may be substituted for a rivet of the same nominal diameter. High strength bolts may be used in joints having painted contact surfaces when these joints are of such size that the slip required to produce bearing would not interfere with the formation, at ultimate loading, of the plastic hinges assumed in the design.

(h) **Lateral Bracing.** Members designed on the basis of ultimate load shall be adequately braced to resist lateral and torsional displacements at the plastic hinge locations. The laterally unsupported distance, "l_{cr}," shall not exceed

$$l_{cr} = \left(60 - 40\frac{M}{M_p}\right) r_y \qquad \text{Formula (26)}$$

except that it need not be less than "$35r_y$"

WHERE:

r_y = the radius of gyration of the member about its weak axis.

M = the lesser of the moments at the ends of the unbraced segment.

M/M_p = the end moment ratio, is positive when the segment is bent in single curvature and negative when bent in double curvature.

EXCEPTION: Laterally unsupported lengths greater than specified above may be justified by an analysis based upon the amount of restraint present at the ends of the segment in the plane of the computed bending moments.

The foregoing provisions need not apply in the region of the last hinge to form, nor in members oriented with their weak axis normal to the plane of bending. However, in the region of the last hinge to form, and in regions not adjacent to a plastic hinge, the maximum distance between points of lateral support shall be such as to satisfy the requirements of Formulas (4), (5) and (6) in this Chapter. For this case the value of "f_a" and "f_b" shall be computed from the moment and axial force at ultimate loading, divided by the applicable load factor.

Members built into a masonry wall and having their web perpendicular to the wall can be assumed to be laterally supported with respect to their weak axis of bending.

Plastic Design (Continued)

(i) **Fabrication.** The provisions of U.B.C. Standard No. 27-2-67 with respect to workmanship shall govern the fabrication of structures, or portions of structures, designed on the basis of maximum strength, subject to the following limitations:

The use of sheared edges shall be avoided in locations subject to plastic hinge rotation at ultimate loading. If used they shall be finished smooth by grinding, chipping or planing.

In locations subject to plastic hinge rotation at ultimate loading, holes for rivets or bolts in the tension area shall be subpunched and reamed or drilled full size.

Light Steel Construction

Sec. 2722. (a) **General.** Steel studs, steel joists, and other supports used in the structural frame of light steel construction shall be lightweight rolled sections, or sections made of commonly accepted or specially formed light-gauge flat rolled sheets; or a combination of both used alone or in combination with other materials of construction. Such studs, supports, or steel joists may be of a determinate truss design with elements effectively joined together by arc or resistance welding, or by rivets. In the case of expanded sections, a portion of the metal may be left intact to form a connection. For steel studs the ratio of "l/r" shall not exceed 180.

U.B.C. Standard No. 27-10-67 shall be accepted as recognized engineering practice for the design of light steel structural members, except as otherwise specifically provided in this Code.

Open web or trussed members shall be so constructed that the lines of force of all connected members shall intersect at a point or proper allowance shall be made in the design for any resulting stress. The web elements shall be of sufficient strength to resist effectively the shearing stresses.

All connections shall be riveted, bolted, or welded. All steelwork, including welds and connections, except where entirely encased in concrete, shall be thoroughly cleaned and given one coat of acceptable metal protection well worked into the joints and open spaces.

Steel used to form individual structural members shall be not less than No. 18 U. S. Standard gauge in thickness.

> EXCEPTION: Steel used to form load-carrying panels other than corrugated or ribbed roof or wall panels shall be not less than No. 22 U. S. Standard gauge in thickness. Corrugated or ribbed steel roof and wall panels shall be not less than No. 30 U. S. Standard gauge in thickness.

(b) **Stresses.** The unit design stress in structural members of light steel shall not exceed the minimum yield strength of the steel divided by 1.65.

(c) **Construction Details.** Steel studs or other steel supporting members used in the structural frame of light steel construction and steel joists shall be connected to the supporting beams, girders, foundations, or other steel supporting members by arc or resistance welding, riveting, bolting, or other approved methods. All such welds in light steel construction shall be made on two sides or two edges of each bearing in such a manner as to resist effectively the stresses developed. Resistance welding shall develop the full strength of the member welded.

Light Steel Construction (Continued)

Steel floor and roof members supported on masonry and reinforced concrete shall have end bearings at least four inches (4″) in length and the ends of such members resting on masonry or reinforced concrete shall be provided with approved joist anchors thoroughly embedded therein.

Bearing plates, when required by design, shall be securely welded, bolted, or riveted to such floor and roof members, studs, or other supporting members.

Bearing studs or other vertical bearing members shall rest on a sole or plate having an effective width equal to the depth of such member and having a sufficient cross section to transfer the required loads of the vertical member resting thereon unless such bearing vertical member is thoroughly embedded in the concrete foundation. Such soles or plates shall be effectively anchored to the foundation.

When bearing studs or other vertical bearing members are spliced, the full strength of such members shall be developed in the splice.

Where studs do not continue full length from one story through the next story above, a cap plate or steel member shall be provided on top of the lower story studs or a sill plate on the upper story. Such cap plate or sill plate shall be of sufficient strength to distribute adequately the loads from the upper story studs to the lower story studs.

All horizontal or diagonal ties or bracing in exterior walls and bearing partitions shall be effectively arc welded, bolted, or riveted to the structural frame or effectively anchored to supporting masonry.

Where plumbing, heating, or other pipes or conduits are placed in or partly in an exterior wall or bearing partition necessitating the cutting of soles or plates, bracing or structural member in said wall, such members shall be reinforced so as to provide sufficient strength to resist the stresses imposed thereon or proper provisions shall be made to transfer such stresses to the points of support.

PART VII

DETAILED REGULATIONS

CHAPTER 28—EXCAVATIONS, FOUNDATIONS, AND RETAINING WALLS

Quality and Design

Sec. 2801. The quality and design of materials used structurally in excavations, footings and foundations shall conform to the requirements specified in Chapters 23, 24, 25, 26, and 27 of this Code.

Excavations and Fills

Sec. 2802. (a) **General.** Excavations or fills for any buildings or structure and excavations or fills accessory thereto shall be so constructed or protected that they do not endanger life and property.

Cut slopes for permanent excavations shall not be steeper than 1½ horizontal to 1 vertical and slopes for permanent fills shall not be steeper than 2 horizontal to 1 vertical unless substantiating data justifying steeper slopes are submitted. Deviation from the foregoing limitations for slopes shall be permitted only upon the presentation of a soil investigation report acceptable to the Building Official.

No fill or other surcharge loads shall be placed adjacent to any building or structure unless such building or structure is capable of withstanding the additional loads caused by the fill or surcharge.

Footings or foundations which may be affected by any excavation shall be underpinned adequately, or otherwise protected against settlement, and shall be protected against lateral movement.

Fills to be used to support the foundations of any building or structure shall be placed in accordance with accepted engineering practice. A soil investigation report and a report of satisfactory placement of fill, both acceptable to the Building Official, shall be submitted.

(b) **Protection of Adjoining Property.** Any person making or causing an excavation to be made to a depth of twelve feet (12′) or less, below the grade, shall protect the excavation so that the soil of adjoining property will not cave in or settle, but shall not be liable for the expense of underpinning or extending the foundation of buildings on adjoining properties where his excavation is not in excess of twelve feet (12′) in depth. Before commencing the excavation the person making or causing the excavation to be made shall notify in writing the owners of adjoining buildings not less than 10 days before such excavation is to be made that the excavation is to be made and that the adjoining buildings should be protected.

Excavations and Fills (Continued)

The owners of the adjoining properties shall be given access to the excavation for the purpose of protecting such adjoining buildings.

Any person making or causing an excavation to be made exceeding twelve feet (12') in depth below the grade, shall protect the excavation so that the adjoining soil will not cave in or settle, and shall extend the foundation of any adjoining buildings below the depth of twelve feet (12') below grade at his own expense. The owner of the adjoining buildings shall extend the foundations of his buildings to a depth of twelve feet (12') below grade at his own expense as provided in the preceding paragraph.

Soil Classification

Sec. 2803. (a) **General.** The classification of the soil under all portions of every building shall be based upon the examination of adequate test borings or excavations made at the site when required by the Building Official. The location of the test borings or excavations and the nature of the subsurface materials shall be indicated on the plans.

> EXCEPTION: Certain buildings of Type V construction may have footings and foundations designed in accordance with the provisions of Section 2806 and Table No. 28-A.

(b) **Moisture Content.** Due allowance shall be made in determining the capacity of subsurface materials for the effect of possible change in moisture content.

(c) **Unequal Loads.** Where footings are to be placed at varying elevations the effect of adjacent loads shall be included in the foundation analysis.

TABLE NO. 28-A—FOUNDATIONS FOR STUD BEARING WALLS

MINIMUM REQUIREMENTS

NUMBER OF STORIES	THICKNESS OF FOUNDATION WALL (Inches)		WIDTH OF FOOTING (Inches)	THICKNESS OF FOOTING (Inches)	DEPTH OF FOUNDATION BELOW NATURAL SURFACE OF GROUND AND FINISH GRADE (Inches)
	CONCRETE	UNIT MASONRY			
1	6	6	12	6	12
2	8	8	15	7	18
3	10	10	18	8	24

NOTES:

Where unusual conditions or frost conditions are found, footings and foundations shall be as required in Section 2806 (a).

The ground under the floor may be excavated to the elevation of the top of the footing.

Allowable Soil Pressures

Sec. 2804. The allowable unit soil pressure upon every footing shall not exceed the values as set forth in Tables No. 28-B and No. 28-C.

EXCEPTION: The tabulated values may be modified as prescribed in Section 2805.

Soil Requirements

Sec. 2805. (a) **Requirements.** Whenever, in the opinion of the Building Official, the adequacy and class of a soil cannot be determined by the test borings or excavations required by the provisions of Section 2803 (a), he may require a special soil investigation before approving the use of the footing.

(b) **Deviations.** Deviations from the allowable unit soil pressures set forth in Tables No. 28-B and No. 28-C shall be permitted only after performance of a special soil investigation by an agency acceptable to the Building Official. The Building Official may approve such deviations only after receiving a written opinion from the investigating agency together with substantiating evidence.

(c) **Load Tests.** Where the bearing capacity of the soil is not definitely known or is in question, the Building Official may require load tests or other adequate proof as to the permissible safe bearing capacity at that particular location. To determine the safe bearing capacity of soil it may be tested by loading an area not less than two square feet (2 sq. ft.) to not less than twice the maximum bearing capacity desired for use. Such load shall be sustained by the soil until no additional settlement takes place for a period of not less than 48 hours in order that such desired bearing capacity may be used. Examination of subsoil conditions may be required when deemed necessary.

Footings

Sec. 2806. (a) **General.** Footings and foundations, unless otherwise specifically provided, shall be constructed of solid masonry or concrete and shall in all cases extend below the frost line. Foundation walls supporting wood shall extend at least six inches (6") above the finish grade adjacent to the wall at all points. Mortar used in foundation walls and footings shall be as specified in Section 2403 (t).

(b) **Bearing Walls.** Bearing walls shall be supported on continuous solid masonry or concrete footings or piles, which shall be of sufficient size to support safely the loads imposed as determined from the character of the soil. Minimum foundation requirements for stud bearing walls shall be as set forth in Table No. 28-A.

EXCEPTIONS: 1. Interior bearing walls in one-story buildings may be supported on piers.

2. Exterior bearing walls in one-story Type V buildings (except Groups H and I Occupancies) may be supported on piers.

(Continued on page 382)

TABLE NO. 28-B—ALLOWABLE SOIL PRESSURE

CLASS OF MATERIAL	MINIMUM DEPTH OF FOOTING BELOW ADJACENT VIRGIN GROUND	VALUE PERMISSIBLE IF FOOTING IS AT MINIMUM DEPTH, POUNDS PER SQUARE FOOT	INCREASE IN VALUE FOR EACH FOOT OF DEPTH THAT FOOTING IS BELOW MINIMUM DEPTH, POUNDS PER SQUARE FOOT	MAXIMUM VALUE POUNDS PER SQUARE FOOT
1	2	3	4	5
Rock	0′	20% of ultimate crushing strength	0	20% of ultimate crushing strength
Compact coarse sand	1′	1500[1]	300[1]	8000
Compact fine sand	1′	1000[1]	200[1]	8000
Loose sand	2′	500[1]	100[1]	3000
Hard clay or sandy clay	1′	4000	800	8000
Medium-stiff clay or sandy clay	1′	2000	200	6000
Soft sandy clay or clay	2′	1000	50	2000
Adobe	1′6″	1000[2]	50	
Compact inorganic sand and silt mixtures	1′	1000	200	4000
Loose inorganic sand silt mixtures	2′	500	100	1000
Loose organic sand and silt mixtures and muck or bay mud	0′	0	0	0

[1]These values are for footings one foot (1′) in width and may be increased in direct proportion to the width of the footing to a maximum of three times the designated value.
[2]For depths greater than eight feet (8′) use values given for clay of comparable consistency.

Footings (Continued)

3. A one-story wood frame building which is not used for human occupancy and which does not exceed four hundred square feet (400 sq. ft.) in area, including additions, may be constructed without a masonry or concrete foundation if the walls are supported on a wood foundation plate.

4. The support of buildings by posts embedded in earth shall be designed as specified in Section 2806 (f). Wood posts or poles embedded in earth shall be pressure treated with an approved preservative. Steel posts or poles shall be protected as specified in Section 2808 (f).

(c) **Stepped Foundations.** Foundations for all buildings where the surface of the ground slopes more than one foot (1′) in ten feet (10′) shall be level or shall be stepped so that both top and bottom of such foundation are level.

(d) **Footing Design.** Except for special provisions of Section 2808 covering the design of piles, all portions of footings shall be designed in accordance with the structural provisions of this Code and shall be designed to minimize differential settlement.

TABLE NO. 28-C—ALLOWABLE LATERAL SOIL PRESSURE

CLASS OF MATERIAL	ALLOWABLE VALUES PER FOOT OF DEPTH BELOW NATURAL GRADE[1] (Pounds per Square Foot)	MAXIMUM ALLOWABLE VALUES (Pounds per Square Foot)
Good – compact well-graded sand and gravel Hard Clay Well-graded fine and coarse sand (All drained so water will not stand)	400	8000
Average—compact fine sand Medium Clay Compact sandy loam Loose coarse sand and gravel (All drained so water will not stand)	200	2500
Poor—Soft Clay Clay Loam Poorly compacted sand Clays containing large amounts of silt (Water stands during wet season)	100	1500

[1]Isolated poles, such as flagpoles, or signs, may be designed using lateral bearing values equal to two times tabulated values.

(e) **Foundation Plates or Sills.** Foundation plates or sills shall be bolted to the foundation or foundation wall with not less than one-half-inch (½") bolts embedded at least seven inches (7") into the masonry or concrete and spaced not *more* than six feet (6') apart. There shall be a minimum of two bolts per piece with one bolt located within twelve inches (12") of each end of each piece. Foundation plates and sills shall be the kind of wood specified in Section 2517 (c).

Footings (Continued)

(f) **Designs Employing Lateral Bearing.** Construction employing posts or poles as columns embedded in earth or embedded in concrete footings in the earth may be used to resist both axial and lateral loads. The depth to resist lateral loads shall be determined by means of the design criteria established herein or other methods approved by the Building Official.

1. **Design criteria—nonconstrained.** The following formula may be used in determining the depth of embedment required to resist lateral loads where no constraint is provided at the ground surface, such as rigid floor or ground surface pavement.

$$d = \frac{A}{2}\left(1 + \sqrt{1 + \frac{4.36h}{A}}\right)$$

WHERE:

$A = \dfrac{2.34P}{S_1 b}$

P = Applied lateral force in pounds.

S_1 = Allowable lateral soil-bearing pressure as set forth in Table No. 28-C based on a depth of one-third the depth of embedment.

S_3 = Allowable lateral soil-bearing pressure as set forth in Table No. 28-C based on a depth equal to the depth of embedment.

b = Diameter of round post or footing or diagonal dimension of square post or footing (feet).

h = Distance in feet from ground surface to point of application of "P."

d = Depth of embedment in earth in feet but not over twelve feet (12') for purpose of computing lateral pressure.

Constrained. The following formula may be used to determine the depth of embedment required to resist lateral loads where constraint is provided at the ground surface, such as a rigid floor or pavement.

$$d^2 = 4.25\frac{Ph}{S_3 b}$$

Footings (Continued)

Vertical load. The resistance to vertical loads is determined by the allowable soil-bearing pressure set forth in Table No. 28-B.

2. **Construction requirements—backfill.** The backfill in the annular space around columns not embedded in poured footings shall be by one of the following methods:

A. Backfill shall be of concrete with an ultimate strength of 2000 pounds per square inch at 28 days. The hole shall be not less than four inches (4″) larger than the diameter of the column at its bottom or four inches (4″) larger than the diagonal dimension of a square or rectangular column.

B. Backfill shall be of clear sand. The sand shall be thoroughly compacted by tamping in layers not more than eight inches (8″) in depth.

3. **Limitations.** The design procedure outlined in this Subsection shall be subject to the following limitations:

The frictional resistance for retaining walls and slabs on silts and clays shall be limited to one-half of the normal force imposed on the soil by the weight of the footing or slab.

Posts embedded in earth shall not be used to provide lateral support for structural or nonstructural materials such as plaster, masonry or concrete unless bracing is provided that develops the limited deflection required.

Grillage Footings

Sec. 2807. When grillage footings of structural steel shapes are used on soils, they shall be completely embedded in concrete with at least six inches (6″) on the bottom and at least four inches (4″) at all other points.

Piles

Sec. 2808. (a) **General.** The use of types of piles not specifically mentioned in this Chapter, and the use of piles under conditions not specifically covered herein, shall be permitted, subject to the approval of the Building Official, upon submission of acceptable test data, calculations, or other information relating to the properties and load-carrying capacity of such piles.

(b) **Column Action.** All piles standing unbraced in air, water, or material not capable of lateral support, shall conform with the applicable column formula as specified in this Code. Such piles driven into firm ground may be considered fixed and laterally supported at five feet (5′) below the ground surface and in soft material at ten feet (10′) below the ground surface unless otherwise prescribed by the Building Official after a foundation investigation by an approved agency.

(c) **Group Action.** Consideration shall be given to the reduction of allowable pile load when piles are placed in groups. Where soil conditions make such load reductions advisable or necessary, the allowable axial load determined for a single pile shall be reduced by any rational method or formula approved by the Building Official.

Piles (Continued)

(d) **Piles in Subsiding Areas.** Where piles are driven through subsiding fills or other subsiding strata and derive support from underlying firmer materials, consideration shall be given to the downward frictional forces which may be imposed on the piles by the subsiding upper strata.

Where the influence of subsiding fills is considered as imposing loads on the pile, the allowable stresses specified in this Chapter may be increased if satisfactory substantiating data are submitted.

(e) **Jetting.** Jetting shall not be used except where and as specifically permitted by the Building Official. When used, jetting shall be carried out in such a manner that the carrying capacity of existing piles and structures shall not be impaired. After withdrawal of the jet, piles shall be driven down until the required resistance is obtained.

(f) **Protection of Pile Materials.** Where the boring records of site conditions indicate possible deleterious action on pile materials because of soil constituents, changing water levels, or other factors, such materials shall be adequately protected by methods or processes approved by the Building Official. The effectiveness of such methods or processes for the particular purpose shall have been thoroughly established by satisfactory service records or other evidence which demonstrates the effectiveness of such protective measures.

(g) **Allowable Loads.** The allowable loads based upon soil conditions shall be established in accordance with Section 2809.

> **EXCEPTION:** Any uncased cast-in-place pile may be assumed to develop a frictional resistance equal to one-sixth of the bearing value of the soil material at minimum depth as set forth in Table No. 28-B but not to exceed 500 pounds per square foot unless a greater value is prescribed by the Building Official after a soil investigation as specified in Section 2805. Frictional resistance and bearing resistance shall not be assumed to act simultaneously.

(h) **Allowable Pile Stresses.** The allowable compressive stresses on all piling materials shall not exceed the values specified in Section 2810, except that stresses may be increased on submission of satisfactory data for specially protected, selected, or high-strength material. In determining stresses the full load shall be assumed as carried on the pile cross section located at the upper surface of the soil supporting the pile.

Allowable Pile Loads Based on Soil Conditions

Sec. 2809. (a) **General.** The allowable axial and lateral loads on piles shall be determined by an approved formula, by load tests, or by a foundation investigation by an approved agency. A foundation investigation shall be made if required by the Building Official.

Allowable Pile Loads Based on Soil Conditions (Continued)

(b) **Allowable Loads.** 1. **Dynamic load tests.** The allowable axial load on a pile shall not exceed the value given by the following formulas unless such load is otherwise determined as specified in Section 2805.

Allowable Axial Load = $R/4$ for all piles.

WHERE:

$$R \text{ (for steel piles)} = \frac{12\,Wh\,\dfrac{W + 0.25P}{W + P}}{S + \dfrac{RL\,24{,}000}{AE}}$$

$$R \text{ (for other piles)} = \frac{12\,Wh\,\dfrac{W + 0.1P}{W + P}}{S + \dfrac{RL\,24{,}000}{AE}}$$

WHERE:

R = ultimate driving resistance, in tons.
W = weight of striking parts, in tons.
h = height of fall of striking parts, in feet.
Wh = striking energy, in foot tons.
P = weight of pile, in tons.
S = permanent settlement of pile under the average of the last 10 blows, in inches.
L = length of pile, in feet.
A = average right cross-sectional area of pile material, in square inches.
E = modulus of elasticity of pile, in pounds per square inch.

2. **Static load tests.** When the allowable axial load of a single pile is determined by load test, one of the following methods shall be used:

Method 1. It shall not exceed 50 per cent of the yield point under test load. The yield point shall be defined as that point at which an increase in load produces a disproportionate increase in settlement.

Method 2. It shall not exceed one-half of the load which causes a net settlement, after deducting rebound, of one one-hundredth inch (.01″) per ton of test load, which has been applied for a period of at least 24 hours.

Method 3. It shall not exceed one-half of that load under which, during a 40-hour period of continuous load application, no additional settlement takes place.

Specific Pile Requirements

Sec. 2810. (a) **Round Wood Piles.** 1. **Material.** Except where untreated piles are permitted, wood piles shall be pressure-treated in accordance with U.B.C. Standard No. 25-12-67. The basic material shall conform to that of untreated piles. Untreated piles may be used only when it has been established that the cutoff will be below lowest ground-water level assumed to exist during the life of the structure. Every wood pile shall conform to the specification for Class A or Class B piles in U.B.C. Standard No. 25-14-67.

2. **Allowable stresses.** The allowable stress in compression parallel to the grain of round wood piles shall not exceed 60 per cent of the basic stress for clear material as set forth in U.B.C. Standard No. 25-1-67 and in no event shall the stress exceed 1000 pounds per square inch.

(b) **Uncased Cast-in-Place Concrete Piles.** 1. **Material.** Concrete piles cast in place against earth in drilled or bored holes shall be made in such a manner as to insure the exclusion of any foreign matter and to secure a full-sized shaft. The length of such pile shall be limited to not more than 30 times the average diameter. Concrete shall have an ultimate compressive strength "f'_c" of not less than 2500 pounds per square inch.

2. **Allowable stresses.** The allowable compressive stress in the concrete shall not exceed .225 f'_c. The allowable stress in the reinforcing steel shall not exceed the values specified in Chapter 26.

(c) **Metal-cased Concrete Piles.** 1. **Material.** All concrete used in metal-cased concrete piles shall have an ultimate compressive strength "f'_c" of not less than 2500 pounds per square inch.

2. **Installation.** Every metal casing for a concrete pile shall have a sealed tip with a diameter of not less than eight inches (8").

Concrete piles cast in place in metal shells shall have shells driven for their full length in contact with the surrounding soil and left permanently in place. The shells shall be sufficiently strong to resist collapse and sufficiently watertight to exclude water and foreign material during the placing of the concrete.

Piles shall be driven in such order and with such spacing as to insure against distortion of or injury to piles already in place. No pile shall be driven within four and one-half average pile diameters of a pile filled with concrete less than 24 hours old unless approved by the Building Official.

3. **Allowable stresses.** The allowable stresses shall not exceed the values specified in Section 2810 (b) 2.

(d) **Precast Concrete Piles.** 1. **Material.** Precast concrete piles shall be cast in one piece and prior to driving and at

Specific Pile Requirements (Continued)

28 days after pouring shall develop an ultimate compressive strength "f'_c" of at least 3000 pounds per square inch.

2. **Reinforcement ties.** The longitudinal reinforcement in driven precast concrete piles shall be laterally tied with steel ties or wire spirals. Ties and spirals shall be spaced not more than three inches (3″) apart, center-to-center, for a distance of two feet (2′) from the ends and not more than eight inches (8″) elsewhere. The gauge of ties and spirals shall be as follows:

For piles having a diameter of sixteen inches (16″) or less, wire shall be not smaller than No. 5 gauge.

For piles having a diameter of more than sixteen inches (16″) and less than twenty inches (20″) wire shall be not smaller than No. 4 gauge.

For piles having a diameter of twenty inches (20″) and larger, wire shall be not smaller than one-fourth-inch (¼″) round or No. 3 gauge.

3. **Allowable stresses.** Precast concrete piling shall be designed to resist stresses induced by handling and driving as well as by loads. The allowable stresses shall not exceed the values specified in Section 2810 (b) 2.

(e) **Precast Prestressed Concrete Piles (Pretensioned).** 1. **Material.** Precast prestressed concrete piles shall develop a compressive strength of not less than 4000 pounds per square inch before driving and an ultimate compressive strength "f'_c" at 28 days after pouring of not less than 5000 pounds per square inch.

2. **Reinforcement.** The longitudinal reinforcement shall be high tensile seven wire strand conforming to U.B.C. Standard No. 26-8-67. Longitudinal reinforcement shall be laterally tied with steel ties or wire spirals.

Ties or spiral reinforcement shall be spaced not more than three inches (3″) apart center-to-center for a distance of two feet (2′) from the ends, and not more than eight inches (8″) elsewhere.

At each end of the pile the first five ties or spirals shall be spaced one inch (1″) center-to-center.

For piles having a diameter of twenty-four inches (24″) or less, wire shall be not smaller than No. 5 gauge. For piles having a diameter greater than twenty-four inches (24″), but less than thirty-six inches (36″), wire shall not be smaller than No. 4 gauge. For piles having a diameter greater than thirty-six inches (36″), wire shall be not smaller than one-fourth-inch (¼″) round or No. 3 gauge.

3. **Allowable stresses.** Precast prestressed piling shall be designed to resist stresses induced by handling and driving as well as by loads. The effective prestress in the pile shall not be less than 400 pounds per square inch for piles up to

thirty feet (30′) in length, 550 pounds per square inch for piles up to fifty feet (50′) in length, and 700 pounds per square inch for piles greater than fifty feet (50′) in length.

Specific Pile Requirements (Continued)

The allowable compressive stress in the concrete due to externally applied load shall not exceed 0.20 "f'_c."

If the compressive stress due to effects of prestressing exceeds 0.20 "f'_c," the allowable compressive stress due to externally applied loads as permitted above, shall be reduced accordingly.

Effective prestress shall be based on an assumed loss of 30,000 pounds per square inch in the prestressing steel.

The allowable stress in the prestressing steel shall not exceed the values specified in Section 2626.

(f) **Structural Steel Piles.** 1. **Material.** Structural steel piles and fully welded steel piles fabricated from plate shall conform to U.B.C. Standard No. 27-1-67.

No section shall have a nominal thickness of metal less than three-eighths inch (⅜″).

2. **Allowable stresses.** The allowable stresses shall not exceed 12,000 pounds per square inch.

(g) **Concrete-filled Steel Pipe Piles.** 1. **Material.** Steel pipe piles shall conform to U.B.C. Standard No. 27-1-67. If it is desired to use pipe of other material, satisfactory substantiating data must be submitted.

The concrete used in concrete-filled steel pipe piles shall have an ultimate compressive strength "f'_c" of not less than 2500 pounds per square inch.

2. **Allowable stresses.** The allowable stresses shall not exceed 12,000 pounds per square inch on the steel plus .25 of the ultimate compressive strength "f'_c" of the concrete.

CHAPTER 29—VENEER

Scope

Sec. 2901. (a) **General.** All veneer and its application shall conform to the requirements of this Code. Wainscots not exceeding four feet (4') in height measured above the adjacent ground elevation for exterior veneer or the finish floor elevation for interior veneer may be exempted from the provisions of this Chapter if approved by the Building Official.

(b) **Limitations.** Exterior veneer shall not be attached to wood frame construction at a point more than twenty feet (20') in height above the adjacent ground elevation except when approved by the Building Official considering special construction designed to provide for differential movement.

Definitions

Sec. 2902. For the purpose of this Chapter, certain terms are defined as follows:

BACKING as used in this Chapter is the surface or assembly to which veneer is attached.

VENEER is nonstructural facing of brick, concrete, stone, tile, metal, plastic or other similar approved material attached to a backing for the purpose of ornamentation, protection, or insulation.

Adhered Veneer is veneer secured and supported through adhesion to an approved bonding material applied over an approved backing.

Anchored Veneer is veneer secured to and supported by approved mechanical fasteners attached to an approved backing.

Exterior Veneer is veneer applied to weather-exposed surfaces as defined in Section 424.

Interior Veneer is veneer applied to surfaces other than weather-exposed surfaces as defined in Section 424.

Materials

Sec. 2903. Materials used in the application of veneer shall conform to the applicable requirements for such materials as set forth elsewhere in this Code.

For masonry units and mortar see Chapter 24.

For precast concrete units see Chapter 26.

For portland cement plaster see Chapter 47.

Anchors, supports and ties shall be incombustible and corrosion-resistant.

Design

Sec. 2904. (a) **General.** The design of all veneer shall comply with the requirements of Chapter 23 and this Section.

Veneer shall support no load other than its own weight and the vertical dead load of veneer above.

Surfaces to which veneer is attached shall be designed to support the additional vertical and lateral loads imposed by the veneer.

Design (Continued)

Consideration shall be given for differential movement of supports including that caused by temperature changes, shrinkage, creep and deflection.

(b) **Adhered Veneer.** Adhered veneer and its backing shall be designed to have a bond to the supporting element sufficient to withstand a shearing stress of 50 pounds per square inch.

(c) **Anchored Veneer.** Anchored veneer and its attachments shall be designed to resist a horizontal force equal to twice the weight of the veneer.

Adhered Veneer

Sec. 2905. (a) **Permitted Backing.** Backing shall be continuous and may be of any material permitted by this Code. It shall have surfaces prepared to secure and support the imposed loads of veneer.

Exterior veneer, including its backing, shall provide a weatherproof covering.

For additional backing requirements, see Sections 1707 (a), 1711 (a), 1711 (b) and 2507 (e).

(b) **Area Limitations.** The height and length of veneered areas shall be unlimited except as required to control expansion and contraction and as limited by Section 2901 (b).

(c) **Unit Size Limitations.** Veneer units shall not exceed thirty-six inches (36") in the greatest dimension, nor more than seven hundred and twenty square inches (720 sq. in.) in total area and shall weigh not more than 15 pounds per square foot unless approved by the Building Official.

> **EXCEPTION:** Veneer units weighing less than three pounds per square foot shall not be limited in dimension or area.

(d) **Application.** In lieu of the design required by Section 2904 (a) adhered veneer may be applied by one of the methods specified in U.B.C. Standard No. 29-1-67.

(e) **Plastic Veneer.** Plastics used as veneer shall conform to the provisions of Chapter 52. When used within a building, plastic veneer shall comply with the interior finish requirements of Chapter 42. All plastic veneer shall be installed in an approved manner.

Anchored Veneer

Sec. 2906. (a) **Permitted Backing.** Backing may be of any material permitted by this Code. Exterior veneer including its backing shall provide a weatherproof covering.

(b) **Height and Support Limitations.** Anchored veneer shall be supported on footings, foundations, or other incombustible supports.

Where anchored veneer is applied more than twenty feet (20') above the adjacent ground elevation, it shall be supported by incombustible, corrosion-resistant, structural framing

Anchored Veneer (Continued)

having horizontal supports spaced not over twelve feet (12′) vertically above the twenty-foot (20′) height.

Incombustible noncorrosive lintels and incombustible supports shall be provided over all openings where the veneer unit is not self-spanning. The deflections of all structural lintels and horizontal supports required by this Subsection shall not exceed 1/500 of the span under full load of the veneer.

(c) **Area Limitations.** The area and length of anchored veneer walls shall be unlimited, except as required to control expansion and contraction and by Section 2901 (b).

(d) **Application.** In lieu of the design required by Section 2904 anchored veneer may be applied by one of the methods specified in U.B.C. Standard No. 29-1-67.

CHAPTER 30—ENCLOSURE OF VERTICAL OPENINGS

Enclosures: When Required

Sec. 3001. Vertical openings are required to be enclosed as set forth in Table No. 17-A. For enclosures of stairways and ramps see Chapter 33.

Elevator Enclosures

Sec. 3002. Walls and partitions enclosing elevators and escalators shall be of not less than the fire-resistive construction required under Types of Construction in Part V. Enclosing walls of elevator shafts may consist of wire glass set in metal frames on the entrance side only. Elevator shafts extending through more than two stories shall be equipped with an approved means of adequate ventilation to and through the main roof of the building.

EXCEPTION: In buildings housing Groups F and G Occupancies and where such buildings are equipped with automatic fire-extinguishing systems throughout, enclosures shall not be required for escalators, provided, however, that the top of the escalator opening at each story shall be provided with a draft curtain.

Such draft curtain shall enclose the perimeter of the unenclosed opening and shall extend from the ceiling downward at least twelve inches (12") on all sides. Automatic sprinklers shall be provided around the perimeter of the opening and within two feet (2') of the draft curtain. The distance between the sprinklers shall not exceed six feet (6') center-to-center.

Other Vertical Openings

Sec. 3003. All shafts, ducts, chutes, and other vertical openings not covered in Section 3002 shall have enclosing walls conforming to the requirements specified under Type of Construction of the building in which they are located.

In other than Group I Occupancies rubbish and linen chutes shall terminate in rooms separated from the remainder of the building by a One-Hour Fire-Resistive Occupancy Separation. Openings into the chutes shall not be located in required exit corridors or stairways.

Air Ducts

Sec. 3004. Air ducts passing through a floor shall be enclosed in a shaft. The shaft shall be as required for vertical openings in Part V. Dampers shall be installed where ducts pierce the shaft enclosure walls. Dampers shall conform to U.B.C. Standard No. 30-1-67. Air ducts in Group I Occupancies need not be enclosed in a shaft if conforming to Uniform Building Code, Volume II, Mechanical.

CHAPTER 31—FLOOR CONSTRUCTION

General

Sec. 3101. Floor construction shall be of materials and construction as specified under Occupancy in Part III and under Types of Construction in Part V.

All floors shall be so framed and tied into the framework and supporting walls as to form an integral part of the whole building.

The types of floor construction used shall provide means to keep the beams and girders from spreading by installing either ties or bridging, with no laterally unsupported length of joists being permitted to exceed eight feet (8′) except as otherwise specified in Section 3102.

Fire-resistive standards of floor construction are specified in Section 4305.

Steel-Joisted Floors

Sec. 3102. Joists shall be securely cross bridged at intervals not to exceed eight feet (8′) along the joist length. Bridging shall be provided during the period of construction to support adequately the top chord or flange against lateral movement and such bridging shall be designed to hold each joist in a vertical plane. Sufficient permanent bridging shall be installed to stay the joists laterally and to transmit any horizontal forces in either direction perpendicular to the direction of the joists. Such bridging shall consist of solid concrete sections, structural steel shapes or plates, portal bridging, diagonal rods, or other bridging which will provide equal stiffness. Any row of bridging shall be capable of transferring 500 pounds from each joist to the adjoining joists.

Wood Floors

Sec. 3103. Wood-joisted floors shall be framed and constructed and anchored to supporting wood stud or masonry walls as specified in Chapter 23.

In wood-frame floor construction where suspended ceilings occur, the space between the ceiling and the floor above shall be divided into areas not exceeding one thousand square feet (1000 sq. ft.) in a manner required for partitioning attic space in Section 3205.

An access crawl hole eighteen inches by twenty-four inches (18″ x 24″) shall be provided to under floor space.

CHAPTER 32—ROOF CONSTRUCTION AND COVERING

Sec. 3201. Roof coverings for all buildings shall be either fire-retardant or ordinary as specified in this Chapter and as required by Occupancy in Part III, by Location in Part IV or by Type of Construction in Part V. For general requirements see Section 1704. **General**

The roof covering shall be securely fastened in an approved manner to the supporting roof construction.

The roof covering shall provide weather protection for the building at the roof.

Sec. 3202. The general requirements for construction of floors as specified in Chapter 31 shall apply to roofs, except that concrete or gypsum roof slabs shall be not less than two inches (2″) in thickness. **Construction**

All roofs shall be so framed and tied into the framework and supporting walls as to form an integral part of the whole building. Roof trusses shall have all joints well fitted and shall have all tension members well tightened before any load is placed on the truss. Diagonal and sway bracing shall be used to brace all roof trusses. The allowable working stresses of materials in trusses shall be as specified in Chapters 25 and 27. The minimum net section of the members after framing shall be used in determining the strength of the truss at any point.

Plywood roof sheathing, unless of exterior type, shall have no surface or edge exposed to the weather and shall not exceed the spans set forth in Table No. 25-R.

Sec. 3203. (a) **General.** Roof coverings shall be as specified in this Section. **Roof Coverings**

(b) **Definitions.** For purposes of this Chapter certain terms are designated as follows:

BASE SHEETS are one or more layers of felt over which is applied a cap sheet, organic, asbestos or other inorganic fiber shingles or mineral aggregate.

BUILT-UP ROOF is two or more layers of roofing consisting of base sheets, and cap sheet, mineral aggregate, ceramic or other similar surfacing material.

CAP SHEET is roofing made of organic, asbestos or other inorganic fibers, saturated, and coated on both sides with a bituminous compound, and surfaced with mineral granules, mica, talc, ilmenite, asbestos or other inorganic fibers, or similar materials, except on the unexposed portions of split cap sheets.

CEMENTING is solidly mopped application of hot asphalt, cold liquid asphalt compound, hot coal tar pitch, or other approved cementing material.

COMBINATION SHEET is ply sheet integrally attached to kraft paper.

Roof Coverings (Continued)

COMPOSITION ROOFING is any asphaltic roofing.

CORROSION-RESISTANT is any nonferrous metal, or any metal having an unbroken surfacing of nonferrous metal, or steel with not less than 10 per cent chromium or with not less than twenty-hundredths per cent copper.

DRY SHEET is felt or other approved underlay applied directly to the roof deck by approved means other than cementing. Dry sheets are not part of built-up roofing assemblies.

FELT is roofing felt made of organic, asbestos or other inorganic fibers, saturated with bituminous compound.

METAL ROOFING is metal shingles or sheets for application on solid roof surfaces, and corrugated or otherwise shaped metal sheets or sections for application on solid roof surfaces or roof frameworks.

PLY SHEET is glass fiber felt sheet coated on both sides with asphalt, and weighing approximately eight pounds per roofing square.

PREPARED ROOFING is any composition roofing other than built-up roofing assemblies.

ROOFING SQUARE is one hundred square feet (100 sq. ft.) of roofing surface.

SPOT-CEMENTING is discontinuous application of hot asphalt, cold liquid asphalt compound, hot coal tar pitch or other approved cementing material.

UNDERLAY is one or more layers of felt applied as required for a base sheet, over which finish roofing is applied.

WEIGHT is the manufacturer's shipping weight in pounds per one hundred square feet (100 sq. ft.) of roof coverage.

WOOD SHINGLES are tapered pieces of Western Red Cedar or Redwood, sawed both sides, of random widths ranging from three inches (3″) to fourteen inches (14″) and sixteen inches (16″), eighteen inches (18″) or twenty-four inches (24″) in length.

WOOD SHAKES are tapered or nontapered pieces of Western Red Cedar or Redwood of random widths ranging from four inches (4″) to fourteen inches (14″), and of the following three types:

1. Hand-split and resawn; tapered and having one sawed and one split face, eighteen inches (18″), twenty-four inches (24″) or thirty-two inches (32″) in length.
2. Taper-split; tapered and having both split faces, twenty-four inches (24″) in length.
3. Straight-split; nontapered and with both split faces, either eighteen inches (18″) or twenty-four inches (24″) in length.

(c) **Roofing Materials.** 1. **Materials.** Materials shall conform to the following Standards:

Roof Coverings (Continued)

MATERIALS AND DESIGN	U.B.C. DESIGNATION
Asphalt, Roofing	32- 1-67 32- 2-67
Coal Tar, Roofing	32- 1-67 32- 2-67
Cap Sheet	32- 1-67
Mineral Surfaced	32- 3-67
Smooth Surfaced	32- 1-67
Felt, Roofing	32- 1-67
Metal Roofing	32- 4-67
Mineral Roofing Aggregate	32- 5-67
Nails, Corrosion-resistant	32- 6-67
ROOFING, COMPOSITION	
Class A	32- 7-67 32- 1-67
Class B	32- 7-67 32- 1-67
Class C	32- 7-67 32- 3-67
Shakes, hand-split	32- 8-67
SHINGLES	
Asbestos	32- 7-67
Asbestos-cement	32- 9-67
Asphalt	32- 3-67
Slate	32-10-67
Wood	32-11-67
TILE	
Concrete	32-12-67
Clay	32-12-67
WIRE	32-13-67

2. **Identification.** All material shall be delivered in the original packages bearing the manufacturer's label.

3. **Built-up roofing materials.** Each package of felts, cements, and base-, ply-, combination or cap sheets shall bear the label of an approved testing laboratory having a service for the inspection of material and finished products during manufacture for such built-up roofing material.

4. **Metal roofing.** Metal roofing exposed to the weather shall be corrosion-resistant.

Corrugated or ribbed steel shall be not less than No. 30 galvanized sheet gauge.

Flat steel sheets shall be not less than No. 30 galvanized sheet gauge.

Flat nonferrous sheets and shingles shall be not less than No. 28 B. & S. gauge.

Roof Coverings (Continued)

Other ferrous sections or shapes shall be not less than No. 26 galvanized sheet gauge. Other nonferrous sections or shapes shall be not less than No. 25 B. & S. gauge.

Corrugated or otherwise shaped sheets or sections shall be designed to support the required live load between supporting members.

Ferrous sheets or sections shall comply with Section 2722 of this Code.

5. **Nails.** Nails for composition roofs shall be not smaller than No. 12 gauge, with heads not less than three-eighths inch (⅜″) in diameter for shingle application and seven-sixteenths inch (7/16″) in diameter for built-up roofs, and shall be long enough to penetrate into the sheathing three-fourths inch (¾″), or through the thickness of the sheathing, whichever is less. Smaller size head nails may be used provided metal discs are used with them. Exposed nails and shingle nails shall be corrosion-resistant.

Nails for wood shingles shall be not less than No. 14½ gauge corrosion-resistant and shall be long enough to penetrate into the sheathing three-fourths inch (¾″), or through the thickness of the sheathing, whichever is less.

Nails for wood shakes shall be the same as required for wood shingles.

Nails for asbestos-cement shingles shall be not less than No. 11 gauge corrosion-resistant and shall be long enough to penetrate into the sheathing three-fourths inch (¾″) or through the thickness of the sheathing, whichever is less.

Nails for slate shingles, and clay or concrete tile shall be not less than No. 14 gauge copper or No. 14 gauge corrosion-resistant as specified and shall be long enough to penetrate into the sheathing three-fourths inch (¾″), or through the thickness of the sheathing, whichever is less.

Staples or other similar fastening devices shall not be used unless approved by the Building Official.

6. **Prepared roofing.** Each package of prepared roofing shall bear the label of an approved testing laboratory having a service for the inspection of material and finished products during manufacture for Class A, B or C roofing.

7. **Shakes.** Each bundle of wood shakes for roofs shall be of Western Red Cedar or Redwood and shall bear the label of an approved inspection bureau or agency certifying compliance with U.B.C. Standard No. 32-8-67.

8. **Shingles.** Each bundle of wood shingles for roofs shall bear the label of an approved inspection bureau or agency certifying compliance with U.B.C. Standard No. 32-11-67.

Packages of composition shingles shall bear the label of an approved testing laboratory having a service for the inspection of material and finished products during manufacture for Class A, B or C roofing.

Slate shingles shall bear the label of an approved inspection bureau or agency certifying compliance with U.B.C. Standard No. 32-10-67. Ribboned or otherwise faulty slate shingles shall not be used.

9. ***Wire.*** Attaching wire for slate shingle and clay or concrete tile shall be not smaller than No. 14 gauge complying with U.B.C. Standard No. 32-13-67.

(d) **Application.** 1. **Built-up roofs.** Built-up roofing shall be applied only to solid surface roofs.

Base sheets shall be cemented to a suitable deck using not less than 25 pounds of hot asphalt or not less than two gallons of cold bituminous compound in accordance with manufacturer's published specifications or 30 pounds of hot coal tar pitch per roofing square, or nailed to roof sheathing using not less than one nail to each one and one-third square feet ($1\frac{1}{3}$ sq. ft.), or may be spot-cemented to a non-nailable deck using not less than 10 pounds of hot asphalt per roofing square.

Successive layers shall be cemented to the base sheets using no less cementing material than that specified for solidly cemented base sheets.

Mineral aggregate[1] surfaced roofs shall be surfaced with not less than 50 pounds of hot asphalt or other cementing material in which is embedded not less than 300 pounds of gravel or other approved surfacing materials or 250 pounds of crushed slag per roofing square. See Section 3203 (e) 2 for minimum amounts of mineral aggregate on fire-retardant roofs.

Cap sheets shall be cemented to the base sheets using no less cementing material than that specified for solidly cemented base sheets.

Hot asphalt shall be applied at a temperature of not less than 375°F. nor more than 400°F. and shall not be heated to a temperature above 425°F.

Coal tar pitch shall not be heated to a temperature above 375°F.

2. **Composition shingles.** Composition shingles shall be applied only to solidly sheathed roofs, except when applied over existing wood shingle roofs as approved by the Building Official.

Composition shingles shall be fastened according to manufacturer's printed instructions but not less than four nails per each strip shingle not more than thirty-six inches (36″) wide and two nails per each individual shingle less than twenty inches (20″) wide.

Composition shingles shall not be installed on a roof having a slope of less than four inches (4″) to twelve inches (12″), unless approved by the Building Official.

Composition shingle roofs shall have an underlay of not less than 15-pound felt, applied as required for a base sheet. The

[1]See U.B.C. Standard No. 32-5-67 for mineral roofing aggregate weighing less than 60 pounds per cubic foot.

Roof Coverings (Continued)

underlay may be omitted over existing roofs, or where the roof slope exceeds seven inches (7″) to twelve inches (12″), or where shingles are laid not less than three thicknesses at any point.

Roof valley flashing shall be the same as required for wood shingles, or shall be of laced composition shingles, applied in an approved manner, with an underlay of not less than 30-pound felt extending ten inches (10″) from the center line *each* way, or shall be of two layers of 90-pound mineral surfaced cap sheet cemented together with the bottom layer not less than twelve inches (12″) wide laid face down, and the top layer not less than twenty-four inches (24″) wide laid face up.

3. **Slate shingles.** Slate shingles shall be applied in an approved manner and securely fastened with corrosion-resistant nails or corrosion-resistant nails and wire.

Slate shingle roofs shall have an underlay of not less than two layers of 15-pound felt or one layer of 30-pound felt, applied as required for a base sheet.

Roof valley flashing shall be the same as required for wood shakes.

4. **Asbestos-cement shingles and sheets.** Asbestos-cement roofing shall be applied in an approved manner. Asbestos-cement roofing shall have an underlay of not less than 15-pound felt, applied as required for a base sheet. The underlay may be omitted where the asbestos-cement shingles or sheets are applied over an existing roof covering.

Asbestos-cement roofing shall not be installed on a roof having a slope of less than three inches (3″) to twelve inches (12″) unless approved by the Building Official.

Corrugated asbestos-cement roofing not less than five-sixteenths inch ($\frac{5}{16}$″) thick may be used wherever No. 24 galvanized sheet gauge corrugated steel is permitted.

Roof valley flashing shall be the same as required for wood shakes.

5. **Metal roofing.** Flat sheets or shingles shall be applied only to solidly sheathed roofs.

Metal roofing shall be applied in an approved manner.

Metal shingles shall not be installed on a roof having a slope of less than three inches (3″) to twelve inches (12″) unless approved by the Building Official.

Metal shingles shall be applied over an underlay of not less than 30-pound felt, applied as required for a base sheet.

6. **Tile, clay and concrete.** All roof tile shall be securely fastened with corrosion-resistant nails or nails and wire, or other approved means.

Tile shall not be installed on a roof having a slope of less than three inches (3″) to twelve inches (12″) unless approved by the Building Official.

Roof Coverings (Continued)

Tile with projecting anchor lugs at the bottom of the tiles shall be held in position by means of one-inch by two-inch (1" x 2") wood stripping, treated to resist moisture deterioration, nailed to the roof sheathing over the underlay, or other approved means.

Tile roofs shall have an underlay of not less than two layers of 15-pound felt or one layer of 30-pound felt, applied as required for a base sheet.

Roof valley flashing shall be the same as required for wood shakes.

7. **Wood shingles.** Shingles may be applied to roofs with solid or spaced sheathing. The spaced sheathing shall be spaced not to exceed four inches (4") clear nor more than the width of the sheathing board. Spaced sheathing shall be not less than one inch by three inches (1" x 3") nominal dimensions.

Shingles shall be laid with a side lap of not less than one and one-half inches (1½") between joints in adjacent courses, and one-half inch (½") in alternate courses. Spacing between shingles shall be not less than one-fourth inch (¼") nor more than three-eighths inch (⅜"). Each wood shingle shall be fastened to the sheathing with two nails only.

Shingles shall not be installed on a roof having a slope less than four inches (4") to twelve inches (12") unless they are installed over an underlay of not less than 15-pound felt, applied as required for a base sheet, and unless approved by the Building Official.

Roof valley flashing shall be provided of not less than No. 28 galvanized sheet gauge corrosion-resistant metal and shall extend at least eight inches (8") from the center line each way, and shall have a splash diverter rib not less than three-fourths inch (¾") high at the flow line formed as part of the flashing. Sections of flashing shall have an end lap of not less than four inches (4").

Weather exposures shall not exceed those set forth in Table No. 32-A. Hip and ridge weather exposures shall not exceed those permitted for the field of the roof.

8. **Wood shakes.** Shakes may be applied to roofs with solid or spaced sheathing. The spaced sheathing shall be spaced not to exceed four inches (4") clear nor more than the width of the sheathing board. Spaced sheathing shall be not less than one-inch by four-inch (1" x 4") nominal size. In snow areas when the roof slope is less than eight inches (8") to twelve inches (12"), sheathing shall be solid and the shakes shall be applied over an underlay of not less than 15-pound felt, applied as required for a base sheet.

Shakes may be laid in straight or staggered courses. Shakes shall be laid with a side lap of not less than one and one-half inches (1½") between joints in adjacent courses. Edges shall be parallel within one inch (1"). Spacing between shakes shall be not more than one-half inch (½").

Roof Coverings (Continued)

Each wood shake shall be fastened to the sheathing with two nails only. The starter course at the eaves shall be doubled and the bottom or first layer may be either fifteen-inch (15″) or eighteen-inch (18″) wood shakes or wood shingles. Fifteen-inch (15″) or eighteen-inch (18″) shakes may be used for the final course at the ridge.

Shakes shall be laid with not less than eighteen-inch (18″) wide strips of not less than 30-pound felt shingled between each course in such a manner that no felt is exposed to the weather below the shake butts.

Shakes shall not be installed on a roof having a slope less than four inches (4″) to twelve inches (12″) unless they are installed over an underlay of not less than 30-pound felt, applied as required for a base sheet, and unless approved by the Building Official.

Roof valley flashing shall be provided of not less than No. 28 galvanized sheet gauge corrosion-resistant metal and shall extend at least eleven inches (11″) from the center line each way and shall have a splash diverter rib not less than one inch (1″) high at the flow line formed as part of the flashing. Sections of flashing shall have an end lap of not less than four inches (4″).

Weather exposures shall not exceed those set forth in Table No. 32-A. Hip and ridge weather exposures shall not exceed those permitted for the field of the roof.

(e) **Fire-retardant Roof Coverings.** A fire-retardant roof covering shall be any one of the following roofings:

1. Any Class A or B built-up roofing assembly.
2. Any mineral aggregate surfaced built-up roof for application to roofs having a slope not more than three inches (3″) to twelve inches (12″) applied as specified in

TABLE NO. 32-A—MAXIMUM EXPOSURE TO WEATHER

WOOD SHINGLES

SLOPE OF ROOF		SHINGLE LENGTH		
Rise	Run	16-Inch	18-Inch	24-Inch
3″ to less than 4″	12″	3¾″	4¼″	5¾″
4″ to less than 5″	12″	4½″	5¼″	7″
5″ or more	12″	5″	5½″	7½″

TAPERED WOOD SHAKES

EXPOSURE TO WEATHER	LENGTH OF SHAKE
7½″	18″
10″	24″
13″	32″

STRAIGHT-SPLIT WOOD SHAKES

EXPOSURE TO WEATHER	LENGTH OF SHAKE
5½″	18″
7½″	24″

Section 3203 (d) 1 consisting of not less than the following: **Roof Coverings (Continued)**

Base Sheets

Four layers of 15-pound perforated organic fiber felt, or

Three layers of 15-pound organic or inorganic fiber felt, and

Surfacing Material[1]

400 pounds per roofing square of gravel, crushed rock, ceramic or approved similar surfacing material, or

300 pounds per roofing square of crushed slag.

3. Any built-up roof for application to roofs having a slope not less than one inch (1") to twelve inches (12"), applied as specified in Section 3203 (d) 1, consisting of not less than the following:

Base Sheets

Two layers of 15-pound organic fiber felt, or

One layer of 14-pound glass fiber felt base sheet, or combination sheet, or

One layer of 30-pound organic fiber felt, or

One layer of 45-pound asbestos fiber felt base sheet, and

Cap Sheets

One layer of 90-pound mineral surfaced organic fiber felt cap sheet,[2] or

Two layers of 55-pound mineral surfaced organic fiber felt split sheet, or

One layer of 80-pound mineral surfaced asbestos fiber felt cap sheet, or

One layer of 72-pound mineral surfaced glass fiber felt cap sheet, or

Two layers of 15-pound asbestos fiber finishing felts.

4. Any Class A or B prepared roofing.
5. Any Class C mineral surfaced asphalt shingles laid so that there are not less than two thicknesses at any point and the total weight per roofing square is not less than 235 pounds.
6. Asbestos-cement shingles or sheets.
7. Concrete slab roof.
8. Metal roof covering.
9. Slate shingles.
10. Clay or concrete roof tile.

(f) **Ordinary Roof Covering.** An ordinary roof covering shall be any one of the following roofings:

1. Any roof covering listed in Section 3203 (e).

[1]See U.B.C. Standard No. 32-5-67 for mineral roofing aggregate weighing less than 60 pounds per cubic foot.

[2]Shall have a minimum underlay of two layers of organic fiber felt applied as required for base sheets.

Roof Coverings (Continued)

2. Any built-up roofing assembly not less than Class C roofing.
3. Any mineral aggregate surfaced built-up roof for application to roofs having a slope of not more than three inches (3″) to twelve inches (12″), applied as specified in Section 3203 (d) 1, consisting of not less than the following:

   Base Sheets

   Three layers of 15-pound organic or inorganic fiber felt, and

   Surfacing Material

   300 pounds per roofing square of gravel or other approved surfacing material, or 250 pounds per roofing square of crushed slag.
4. Any prepared roofing not less than Class C roofing.
5. Wood shingles.
6. Wood shakes.

   EXCEPTION: Unless otherwise required because of location as specified in Parts IV and V of this Code, Group J, Division 1, roof coverings shall consist of not less than one layer of 55-pound smooth surfaced organic cap sheet, or built-up roofing consisting of two layers of 15-pound organic fiber felt and one layer of surfacing material as specified in Section 3203 (f) 3.

Roof Insulation

Sec. 3204. The use of combustible roof insulation shall be permitted in all Types of Construction provided it is covered with approved roof covering applied directly thereto.

Attics: Access, Area Separations and Ventilation

Sec. 3205. (a) **Access.** An attic access opening shall be provided in the ceiling of the top floor of buildings with combustible ceiling or roof construction. The opening shall be located in a corridor or hallway of buildings of three or more stories in height, and readily accessible in buildings of any height.

The opening shall be not less than twenty-two inches by thirty inches (22″ x 30″).

Thirty-inch (30″) minimum clear head room shall be provided above the access opening.

Attics with a maximum vertical clear height of less than thirty inches (30″) need not be provided with access openings.

For ladder requirements see Uniform Building Code, Volume II, Mechanical.

(b) **Area Separations.** Enclosed attic spaces formed of combustible construction shall be divided into horizontal areas not exceeding two thousand and five hundred square feet (2500 sq. ft.) by partitions extending from the ceiling to the roof.

Such partitions shall be not less than one-half-inch (½″) thick gypsum wallboard, or one-inch (1″) nominal thickness

Attics: Access, Area Separations and Ventilation (Continued)

tight-fitting wood, three-eighths-inch (⅜") thick plywood, or approved incombustible material adequately supported.

Openings in the partitions shall be protected by self-closing doors constructed as required for the partitions.

> **EXCEPTION:** Where the entire attic is equipped with an approved automatic fire-extinguishing system, the attic space may be divided into areas not to exceed seven thousand and five hundred square feet (7500 sq. ft.).

(c) **Draft Stops.** Regardless of the Type of Construction, draft stops shall be installed in trussed roofs, between roof and bottom chord of trusses, in all buildings exceeding twenty thousand square feet (20,000 sq. ft.) of floor area. Such draft stops shall divide the under roof area into sections not to exceed twenty thousand square feet (20,000 sq. ft.). Draft stops shall be constructed as for attic area separations, and in accordance with the Type of Construction.

(d) **Ventilation.** Enclosed attics and enclosed rafter spaces formed where ceilings are applied direct to the underside of roof rafters, shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain and snow. The net free ventilating area shall be not less than 1/150 of the area of the space ventilated, except that the area may be 1/300 provided at least 50 per cent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least three feet (3') above eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents.

Roof Drainage

Sec. 3206. (a) **General.** Roof systems not designed to support accumulated water shall be sloped for drainage. See Section 2305 (f).

(b) **Roof Drains.** Unless roofs are sloped to drain over roof edges or are designed to support accumulated water, roof drains shall be installed at each low point of the roof.

Roof drains shall be adequate in size to convey the water tributary to the roof drains.

(c) **Overflow Drains and Scuppers.** Where roof drains are required, overflow drains having the same size as the roof drains shall be installed with the inlet flow line located two inches (2") above the low point of the roof, or overflow scuppers having three times the size of the roof drains may be installed in adjacent parapet walls with the inlet flow line located two inches (2") above the low point of the adjacent roof and having a minimum opening height of four inches (4").

Overflow drains shall be connected to drain lines independent from the roof drains.

(d) **Concealed Piping.** Roof drains and overflow drains, when concealed within the construction of the building, shall be installed in accordance with the Plumbing Code.

Roof Drainage (Continued)

(e) **Over Public Property.** Roof drainage water from a building shall not be permitted to flow over public property.

EXCEPTION: Groups I and J Occupancies.

Flashing

Sec. 3207. At the juncture of the roof and vertical surfaces, flashing and counterflashing shall be provided as required in Section 1707 (b).

For roof valley flashing see Section 3203 (d).

CHAPTER 33—STAIRS, EXITS AND OCCUPANT LOADS

Sec. 3301. (a) **Purpose.** The purpose of this Chapter is to determine occupant loads and to provide minimum standards of egress facilities for occupants of buildings, reviewing stands, bleachers and grandstands. **General**

(b) **Scope.** Every building or portion thereof shall be provided with exits as required by this Chapter. Where there is a conflict between a general requirement and a specific requirement for an individual occupancy, the specific requirement shall be applicable.

(c) **Definitions.** For the purpose of this Chapter, certain terms are defined as follows:

BALCONY, EXTERIOR EXIT, is a landing or porch projecting from the wall of a building, and which serves as a required means of egress. The long side shall be at least 50 per cent open, and the open area above the guardrail shall be so distributed as to prevent the accumulation of smoke or toxic gases.

EXIT is a continuous and unobstructed means of egress to a public way, and shall include intervening doors, doorways, corridors, exterior exit balconies, ramps, stairways, smokeproof enclosures, horizontal exits, exit passageways, exit courts, and yards.

EXIT COURT is a yard or court providing egress to a public way for one or more required exits.

EXIT PASSAGEWAY is an enclosed means of egress connecting a required exit or exit court with a public way.

HORIZONTAL EXIT is a means of passage from one building into another building occupied by the same tenant, or from one section of a building into another section of the same building occupied by the same tenant, through a separation wall having a minimum fire resistance of one hour.

OCCUPANT LOAD is the total number of persons that may occupy a building or portion thereof at any one time.

PANIC HARDWARE is a bar which extends across at least one-half the width of each door leaf, which will open the door if subjected to pressure.

PRIVATE STAIRWAY is a stairway serving one tenant only.

PUBLIC WAY is any parcel of land unobstructed from the ground to the sky, more than ten feet (10′) in width, appropriated to the free passage of the general public.

(d) **Determination of Occupant Load.** The occupant load permitted in any building or portion thereof shall be deter-

General (Continued)

mined by dividing the floor area assigned to that use by the square feet per occupant as set forth in Table No. 33-A.

When the square feet per occupant are not given for a particular occupancy it shall be determined by the Building Official, based on the area given for the occupancy which it most nearly resembles.

EXCEPTIONS: 1. The occupant load of an area having fixed seats shall be determined by the number of fixed seats installed. Aisles serving the fixed seats and not used for any other purpose shall not be assumed as adding to the occupant load.

2. The occupant load permitted in a building or portion thereof may be increased above that specified in this Section if the necessary exits are provided. An approved aisle or seating diagram may be required by the Building Official to substantiate an increase in occupant load.

In determining the occupant load, all portions of a building shall be presumed to be occupied at the same time.

EXCEPTION: Accessory use areas which ordinarily are used only by persons who occupy the main areas of an occupancy shall be provided with exits as though they were completely occupied, but their occupant load need not be included in computing the total number of occupants for the building.

(e) **Overcrowding.** The number of occupants of any building or portion thereof shall not exceed the permitted or posted capacity.

(f) **Benches, Pews, Booths.** Where benches or pews are used, the number of seats shall be based on one person for each eighteen inches (18") of length of the pews or benches. Where booths are used in dining areas, the number of seats shall be based on one person for each twenty-four inches (24") or major portion thereof of length of booth.

(g) **Mixed Occupancies.** The capacity of a building containing mixed occupancies shall be determined by adding the number of occupants of the various portions as set forth in Table No. 33-A.

(h) **More Than One Purpose.** For determining exit requirements the capacity of a building or portion thereof which is used for different purposes, shall be determined by the occupant load which gives the largest number of persons.

(i) **Exit Obstruction.** No obstructions shall be placed in the required width of an exit except projections permitted by this Chapter.

(j) **Posting of Room Capacity.** Any room having an occupant load of more than 50 where fixed seats are not installed, and which is used for classroom, assembly, or similar purpose, shall have the capacity of the room posted in a conspicuous place near the main exit from the room. Approved signs shall be maintained in a legible manner by the owner or his authorized agent, and shall indicate the number of occupants permitted for each room use.

General (Continued)

(k) **Changes in Elevation.** Except in Group I Occupancies, changes in elevation of less than twelve inches (12″) along any exit serving a tributary occupant load of 10 or more, shall be by means of ramps.

Exits Required

Sec. 3302. (a) **Number of Exits.** Every building or usable portion thereof shall have at least one exit, and shall have not less than two exits where required by Table No. 33-A.

In all occupancies, floors above the first story having an occupant load of more than 10 shall have not less than two exits.

Each mezzanine used for other than storage purposes, if greater in area than two thousand square feet (2000 sq. ft.), or if more than sixty feet (60′) in any dimension shall have not less than two stairways to an adjacent floor.

For special requirements for Groups A, B, C, D, E, H, and I Occupancies, see Sections 3315, 3316, 3317, 3318, 3319, and 3320. For stage exits, see Section 3907.

Every story or portion thereof, having an occupant load of 500 to 999 shall have not less than three exits.

Every story or portion thereof, having an occupant load of 1000 or more shall have not less than four exits.

The number of exits required from any story of a building shall be determined by using the occupant load of that story, plus the percentages of the occupant loads of floors which exit through the level under consideration as follows:

1. Fifty per cent of the occupant load in the first adjacent story above (and the first adjacent story below, when a story below exits through the level under consideration).

2. Twenty-five per cent of the occupant load in the story immediately beyond the first adjacent story.

The maximum number of exits required for any story shall be maintained until egress is provided from the structure. (See Section 3311.)

For purposes of this Section, basements or cellars and occupied roofs shall be provided with exits as required for stories. Floors above the second story, basements and cellars used for other than service of the building shall have not less than two exits.

(b) **Width.** The total width of exits in feet shall be not less than the total occupant load served divided by 50. Such width of exits shall be divided approximately equally among the separate exits.

The total exit width required from any story of a building shall be determined by using the occupant load of that story,

Exits Required (Continued)

plus the percentages of the occupant loads of floors which exit through the level under consideration as follows:

1. Fifty per cent of the occupant load in the first adjacent story above (and the first adjacent story below, when a story below exits through the level under consideration).

2. Twenty-five per cent of the occupant load in the story immediately beyond the first adjacent story.

The maximum exit width required from any story of a building shall be maintained.

(c) **Arrangement of Exits.** If only two exits are required they shall be placed a distance apart equal to not less than one-fifth of the perimeter of the area served measured in a straight line between exits. Where three or more exits are required they shall be arranged a reasonable distance apart so that if one becomes blocked others will be available.

(d) **Distance to Exits.** No point in an unsprinklered building shall be more than one hundred and fifty feet (150′) from an exterior exit door, a horizontal exit, exit passageway or an enclosed stairway, measured along the line of travel.

In a building equipped with a complete automatic fire-extinguishing system the distance from exits may be increased to two hundred feet (200′).

Doors

Sec. 3303. (a) **General.** This Section shall apply to every exit door serving an area having an occupant load of more than 10, or serving hazardous rooms or areas. Subsections (h) and (i) shall apply to all doors, regardless of occupant load.

(b) **Swing.** Exit doors shall swing in the direction of exit travel when serving any hazardous area or when serving an occupant load of 50 or more.

Double acting doors shall not be used as exits serving a tributary occupant load of more than 100; nor shall they be used as a part of a fire assembly, nor equipped with panic hardware. A double acting door shall be provided with a view panel of not less than two hundred square inches (200 sq. in.).

(c) **Type of Lock or Latch.** Exit doors shall be openable from the inside without the use of a key or any special knowledge or effort.

> **EXCEPTION:** This requirement shall not apply to exterior exit doors in a Group F or G Occupancy if there is a readily visible, durable sign on or adjacent to the door, stating "THIS DOOR TO REMAIN UNLOCKED DURING BUSINESS HOURS." The sign shall be in letters not less than one inch (1″) high on a contrasting background. The locking device must be of a type that will be readily distinguishable as locked. The use of this Exception may be revoked by the Building Official for due cause.

Flush bolts or surface bolts are prohibited.

TABLE NO. 33-A—AVAILABLE SQUARE FEET PER OCCUPANT

Use[1]	Minimum of Two Exits Required Where Number of Occupants Is Over	Square Feet Per Occupant
Aircraft Hangars (No repair)	10	500
Auction Rooms	30	7
Assembly Areas, Concentrated Use (without fixed seats)	50	7
Auditoriums		
Bowling Alleys (Assembly areas)		
Churches and Chapels		
Dance Floors		
Lodge Rooms		
Reviewing Stands		
Stadiums		
Assembly Areas, Less-concentrated Use	50	15
Conference Rooms		
Dining Rooms		
Drinking Establishments		
Exhibit Rooms		
Gymnasiums		
Lounges		
Skating Rinks		
Stages		
Children's Homes and Homes for the Aged	5	80
Classrooms	50	20
Dormitories	10	50
Dwellings	10	300
Garage, Parking	30	200
Hospitals and Sanitariums-Nursing Homes	5	80
Hotels and Apartments	10	200
Kitchen—Commercial	30	200
Library Reading Room	50	50
Locker Rooms	30	50
Mechanical Equipment Room	30	300
Nurseries for Children (Day-care)	5	50
Offices	30	100
School Shops and Vocational Rooms	50	50
Stores—Retail Sales Rooms		
Basement	[2]	20
Ground Floor	50	30
Upper Floors	10	50
Warehouses	30	300
All Others	50	100

[1]Refer to Sections 3318, 3319, 3320 for other specific requirements.
[2]See Section 3302 for basement exit requirements.

(d) **Width and Height.** Every required exit doorway shall be of a size as to permit the installation of a door not less than three feet (3′) in width and not less than six feet eight inches (6′8″) in height. When installed in exit doorways, exit

Doors (Continued)

Doors (Continued)

doors shall be capable of opening at least 90 degrees and shall be so mounted that the clear width of the exitway is not less than twenty-eight inches (28″). In computing the exit width required by Section 3302 (b), the net dimension of the exitway shall be used.

(e) **Door Leaf Width.** No leaf of an exit door shall exceed four feet (4′) in width.

(f) **Special Doors.** Revolving, sliding and overhead doors shall not be used as required exits.

(g) **Egress from Door.** Every exit door required by this Section shall give immediate access to an approved means of egress from the building.

(h) **Change in Floor Level at Doors.** Regardless of the occupant load, there shall be a floor or landing on each side of an exit door. The floor or landing shall be level with, or not more than two inches (2″) lower than the threshold of the doorway.

EXCEPTION: In Group I Occupancies and within individual units of Group H Occupancies, a door may open on the top step of a flight of stairs or on an exterior landing providing the door does not swing over the top step or exterior landing and the landing is not more than seven and one-half inches (7½″) below the floor level.

(i) **Door Identification.** Glass doors shall conform to the requirements specified in Section 5406.

Other exit doors shall be so marked that they are readily distinguishable from the adjacent construction.

(j) **Additional Doors.** When additional doors are provided for egress purposes, they shall conform to all provisions of this Chapter.

EXCEPTION: Approved revolving doors having leaves which will collapse under opposing pressures may be used in exit situations provided: 1. Such doors have a minimum width of six feet six inches (6′6″).

2. They are not used in occupancies where exits are required to be equipped with panic hardware.

3. At least one conforming exit door is located adjacent to each revolving door installed in a building.

4. The revolving door shall not be considered to provide any exit width.

Corridors and Exterior Exit Balconies

Sec. 3304. (a) **General.** This Section shall apply to every corridor and exterior exit balcony serving as a required exit for an occupant load of more than 10. Subsection (e) shall apply regardless of occupant load.

(b) **Width.** Every corridor or exterior exit balcony shall be not less in width than forty-four inches (44″). For special requirements for Groups C and D Occupancies, see Sections 3317 and 3318.

Corridors and Exterior Exit Balconies (Continued)

(c) **Projections.** The required width of corridors and exterior exit balconies shall be unobstructed.

> EXCEPTION: Trim handrails, and doors when fully opened, shall not reduce the required width by more than seven inches (7"). Doors in any position shall not reduce the required width by more than one-half.

(d) **Access to Exits.** When more than one exit is required, they shall be so arranged that it is possible to go in either direction from any point in a corridor or exterior exit balcony to a separate exit, except for dead ends permitted by this Section.

(e) **Dead Ends.** Corridors and exterior exit balconies with dead ends are permitted when the dead end does not exceed twenty feet (20') in length.

(f) **Construction.** Walls and ceilings of corridors shall be not less than one-hour fire-resistive construction. Floors, walls, and ceilings of exterior exit balconies shall have the same period of fire resistance as required for the floors, walls and ceilings of the building.

> EXCEPTION: This Subsection shall not apply to exterior exit balcony railings, corridors of a one-story building housing a Group F or G Occupancy occupied by one tenant only and which serves an occupant load of 30 or less, nor to corridors formed by temporary partitions regulated by Section 1705 (a).

Exterior exit balconies cannot project into an area where protected openings are required.

(g) **Openings.** Where corridor walls are required to be one-hour fire-resistive construction every interior door opening shall be protected as set forth in Table No. 33-B. Other interior openings, except ventilation louvers equipped with approved automatic fire shutters shall be one-fourth-inch (¼") fixed wire glass set in steel frames. The total area of all openings other than doors, in any portion of an interior corridor wall shall not exceed 25 per cent of the area of the corridor wall of the room which it is separating from the corridor.

Individual glass lights shall not exceed twelve hundred square inches (1200 sq. in.) and any single window shall not exceed the limits specified in Section 4306 (g).

> EXCEPTION: In corridors of Groups F and G Occupancies, interior openings may have fixed plain glass as specified in Section 5406 of unlimited area provided the corridors are at least ten feet (10') in width and do not serve as means of egress for other floors in the building. Such corridors shall have exits at each extremity. All portions of the floor served whose occupant loads are tributary to the corridor shall have access to at least one additional exit leading to the exterior of the building except where an approved automatic fire-extinguishing system is installed throughout the story in which such corridors are located.

Openings located between the end of an exterior exit balcony and the nearest stairway shall be protected as required for corridors. Other openings to an exterior exit balcony need not be protected unless required by other provisions of this Code.

Stairways

Sec. 3305. (a) **General.** Every stairway serving any building or portion thereof shall conform to the requirements of this Section.

EXCEPTION: Stairs or ladders used only to attend equipment are exempt from the requirements of this Section.

(b) **Width.** Stairways serving an occupant load of more than 50 shall be not less in width than forty-four inches (44"). Stairways serving an occupant load of 50 or less may be thirty-six inches (36") wide. Private stairways serving an occupant load of less than 10 may be thirty inches (30") wide. Trim and handrails shall not reduce the required width by more than three and one-half inches (3½").

(c) **Rise and Run.** The rise of every step in a stairway shall not exceed seven and one-half inches (7½") and the run shall be not less than ten inches (10"). Except as provided under Subsection (d) the maximum variations in the height of risers and the width of treads in any one flight shall be three-sixteenths inch (3/16").

EXCEPTION: In private stairways serving an occupant load of less than 10 the rise may be eight inches (8") and the run may be nine inches (9").

(d) **Winding Stairways.** In Group I Occupancies and in private stairways in Group H Occupancies, winders may be used if the required width of run is provided at a point not more than twelve inches (12") from the side of the stairway where the treads are the narrower, but in no case shall any width of run be less than six inches (6") at any point.

(e) **Circular Stairways.** Circular stairs may be used as an exit providing the minimum width of run is not less than ten inches (10") and the smaller radius is not less than twice the width of the stairway. All treads in any one flight between landings shall have identical dimensions within a three-sixteenths-inch (3/16") tolerance.

(f) **Landings.** Every landing shall have a dimension measured in the direction of travel equal to the width of the stairway. Such dimension need not exceed four feet (4') when the stair has a straight run. Landings, when provided, shall not be reduced in width by more than three and one-half inches (3½") by a door when fully open. See Section 3303 (h).

(g) **Basement Stairways.** Where a basement stairway and a stairway to an upper story terminate in the same exit enclosure, an approved barrier shall be provided to prevent persons from continuing on into the basement. Directional exit signs shall be provided as specified in Section 3312 (b).

(h) **Distance Between Landings.** There shall be not more than twelve feet (12') vertically between landings.

(i) **Handrails.** Stairways shall have handrails on each side, and every stairway required to be more than eighty-eight inches (88") in width shall be provided with not less than one intermediate handrail for each eighty-eight inches (88") of required width. Intermediate handrails shall be spaced approximately equal within the entire width of the stairway.

Handrails shall be placed not less than thirty inches (30") nor more than thirty-four inches (34") above the nosing of treads, and ends of handrails shall be returned or shall terminate in newel posts or safety terminals.

> **EXCEPTIONS:** 1. Stairways forty-four inches (44") or less in width and stairways serving one individual dwelling unit in Group H or I Occupancies may have one handrail, except that such stairways open on one or both sides shall have handrails provided on the open side or sides.
>
> 2. Stairways having less than four risers need not have handrails.

(j) **Guardrails.** See Section 1714.

(k) **Exterior Stairway Protection.** All openings in the exterior wall below or within ten feet (10'), measured horizontally, of an exterior exit stairway serving a building over two stories in height shall be protected by a self-closing fire assembly having a three-fourths-hour fire-resistive rating.

> **EXCEPTION:** Openings may be unprotected when two separated exterior stairways serve an exterior exit balcony.

(l) **Stairway Construction—Interior.** Interior stairways shall be constructed as specified in Part V of this Code.

Where there is enclosed usable space under stairs the walls and soffits of the enclosed space shall be protected on the enclosed side as required for one-hour fire-resistive construction. See Section 3308.

(m) **Stairway Construction—Exterior.** Exterior stairways shall be of incombustible material except that on Type III buildings not exceeding two stories in height, located in Fire Zones No. 2 and No. 3, and on Type V buildings, they may be of wood not less than two inches (2") in nominal thickness.

Exterior stairs shall be protected as required for exterior walls due to location on property, as specified in Parts IV and V of this Code. Exterior stairways shall not project into an area where openings are required to be protected.

Where there is enclosed usable space under stairs, the walls and soffits of the enclosed space shall be protected on the enclosed side as required for one-hour fire-resistive construction.

(n) **Stairway to Roof.** In every building more than two stories in height, one stairway shall extend to the roof surface, unless the roof has a slope greater than four in 12.

TABLE NO. 33-B—REQUIREMENTS FOR DUAL PURPOSE FIRE-EXIT DOORS[1, 2]

Occupancy	Doors to Corridors			Exit Enclosure (In Accordance with Section 3308)			Boiler and Furnace Rooms[3]			Corridors Crossing Area Separation Walls		
	Hour Rating	Glazing Per Leaf (Square Inches)	Closing Device	Hour Rating	Glazing Per Opening (Square Inches)	Closing Device	Hours[4] Rating	Glazing (Square Inches)	Closing Device	Hour Rating	Glazing Per Leaf (Square Inches)	Closing Device
A	¾	720	A or B	1	100	A or B	1	0	A	Not applicable		
B	[5]	1200[6]	C	1	100	A or B	1	0	A	Not permitted except in combination with Group C Occupancies		
C	[5]	1200[6]	C	1	100	A or B	1	0	A	1	100	A or B
D-1	¾[7]	720	C	1½[8]	100	A or B	1	0	A	No exits permitted		
D-2 D-3	[5]	1200[6]	C	1½[8]	100	A or B	1	0	A	1	100	A or B
E-1 -2, -3	¾	100	A or D	1½[8]	100	A or B	No interior openings permitted			No exits permitted		
E-4 E-5	¾	100	A or D	1½[8]	100	A or B	No interior openings permitted			No exits permitted		
F-1 F-3	¾	100	A or D	1½[8]	100	A or B	1	0	A	No exits permitted		

TABLE NO. 33-B—REQUIREMENTS FOR DUAL PURPOSE FIRE-EXIT DOORS[1, 2] (Continued)

Occupancy	Doors to Corridors			Exit Enclosure (In Accordance with Section 3308)			Boiler and Furnace Rooms[3]			Corridors Crossing Area Separation Walls		
	Hour Rating	Glazing Per Leaf (Square Inches)	Closing Device	Hour Rating	Glazing Per Opening (Square Inches)	Closing Device	Hours[4] Rating	Glazing (Square Inches)	Closing Device	Hour Rating	Glazing Per Leaf (Square Inches)	Closing Device
F-2	5	1200[6]	C	1	100	A or B	1	0	A	No exits permitted		
G	5	1200[6]	C	1	100	A or B	1	0	A	No exits permitted		
H	5	1200[6]	C	1	100	A or B	1	0	A	No exits permitted		
I	NOT APPLICABLE											

A—Self-closing.

B—Automatic-closing doors shall close automatically when released by activation of a detector set to operate when smoke reduces the intensity of a one-foot (1′) long beam of white light by four per cent, or any other detection device which will work within that limitation.

C—None required.

D—Automatic-closing at 165°F. fusible link, or equal.

[1]For occupancy separations and protection of openings see Table No. 5-B and Section 503 (c).

[2]For hardware requirements see Section 4306 (e), for glazing see Section 4306 (f).

[3]Where oil-fired boilers are used a six-inch (6″) incombustible sill (dike) shall be provided.

[4]Mounted within the boiler room.

[5]Tight-fitting smoke or draft stop door is required; doors equal to not less than an exterior type solid wood door (without voids, assembled with exterior type glue) one and three-fourths-inch (1¾″) minimum thickness with wired glass installed in steel frames. Hardware shall be capable of holding door closed against fire for 25 minutes.

[6]When included as part of the 25 per cent area limitation specified in Section 3304 (g), a second light not to exceed twelve hundred square inches (1200 sq. in.) may be used in each door leaf.

[7]Except jails, prisons, etc., where open barred cells are provided.

[8]Less than five stories in height, one-hour will be permitted. Smokeproof enclosures shall comply with Section 3309 (e).

Stairways (Continued)

(o) **Headroom.** Every required stairway shall have a headroom clearance of not less than six feet six inches (6'6"). Such clearances shall be established by measuring vertically from a plane parallel and tangent to the stairway tread nosing to the soffit above at all points.

Ramps

Sec. 3306. (a) **General.** A ramp conforming to the requirements of this Section may be used as an exit.

(b) **Width.** The width of ramps shall be as required for corridors.

(c) **Slope.** The slope of a ramp shall not exceed one foot (1') in eight feet (8').

(d) **Handrails.** A ramp with slope exceeding one foot (1') in ten feet (10') shall have handrails as required for stairways, except that intermediate handrails shall not be required.

(e) **Construction.** Ramps shall be constructed as required for stairways.

(f) **Surface.** The surface of ramps shall be roughened or shall be of nonslip materials.

Horizontal Exit

Sec. 3307. (a) **Used as a Required Exit.** If conforming to the provisions of this Chapter, a horizontal exit may be considered as a required exit.

(b) **Openings.** All openings in a separation wall shall be protected by a fire assembly having a fire-resistive rating of not less than one hour.

(c) **Discharge Areas.** A horizontal exit shall lead into a floor area having capacity for an occupant load not less than the occupant load served by such exit. The capacity shall be determined by allowing three square feet (3 sq. ft.) of net clear floor area per ambulatory occupant and twenty square feet (20 sq. ft.) per nonambulatory occupant. The area into which the horizontal exit leads shall be provided with exits other than additional horizontal exits as required by Section 3302.

Exit Enclosures

Sec. 3308. (a) **General.** Every interior stairway, ramp, or escalator shall be enclosed as specified in this Section.

EXCEPTIONS: 1. In other than Group D Occupancies, an enclosure will not be required for a stairway, ramp, or escalator serving only one adjacent floor and not connected with corridors or stairways serving other floors. For enclosure of escalators serving Groups F and G Occupancies, see Chapter 30.

2. Stairs in Group I Occupancies need not be enclosed.

(b) **Enclosure Construction.** Enclosure walls shall be of not less than two-hour fire-resistive construction in buildings

Exit Enclosures (Continued)

more than four stories in height and shall be of not less than one-hour fire-resistive construction elsewhere.

(c) **Openings into Enclosures.** There shall be no openings into exit enclosures except exit doorways and openings in exterior walls. All exit doors in an exit enclosure shall be protected as set forth in Table No. 33-B.

(d) **Extent of Enclosure.** Stairway and ramp enclosures shall include landings and parts of floors connecting stairway flights and shall also include a corridor on the ground floor leading from the stairway to the exterior of the building. Enclosed corridors or passageways are not required from unenclosed stairways.

(e) **Barrier.** A stairway in an exit enclosure shall not continue below the grade level exit unless an approved barrier is provided at the ground floor level to prevent persons from accidentally continuing into the basement.

(f) **Use of Space Under Stair.** There shall be no enclosed usable space under stairways in an exit enclosure, nor shall the open space under such stairways be used for any purpose.

Smokeproof Enclosures

Sec. 3309. (a) **General.** A smokeproof enclosure shall consist of a continuous stairway enclosed from the highest point to the lowest point by walls of two-hour fire-resistive construction. The supporting structural frame shall be protected as set forth in Table No. 17-A.

(b) **Where Required.** In buildings five stories or more in height, one of the required exits shall be a smokeproof enclosure. When a smokeproof enclosure is required it shall be used to meet the requirements of Subsection 3305 (n).

(c) **Construction.** Stairs in smokeproof enclosures shall be of incombustible construction.

(d) **Openings and Access.** There shall be no openings in smokeproof enclosures, except exit doorways and openings in exterior walls. There shall be no opening directly into the interior of the building. Access shall be through a vestibule with one wall at least 50 per cent open to the exterior and having an exit door from the interior of the building and an exit door leading to the smokeproof enclosure. In lieu of a vestibule, access may be by way of an open exterior balcony of incombustible materials.

(e) **Doors.** The opening from the building to the vestibule or balcony shall be protected with a self-closing fire assembly having a one-hour fire-resistive rating. The opening from the vestibule or balcony to the stair tower shall be protected by a self-closing fire assembly having a one-hour fire-resistive rating.

(f) **Outlet.** A smokeproof enclosure shall exit into a public way or into an exit passageway leading to a public way. The

Smokeproof Enclosure (Continued)

exit passageway shall be without other openings and shall have walls, floors and ceilings of two-hour fire resistance.

(g) **Barrier.** A stairway in a smokeproof enclosure shall not continue below the grade level exit unless an approved barrier is provided at the ground floor level to prevent persons from accidentally continuing into the basement.

Exit Outlets

Sec. 3310. Every exit shall discharge into a public way, exit court, or exit passageway.

Exit Courts and Exit Passageways

Sec. 3311. (a) **Discharge.** Every exit court shall discharge into a public way, or exit passageway. Passageways shall be without openings other than required exits and shall have walls, floors and ceilings of the same period of fire resistance as the walls, floors and ceilings of the building but shall be not less than one-hour fire-resistive construction.

(b) **Width.** Every exit court and exit passageway shall be at least as wide as the required total width of the tributary exits, such required width being based on the occupant load served.

The required width of exit courts or exit passageways shall be unobstructed except as permitted in corridors. See Section 3304 (c).

At any point where the width of an exit court is reduced from any cause, the reduction in width shall be effected gradually by a guardrail at least three feet (3′) in height. The guardrail shall make an angle of not more than 30 degrees with the axis of the exit court.

(c) **Slope.** The slope of exit courts shall not exceed one in 10. The slope of exit passageways shall not exceed one in eight. For handrail requirements see Section 3306 (d).

(d) **Number of Exits.** Every exit court shall be provided with exits as required by Section 3302.

(e) **Openings.** All openings into an exit court less than ten feet (10′) wide shall be protected by fire assemblies having a three-fourths-hour fire-resistive rating.

EXCEPTION: Openings more than ten feet (10′) above the floor of the exit court may be unprotected.

Exit Signs and Illumination

Sec. 3312. (a) **Exit Illumination.** Exits shall be illuminated at any time the building is occupied with light having an intensity of not less than one-foot candle at floor level.

EXCEPTION: Group I Occupancies.

Exit illumination shall be provided with separate circuits or separate sources of power (but not necessarily separate from exit signs) when these are required for exit sign illumination. See Section 3312 (c).

(b) **Exit Signs.** At every required exit doorway, and wherever otherwise required to clearly indicate the direction of egress, an exit sign with letters at least five inches (5") high shall be provided from all areas serving the occupant load specified in this Subsection. In interior stairways the floor level leading direct to the exterior shall be clearly indicated.

Exit Signs and Illumination (Continued)

Group A Occupancies and Groups B, D and H Occupancies with an occupant load of more than 50.

All other occupancies serving an occupant load of more than 100.

EXCEPTION: Main exterior exit doors which obviously and clearly are identifiable as exits need not be sign posted when approved by the Building Official.

(c) **Illumination of Signs.** Exit signs serving the occupant loads specified in this Subsection shall be lighted with two electric lamps of not less than 15 watts each in the following manner:

1. Two separate sources of supply shall be provided for the following occupancies:

A. Group A Occupancies.

B. Divisions 1 and 2 of Group B Occupancies with an occupant load over 500 persons, except churches with an occupant load of less than 750 persons.

C. Group D Occupancies with an occupant load over 100 persons.

2. Separate circuits, one of which shall be separated from all other circuits in the building and independently controlled, shall be required for the following occupancies:

A. Groups B, C, F and G Occupancies with an occupant load over 300 persons.

B. Groups E and H Occupancies with an occupant load over 100 persons.

C. Group D Occupancies with an occupant load over 50 persons.

Aisles

Sec. 3313. (a) **General.** Every portion of every building in which are installed seats, tables, merchandise, equipment or similar materials shall be provided with aisles leading to an exit.

(b) **Width.** Every aisle shall be not less than three feet (3') wide if serving only one side, and not less than three feet six inches (3'6") wide if serving both sides. Such minimum width shall be measured at the point farthest from an exit, cross aisle, or foyer and shall be increased by one and one-half inches (1½") for each five feet (5') in length toward the exit, cross aisle, or foyer.

With continental spacing, as specified in Section 3314 (a), side aisles shall be not less than forty-four inches (44") in width.

Aisles (Continued)

(c) **Distances to Nearest Exit.** In areas occupied by seats, and in Groups A and B Occupancies without seats, the line of travel to an exit door by an aisle shall be not more than one hundred and fifty feet (150′).

(d) **Aisle Spacing.** With standard spacing, as specified in Section 3314 (a), aisles shall be so located that there will be not more than six intervening seats between any seat and the nearest aisle.

With continental spacing, as specified in Section 3314 (a), the number of intervening seats may be increased to 29 where exit doors are provided along each side aisle of the row of seats at the rate of one pair of exit doors for each five rows of seats. Such exit doors shall provide a minimum clear width of sixty-six inches (66″).

(e) **Cross Aisles.** Aisles shall terminate in a cross aisle, foyer, or exit. The width of the cross aisle shall be not less than the sum of the required width of the widest aisle plus 50 per cent of the total required width of the remaining aisles leading thereto. In Groups A, B, and C Occupancies, aisles shall not provide a dead end greater than twenty feet (20′) in length.

(f) **Vomitories.** Vomitories connecting the foyer or main exit with the cross aisles shall have a total width not less than the sum of the required width of the widest aisle leading thereto plus 50 per cent of the total required width of the remaining aisles leading thereto.

(g) **Slope.** The slope portion of aisles shall not exceed one foot (1′) fall in eight feet (8′).

Seats

Sec. 3314. (a) **Seat Spacing.** With standard seating the spacing of rows of seats from back-to-back shall be not less than thirty-three inches (33″), nor less than twenty-seven inches (27″) plus the sum of the thickness of the back and inclination of the back.

With continental seating, the spacing of rows of unoccupied seats shall provide a clear width measured horizontally as follows (automatic or self-rising seats shall be measured in the seat-up position, other seats shall be measured in the seat-down position):

Eighteen inches (18″) clear for rows of 18 seats or less
Twenty inches (20″) clear for rows of 35 seats or less
Twenty-one inches (21″) clear for rows of 45 seats or less
Twenty-two inches (22″) clear for rows of 46 seats or more

(b) **Width.** The width of any seat shall be not less than eighteen inches (18″).

(c) **Bleacher Seats.** Seats used in grandstands, bleachers and reviewing stands shall conform to Section 3322.

Exits: Group A Occupancies

Sec. 3315. (a) **Main Exit.** Every Group A Occupancy shall be provided with a main exit.

The main exit shall be of sufficient width to accommodate one-half of the total occupant load but shall be not less than the total required width of all aisles, exit passageways, and stairways leading thereto, and shall connect to a stairway or ramp leading to a public way.

(b) **Side Exits.** Every auditorium of a Group A Occupancy shall be provided with exits on each side. The exits on each side of the auditorium shall be of sufficient width to accommodate one-third of the total occupant load served. Side exits shall open directly to a public way or into an exit court, approved stairway, exterior stairway or exit passageway leading to a public way. Side exits shall be accessible from a cross aisle.

(c) **Balcony Exits.** Every balcony having an occupant load of more than 10 shall be provided with a minimum of two exits. Balcony exits shall open directly onto an exterior stairway or into an approved stairway or ramp. When there is more than one balcony, exits shall open into an exterior or enclosed stairway or ramp. Balcony exits shall be accessible from a cross aisle. The number and distribution of exits shall be as otherwise specified in this Chapter.

(d) **Panic Hardware.** An exit door from a Group A Occupancy having an occupant load of more than 100 shall not be provided with a latch or lock unless it is panic hardware.

Exits: Group B Occupancies

Sec. 3316. (a) **Group B, Divisions 1, 2 and 3.** Group B, Divisions 1 and 2 Occupancies shall have exits as required by Section 3315. In Group B, Division 3 Occupancies having an occupant load of more than 100, exit doors shall not be provided with a latch or lock unless it is panic hardware.

> EXCEPTION: Group B, Division 2 and 3 Occupancies, such as restaurants, bars, bowling alleys, auditoriums and similar commercial uses, and in churches, panic hardware may be omitted from the main exit when the main exit consists of a single door or one pair of doors. A key locking device may be used in place of the panic hardware provided there is a readily visible metallic sign adjacent to the doorway stating "THIS DOOR MUST REMAIN UNLOCKED DURING BUSINESS HOURS." The sign shall be in letters not less than one inch (1″) high on a contrasting background. When unlocked, a single door and each leaf of a pair of doors must be free to swing without operation of any latching device. The locking device on a pair of doors must be arranged so that when one leaf is unlocked, the other is free to swing. Flush, edge or surface bolts or any other type of device that may be used to close or restrain the doors other than by operation of the locking device are prohibited. The use of this Exception may be revoked by the Building Official for due cause.

(b) **Group B, Division 4.** In Group B, Division 4 Occupancies having an occupant load of more than 100, exit doors

Exits: Group B Occupancies (Continued)

shall not be provided with a latch or lock unless it is panic hardware. Panic hardware may be waived on gates surrounding stadiums, when the gates are under constant immediate supervision while the public is present and provided safe dispersal areas based upon three square feet (3 sq. ft.) per occupant are located between the stadium and the fence. The required dispersal area shall be located not less than fifty feet (50′) from the stadium. See Section 3322 for exits from dispersal areas.

(c) **Skating Rinks.** Skating rinks shall be located at or near the adjacent ground level and exits shall be by means of ramps.

Exits: Group C Occupancies

Sec. 3317. (a) **Corridors and Exterior Exit Balconies.** The width of a corridor in a Group C Occupancy shall be the width required by Section 3302 plus two feet (2′) but no corridor shall be less than six feet (6′) wide.

Corridor walls and ceilings shall be of not less than one-hour fire-resistive construction.

> EXCEPTION: When each room used for instruction has at least one exit door directly to the exterior at ground level and when rooms used for assembly purposes have at least one-half of the required exits directly to the exterior at ground level, one-hour fire-resistive construction of corridor walls and ceilings is not required.

There shall be no change of elevation of less than two feet (2′) in a corridor or exterior exit balcony unless ramps are used.

(b) **Exits Serving Auditoriums.** An exit serving both an auditorium and other rooms need provide only for the capacity of whichever requires the greater width if the auditorium is not to be used simultaneously with the other rooms.

(c) **Stairs.** Each floor above or below the ground floor level shall have not less than two exit stairs and the required exit width shall be equally divided between such stairs, provided that no stair serving an occupant load of more than 100 shall be less than five feet (5′) in clear width.

> EXCEPTION: This Subsection does not apply to rooms used for maintenance, storage, and similar purposes.

(d) **Doors.** The width of exit doors from corridors, halls and stairs shall be not more than two feet (2′) narrower than the width required by Section 3317 (a).

Exit doors in school rooms having an occupant load of more than 20 shall swing in the direction of egress.

(e) **Rooms Below Grade.** One exit accessible to every room below grade shall lead directly to the exterior at grade level.

(f) **Panic Hardware.** Exit doors from rooms having an occupant load of more than 100 and from corridors shall not be provided with a latch or lock unless it is panic hardware.

(g) **Fences and Gates.** School grounds may be fenced in and gates equipped with locks provided safe dispersal areas located not less than fifty feet (50') from the buildings are available for persons between buildings and fence. Dispersal areas shall be based upon an area of not less than three square feet (3 sq. ft.) per occupant. Gates shall not be permitted across corridors or passageways leading to such dispersal areas unless they comply with exit requirements. See Section 3322 for exits from dispersal areas.

Exits: Group C Occupancies (Continued)

Exits: Group D Occupancies

Sec. 3318. (a) **Separate Access.** Every room in a Group D Occupancy shall have access to at least two approved means of egress from the building without passage through intervening rooms other than corridors or lobbies. All required exterior exit doors shall open in direction of exit travel.

(b) **Minimum Size of Exits.** Every exit opening through which patients are transported in wheelchairs, stretchers or beds shall be of sufficient width to permit the ready passage of such equipment, but shall have a clear width of not less than forty-four inches (44"). There shall be no projections within the forty-four-inch (44") clear width.

(c) **Corridors.** The minimum clear width of a corridor shall be forty-four inches (44"), except that corridors serving any area housing one or more nonambulatory persons shall be not less than eight feet (8') in width. There shall be no change of elevation in a corridor serving nonambulatory persons unless ramps are used.

(d) **Basement Exits.** One exit accessible to every room below grade shall lead directly to the exterior at grade level.

(e) **Ramps.** Every portion of Group D, Division 2 Occupancies housing bedridden patients shall have access to a horizontal exit or ramp leading to the exterior of the building at the ground floor level.

(f) **Hardware.** Exit doors serving an occupant load of more than 50 shall not be provided with a latch or lock unless it is panic hardware. Patient room doors shall be readily openable from either side without the use of keys.

> EXCEPTION: No requirements of this Chapter shall be so construed as to prohibit the construction of cell blocks in jails, or prevent the use of any locks or safety devices where it is necessary to forcibly restrain the inmates.

(g) **Locking Devices.** In buildings housing occupancies in which the personal liberties of inmates or patients are restrained within the building and which are constructed in conformance with the special provisions of Section 902 (b), the exterior doors may be fastened with locks, provided that room doors shall not be fastened by other means than door-

Exits: Group D Occupancies (Continued)

knobs or similar devices which can be opened readily from the corridor side without the use of keys or any special knowledge or effort.

Exits: Group E Occupancies

Sec. 3319. Every portion of a Group E Occupancy having a floor area of two hundred square feet (200 sq. ft.) or more shall be served by at least two separate exits.

In Divisions 1 and 2, no part of any room shall be more than seventy-five feet (75′) from an exit.

Exits: Groups H and I Occupancies

Sec. 3320. Every sleeping room below the fourth floor in Groups H and I Occupancies shall have at least one openable window or exterior door to permit emergency exit or rescue. Where windows are provided they shall have a sill height of not more than forty-eight inches (48″) above the floor and shall provide not less than five square feet (5 sq. ft.) of openable area with no dimension less than twenty-two inches (22″).

Special Hazards

Sec. 3321. (a) **Boiler Rooms.** Except in Group I Occupancies, every boiler room and every room containing an incinerator or L-P Gas or liquid fuel-fired equipment, shall be provided with at least two means of egress, one of which may be a ladder. All interior openings shall be protected as set forth in Table No. 33-B.

(b) **Cellulose Nitrate Handling.** Film laboratories, projection rooms, and nitrocellulose processing rooms shall have not less than two exits.

Reviewing Stands, Grandstands and Bleachers

Sec. 3322. (a) **Scope.** All reviewing stands, grandstands and bleachers shall conform to the provisions of this Section.

(b) **Definitions.** For the purpose of this Section certain terms are defined as follows:

EXIT. Exit shall be deemed to be that point which opens directly into a safe dispersal area or public way. All measurements are to be made to that point when determining the permissible distance of travel.

SAFE DISPERSAL AREA. Safe dispersal area shall mean an area which will accommodate a number of persons equal to the total capacity of the stand and building it serves, in such a manner that no person within the area need be closer than fifty feet (50′) from the stand or building. Dispersal areas shall be based upon an area of not less than three square feet (3 sq. ft.) per person.

(c) **Height of Stands.** Stands employing combustible framing shall be limited to 11 rows or nine feet (9′) in height.

(d) **Design Requirements.** The minimum unit live load for reviewing stands, grandstands, and bleachers shall be 100 pounds per square foot of horizontal projection for the structure as a whole. Seat and footboards shall be 120 pounds per lineal foot. The sway force, applied to seats, shall be 24 pounds per lineal foot parallel to the seats, and 10 pounds per lineal foot perpendicular to the seats. Sway forces need not be applied simultaneously with other lateral forces.

(e) **Spacing of Seats. 1. Row spacing.** The minimum spacing of rows of seats measured from back to back shall be: Twenty-two inches (22″) for seats without backrests in open air stands; thirty inches (30″) for seats with backrests, and thirty-three inches (33″) for chair seating.

There shall be a space of not less than twelve inches (12″) between the back of each seat and the front of the seat immediately behind it.

2. **Rise between rows.** The maximum rise from one row of seats to the next shall not exceed sixteen inches (16″).

3. **Seating capacity.** For determining the seating capacity of a stand, the width of any seat shall be not less than eighteen inches (18″) nor more than nineteen inches (19″).

4. **Number of seats between aisles.** The number of seats between any seat and an aisle shall not be greater than 15 for open air stands with seats without backrests; nine for open air stands with seats having backrests; nine for seats without backrests within buildings, and six for seats with backrests in buildings.

(f) **Aisles. 1. Aisles required.** Aisles shall be provided in all stands.

> EXCEPTION: Aisles may be omitted when all of the following conditions exist: 1. Seats are without backrests.
>
> 2. The rise from row to row does not exceed twelve inches (12″) per row.
>
> 3. The number of rows does not exceed 11 in height.
>
> 4. The top seating board is not over ten feet (10′) above grade.
>
> 5. The first seating board is not more than twenty inches (20″) above grade.

2. **Obstructions.** No obstruction shall be placed in the required width of any aisle or exitway.

3. **Stairs required.** When an aisle is elevated more than eight inches (8″) above grade, the aisle shall be provided with a stairway or ramp whose width is not less than the width of the aisle.

4. **Dead end.** No vertical aisle shall have a dead end more than 16 rows in depth regardless of the number of exits required.

5. **Width.** Aisles shall have a minimum width of forty-two inches (42″).

(g) **Stairs and Ramps. 1. Scope.** The requirements of this Section shall apply to all stairs and ramps except for portions that pass through the seating area.

Reviewing Stands, Grandstands and Bleachers (Continued)

2. **Stair rise and run.** The maximum rise of treads shall not exceed eight inches (8″) and the minimum width of the run shall be eleven inches (11″). The maximum variations in the width of treads in any one flight shall be not more than three-sixteenths inch ($\frac{3}{16}$″) and the maximum variation in the height of two adjacent risers shall not exceed three-sixteenths inch ($\frac{3}{16}$″).

3. **Ramp slope.** The slope of a ramp shall not exceed one foot (1′) in eight feet (8′). Ramps shall be roughened or shall be of approved nonslip material.

4. **Handrails.** A ramp with a slope exceeding one foot (1′) in ten feet (10′) shall have handrails. Stairs from stands shall have handrails. Handrails shall conform to Section 3305 (i).

(h) **Guardrails.** Guardrails shall be required in all locations where the top of a seat plank is more than four feet (4′) above the grade and at the front of stands elevated more than two feet (2′) above grade. Where only sections of stands are used, guardrails shall be provided as required in this Section.

Railings shall be forty-two inches (42″) above the rear of a seat plank or forty-two inches (42″) above the rear of the steps in an aisle when the guardrail is parallel and adjacent to the aisle.

> **EXCEPTION:** The height may be reduced to thirty-six inches (36″) for guardrails located in front of the grandstand.

A midrail shall be placed adjacent to any seat to limit the open distance above the top of any part of a seat to ten inches (10″) where the seat is at the extreme end or at the extreme rear of the bleachers or grandstand. The intervening space shall have one additional rail midway in the opening.

> **EXCEPTION:** Railings may be omitted when stands are placed directly against a wall or fence giving equivalent protection.

Stairs and ramps shall be provided with guardrails.

Handrails at the front of stands and adjacent to an aisle shall be designed to resist a load of 50 pounds per lineal foot applied at the top rail. Other handrails shall be designed to resist a load of 20 pounds.

(i) **Footboards.** Footboards shall be provided for all rows of seats above the third row, or beginning at such point where the seating plank is more than two feet (2′) above grade.

> **EXCEPTION:** Where the same level is used for both seats and footrests, and these levels are not less than twenty-two inches (22″) in width, footrests will not be required.

(j) **Exits.** 1. **Distance to exit.** The line of travel to an exit shall be not more than one hundred and fifty feet (150′). For stands with seats without backrests this distance may be measured by direct line from a seat to the exit from the stand.

2. **Aisle used as exit.** An aisle may be considered as only one exit unless it is continuous at both ends to a legal building exit or to a safe dispersal area.

3. **Two exits required.** A stand with the first seating board not more than twenty inches (20") above grade or floor may be considered to have two exits when the bottom of the stand is open at both ends.

Every stand or section of a stand within a building shall have at least two means of egress when the stand accommodates more than 50 persons.

Every open air stand having seats without backrests shall have at least two means of egress when the stand accommodates more than 300 persons.

4. **Three exits required.** Three exits shall be required for stands within a building when there are more than 300 occupants within a stand, and for open air stands with seats without backrests where a stand or section of a stand accommodates more than 1000 occupants.

5. **Four exits required.** Four exits shall be required when a stand or section of a stand accommodates more than 1000 occupants.

> EXCEPTION: For an open air stand with seats without backrests four exits need not be provided unless there are accommodations for more than 3000 occupants.

6. **Determination of exit width.** The total width of exits in feet shall be not less than the total occupant load served divided by 50.

> EXCEPTION: For open air stands with seats without backrests the total width of exits in feet shall be not less than the total occupant load served divided by 150 when exiting by stairs, and divided by 200 when exiting by ramps or horizontally. When both horizontal and stair exits are used, the total width of exits shall be determined by using both figures as applicable.

7. **Minimum exit width.** No exit shall be less than forty-two inches (42") in width.

8. **Exit arrangement.** Exits shall be arranged a reasonable distance apart. When but two exits are provided, they shall be spaced not less than one-fifth of the perimeter apart.

(k) **Securing of Chairs. 1. Raised stands.** Chairs and benches used on raised stands shall be secured to the platforms upon which they are placed.

> EXCEPTION: When less than 25 chairs are used upon a single raised platform the fastening of seats to the platform may be omitted.

2. **Ground seats.** When more than 500 loose chairs are used in connection with athletic events, chairs shall be fastened together in groups of not less than three, and shall be tied or staked to the ground.

Reviewing Stands, Grandstands and Bleachers (Continued)

(l) **Dispersal Area Exits.** Each safe dispersal area shall have at least two exits. If more than 6000 persons are to be accommodated within such an area, there shall be a minimum of three exits, and for more than 9000 persons there shall be at least four exits. The aggregate clear width of exits from a safe dispersal area shall be determined on the basis of not less than one exit unit of twenty-two inches (22″) for each 500 persons to be accommodated and no exit shall be less than forty-four inches (44″) in width. Exits shall be a reasonable distance apart but shall be spaced not less than one-fifth of the perimeter of the area apart from each other.

CHAPTER 34—SKYLIGHTS

Skylights

Sec. 3401. Except for Groups I and J Occupancies all skylights shall be constructed with metal frames. Frames of skylights shall be designed to carry loads required for roofs as specified in Section 2305. All skylights, the glass of which is set at an angle of less than 45 degrees from the horizontal, if located above the first story, shall be set at least four inches (4″) above the roof. The curbs on which the skylight rests shall be constructed of incombustible materials except for Type III or Type V buildings.

Spacing between supports in one direction for flat wired glass in skylights shall not exceed twenty-five inches (25″). Corrugated wired glass may have supports five feet (5′) apart in the direction of the corrugation. All glass in skylights shall be wire glass, except that skylights over vertical shafts extending through two or more stories shall be glazed with plain glass as specified in this Section; provided, that wire glass may be used if ventilation equal to not less than one-eighth the cross-sectional area of the shaft but never less than four feet (4′) is provided at the top of such shaft.

Any glass not wire glass shall be protected above and below with a screen constructed of wire not smaller than No. 12 U. S. gauge with a mesh not larger than one inch (1″). The screen shall be substantially supported below the glass.

Skylights installed for the use of photographers may be constructed of metal frames and plate glass without wire netting.

Ordinary glass may be used in the roofs and skylights for greenhouses, provided the height of the greenhouse at the ridge does not exceed twenty feet (20′) above the grade. The use of wood in the frames of skylights will be permitted in greenhouses outside of Fire Zones No. 1 and No. 2 if the height of the skylight does not exceed twenty feet (20′) above the grade, but in other cases metal frames and metal sash bars shall be used.

Glass used for the transmission of light, if placed in floors or sidewalks, shall be supported by metal or reinforced concrete frames, and such glass shall be not less than one-half

Skylights (Continued)

inch (½") in thickness. Any such glass over sixteen square inches (16 sq. in.) in area shall have wire mesh embedded in the same or shall be provided with a wire screen underneath as specified for skylights in this Section. All portions of the floor lights or sidewalk lights shall be of the same strength as is required by this Code for floor or sidewalk construction, except in cases where the floor is surrounded by a railing not less than three feet six inches (3'6") in height, in which case the construction shall be calculated for not less than roof loads.

For additional requirements for plastic skylights see Section 5205.

CHAPTER 35—BAYS, PORCHES, AND BALCONIES

Bay and Oriel Windows

Sec. 3501. Construction of walls and floors in bay and oriel windows shall conform to the construction allowed for exterior walls and floors of the type of construction of the building to which they are attached. The roof covering of a bay or oriel window shall conform to the requirements for roofing of the main roof of the building.

Balconies and Porches

Sec. 3502. Exterior balconies attached to or supported by walls required to be of masonry shall have brackets or beams constructed of incombustible material. Railings shall be provided for balconies, landings, or porches which are more than thirty inches (30") above grade.

CHAPTER 36—PENTHOUSES AND ROOF STRUCTURES

Penthouses and Roof Structures

Sec. 3601. (a) **Height.** No penthouse or other projection above the roof in structures of other than Type I construction shall exceed twenty-eight feet (28') in height above the roof when used as an enclosure for tanks or for elevators which run to the roof and in all other cases shall not extend more than twelve feet (12') in height above the roof.

(b) **Area.** The aggregate area of all penthouses and other roof structures shall not exceed 33⅓ per cent of the area of the supporting roof.

(c) **Prohibited Uses.** No penthouse, bulkhead, or any other similar projection above the roof shall be used for purposes other than shelter of mechanical equipment or shelter of vertical shaft openings in the roof. Penthouses or bulkheads used for purposes other than permitted by this Section shall conform to the requirements of this Code for an additional story.

(d) **Construction.** Roof structures shall be constructed with walls, floors, and roof as required for the main portion of the building.

Penthouses and Roof Structures (Continued)

EXCEPTIONS: 1. On Types I and II buildings the exterior walls and roofs of penthouses which are five feet (5′) or more from an adjacent property line may be of one-hour fire-resistive incombustible construction.

2. Walls not less than five feet (5′) from an exterior wall of a Type III building may be of one-hour fire-resistive incombustible construction.

3. Enclosures housing only mechanical equipment and located at least twenty feet (20′) from adjacent property lines may be of unprotected incombustible construction.

The restrictions of this Subsection shall not prohibit the placing of wood flagpoles or similar structures on the roof of any building.

Towers and Spires

Sec. 3602. Towers or spires when enclosed shall have exterior walls as required for the building to which they are attached. Towers not enclosed and which extend more than seventy-five feet (75′) above grade shall have their framework constructed of iron, steel, or reinforced concrete. No tower or spire shall occupy more than one-fourth of the street frontage of any building to which it is attached and in no case shall the base area exceed sixteen hundred square feet (1600 sq. ft.) 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 the tower or spire exceeds one hundred square feet (100 sq. ft.) at any horizontal cross section, its supporting frame shall extend directly to the ground. The roof covering of spires shall be as required for the main roof of the rest of the structure.

Skeleton towers used as radio masts and placed on the roof of any building shall be constructed entirely of incombustible materials when more than twenty-five feet (25′) in height and shall be directly supported on an incombustible framework to the ground. They shall be designed to withstand a wind load from any direction as specified in Section 2308 in addition to any other loads.

CHAPTER 37—CHIMNEYS, FIREPLACES AND BARBECUES

Sec. 3701. (a) **General.** Chimneys, flues, and fireplaces and their connections, carrying products of combustion shall conform to the requirements of this Chapter. **Scope**

(b) **Definitions. BARBECUE** is a stationary open hearth or brazier, either fuel fired or electric, used for food preparation.

CHIMNEY, FACTORY-BUILT is a listed chimney.

CHIMNEY, MASONRY is a chimney of solid masonry units, bricks, stones, listed hollow unit masonry units or reinforced concrete.

CHIMNEY CLASSIFICATIONS:*

Chimney, Residential Appliance Type is a factory-built or masonry chimney suitable for removing products of combustion from residential type appliances producing combustion gases not in excess of 1000°F. measured at the appliance flue outlet.

Chimney, Low-Heat Appliance Type is a factory-built, masonry or metal chimney suitable for removing the products of combustion from fuel-burning low-heat appliances producing combustion gases not in excess of 1000°F. under normal operating conditions but capable of producing combustion gases of 1400°F. during intermittent forced firing for periods up to one hour. All temperatures are measured at the appliance flue outlet.

Chimney, Medium-Heat Appliance Type is a factory-built, masonry or metal chimney suitable for removing the products of combustion from fuel-burning medium-heat appliances producing combustion gases not in excess of 2000°F. measured at the appliance flue outlet.

Chimney, High-Heat Appliance Type is a factory-built, masonry or metal chimney suitable for removing the products of combustion from fuel-burning high-heat appliances producing combustion gases in excess of 2000°F. measured at the appliance flue outlet.

CHIMNEY CONNECTOR is the pipe which connects a fuel-burning appliance to a chimney. (See Section 915, Uniform Building Code, Volume II, Mechanical.)

CHIMNEY LINER is a lining material of fire clay or other approved material that meets the requirements of U.B.C. Standard No. 37-1-67.

EQUIVALENT SOLID THICKNESS is defined in U.B.C. Standard No. 24-4-67.

FIREBRICK is a refractory brick which meets the requirements of U.B.C. Standard No. 37-1-67.

*See Chimney Selection Chart, Table No. 9-A, Uniform Building Code, Volume II, Mechanical.

Scope (Continued)

FIREPLACE is a hearth and fire chamber or similarly prepared place in which a fire may be made and which is built in conjunction with a chimney.

LISTED AND LISTING are terms referring to equipment which is shown in a list published by an approved testing agency, qualified and equipped for experimental testing, and maintaining an adequate periodic inspection of current productions and whose listing states that the equipment complies with nationally recognized safety standards.

Chimneys

Sec. 3702. (a) **Requirements.** Every chimney shall be constructed and installed in accordance with the applicable requirements of this Chapter.

(b) **Draft.** Every chimney shall be capable of producing a draft at the appliance not less than that required for the safe operation of the appliance connected thereto.

(c) **Structural Design.** Chimneys shall be designed, anchored, supported, and reinforced when so designed as required in this Chapter and Chapters 23 and 28. No chimney shall support any structural load other than its own weight unless it is designed to act as a supporting member. Chimneys in wood-frame buildings shall be anchored laterally at the ceiling line and at each floor line which is more than six feet (6′) above grade, except when entirely within the framework or when designed to be freestanding.

(d) **Walls.** Every masonry chimney shall have walls of masonry units, bricks, stones, listed masonry units, reinforced concrete or equivalent solid thickness of hollow masonry and lined with suitable liners in accordance with the following requirements:

1. **Masonry chimneys for residential-type appliances.** Masonry chimneys shall be constructed of masonry units or reinforced concrete with walls not less than four inches (4″) thick or rubble stone masonry not less than twelve inches (12″) thick. The chimney liner shall be in accordance with Section 3702 (e).

2. **Masonry chimneys for low-heat appliances.** Masonry chimneys shall be constructed of masonry units or reinforced concrete with walls not less than eight inches (8″) thick, except that rubble stone masonry shall be not less than twelve inches (12″) thick. The chimney liner shall be in accordance with Section 3702 (e).

3. **Masonry chimneys for medium-heat appliances.** Masonry chimneys for medium-heat appliances shall be constructed of solid masonry units or of reinforced concrete not less than eight inches (8″) thick, except that stone masonry shall be not less than twelve inches (12″) thick; and, in addition, shall be lined with not less than four inches (4″) of firebrick laid in a solid bed of fire clay mortar with solidly filled

head, bed and wall joints, starting not less than two feet (2′) below the chimney connector entrance and extending for a distance of at least twenty-five feet (25′) above the chimney connector entrance. Chimneys extending twenty-five feet (25′) or less above the chimney connector shall be lined to the top.

Chimneys (Continued)

4. **Masonry chimneys for high-heat appliances.** Masonry chimneys for high-heat appliances shall be constructed with double walls of solid masonry units or of reinforced concrete not less than eight inches (8″) in thickness, with an air space of not less than two inches (2″) between the walls. The inside of the interior walls shall be of firebrick not less than four inches (4″) in thickness laid in a solid bed of fire clay mortar with solidly filled head, bed and wall joints.

5. **Masonry chimneys for incinerators installed in multistory buildings (apartment-type incinerators).** Chimneys for incinerators installed in multistory buildings using the chimney passageway as a refuse chute where the horizontal grate area of combustion chamber does not exceed nine square feet (9 sq. ft.) shall have walls of solid masonry or reinforced concrete, not less than four inches (4″) thick with a chimney lining as specified in Subsection (e) of this Section. If the grate area of such an incinerator exceeds nine square feet (9 sq. ft.), walls shall be not less than four inches (4″) thick and shall be lined with not less than four inches (4″) of firebrick, except that higher than thirty feet (30′) above the roof of the combustion chamber, common brick alone, eight inches (8″) in thickness, may be used.

6. **Masonry chimneys for commercial and industrial-type incinerators.** Chimneys for commercial and industrial-type incinerators of a size designed for not more than 250 pounds of refuse per hour and having a horizontal grate area not exceeding nine square feet (9 sq. ft.) shall have walls of solid masonry or reinforced concrete not less than four inches (4″) thick with lining of not less than four inches (4″) of firebrick, which lining shall extend for not less than forty feet (40′) above the roof of the combustion chamber. If the design capacity or grate area of such an incinerator exceeds 250 pounds per hour and nine square feet (9 sq. ft.) respectively, walls shall be not less than eight inches (8″) thick, lined with not less than four inches (4″) of firebrick extending the full height of the chimney.

(e) **Lining.** Fire clay chimney lining shall be not less than five-eighths inch (⅝″) thick. The lining shall extend from eight inches (8″) below the lowest inlet or, in the case of fireplaces, from the throat of the fireplace to a point above enclosing masonry walls. Fire clay chimney linings shall be installed ahead of the construction of the chimney as it is carried up, carefully bedded one on the other in fire clay mortar, with close-fitting joints left smooth on the inside. Fire-

Chimneys (Continued)

brick not less than two inches (2″) thick may be used in place of fire clay chimney lining as set forth in Table No. 37-A.

(f) **Area.** No chimney passageway shall be smaller in area than the vent connection on the appliance attached thereto nor less than as set forth in Table No. 37-A unless engineering methods approved by the Building Official have been used to design the system.

(g) **Height.** Every masonry chimney shall extend at least two feet (2′) above the part of the roof through which it passes and at least two feet (2′) above the highest elevation of any part of a building within ten feet (10′) of the chimney. The Building Official may approve a chimney of lesser height installed with an approved vent cowl having a spark arrester whose opening shall be not less than six feet (6′) from any part of the building measured horizontally. For altitudes over two thousand feet (2000′) the Building Official shall be consulted in determining the height of the chimney.

(h) **Corbeling.** No masonry chimney shall be corbeled from a wall more than six inches (6″); nor shall a masonry

TABLE NO. 37-A—MINIMUM PASSAGEWAY AREAS FOR MASONRY CHIMNEYS[1]

TYPE OF MASONRY CHIMNEY	MINIMUM CROSS-SECTIONAL AREA		
	Round	Square or Rectangle	Lined with Firebrick or Unlined
Residential	50 Sq. in.	50 Sq. in.	85 Sq. in.
Fireplace[2]	1/12 of opening Minimum 50 Sq. in.	1/10 of opening Minimum 64 Sq. in.	1/8 of opening Minimum 100 Sq. in.
Low Heat	50 Sq. in.	57 Sq. in.	135 Sq. in.
Incinerator Apartment Type 1 opening 2 to 6 openings 7 to 14 openings 15 or more openings	 196 Sq. in. 324 Sq. in. 484 Sq. in. 484 Sq. in. plus 10 Sq. in. for each additional opening		Not Applicable

[1]Areas for medium- and high-heat chimneys shall be determined using accepted engineering methods and as approved by the Building Official.

[2]Where fireplaces open on more than one side, the fireplace opening shall be measured along the greatest dimension.

Note: For altitudes over two thousand feet (2000′) above sea level, the Building Official shall be consulted in determining the area of the passageway.

chimney be corbeled from a wall which is less than twelve inches (12") in thickness unless it projects equally on each side of the wall. In the second story of a two-story building of Group I Occupancy, corbeling of masonry chimneys on the exterior of the enclosing walls may equal the wall thickness. In every case the corbeling shall not exceed one-inch (1") projection for each course of brick.

Chimneys (Continued)

(i) **Change in Size or Shape.** No change in the size or shape of a masonry chimney where the chimney passes through the roof shall be made within a distance of six inches (6") above or below the roof joists or rafters.

(j) **Separation of Masonry Chimney Passageways.** When more than one passageway is contained in the same chimney, masonry separation at least four inches (4") thick bonded into the masonry wall of the chimney shall be provided to separate passageways.

(k) **Inlets.** Every inlet to any masonry chimney shall enter the side thereof and shall be of not less than one-eighth-inch (⅛") thick metal or five-eighths-inch (⅝") thick refractory material.

(l) **Clearance.** Combustible material shall not be placed within two inches (2") of smoke chamber walls or masonry chimney walls when built within a structure, or within one inch (1") when the chimney is built entirely outside the structure. For special conditions covering fireplaces see Section 3704.

(m) **Termination.** All incinerator chimneys shall terminate in a substantially constructed spark arrester having a mesh not exceeding three-fourths inch (¾").

(n) **Cleanouts.** Cleanout openings shall be provided at the base of every masonry chimney.

Types of Chimneys

Sec. 3703. (a) **Factory-built Chimneys.** Factory-built chimneys are listed chimneys and shall be installed in strict accordance with the terms of their listings and the manufacturer's instructions.

(b) **Masonry Chimneys.** Masonry chimneys shall be constructed to meet the requirements of Section 3702.

Fireplaces and Barbecues

Sec. 3704. (a) **General.** Fireplaces, barbecues, smoke chambers and fireplace chimneys shall be of solid masonry or reinforced concrete and shall conform to the minimum requirements specified in this Section. Factory-built metal room heating stoves may be used in accordance with their approvals and if approved by the Building Official.

(b) **Fireplace Walls.** Walls of fireplaces shall be not less than eight inches (8") in thickness. Walls of fireboxes shall be not less than ten inches (10") in thickness, except that where a lining of firebrick is used such walls shall be not

Fireplaces and Barbecues (Continued)

less than eight inches (8″) in thickness. The firebox shall be not less than twenty inches (20″) in depth. The maximum thickness of joints in firebrick shall be one-fourth inch (¼″).

(c) **Hoods.** Metal hoods used as a part of a fireplace or barbecue shall be not less than No. 18 gauge copper, galvanized steel, or other equivalent corrosion-resistant ferrous metal with all seams and connections of smokeproof unsoldered construction. The hoods shall be sloped at an angle of 45 degrees or less from the vertical and shall extend horizontally at least six inches (6″) beyond the limits of the firebox. Metal hoods shall be kept a minimum of eighteen inches (18″) from combustible materials unless approved for reduced clearances.

(d) **Metal Heat Circulators.** Approved metal heat circulators may be installed in fireplaces.

(e) **Smoke Chamber.** Front and side walls shall be not less than eight inches (8″) in thickness. Smoke chamber back walls shall be not less than six inches (6″) in thickness.

(f) **Fireplace Chimneys.** Walls of chimneys without flue lining shall be not less than eight inches (8″) in thickness. Walls of chimneys with flue lining shall be not less than four inches (4″) in thickness and shall be constructed in accordance with Section 3702 (d) 1.

Where grouted masonry is used in fireplaces and their chimneys, grout shall be Type S mortar or fine grout. See Section 3702 (e) for flue lining and Section 2403 (r) and Section 2403 (s) for mortar and grout.

Where necessary, such chimneys may be corbeled at a slope of not more than four inches (4″) in twenty-four inches (24″) but not more than one-third the dimension of the chimney in the direction of the corbeling. Where lined, the lining shall be accurately cut to fit.

(g) **Clearance to Combustible Material.** Combustible material shall not be placed within two inches (2″) of fireplace, smoke chamber, or chimney walls when built entirely within a structure, or within one inch (1″) when the chimney is built entirely outside the structure. In lieu of one-inch (1″) clearance between chimney and exterior wall, one-half-inch (½″) gypsum board may be substituted. Combustible materials shall not be placed within six inches (6″) of the fireplace opening. No such combustible material within twelve inches (12″) of the fireplace opening shall project more than one-eighth inch (⅛″) for each one-inch (1″) clearance from such opening.

No part of metal hoods used as part of a fireplace, barbecue or heating stove shall be less than eighteen inches (18″) from combustible material. This clearance may be reduced to the minimum requirements set forth in Uniform Building Code, Volume II, Mechanical.

Fireplaces and Barbecues (Continued)

(h) **Areas of Flues, Throats and Dampers.** The net cross-sectional area of the flue and of the throat between the firebox and the smoke chamber of a fireplace shall be not less than as set forth in Table No. 37-A. Where dampers are used, they *shall* be of not less than No. 12 gauge metal. When fully opened, damper openings shall be not less than 90 per cent of the required flue area. When fully opened, damper blade shall not extend beyond the line of the inner face of the flue.

(i) **Lintel.** Masonry over the fireplace opening shall be supported by an incombustible lintel.

(j) **Hearth.** Every fireplace shall be provided with a brick, concrete, stone or other approved incombustible hearth slab at least twelve inches (12″) wider on each side than the fireplace opening and projecting at least eighteen inches (18″) therefrom. This slab shall be not less than four inches (4″) thick and shall be supported by incombustible materials or reinforced to carry its own weight and all imposed loads. Combustible forms and centering shall be removed.

(k) **Firestopping.** Firestopping between chimneys and wooden construction shall meet the requirements specified in Section 2508.

(l) **Nonconforming Fireplaces.** Imitation and other fireplaces not conforming to the other requirements of this Section shall not exceed six inches (6″) in depth. Gas-burning appliances may be installed in such nonconforming fireplaces provided that compliance is made in accordance with the requirements of Uniform Building Code, Volume II, Mechanical.

(m) **Support.** Fireplaces shall be supported on foundations designed as specified in Chapters 23, 24 and 28.

(n) **Reinforcing.** Unless a specific design is provided, every masonry or concrete chimney in Seismic Zone No. 3 shall be reinforced with not less than four one-half-inch (½″) diameter vertical steel reinforcing bars conforming to the provisions of Chapter 24 or 26 of the Code. The bars shall extend the full height of the chimney and shall be spliced in accordance with the applicable requirements of Chapters 24 and 26. The bars shall be tied horizontally at twenty-four-inch (24″) intervals with not less than one-fourth-inch (¼″) diameter steel ties. Where the width of the chimney exceeds forty inches (40″), two additional one-half-inch (½″) diameter vertical bars shall be provided for each additional flue incorporated in the chimney or for each additional forty inches (40″) in width or fraction thereof.

CHAPTER 38—FIRE-EXTINGUISHING SYSTEMS

Automatic Fire-Extinguishing Systems: Where Required

Sec. 3801. Standard automatic fire-extinguishing systems shall be installed as specified in this Chapter in the following places:

1. In every story, basement or cellar of a building when the floor area exceeds fifteen hundred square feet (1500 sq. ft.) and there is not provided at least twenty square feet (20 sq. ft.) of opening entirely above grade in each fifty lineal feet (50 lin. ft.) or fraction thereof of exterior wall in the story or basement or cellar on at least one side of the building. Openings shall have a minimum dimension of not less than thirty inches (30").

When openings in a story, basement, or cellar are provided on only one side and the opposite wall of such story, basement, or cellar is more than seventy-five feet (75') from such openings, the story, basement, or cellar shall be provided with an approved automatic fire-extinguishing system or openings as specified above shall be provided on at least two sides of the exterior walls of the story, basement, or cellar.

If any portion of a basement or cellar is located more than seventy-five feet (75') from openings required in this Section, the basement or cellar shall be provided with an approved automatic fire-extinguishing system.

2. In cellars in Groups A, B and C Occupancies and in all usable space below a cellar or basement.

3. In the following locations in Group A Occupancies and Divisions 1 and 2, Group B Occupancies having a stage or enclosed platform:

A. In all dressing room sections, workshops, and storerooms.

B. Where there is a stage; under the gridiron, stage floor, tie and fly galleries, and in all places back of the proscenium wall.

C. Over enclosed platforms having an area of more than one thousand square feet (1000 sq. ft.) and over any usable space under such platforms.

4. In any enclosed occupied space in Groups B, C, and D Occupancies below or over a stairway, except where the entire construction is as required for Type I or II buildings, and in all portions of basements or cellars used for storage or maintenance work rooms.

5. In Divisions 1 and 2, Group E Occupancies having an area of more than fifteen hundred square feet (1500 sq. ft.); in Division 3, Group E Occupancies having an area of more than three thousand square feet (3000 sq. ft.); and in Division 4, Group E Occupancies more than one story in height.

Detailed Requirements

Sec. 3802. Required automatic fire-extinguishing systems shall comply in all respects with the regulations set forth in U.B.C. Standard No. 38-1-67 or No. 38-2-67.

Detailed Requirements (Continued)

EXCEPTIONS: 1. A single water supply equal to the primary supply required by such regulations may be accepted as complying with the requirements of this Code.

2. Automatic fire-extinguishing systems required in paragraph 4, Section 3801, may be supplied from the domestic water system and need not comply with the provisions of this Section except as to pipe sizes and spacing of heads, provided that where the domestic water supply has a pressure less than 15 pounds per square inch, an approved automatic chemical extinguisher may be used in lieu of the automatic fire-extinguishing system.

3. The alarm valve required for a standard automatic fire-extinguishing system shall not be required in the cellars of Groups B, C, D, E, F, G, and H Occupancies where the area of such cellar is less than three thousand square feet (3000 sq. ft.).

Dry Standpipes

Sec. 3803. Every building four or more stories in height shall be equipped with one or more dry standpipes.

Dry Standpipes: Detailed Requirements

Sec. 3804. (a) **Construction.** Dry standpipes shall be of wrought iron or galvanized steel and together with fittings and connections shall be of sufficient strength to withstand 300 pounds of water pressure to the square inch when ready for service, without leaking at the joints, valves, or fittings.

Tests shall be conducted by the owner or contractor in the presence of a representative of the Fire Department whenever deemed necessary and ordered by the Building Official. The tests shall be applied at the top and bottom connections of such standpipes and the owner or contractor shall be responsible for any damage caused by breakage or faulty installation while such tests are being conducted. After such standpipes have been tested, the owner or contractor shall remove all water therefrom.

(b) **Size.** Dry standpipes shall be of such a size as to be capable of delivering 250 gallons per minute from each of any three outlets simultaneously under the pressure created by one fire engine or pumper, based on the existing city equipment available. No part of a dry standpipe system other than hose connections shall be less than three inches (3") in diameter.

(c) **Number Required.** Every building four or more stories in height where the area of any floor above the third floor is ten thousand square feet (10,000 sq. ft.) or less shall be equipped with not less than one dry standpipe and an additional standpipe shall be installed for each additional ten thousand square feet (10,000 sq. ft.) or fraction thereof.

(d) **Location.** Standpipes shall be located within stairway enclosures or as near such stairways as possible or shall be on the outside of, embedded within, or immediately inside of an exterior wall and within one foot (1') of an opening in a stairway enclosure or the balcony or vestibule of a smokeproof tower or an outside exit stairway.

Dry Standpipes: Detailed Requirements (*Continued*)

(e) **Siamese Connections.** All four-inch (4″) dry standpipes shall be equipped with a two-way Siamese fire department connection. All five-inch (5″) dry standpipes shall be equipped with a three-way Siamese fire department connection and all six-inch (6″) dry standpipes shall be equipped with a four-way Siamese fire department connection. All Siamese inlet connections shall be located on a street front of the building and not less than one foot (1′) nor more than four feet (4′) above the grade and shall be equipped with clapper-checks and substantial plugs. All Siamese inlet connections shall be recessed in the wall or otherwise substantially protected.

(f) **Outlets.** All dry standpipes shall extend from the ground floor to and over the roof and shall be equipped with a two and one-half-inch (2½″) outlet not more than four feet (4′) above the floor level at each story. All dry standpipes shall be equipped with a two-way two and one-half-inch (2½″) outlet above the roof. All outlets shall be equipped with gate valves with substantial chains.

(g) **Threads.** All hose threads in connection with such standpipe installations shall be uniform with that used by the local fire department.

(h) **Signs.** An iron or bronze sign with raised letters at least one inch (1″) high shall be rigidly attached to the building adjacent to all Siamese connections and such sign shall read: "CONNECTION TO DRY STANDPIPE."

Wet Standpipes: Where Required

Sec. 3805. Every Group A and B Occupancy of any height, and every Group C Occupancy two or more stories in height, and every Group D, E, F, G, and H Occupancy three or more stories in height and every Group E and F Occupancy over twenty thousand square feet (20,000 sq. ft.) in area shall be equipped with one or more interior wet standpipes extending from the cellar or basement into the topmost story, provided that Group B buildings having no stage and having a seating capacity of less than 500 need not be equipped with interior standpipes.

Wet Standpipes: Detailed Requirements

Sec. 3806. (a) **Construction.** Interior wet standpipes shall be constructed as required for dry standpipes.

(b) **Size.** Interior wet standpipes shall have an internal diameter sufficient to deliver 50 gallons of water per minute under 30 pounds per square inch pressure at the hose connection, based on the available water supply. Buildings of Groups A and B Occupancies shall have wet standpipe systems capable of delivering the required quantity and pressure from any two outlets simultaneously; for all other occupancies only one outlet need be figured to be open at one time. In no case shall the internal diameter of a wet standpipe be less than two inches (2″), except when the standpipe is attached to an automatic fire-extinguishing system as set forth in U.B.C. Standard No. 38-1-67.

Wet Standpipes: Detailed Requirements (Continued)

Any approved formula which determines pipe sizes on a pressure drop basis may be used to determine pipe sizes for wet standpipe systems. The Building Official may require delivery and pressure tests on completed wet standpipe systems before approving such systems.

(c) **Number Required.** Wet standpipes shall be so located that any portion of the building can be reached therefrom with a hose not exceeding seventy-five feet (75′) in length.

(d) **Location.** In Groups A and B Occupancies, outlets shall be located as follows:

On each side of the stage, on each side of the rear of the auditorium, and on each side of the rear of the balconies. Where occupant loads are less than 500 the number of locations noted above may be reduced upon the approval of the Building Official. In Groups C, D, E, F, G, and H Occupancies the location of all interior wet standpipes shall be approved by the Building Official.

(e) **Outlets.** All interior wet standpipes shall be equipped with a one and one-half-inch (1½″) valve in each story, including the basement or cellar of the building, and located not less than one foot (1′) nor more than six feet (6′) above the floor.

(f) **Threads.** All hose threads in connection with the installation of such standpipes, including valves and reducing fittings, shall be uniform with that used by the local fire department.

(g) **Water Supplies.** All interior wet standpipes shall be connected to a street water main not less than four inches (4″) in diameter, or when the water pressure is insufficient to maintain 30 pounds pressure at the highest hose outlet such standpipe shall be connected to a pressure tank, gravity tank, or fire pump. Such supply shall be sufficient to furnish at least 30 pounds pressure at the topmost standpipe outlet.

When more than one interior wet standpipe is required in the building, such standpipes shall be connected at their bases or at their tops by pipes of equal size.

(h) **Pressure and Gravity Tanks.** Tanks shall have a capacity sufficient to furnish at least 250 gallons per minute for a period of not less than 10 minutes. Such tanks shall be located so as to provide not less than 25 pounds pressure at the topmost hose outlet for its entire supply. Discharge pipes from pressure tanks shall extend two inches (2″) into and above the bottom of such tanks. All tanks shall be equipped with a manhole, ladder and platform, drainpipe, water and pressure gauges. Every pressure tank shall be tested in place after installation and proved tight at a hydrostatic pressure 50 per cent in excess of the working pressure required. Where such tanks are used for domestic purposes the supply pipe for such purposes shall be located at or above the center line of such tanks. Incombustible supports

Wet Standpipes: Detailed Requirements *(Continued)*

shall be provided for all such supply tanks and not less than a three-foot (3′) clearance shall be maintained over the top and under the bottom of all pressure tanks.

(i) **Fire Pumps.** Fire pumps shall have a capacity of not less than 250 gallons per minute with a pressure of not less than 25 pounds at the topmost hose outlet. The source of supply for such pump shall be a street water main of not less than four-inch (4″) diameter or a well or cistern containing a one-hour supply. Such pumps shall be supplied with an adequate source of power and shall be automatic in operation.

(j) **Hose and Hose Reels.** Each hose outlet of all interior wet standpipes shall be supplied with a hose not less than one and one-half inches (1½″) in diameter. Such hose shall be equipped with a suitable brass or bronze nozzle and shall be not over seventy-five feet (75′) in length. An approved standard form of wall hose reel or rack shall be provided for the hose and shall be located so as to make the hose readily accessible at all times and shall be recessed in the walls or protected by suitable cabinets.

Basement Pipe Inlets

Sec. 3807. Basement pipe inlets shall be installed in the first floor of every store, warehouse, or factory where there are cellars or basements under same, except where in such cellars or basements there is installed a fire-extinguishing system as specified by this Code, or where the cellars or basements are used for banking purposes, safe deposit vaults, or similar uses.

All basement pipe inlets shall be of cast iron, steel, brass, or bronze with lids of cast brass or bronze and shall consist of a sleeve not less than eight inches (8″) in diameter through the floor extending to and flush with the ceiling below and with a top flange, recessed with an inside shoulder, to receive the lid and flush with the finish floor surface. The lid shall be a solid casting and have a ring lift recessed in the top thereof, so as to be flush. The lid shall have the words "FIRE DEPARTMENT ONLY, DO NOT COVER UP," cast in the top thereof. The lid shall be installed in such a manner as to permit its removal readily from the inlet.

The location of such basement pipe inlets shall be approved by the Building Official and shall be kept readily accessible at all times to the Fire Department.

Approvals

Sec. 3808. All fire-extinguishing systems, including automatic sprinklers, wet and dry standpipes, automatic chemical extinguishers, basement pipe inlets and the appurtenances thereto shall meet the approval of the Fire Department as to installation and location and shall be subject to such periodic tests as it may require.

CHAPTER 39—STAGES AND PLATFORMS

Stage Ventilators

Sec. 3901. (a) **General.** There shall be one or more ventilators constructed of metal or other incombustible material near the center and above the highest part of any working stage raised above the stage roof and having a total ventilation area equal to at least five per cent of the floor area within the stage walls. The entire equipment shall conform to the following requirements specified in Subsections (b) to (i) of this Section, or their equivalent.

(b) **Opening Action.** Ventilators shall open by spring action or force of gravity sufficient to overcome the effects of neglect, rust, dirt, frost, snow, or expansion by heat or warping of the framework.

(c) **Glass.** Glass, if used in ventilators, must be protected against falling on the stage. A wire screen, if used under the glass, must be so placed that if clogged it cannot reduce the required ventilating area or interfere with the operating mechanism or obstruct the distribution of water from the automatic fire-extinguishing systems.

(d) **Design.** Ventilators, penthouses, and supporting framework shall be designed in accordance with Chapter 23.

(e) **Automatic Openings.** Each ventilator shall be arranged to open automatically after the outbreak of fire by the use of an approved automatic closing device as defined in Chapter 43. The fusible link and operating cable shall hold each door closed against a minimum 30-pound counterforce exerted by springs or counterweights. This minimum counterforce shall be exerted on each door through its entire arc of travel and for a minimum 115°. A manual control shall be provided.

(f) **Spring Actuation.** Springs, when employed to actuate ventilator doors, shall be capable of maintaining full required tension indefinitely. Springs shall not be stressed more than 50 per cent of their rated capacity and shall not be located directly in the air stream, nor exposed to the elements.

(g) **Location of Fusible Links.** A fusible link shall be placed in the cable control system on the underside of the ventilator at or above the roof line, or as approved by the Building Official, and shall be so located as not to be affected by the operation of fire-extinguishing systems.

(h) **Control.** Remote, manual or electrical control shall provide for both opening and closing of the ventilator doors for periodic testing and shall be located at a point on the stage designated by the Building Official. When remote control of ventilator is electrical, power failure shall not affect its instant operation in the event of fire. Hand winches may be employed to facilitate operation of manually controlled ventilators.

(i) **Curb Construction.** Curbs shall be constructed as required for the roof.

Gridirons

Sec. 3902. Gridirons, fly galleries, and pinrails shall be constructed of incombustible materials and fire protection of steel and iron may be omitted. Gridirons and fly galleries shall be designed to support not less than 75 pounds live load per square foot.

Each loft block well shall be designed to support 250 pounds per lineal foot and the head block well shall be designed to support the aggregate weight of all the loft block wells served. The head block well must be provided with an adequate strongback or lateral brace to offset torque.

The main counterweight sheave beam shall be designed to support a horizontal and vertical uniformly distributed live load sufficient to accommodate the weight imposed by the total number of loft blocks in the gridiron. The sheave blocks shall be designed to accommodate the maximum load for the loft blocks or head blocks served with a safety factor of five.

Rooms Accessory to Stage

Sec. 3903. In buildings having a stage, the dressing room sections, workshops, and storerooms shall be located on the stage side of the proscenium wall and shall be separated from each other and from the stage by not less than a One-Hour Fire-Resistive Occupancy Separation, as defined in Chapter 5.

Proscenium Walls

Sec. 3904. A stage as defined in Section 420 shall be completely separated from the auditorium by a proscenium wall of not less than two-hour incombustible construction. The proscenium wall shall extend not less than four feet (4′) above the roof over the auditorium.

Proscenium walls may have, in addition to the main proscenium opening, one opening at the orchestra pit level and not more than two openings at the stage floor level, each of which shall be not more than twenty-five square feet (25 sq. ft.) in area.

All openings in the proscenium wall of a stage shall be protected by a fire assembly having a one and one-half-hour fire-resistive rating. The proscenium opening, which shall be the main opening for viewing performances, shall be provided with a self-closing fire-resistive curtain as provided in U.B.C. Standard No. 6-1-67.

Stage Floors

Sec. 3905. All parts of stage floors shall be of Type I construction except the part of the stage extending back from and six feet (6′) beyond the full width of the proscenium opening on each side, which may be constructed of steel or heavy timbers covered with a wood floor of not less than two inches (2″) nominal thickness. No part of the combustible construction except the floor finish shall be carried through the proscenium opening. All parts of the stage floor shall be designed to support not less than 125 pounds per square foot.

Openings through stage floors shall be equipped with tight-fitting trap doors of wood of not less than two inches (2″) nominal thickness.

Platforms

Sec. 3906. (a) **Ventilators.** Enclosed platforms shall be provided with one or more ventilators conforming to the requirements of Section 3901, except that the total area shall be equal to five per cent of the area of the platform. When more than one ventilator is provided, they shall be so spaced as to provide proper exhaust ventilation.

Ventilators shall not be required for enclosed platforms having a floor area of five hundred square feet (500 sq. ft.) or less.

(b) **Construction.** Walls and ceiling of an enclosed platform in an assembly room shall be of not less than one-hour fire-resistive construction.

Any usable space having headroom of four feet (4′) or more under a raised platform of an assembly room shall be of not less than one-hour fire-resistive construction.

(c) **Accessory Rooms.** In buildings having an enclosed platform, the dressing-room section, workshops, and store-rooms shall be separated from each other and from the rest of the building by not less than a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5, except that a chair-storage area having headroom of not more than four feet (4′) need not be so separated.

Stage Exits

Sec. 3907. At least one exit not less than thirty-six inches (36″) wide shall be provided from each side of the stage opening directly or by means of a passageway not less than thirty-six inches (36″) in width to a street or exit court. An exit stair not less than two feet six inches (2′6″) wide shall be provided for egress from each fly gallery. Each tier of dressing rooms shall be provided with at least two means of egress each not less than two feet six inches (2′6″) wide and all such stairs shall be constructed as specified in Chapter 33. The stairs required in this Section need not be enclosed.

Miscellaneous

Sec. 3908. A protecting hood shall be provided over the full length of the stage switchboard.

Flame-retarding Requirements

Sec. 3909. No combustible scenery, drops, props, decorations, or other combustible effects shall be placed on any stage or enclosed platform unless it is treated with an effective fire-retardant solution and maintained in a nonflammable condition as approved by the Fire Department.

CHAPTER 40—MOTION PICTURE PROJECTION ROOMS

General

Sec. 4001. (a) **Scope.** The provisions of this Chapter shall apply only where ribbon type motion picture film in excess of seven-eighths-inch (⅞") width and electric arc projection equipment are used.

(b) **Projection Room Required.** Every motion picture machine using ribbon type film in excess of seven-eighths-inch (⅞") width and electric arc projection equipment, together with all electrical devices, rheostats, machines, and all such films present in any Group A, B, or C Occupancy, shall be enclosed in a projection room large enough to permit the operator to walk freely on either side and back of the machine.

Construction

Sec. 4002. Every projection room shall be of not less than one-hour fire-resistive construction throughout and the walls and ceiling shall be finished with incombustible material.

The ceiling shall be not less than eight feet (8') from the finished floor. The room shall have a floor area of not less than eighty square feet (80 sq. ft.) and forty square feet (40 sq. ft.) for each additional machine.

Exits

Sec. 4003. Every projection room shall have at least two doorways separated by not less than one-third the perimeter of the room, each at least thirty inches (30") wide and eighty inches (80") high.

All entrances to a projection room shall be protected by a self-closing fire assembly having a three-fourths-hour fire-resistive rating. Such doors shall open outward and lead to proper exits as required in Chapter 33 and shall not be equipped with any latch. The maximum width of such door need be no more than thirty inches (30").

Ports and Openings

Sec. 4004. (a) **Types.** Ports in projection room walls shall be of three kinds: projection ports; observation ports; and combination ports used for both observation and for stereopticon, spot, or floodlight machines.

(b) **Ports Required.** There shall be provided for each motion picture projector not more than one projection port, which shall be limited in area to one hundred and twenty square inches (120 sq. in.), and not more than one observation port, which shall be limited in area to two hundred square inches (200 sq. in.). There shall be not more than three combination ports, each of which shall not exceed thirty inches by twenty-four inches (30" x 24"). Each port opening shall be completely covered with a pane of glass.

> EXCEPTION: When acetate (safety) film is used projection ports may be increased in size to an area not to exceed seven hundred and twenty square inches (720 sq. in.).

Ports and Openings (Continued)

(c) **Shutters.** Each port and every other opening in projection room walls, including any fresh-air inlets but excluding exit doors and exhaust ducts, shall be provided with a shutter of not less than No. 10 U. S. gauge sheet metal or its equivalent large enough to overlap at least one inch (1″) on all sides of such opening. Shutters shall be arranged to slide without binding in guides constructed of material equal to the shutters in strength and fire resistance. Each shutter shall be equipped with a 165°F. fusible link, which when fused by heat will cause closure of the shutter by gravity. Shutters of a size greater than two hundred square inches (200 sq. in.) shall be equipped with a counterbalance. There shall also be a fusible link located over the upper magazine of each projector, which, upon operating, will close all the shutters. In addition, there shall be provided suitable means for manually closing all shutters simultaneously from any projector head and from a point within the projection room near each exit door. Shutters on openings not in use shall be kept closed.

EXCEPTION: Shutters may be omitted when acetate (safety) film only is used.

Ventilation

Sec. 4005. (a) **Inlet.** A fresh-air inlet from the exterior of the building not less than one hundred and forty-four square inches (144 sq. in.) and protected with wire netting shall be installed within two inches (2″) of the floor in every projection room, the source of which shall be remote from other outside vents or flues.

(b) **Outlets.** Ventilation shall be provided by one or more mechanical exhaust systems which shall draw air from each arc lamp housing and from one or more points near the ceiling. Systems shall exhaust to outdoors either directly or through an incombustible flue used for no other purpose. Exhaust capacity shall be not less than 15 cubic feet nor more than 50 cubic feet per minute for each arc lamp plus 200 cubic feet per minute for the room itself. Systems shall be controlled from within the enclosure and have pilot lights to indicate operation. The exhaust system serving the projection room may be extended to cover rooms associated therewith such as rewind rooms. No dampers shall be installed in such exhaust systems.

Ventilation of these rooms shall not be connected in any way with ventilating or air-conditioning systems serving other portions of the building.

(c) **Exhaust Ducts.** Exhaust ducts shall be of incombustible material, and shall either be kept one inch (1″) from combustible material or covered with one-half inch (½″) of incombustible heat-insulating material.

Regulation of Equipment

Sec. 4006. (a) **Shelves and Fixtures.** All shelves, fixtures, and fixed equipment in a projection room shall be constructed of incombustible materials.

Regulation of Equipment (Continued)

(b) **Films.** All films not in actual use shall be stored in metal cabinets having individual compartments for reels or shall be in I.C.C. shipping containers. Metal used in the construction of cabinets shall be not less than No. 18 U. S. Standard gauge. No solder shall be used in the construction of such metal cabinets.

Sanitary Requirements

Sec. 4007. Every projection room shall be provided with an unenclosed water closet and lavatory.

PART VIII

FIRE-RESISTIVE STANDARDS FOR FIRE PROTECTION

CHAPTER 42—INTERIOR WALL AND CEILING FINISH

General

Sec. 4201. Interior wall and ceiling finish shall mean interior wainscoting, paneling, or other finish applied structurally or for decoration, acoustical correction, surface insulation, or similar purposes. Requirements for finishes shall not apply to trim, doors and windows or their frames, nor to materials which are less than one twenty-eighth inch (0.036") in thickness cemented to the surface of walls or ceilings, if these materials have flame-spread characteristics no greater than paper of this thickness cemented to an incombustible backing.

Testing and Classification of Materials

Sec. 4202. (a) **Testing.** Tests shall be made by an approved testing agency to establish flame-spread characteristics and to show that materials when cemented or otherwise fastened in place will not readily become detached when subjected to room temperatures of 300°F. for 25 minutes. Flame-spread characteristics shall be determined by one of the following methods:

1. The "Tunnel Test" as set forth in U.B.C. Standard No. 42-1-67.

2. Any other recognized method of test procedure for determining the flame-spread characteristics of finish materials that will give comparable results to those specified in Method No. 1 above.

(b) **Classification.** The classes of materials based upon their flame-spread characteristics under the Tunnel Test shall be as set forth in Table No. 42-A. The smoke density shall be no greater than that obtained from the burning of untreated wood under similar conditions when tested in accordance with U.B.C. Standard No. 42-1-67 in the way intended for use. The products of combustion shall be no more toxic than the burning of untreated wood under similar conditions.

Application of Controlled Interior Finish

Sec. 4203. Interior finish materials applied to walls and ceilings shall be tested as specified in Section 4202 and regulated for purposes of limiting flame-spread by the following provisions:

1. When walls and ceilings are required by any provision in this Code to be of fire-resistive or incombustible construction, the finish material of any class shall be applied directly against such fire-resistive construction or to furring strips not exceeding one and three-fourths inches (1¾") applied directly against such surfaces. The intervening spaces between such furring strips shall be filled with inorganic or Class I material or shall be firestopped not to exceed eight feet (8') in any direction.

Application of Controlled Interior Finish (Continued)

2. Where walls and ceilings are required to be of fire-resistive or incombustible construction and walls are set out or ceilings are dropped distances greater than specified in paragraph 1 of this Section, Class I finish materials shall be used except where the finish materials are protected on both sides by automatic fire-extinguishing systems or are attached to an incombustible backing or to furring strips installed as specified in paragraph 1. The hangers and assembly members of such dropped ceilings that are below the main ceiling line shall be of incombustible materials except that in Types III and V construction fire-retardant treated wood may be used. The construction of each set-out wall shall be of fire-resistive construction as required elsewhere in this Code. See Section 2508 for firestopping.

3. Wall and ceiling finish materials of all classes as permitted in this Chapter may be installed directly against the wood decking or planking of Heavy-Timber Construction or to wood furring strips applied directly to the wood decking or planking installed and firestopped as specified in paragraph 1.

TABLE NO. 42-A—FLAME-SPREAD CLASSIFICATION

MATERIAL QUALIFIED BY:	
Class	Tunnel Test
I	0- 25
II	26- 75
III	76-225

TABLE NO. 42-B—MINIMUM INTERIOR-FINISH CLASSIFICATIONS

OCCUPANCY GROUP	ENCLOSED VERTICAL EXITWAYS	OTHER EXITWAYS	ROOMS OR AREAS
A	I	II	III
B	I	II	III
C	I	II	III
D	I	II	II[1]
E	I	II	III[2]
F	I	II	III
G	I	II	III
H	I	II	III[1]
I	NO RESTRICTIONS		
J	NO RESTRICTIONS		

[1]In rooms in which personal liberties of inmates are forcibly restrained, Class I material only may be used.

[2]Over two stories shall be of Class II.

4. All interior wall or ceiling finish other than Class I material which is less than one-fourth inch (¼") thick shall be applied directly against an incombustible backing unless the qualifying tests were made with the material suspended from the incombustible backing.

Application of Controlled Interior Finish (Continued)

Finishes Based on Occupancy

Sec. 4204. The minimum flame-spread classification of interior finish, as determined by tests, shall be based on use or occupancy as set forth in Table No. 42-B.

EXCEPTIONS: 1. Except in Group D Occupancy and in enclosed vertical exitways, Class III may be used in other exitways and rooms as wainscoting extending not more than forty-eight inches (48") above the floor and for tack and bulletin boards covering not more than five per cent of the gross wall area of the room.

2. Where approved full fire-extinguishing system protection is provided, the flame-spread classification rating may be reduced one classification, but in no case shall materials having a classification greater than Class III be used.

3. The exposed faces of Type III-H.T., structural members and Type III-H.T., decking and planking, where otherwise permissible under this Code are excluded from flame-spread requirements.

CHAPTER 43—FIRE-RESISTIVE STANDARDS

General

Sec. 4301. In addition to all the other requirements of this Code, fire-resistive materials shall meet the requirements for fire-resistive construction given in this Chapter.

Fire-resistive Materials

Sec. 4302. (a) **General.** Materials and systems used for fire-resistive purposes shall be limited to those specified in this Chapter unless accepted under the procedure given in Section 4302 (b), and shall conform to the following standards. For standards for the specific materials of construction referred to in this Chapter, see the appropriate Chapter in Volume I or the Uniform Building Code Standards specifically regulating such materials.

The materials and details of construction for the fire-resistive systems described in this Chapter shall be in accordance with all other provisions of this Code except as modified herein.

MATERIALS AND TESTS	U.B.C. DESIGNATION
FIRE DAMPERS	30- 1-67
FIRE TEST OF BUILDING CONSTRUCTION AND MATERIAL	43- 1-67
FIRE TESTS OF DOOR ASSEMBLIES	43- 2-67
TIN-CLAD FIRE DOORS	43- 3-67
FIRE TESTS OF WINDOW ASSEMBLIES	43- 4-67
INSTALLATION OF FIRE DOORS AND FIRE WINDOWS	43- 5-67
SMOKE AND FIRE DETECTORS FOR FIRE PROTECTIVE SIGNALING SYSTEMS	43- 6-67

(b) **Tests.** For the purpose of determining the degree of fire resistance afforded, the materials of construction listed in this Chapter shall be assumed to have the fire-resistance rating indicated. Any material or assembly of materials of construction tested in accordance with the requirements set forth in U.B.C. Standard No. 43-1-67 shall be rated for fire-resistance in accordance with the results and conditions of such tests.

(c) **Concrete.** Grade A concrete is made with aggregates such as limestone, calcareous gravel, trap rock, slag, expanded clay, shale, slate or any other aggregates possessing equivalent fire-resistive properties.

Grade B concrete is all concrete other than Grade A concrete and includes concrete made with aggregates containing more than 40 per cent quartz, chert, or flint.

(d) **Pneumatically-placed Concrete.** Pneumatically-placed concrete without coarse aggregate shall be classified as Grade A or B concrete in accordance with the aggregate used.

Protection of Structural Members

Sec. 4303. (a) **General.** Structural members having the fire-resistive protection set forth in Table No. 43-A shall be assumed to have the fire-resistance ratings set forth therein.

Protection of Structural Members (Continued)

(b) **Protective Coverings. 1. Thickness of protection.** The thickness of fire-resistive materials required for protection of structural members shall be not less than set forth in Table No. 43-A, except as modified in this Section. The figures shown shall be the net thickness of the protecting materials and shall not include any hollow space back of the protection.

2. **Unit masonry protection.** Where required, metal ties shall be embedded in transverse joints of unit masonry for protection of steel columns. Such ties shall be as set forth in Table No. 43-A or be equivalent thereto.

3. **Reinforcement for cast-in-place concrete column protection.** Cast-in-place concrete protection for steel columns shall be reinforced at the edges of such members with wire ties of not less than .18 inch in diameter wound spirally around the columns on a pitch of not more than eight inches (8").

4. **Embedment of pipes.** Conduits and pipes shall not be embedded in required fire protection of structural members.

5. **Column jacketing.** Where the fire-resistive covering on columns is exposed to injury from moving vehicles, the handling of merchandise or other means, it shall be protected in an approved manner.

6. **Ceiling protection.** Where a ceiling forms the protective membrane for fire-resistive assemblies, the constructions and their supporting horizontal structural members need not be individually fire protected except where such members support directly applied loads from more than one floor or roof. The required fire resistance shall be not less than that required for individual protection of members.

Ceilings shall form continuous fire-resistive membranes, but may have openings for copper, sheet steel, or ferrous plumbing pipes, ducts and electrical outlet boxes provided the areas of such openings through the ceiling aggregate not more than one hundred square inches (100 sq. in.) for any one hundred square feet (100 sq. ft.) of ceiling area.

Individual electrical outlet boxes shall be of steel and not greater than sixteen square inches (16 sq. in.) in area. All duct openings in such ceilings shall be protected by approved fire dampers.

> EXCEPTION: Larger openings than permitted above may be installed where such openings and the assemblies in which they are utilized are in accordance with the results of tests pursuant to the provisions of Section 4302 (b).

(c) **Protected Members. 1. Attached metal members.** The edges of lugs, brackets, rivets, and bolt heads attached to structural members may extend to within one inch (1") of the surface of the fire protection.

2. **Reinforcing.** Thickness of protection for concrete or masonry reinforcement shall be measured to the outside of the reinforcement except that stirrups and spiral reinforcement ties may project not more than one-half inch (½") into the protection.

(Continued on page 463)

TABLE NO. 43-A—MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS INCOMBUSTIBLE INSULATING MATERIALS

STRUCTURAL PARTS TO BE PROTECTED	ITEM NUMBER	INSULATING MATERIAL USED	MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Steel Columns and All Members of Primary Trusses	1	Grade A concrete, members 6″ x 6″ or greater (not including sandstone, granite and siliceous gravel)[1]	2½	2	1½	1
	2	Grade A concrete, members 8″ x 8″ or greater (not including sandstone, granite and siliceous gravel)[1]	2	1½	1	1
	3	Grade A concrete, members 12″ x 12″ or greater (not including sandstone, granite and siliceous gravel)[1]	1½	1	1	1
	4	Grade B concrete and Grade A concrete excluded above, members 6″ x 6″ or greater[1]	3	2	1½	1
	5	Grade B concrete and Grade A concrete excluded above, members 8″ x 8″ or greater[1]	2½	2	1	1
	6	Grade B concrete and Grade A concrete excluded above, members 12″ x 12″ or greater[1]	2	1	1	1

TABLE NO. 43-A—Continued

Steel Columns and All Members of Primary Trusses (Cont'd.)	7	Clay or shale brick with brick and mortar fill[1]	3¾			2¼
	8	4″ Hollow clay tile in two 2″ layers; ½″ mortar between tile and column; ⅜″ metal mesh (wire diameter = .046″) in horizontal joints; tile fill[1]	4			
	9	2″ Hollow clay tile; ¾″ mortar between tile and column; ⅜″ metal mesh (.046″ wire diameter) in horizontal joints; Grade A concrete fill[1]; plastered with ¾″ gypsum plaster	3			
	10	2″ Hollow clay tile with outside wire ties (.08″ diameter) at each course of tile or ⅜″ metal mesh (.046″ diameter wire) in horizontal joints; Grade A concrete fill[1] extending 1″ outside column on all sides			3	
	11	2″ Hollow clay tile with outside wire ties (.08″ diameter) at each course of tile with or without Grade A concrete fill; ¾″ mortar between tile and column				2
	12	Solid gypsum blocks with woven wire mesh[2] in horizontal joints, laid with 1″ mortar on flanges[1] and plastered with ½″ gypsum plaster	2½	2½		

(Continued)

TABLE NO. 43-A—MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS INCOMBUSTIBLE INSULATING MATERIALS—Continued

STRUCTURAL PARTS TO BE PROTECTED	ITEM NUMBER	INSULATING MATERIAL USED	MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Steel Columns and All Members of Primary Trusses (Cont'd.)	13	Hollow gypsum blocks with ⅞" wide No. 12 gauge metal cramps and woven wire mesh[2] in horizontal joints. PL denotes ½" gypsum plaster	3½ PL	3½ PL	3	3
	14	Wood-fibered gypsum plaster poured solid, (reentrant space filled) and reinforced with 4" x 4" x No. 14 gauge wire mesh	2	1½	1	1
	15	Portland cement plaster over metal lath wire tied to ¾" cold-rolled vertical channels with No. 18 gauge wire ties spaced 3" to 6" on center. Plaster mixed 1:2½ by volume, cement to sand			2½[3]	⅞
	16	Vermiculite concrete, 1:4 mix by volume over paperbacked wire fabric lath wrapped directly around column with additional 2" x 2" No. 16/16 gauge wire fabric placed ¾" from outer concrete surface. Wire fabric tied with No. 18 gauge wire spaced 6" on center for inner layer and 2" on center for outer layer	2			
	17	Perlite or vermiculite gypsum plaster over metal lath wrapped around column and furred 1¼" from column flanges. Sheets lapped at ends and tied at 6" intervals with No. 18 gauge tie wire. Plaster pushed through to flanges	1½	1		

TABLE NO. 43-A—Continued

Steel Columns and All Members of Primary Trusses (Cont'd.)	18	Perlite or vermiculite gypsum plaster over self-furring metal lath wrapped directly around column, lapped 1" and tied at 6" intervals with No. 18 gauge wire	1¾	1⅜	1	
	19	Perlite or vermiculite gypsum plaster on metal lath applied to ¾" cold-rolled channels spaced 24 inches apart vertically and wrapped flatwise around column	1½			
	20	Perlite or vermiculite gypsum plaster over 2 layers of ½" plain full-length gypsum lath applied tight to column flanges. Lath wrapped with 1" hexagonal mesh of No. 20 gauge wire and tied with doubled No. 18 gauge wire ties spaced 23" on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2½ cubic feet of aggregate for the three-hour system	2½	2		
	21	Perlite or vermiculite gypsum plaster over one layer of ½" plain full-length gypsum lath applied tight to column flanges. Lath tied with doubled No. 18 gauge wire ties spaced 23" on center and scratch coat wrapped with 1" hexagonal mesh No. 20 gauge wire fabric. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2½ cubic feet of aggregate		2		
	22	Perlite or vermiculite gypsum plaster over ⅜" perforated gypsum lath applied tight to column flanges and tied with doubled No. 18 gauge wire ties spaced 15" on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2½ cubic feet of aggregate for the two-hour system		1¾	1⅜	
	23	Gypsum plaster over ⅜" perforated gypsum lath applied tight to column flanges and tied with doubled No. 18 gauge wire ties spaced 15" on center		2⅜	1¾	⅞

(Continued)

TABLE NO. 43-A—MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS INCOMBUSTIBLE INSULATING MATERIALS—Continued

STRUCTURAL PARTS TO BE PROTECTED	ITEM NUMBER	INSULATING MATERIAL USED	MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Steel Columns and All Members of Primary Trusses (Cont'd.)	24	Multiple layers of ½″ gypsum wallboard adhesively[4] secured to column flanges and successive layers. Wallboard applied without horizontal joints. Corner edges of each layer staggered. Wallboard layer below outer layer secured to column with doubled No. 18 gauge wire ties spaced 15″ on center. Exposed corners taped and treated			2	1
	25	Three layers of ⅝″ Type "X" gypsum wallboard. First and second layer held in place by ⅛″ diameter by 1⅜″ long ring shank nails with 5/16″ diameter heads spaced 24″ on center at corners. Middle layer also secured with metal straps at mid-height and 18″ from each end, and by metal corner bead at each corner held by the metal straps. Third layer attached to corner bead with 1″ long gypsum wallboard screws spaced 12″ on center			1⅞	
	26	Three layers of ⅝″ Type "X" gypsum wallboard, each layer screw attached to 1⅝″ steel studs (No. 25 gauge) at each corner of column. Middle layer also secured with No. 18 gauge double strand tie wire, 24″ on center. Screws are No. 6 by 1″ spaced 24″ on center for inner layer, No. 6 by 1⅝″ spaced 12″ on center for middle layer and No. 8 by 2¼″ spaced 12″ on center for outer layer		1⅞		

TABLE NO. 43-A—Continued

Webs or Flanges of Steel Beams and Girders	27	Grade A concrete (not including sandstone, granite and siliceous gravel) with 3″ or finer metal mesh placed 1″ from the finished surface anchored to the top flange and providing not less than .025 square inch of steel area per foot in each direction	2	1½	1	1
	28	Grade B concrete and Grade A concrete excluded above with 3″ or finer metal mesh placed 1″ from the finished surface anchored to the top flange and providing not less than .025 square inch of steel area per foot in each direction	2½	2	1½	1
	29	Portland cement plaster on metal lath attached to ¾″ cold-rolled channels with No. 18 gauge wire ties spaced 3″ to 6″ on center. Plaster mixed 1:2½ by volume, cement to sand			2½[3]	⅞
Bonded Tendons in Prestressed Concrete[5]	30	Grade A[6] concrete — Beams or girders	4[7]	3[7]	2½[7]	1½
		Grade A[6] concrete — Solid slabs[8]		2	1½	1
Reinforcing Steel in Reinforced Concrete Columns, Beams, Girders and Trusses	31	Grade A concrete, members 12″ or larger, square or round (Size limit does not apply to beams and girders monolithic with floors)	1½	1½	1½	1½
	32	Grade B concrete, members 12″ or larger, square or round (Size limit does not apply to beams and girders monolithic with floors)	2	1½	1½	1½

(Continued)

TABLE NO. 43-A—Continued

STRUCTURAL PARTS TO BE PROTECTED	ITEM NUMBER	INSULATING MATERIAL USED	MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Reinforcing Steel in Reinforced Concrete Joists[9]	33	Grade A concrete	1¼	1¼	1	¾
	34	Grade B concrete	1¾	1½	1	¾
Reinforcing and Tie Rods in Floor and Roof Slabs[9]	35	Grade A concrete	1	1	¾	¾
	36	Grade B concrete	1¼	1	1	¾

[1]Reentrant parts of protected members to be filled solidly.

[2]Woven wire mesh consists of three-eighths-inch (⅜″) mesh of No. 17 gauge wire.

[3]Two layers of equal thickness with a three-fourths-inch (¾″) air space between.

[4]An approved adhesive qualified under U.B.C. Standard No. 43-1-67.

[5]Cover for end anchorages shall be twice that shown for the respective ratings. Where lightweight Grade A concrete aggregates producing structural concrete having an oven-dried weight of 110 pounds per cubic foot or less are used, the tabulated minimum cover may be reduced 25 per cent.

[6]For Grade B concrete increase tendon cover 20 per cent.

[7]Adequate provisions against spalling shall be provided by U-shaped or hooped stirrups spaced not to exceed the depth of the member with a clear cover of one inch (1″).

[8]Prestressed slabs shall have a thickness not less than that required in Table No. 43-C for the respective fire-resistive time period.

[9]For use with monolithic reinforced concrete slabs having a comparable fire endurance. Thicknesses do not apply to precast construction.

(Continued from page 455)

Protection of Structural Members (Continued)

3. **Bonded prestressed concrete tendons.** For members having a single tendon or more than one tendon installed with equal concrete cover measured from the nearest surface, the cover shall be not less than that set forth in Table No. 43-A.

For members having multiple tendons installed with variable concrete cover, the average tendon cover shall be not less than that set forth in Table No. 43-A provided:

A. The clearance from each tendon to the nearest exposed surface is used to determine the average cover.

B. In no case can the clear cover for individual tendons be less than one-half of that set forth in Table No. 43-A. A minimum cover of three-fourths inch (¾") for slabs and one inch (1") for beams is required for any aggregate concrete.

C. For the purpose of establishing a fire-resistive rating, tendons having a clear cover less than that set forth in Table No. 43-A shall not contribute more than 50 per cent of the required ultimate moment capacity of the member. For structural design purposes, however, tendons having a reduced cover are assumed to be fully effective.

(d) **Fire Protection Omitted.** Fire protection may be omitted from the bottom flange of lintels, spanning not over six feet (6'), shelf angles, or plates that are not a part of the structural frame.

Walls and Partitions

Sec. 4304. (a) **General.** Fire-resistive walls and partitions shall be assumed to have the fire-resistance ratings set forth in Table No. 43-B.

(b) **Combustible Members.** Combustible members framed into a wall shall be protected at their ends by not less than one-half the required fire-resistive thickness of such wall.

(c) **Exterior Walls.** In fire-resistive exterior wall construction the fire-resistive rating shall be maintained for such walls passing through attic areas.

Floor-ceilings or Roof-ceilings

Sec. 4305. (a) **General.** Fire-resistive floor-ceiling or roof-ceiling construction systems shall be assumed to have the fire-resistance ratings set forth in Table No. 43-C.

(b) **Floors.** Fire-resistive floors shall be continuous and all openings for mechanical and electrical equipment shall be enclosed as specified in Chapter 30.

EXCEPTIONS: 1. Occasional pipes, conduits, sleeves and electrical outlets of copper, sheet steel or ferrous construction may be installed within or through fire-resistive floor systems provided such installations do not unduly impair the required fire-resistance of the assembly.

2. The provisions of this Section shall not apply when such openings are in accordance with the results of tests conducted pursuant to the provisions of Section 4302 (b).

(c) **Roofs.** Fire-resistive roofs may have the same openings as permitted for floors and may contain other openings as permitted by this Code. See Chapter 34 for skylight construction.

Floor-ceilings or Roof-ceilings (Continued)

(d) **Unusable Space Above or Below.** In one-hour fire-resistive construction the ceiling may be omitted over unusable space and flooring may be omitted where unusable space occurs above.

Fire-resistive Assemblies for Protection of Openings

Sec. 4306. (a) **General.** Where required by this Code for the fire-protection of openings, fire-resistive assemblies shall meet the requirements of this Chapter. For additional requirements for dual purpose fire exit doors, see Table No. 33-B.

(b) **Definitions. FIRE ASSEMBLY** is the assembly of a fire door, fire window, or fire damper, including all required hardware, anchorage, frames, and sills.

FIRE ASSEMBLY, AUTOMATIC CLOSING, is a fire assembly which may remain in an open position and which will close automatically if subjected to either of the following:

1. An increase in temperature.
2. Products of combustion.

Unless otherwise specified, the closing device shall be one rated at a maximum temperature of 165°F. If products of combustion are being detected to actuate the closing device, the closing device shall operate by the activation of an approved unit-type smoke detector or an approved detection device having an equivalent response to smoke and products of combustion. Unit-type smoke detectors shall conform to the requirements specified in U.B.C. Standard No. 43-6-67.

FIRE ASSEMBLY, SELF-CLOSING, is a fire assembly which is kept in a normally closed position and is equipped with an approved device to insure closing and latching after having been opened for use.

(c) **Identification of Fire Assemblies.** All fire assemblies having fire-protection ratings of three hours, one and one-half hours, one hour, and three-fourths hour shall bear the label or other identification showing the rating thereof. Such label shall be issued by an approved testing agency having a service for the inspection of materials and workmanship at the factory during fabrication and assembly.

> EXCEPTION: A three-fourths-hour labeled fire assembly may be used where a one-hour rating is required provided the door is tested, together with a type of hardware not necessarily specified in this Code, for a period of one hour in accordance with the requirements specified in U.B.C. Standard No. 43-2-67.

(d) **Fire-resistive Tests.** The fire-protection rating of all types of required fire assemblies shall be determined in accordance with the requirements specified in U.B.C. Standards No. 43-2-67 and No. 43-4-67. A minimum transmitted temperature end point shall not be required except for fire-exit doors in stairway enclosures where the temperature shall not exceed 450°F. at the end of 30 minutes of the fire exposure specified in U.B.C. Standard No. 43-2-67.

Fire-resistive Assemblies for Protection of Openings (Continued)

(e) **Hardware.** Every fire assembly required to have a three-hour fire-protection rating shall be of an automatic closing type as specified in Section 4306 (b). Every fire assembly required to have a one and one-half hour, one-hour, or three-fourths-hour fire-protection rating shall be of an automatic or self-closing type as specified in Section 4306 (b).

EXCEPTIONS: 1. Dual purpose fire-exit doors shall have closing devices as set forth in Table No. 33-B.

2. Closing devices may be omitted on three-fourths-hour fire-protection assemblies required as protection for openings in exterior walls by Section 504 and Parts IV and V.

Heat-actuated devices used in automatic fire assemblies shall be installed, one on each side of the wall at the top of the opening and one on each side of the wall at ceiling height where the ceiling is more than three feet (3′) above the opening.

Devices detecting products of combustion shall meet the approval of the Building Official as to installation and location, and shall be subject to such periodic tests as may be required.

(f) **Glazed Openings in Fire Doors.** Glazed openings in fire doors shall not be permitted in a fire assembly required to have a three-hour fire-resistive rating.

The area of glazed openings in a fire door required to have one and one-half hour or one-hour fire-resistive rating shall be limited to one hundred square inches (100 sq. in.) with a minimum dimension of four inches (4″). When both leaves of a pair of doors have observation panels, the total area of the glazed openings shall not exceed one hundred square inches (100 sq. in.) for each leaf.

Glazed openings shall be limited to twelve hundred and ninety-six square inches (1296 sq. in.) in wood and plastic-faced composite or hollow metal doors, per light, when fire-resistive assemblies are required to have a three-fourths-hour fire-resistive rating.

In addition to the general requirements set forth in this Subsection, glazed openings in dual purpose fire-exit doors shall meet the requirements set forth in Table No. 33-B.

(g) **Glazed Openings in Fire Windows.** Windows required to have a three-fourths-hour fire-resistive rating may have an area not greater than eighty-four square feet (84 sq. ft.) with neither width nor height exceeding twelve feet (12′).

(h) **Glazing.** Glazing shall be glass not less than one-fourth inch (¼″) thick and shall be reinforced with wire mesh No. 24 gauge or heavier embedded in the glass with openings not larger than one inch (1″) square. Glass not conforming to these requirements may be used when qualified by tests in accordance with U.B.C. Standard No. 43-2-67 (for doors) or No. 43-4-67 (for windows). Glass shall be held in place by

(Continued on page 491)

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS

MATERIAL	ITEM NUMBER	CONSTRUCTION[1]	MINIMUM FINISHED THICKNESS FACE-TO-FACE[2] (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Brick of Clay or Shale	1	Solid units (at least 75 per cent solid)	8		6[3]	4
	2	Solid units plastered each side with ⅝″ gypsum or portland cement plaster. Portland cement plaster mixed 1:2½ by weight, cement to sand			4¾[4]	
	3	Hollow brick units[5] at least 71 per cent solid		8		
	4	Hollow brick units[5] at least 71 per cent solid, plastered each side with ⅝″ gypsum plaster	8¾			
	5	Hollow (rowlock[6])	12		8	
	6	Hollow (rowlock[6]) plastered each side with ⅝″ gypsum or portland cement plaster. Portland cement plaster mixed 1:2½ by weight, cement to sand	9			
	7	Hollow cavity wall consisting of two 4″ nominal clay brick units with air space between	10			
Hollow Clay Tile, Non-load-bearing (End or Side Construction)	8	One cell in wall thickness, units at least 50 per cent solid, plastered each side with ⅝″ gypsum plaster				4¼
	9	Two cells in wall thickness, units at least 45 per cent solid				6
	10	Two cells in wall thickness, units at least 45 per cent solid. Plastered each side with ⅝″ gypsum plaster			7	
	11	Two cells in wall thickness, units at least 60 per cent solid. Plastered each side with ⅝″ gypsum plaster			5	
	12	Two cells in wall thickness, units at least 40 per cent solid				8

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

Hollow Clay Tile, Load-bearing (End or Side Construction)	13	Two cells in wall thickness, units at least 40 per cent solid. Plastered one side with ⅝″ gypsum plaster			8½	
	14	Two cells in wall thickness, units at least 49 per cent solid			8	
	15	Three cells in wall thickness, units at least 40 per cent solid			12	
	16	Two units and three cells in wall thickness, units at least 40 per cent solid		12		
	17	Two units and four cells in wall thickness, units at least 45 per cent solid	12			
	18	Two units and three cells in wall thickness, units at least 40 per cent solid. Plastered one side with ⅝″ gypsum plaster	12½			
	19	Three cells in wall thickness, units at least 43 per cent solid. Plastered one side with ⅝″ gypsum plaster		8½		
	20	Two cells in wall thickness, units at least 40 per cent solid. Plastered each side with ⅝″ gypsum plaster		9		
	21	Three cells in wall thickness, units at least 43 per cent solid. Plastered each side with ⅝″ gypsum plaster	9			
	22	Three cells in wall thickness, units at least 40 per cent solid. Plastered each side with ⅝″ gypsum plaster	13			
	23	Hollow cavity wall consisting of two 4″ nominal clay tile units (at least 40 per cent solid) with air space between. Plastered one side (exterior) with ¾″ portland cement plaster and other side with ⅝″ gypsum plaster. Portland cement plaster mixed 1:3 by volume, cement to sand	10			
Combination of Clay Brick and Load-bearing Hollow Clay Tile	24	4″ brick and 8″ tile	12			
	25	4″ brick and 4″ tile		8		
	26	4″ brick and 4″ tile plastered on the tile side with ⅝″ gypsum plaster	8½			

(Continued)

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

MATERIAL	ITEM NUMBER	CONSTRUCTION[1]		MINIMUM FINISHED THICKNESS FACE-TO-FACE[2] (In Inches) 4 Hr.	3 Hr.	2 Hr.	1 Hr.
Concrete Masonry Units[7]	27	Expanded slag or pumice		4.7	4.0	3.2	2.1
	28	Expanded clay or shale		5.7	4.8	3.8	2.6
	29	Limestone, cinders or air cooled slag		5.9	5.0	4.0	2.7
	30	Calcareous gravel		6.2	5.3	4.2	2.8
Solid Concrete	31	Horizontal reinforcement not less than 0.25 per cent and vertical reinforcement not less than 0.15 per cent. (Three-fourths as much for welded wire fabric)	Grade A Concrete	6½	6	5	3½
			Grade B Concrete	7½	6½	5½	4[4]
Hollow Gypsum Tile	32	3″ tile not less than 70 per cent solid					3[4]
	33	3″ tile plastered one side with ⅝″ gypsum plaster				3⅝[4]	
	34	4″ tile plastered one side with ½″ gypsum plaster			4½[4]		
	35	3″ tile plastered both sides with ½″ gypsum plaster			4[4]		
	36	4″ tile plastered both sides with ½″ gypsum plaster		5[4]			
Glazed or Unglazed Facing Tile, Nonload-bearing	37	One 2″ unit cored 15 per cent maximum and one 4″ unit cored 25 per cent maximum with ¾″ mortar filled collar joint. Unit positions reversed in alternate courses			6⅜		
	38	One 2″ unit cored 15 per cent maximum and one 4″ unit cored 40 per cent maximum with ⅜″ mortar filled collar joint. Plastered one side with ¾″ gypsum plaster. Two wythes tied together every fourth course with No. 22 gauge corrugated metal ties			6¾		

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

Glazed or Unglazed Facing Tile, Nonload-bearing (Cont'd.)	39	One unit with three cells in wall thickness, cored 29 per cent maximum			6	
	40	One 2″ unit cored 22 per cent maximum and one 4″ unit cored 41 per cent maximum with ¼″ mortar filled collar joint. Two wythes tied together every third course with No. 22 gauge corrugated metal ties			6	
	41	One 4″ unit cored 25 per cent maximum with ¾″ gypsum plaster on one side			4¾	
	42	One 4″ unit with two cells in wall thickness, cored 22 per cent maximum				4
	43	One 4″ unit cored 30 per cent maximum with ¾″ vermiculite gypsum plaster on one side			4½	
	44	One 4″ unit cored 39 per cent maximum with ¾″ gypsum plaster on one side				4½
Solid Gypsum Plaster	45	¾″ by No. 16 gauge vertical cold-rolled channels, 16″ on center with 2.5-pound flat metal lath applied to one face and tied with No. 18 gauge wire at 6″ spacing. Gypsum plaster each side mixed 1:2 by weight, gypsum to sand aggregate				2[4]
	46	Studless with ½″ full-length plain gypsum lath and gypsum plaster each side. Plaster mixed 1:1 for scratch coat and 1:2 for brown coat, by weight, gypsum to sand aggregate				2[4]
	47	¾″ by No. 16 gauge cold-rolled channels 16″ on center with metal lath applied to one face and tied with No. 18 gauge wire at 6″ spacing. Perlite or vermiculite gypsum plaster each side. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2½ cubic feet of aggregate for the one-hour system			2½[4]	2[4]

(Continued)

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

MATERIAL	ITEM NUMBER	CONSTRUCTION[1]	MINIMUM FINISHED THICKNESS FACE-TO-FACE[2] (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Solid Gypsum Plaster (Cont'd.)	48	Studless with ½" full-length plain gypsum lath and perlite or vermiculite gypsum plaster each side			2½[4]	2[4]
	49	Studless partition with ⅜" rib metal lath installed vertically, adjacent edges tied 6" on center with No. 18 gauge wire ties, gypsum plaster each side mixed 1:2 by weight, gypsum to sand aggregate				2[4]
Solid Perlite and Portland Cement	50	Perlite mixed in the ratio of 3 cubic feet to 100 pounds of portland cement and machine applied to stud side of 1½" mesh by No. 17 gauge paperbacked woven wire lath nailed to 4" deep steel trussed wire[8] studs 16" on center with 1" long by No. 11 gauge by 7/16" head annular ring shank nails			3⅛[4]	
Solid Neat Wood Fibered Gypsum Plaster	51	¾" by No. 16 gauge cold-rolled channels, 12" on center with 2.5-pound flat metal lath applied to one face and tied with No. 18 gauge wire at 6" spacing. Neat gypsum plaster applied each side			2[4]	
Solid Gypsum Wallboard Partition	52	One full-length layer ½" Type "X" gypsum wallboard laminated to each side of 1" full length V-edge gypsum coreboard with approved laminating compound. Vertical joints of face layer and coreboard staggered at least 3"			2[4]	
	53	One full-length layer of ½" gypsum wallboard laminated to each side of 1" full length interlocking factory laminated gypsum coreboard with approved laminating compound. Vertical joints of face layer and coreboard staggered			2[4]	

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

Hollow (Studless) Gypsum Wallboard Partition	54	One full-length layer of ⅝" Type "X" gypsum wallboard attached to both sides of wood or metal top and bottom runners laminated to each side of 1" x 6" full-length gypsum coreboard ribs spaced 24" on center with approved laminating compound. Ribs centered at vertical joints of face plies and joints staggered 24" in opposing faces. Ribs may be recessed 6" from the top and bottom				2¼[4]
	55	1" regular gypsum "V" edge full-length backing board attached to both sides of wood or metal top and bottom runners with nails or 1⅝" drywall screws at 24" on center. Minimum width of runners 1⅝". Face layer of ½" regular full-length gypsum wallboard laminated to outer faces of backing board with approved laminating compound			4⅝[4]	
Incombustible Studs —Interior Partition with Plaster Each Side	56	3¼" by No. 18 gauge steel studs spaced 24" on center. ⅝" gypsum plaster on metal lath each side mixed 1:2 by weight, gypsum to sand aggregate				4¾[4]
	57	3⅝" No. 16 gauge approved nailable[9] studs spaced 24" on center. ⅝" neat gypsum wood fibered plaster each side over ⅜" rib metal lath nailed to studs with 6d common nails, 8" on center. Nails driven 1¼" and bent over			5⅝	
	58	2½" steel studs 16" on center formed with No. 16 gauge angle flanges and No. 7 gauge wire diagonals. ⅜" perforated gypsum lath attached to the studs each side with No. 12 gauge wire clips at horizontal and vertical joints. ½" gypsum plaster applied each side mixed 1:2 by weight, gypsum to sand aggregate				4¼[4]
	59	2½" steel studs 16" on center formed with No. 16 gauge angle flanges and No. 7 gauge wire diagonals. ⅜" perforated gypsum lath attached to the studs each side with No. 12 gauge approved steel wire clips. End joints of lath held by approved end joint clips. ¾" perlite or vermiculite gypsum plaster applied each side			4¾[4]	

(Continued)

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

MATERIAL	ITEM NUMBER	CONSTRUCTION[1]	MINIMUM FINISHED THICKNESS FACE-TO-FACE[2] (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Incombustible Studs —Interior Partition with Plaster Each Side (Cont'd.)	60	4″ No. 18 gauge channel-shaped steel studs at 16″ on center. On each side approved resilient clips pressed onto stud flange at 16″ vertical spacing, ¼″ pencil rods snapped into or wire-tied onto outer loop of clips, metal lath wire-tied to pencil rods at 6″ intervals, 1″ perlite gypsum plaster, each side		7⅝[4]		
Wood Studs Interior Partition with Plaster Each Side	61	2″ x 4″ wood studs 16″ on center with ⅝″ gypsum plaster on metal lath. Lath attached by 4d common nails bent over or No. 14 gauge by 1¼″ x ¾″ crown width staples spaced 6″ on center. Plaster mixed 1:1½ for scratch coat and 1:3 for brown coat, by weight, gypsum to sand aggregate				5¼
	62	2″ x 4″ wood studs 16″ on center with metal lath and ⅞″ neat wood fibered gypsum plaster each side. Lath attached by 6d common nails, 7″ on center. Nails driven 1¼″ and bent over			5⅝[4]	
	63	2″ x 4″ wood studs 16″ on center with ⅜″ perforated or plain gypsum lath and ½″ gypsum plaster each side. Lath nailed with 1⅛″ by No. 13 gauge by $\frac{19}{64}$″ head plasterboard blued nails, 4″ on center. Plaster mixed 1:2 by weight, gypsum to sand aggregate				5⅜
	64	2″ x 4″ wood studs 16″ on center with ⅜″ Type "X" gypsum lath and ½″ gypsum plaster each side. Lath nailed with 1⅛″ by No. 13 gauge by $\frac{19}{64}$″ head plasterboard blued nails, 5″ on center. Plaster mixed 1:2 by weight, gypsum to sand aggregate				5⅜

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

Wood Studs Interior Partition with Plaster Each Side (Cont'd.)	65	2" x 4" wood studs 16" on center with ⅜" plain gypsum lath and ½" neat wood-fibered gypsum plaster each side. Lath nailed with 4d common wire nails, 5" on center				5⅜
	66	2" x 4" wood studs 16" on center with ⅜" perforated gypsum lath and ½" perlite or vermiculite gypsum plaster each side. Lath nailed with 1⅛" by No. 13 gauge by 19/64" head plasterboard blued nails, 5" on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2½ cubic feet of aggregate				5⅜
	67	2" x 4" wood studs 16" on center with ⅜" perforated gypsum lath with 1" hexagonal mesh of No. 20 gauge wire furred out 5/16" and 1" perlite or vermiculite gypsum plaster each side. Lath nailed with 1⅛" by No. 13 gauge by 19/64" head plasterboard blued nails spaced 5" on center. Mesh attached by 1¾" by No. 12 gauge by ⅜" head nails with ⅜" furrings, spaced 8" on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2½ cubic feet of aggregate			6⅜	
Incombustible Studs —Interior Partition with Gypsum Wallboard Each Side	68	No. 25 gauge channel-shaped studs 16"[12] on center with one full-length layer of ⅝" Type "X" gypsum wallboard applied vertically attached with 1" long No. 6 drywall screws to each side. Screws are 8" on center around the perimeter and 12" on center on the intermediate stud				4⅞[4]
	69	No. 25 gauge channel-shaped studs 24" on center with two full-length layers of ⅝" Type "X" gypsum wallboard applied vertically each side. First layer attached with 1" long, No. 6 drywall screws, 8" on center around the perimeter and 12" on center on the intermediate stud. Second layer applied with vertical joints offset one stud space from first layer using an approved adhesive.			6⅛[4]	

(Continued)

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

MATERIAL	ITEM NUMBER	CONSTRUCTION[1]	MINIMUM FINISHED THICKNESS FACE-TO-FACE[2] (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Incombustible Studs—Interior Partition with Gypsum Wallboard Each Side (Cont'd.)	70	No. 25 gauge channel-shaped studs 24″ on center with two full-length layers of ½″ Type "X" gypsum wallboard applied vertically each side. First layer attached with 1″ long, No. 6 drywall screws, 8″ on center around the perimeter and 12″ on center on the intermediate stud. Second layer applied with vertical joints offset one stud space from first layer using 1⅝″ long, No. 6 drywall screws spaced 9″ on center along vertical joints, 12″ on center at intermediate studs and 24″ on center along top and bottom runners			3⅝[4]	
	71	No. 16 gauge approved nailable metal studs[9] 16″[12] on center with full-length ⅝″ Type "X" gypsum wallboard applied vertically and nailed 7″ on center with 6d cooler nails. Approved metal fastener grips used with nails at vertical butt joints along studs				4⅞
Wood Studs—Interior Partition with Gypsum Wallboard Each Side	72	2″ x 4″ wood studs 16″ on center with two layers ⅜″ regular gypsum wallboard each side, 4d cooler nails 8″ on center first layer, 5d cooler nails 8″ on center second layer with laminating compound between layers. Joints staggered. First layer applied full length vertically, second layer applied horizontally or vertically				5⅛

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

Wood Studs—Interior Partition with Gypsum Wallboard Each Side (Cont'd.)	73	2" x 4" wood studs 16" on center with space between filled with mineral wool batts[10] nailed to studs and full-length ½" regular gypsum wallboard applied vertically nailed with 5d cooler nails spaced 7" on center				4⅝
	74	2" x 4" wood studs 16" on center with two layers ½" regular gypsum wallboard applied vertically or horizontally each side, joints staggered. Nail base layer with 5d cooler nails at 8" on center, face layer with 8d cooler nails at 8" on center				5⅝
	75	2" x 4" wood studs 16" on center with ⅝" Type "X" gypsum wallboard applied vertically or horizontally nailed with 6d cooler nails 7" on center with end joints on nailing members				4⅞
	76	2" x 4" fire-retardant treated wood studs spaced 16"[12] on center with one layer of ⅝" thick Type "X" gypsum wallboard applied with face paper grain (long dimension) parallel to studs. Wallboard attached with 6d cooler nails spaced 7" on center				4⅞[4]
	77	2" x 4" wood studs 16" on center with two layers ⅝" Type "X" gypsum wallboard each side. Base layers applied vertically and nailed with 6d cooler nails 9" on center. Face layer applied vertically or horizontally and nailed with 8d cooler nails 7" on center. For nail-adhesive application, base layers are nailed 6" on center. Face layers applied with coating of approved wallboard adhesive and nailed 12" on center			6⅛	

(Continued)

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

MATERIAL	ITEM NUMBER	CONSTRUCTION[1]	MINIMUM FINISHED THICKNESS FACE-TO-FACE[2] (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.
Exterior or Interior Walls	78	¾″ drop siding or ⅜″ exterior type plywood over ½″ gypsum sheathing on 2″ x 4″ wood studs at 16″ on center on exterior surface with interior surface treatment as required for one-hour rated extension or interior 2″ x 4″ wood stud partitions. Gypsum sheathing nailed with 1¾″ by No. 11 gauge by 7/16″ head galvanized nails at 8″ on center. Siding nailed with 7d galvanized smooth box nails. Plywood nailed with 6d galvanized siding or casing nails, 6″ on center around the perimeter and 12″ on center elsewhere				Varies
	79	2″ x 4″ wood studs 16″ on center with metal lath and ¾″ exterior cement plaster[11] on each side. Lath attached with 6d common nails 7″ on center driven to 1″ minimum penetration and bent over. Plaster mix 1:2 scratch coat and 1:3 brown coat, by weight, cement to sand				5½
	80	2″ x 4″ wood studs 16″ on center with ⅞″ exterior cement plaster (measured from the face of studs) on the exterior surface with interior surface treatment as required for interior wood stud partitions in this Table. Plaster mix 1:2 scratch coat and 1:3 brown coat, by weight, cement to sand				Varies
	81	3⅝″ No. 16 gauge incombustible studs 16″ on center with ⅞″ exterior cement plaster (measured from the face of the studs) on the exterior surface with interior surface treatment as required for interior, nonbearing, incombustible stud partitions in this Table. Plaster mix 1:2 for scratch coat and 1:3 for brown coat, by weight, cement to sand				Varies[4]

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued

Exterior or Interior Walls (Cont'd.)	82	2¼" x 3¾" clay face brick with cored holes over ½" gypsum sheathing on exterior surface of 2" x 4" wood studs at 16" on center and two layers ⅝" Type "X" gypsum wallboard on interior surface. Sheathing placed horizontally or vertically with vertical joints over studs nailed 6" on center with 1¾" by No. 11 gauge by 7/16" head galvanized nails. Inner layer of wallboard placed horizontally or vertically and nailed 8" on center with 6d cooler nails. Outer layer of wallboard placed horizontally or vertically and nailed 8" on center with 8d cooler nails. All joints staggered with vertical joints over studs. Outer layer joints taped and finished with compound. Nailheads covered with joint compound. No. 20 gauge corrugated galvanized steel wall ties ¾" x 6⅝" attached to each stud with two 8d cooler nails, every sixth course of bricks			10⅛	

[1]Staples with equivalent holding power and penetration may be used as alternate fasteners to nails for attachment to wood framing.

[2]Thicknesses shown for brick and clay tile are nominal thicknesses unless plastered, in which case thicknesses are net. Thicknesses shown for concrete masonry units are "equivalent thicknesses" as defined in U.B.C. Standard No. 24-4-67. Thickness includes plaster, lath and gypsum wallboard where mentioned. Plaster thickness is measured from face of lath or other plaster base unless otherwise stated.

[3]Single wythe brick.

[4]Shall be used for nonbearing purposes only.

[5]Hollow brick units four-inch by eight-inch by twelve-inch (4" x 8" x 12") nominal with two interior cells having a one and one-half-inch (1½") web thickness between cells and one and three-fourths-inch (1¾") thick face shells.

[6]Rowlock design employs clay brick with all or part of bricks laid on edge with the bond broken vertically.

[7]See also Footnote No. 2. The equivalent thickness may include the thickness of gypsum or portland cement plaster applied in accordance with the requirements of Chapter 47 of the Code.

[8]Studs are doubled trussed wire studs each with No. 3 gauge flange wires and No. 11 gauge truss wires, welded together.

[9]Nailable metal studs consist of two channel studs spot welded back-to-back with a crimped web forming a nailing groove.

[10]Mineral or slag wool batts shall weigh not less than 1 pound and glass wool batts not less than .6 pound per square foot of wall surface.

[11]Three pounds of asbestos fiber added for each bag of portland cement.

[12]Stud spacing has been limited to sixteen inches (16") on center to correspond with the limits set forth in Table No. 47-G. The fire test specimen qualified at a twenty-four inch (24") stud spacing. In the case of item No. 76, the gypsum wallboard was applied horizontally when studs were twenty-four inches (24") on center.

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]

FLOOR OR ROOF CONSTRUCTION	ITEM NUMBER	CEILING CONSTRUCTION	THICKNESS OF FLOOR OR ROOF SLAB (In Inches)				MINIMUM THICKNESS OF CEILING (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.	4 Hr.	3 Hr.	2 Hr.	1 Hr.
Concrete - Excluding Expanded Clay Shale or Slate (by Rotary Kiln Process) or Expanded Slag	1	Slab (no ceiling required)	6½	5½	4½	3½[2]				
Concrete-Expanded Clay Shale or Slate (by Rotary Kiln Process) or Expanded Slag	2	Slab (no ceiling required)	5	4½	4	3				
Reinforced Concrete Joists	3	Slab with suspended ceiling of vermiculite gypsum plaster over metal lath attached to ¾" cold-rolled channels spaced 12" on center. Ceiling located 6" minimum below joists	3	2			1	¾		

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

	4	Gypsum plaster on metal lath attached to the bottom chord with single No. 16 gauge or doubled No. 18 gauge wire ties spaced 6″ on center. Plaster mixed 1:2 for scratch coat, 1:3 for brown coat, by weight, gypsum to sand aggregate for two-hour system. For three-hour system plaster is neat		2½	2¼			¾	⅝	
Steel Joist Construction with a Reinforced Concrete Slab on Top Poured on a Metal Lath Form[3]	5	Vermiculite gypsum plaster on metal lath attached to the bottom chord with single No. 16 gauge or doubled No. 18 gauge wire ties 6″ on center		2				⅝		
	6	Portland cement plaster over metal lath attached to the bottom chord of joists with single No. 16 gauge or doubled No. 18 gauge wire ties spaced 6″ on center. Plaster mixed 1:2 for scratch coat, 1:3 for brown coat for one-hour system and 1:1 for scratch coat, 1:1½ for brown coat for two-hour system, by weight, cement to sand			2¼	2			⅝[4]	⅝[5]

(Continued)

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

FLOOR OR ROOF CONSTRUCTION	ITEM NUMBER	CEILING CONSTRUCTION	THICKNESS OF FLOOR OR ROOF SLAB (In Inches)				MINIMUM THICKNESS OF CEILING (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.	4 Hr.	3 Hr.	2 Hr.	1 Hr.
Steel Joist Construction with a Reinforced Concrete Slab on Top Poured on a Metal Lath Form[3] (Cont'd.)	7	Perlite or vermiculite gypsum plaster on ⅜" perforated gypsum lath attached to ¾" cold-rolled channels with approved clips giving continuous support to lath. Channels attached to or suspended below joists and held to bottom chord of joists	2	2	2	2	1⅜[6,8]	⅞[6] 1[7,8]	⅞[7]	1
	8	Gypsum plaster on ⅜" perforated gypsum lath attached to ¾" cold-rolled channels, with approved clips giving continuous support to lath. Channels attached to or suspended below joists and wire tied to bottom chord of joists			2				1[8]	
	9	⅝" Type "X" gypsum wallboard attached to approved nailing channels 16" on center with 1¼" by No. 11 gauge by $\frac{5}{16}$" head nails with annular								

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

Steel Joist Construction with a Reinforced Concrete Slab on Top Poured on a Metal Lath Form[3] (Cont'd.)	9	ring shanks spaced 7″ on center. Double channels at end joints. Channels attached to bottom chord of joists with doubled No. 18 gauge wire ties or suspended below joists on wire hangers				2				⅝
	10	Ceiling of ⅝″ Type "X" wallboard attached to ⅞″ deep by 2⅝″ by No. 25 gauge hat-shaped furring channels 12″ on center with 1″ long No. 6 wallboard screws at 8″ on center. Channels wire tied to bottom chord of joists with doubled No. 18 gauge wire or suspended below joists on wire hangers			2½				⅝	
Reinforced Gypsum Concrete Slab Poured on ½″ Gypsum Formboard Supported on Unprotected Steel Bulb Tees, 32⅝″ on Center, Supported on Individually Protected Steel Beams[9]	11	None			2½	2				

(Continued)

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

FLOOR OR ROOF CONSTRUCTION	ITEM NUMBER	CEILING CONSTRUCTION	THICKNESS OF FLOOR OR ROOF SLAB (In Inches)				MINIMUM THICKNESS OF CEILING (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.	4 Hr.	3 Hr.	2 Hr.	1 Hr.
Reinforced Concrete Slab and Joists with Hollow Clay Tile Fillers Laid End to End in Rows 2½″ or More Apart; Reinforcement Placed Between Rows and Concrete Cast Around and Over Tile	12	⅝″ gypsum plaster on bottom of floor or roof construction			8[10]				⅝	
	13	None				5½[11]				
Steel Joist Construction with a Reinforced Concrete Slab on Top poured on a ½″ deep Steel Deck	14	Vermiculite gypsum plaster on metal lath attached to ¾″ cold-rolled channels with No. 18 gauge wire ties spaced 6″ on center.	2½[12]				¾			
3″ Deep Cellular Steel Deck with Concrete Slab on Top. Slab Thickness Measured to Top of Cells	15	Perlite or vermiculite gypsum plaster on ⅜″ perforated gypsum lath attached to ¾″ cold-rolled channels with approved clips. Channels suspended by No. 8 gauge hanger wire through units between cells		2½				⅞[7,8]		

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

3″ Deep Cellular Steel Deck with Concrete Slab on Top. Slab Thickness Measured to Top of Cells (Cont'd.)	16	Suspended ceiling of vermiculite gypsum plaster base coat and vermiculite acoustical plastic on metal lath attached at 6″ intervals to ¾″ cold-rolled channels spaced 12″ on center and secured to 1½″ cold-rolled channels spaced 36″ on center with No. 16 gauge wire. 1½″ channels supported by No. 8 gauge wire hangers at 36″ on center. Beams within envelope and with a 2½″ air space between beam soffit and lath have a 4-hour rating	2½				1⅛[13]			
1½″ Deep Steel Roof Deck on Steel Framing. Insulation Board, 30 lbs. per Cubic Foot Density, Composed of Wood Fibers with Cement Binders of Thickness Shown Bonded to Deck with Unfinished Asphalt Adhesive. Covered with a Fire-retardant Roof Covering	17	Ceiling of gypsum plaster on metal lath. Lath attached to ¾″ furring channels with No. 18 gauge wire ties spaced 6″ on center. ¾″ channel saddle-tied to 2″ channels with doubled No. 16 gauge wire ties. 2″ channels spaced 36″ on center suspended 2″ below steel framing and saddle-tied with No. 8 gauge wire. Plaster mixed 1:2 by weight, gypsum to sand aggregate			1⅞	1			¾[8]	¾[8]

(Continued)

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

FLOOR OR ROOF CONSTRUCTION	ITEM NUMBER	CEILING CONSTRUCTION	THICKNESS OF FLOOR OR ROOF SLAB (In Inches)				MINIMUM THICKNESS OF CEILING (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.	4 Hr.	3 Hr.	2 Hr.	1 Hr.
1½" Deep Steel Roof Deck on Steel Framing Wood Fiber Insulation Board, 17.5 lbs., per Cubic Foot Density on Top Applied Over a 15-lb. Asphalt Saturated Felt. Fire-retardant Roof Covering	18	Ceiling of gypsum plaster on metal lath. Lath attached to ¾" furring channels with No. 18 gauge wire ties spaced 6" on center. ¾" channels saddle-tied to 2" channels with doubled No. 16 gauge wire ties. 2" channels spaced 36" on center suspended 2" below steel framing and saddle-tied with No. 8 gauge wire. Plaster mixed 1:2 for scratch coat and 1:3 for brown coat, by weight, gypsum to sand aggregate for one-hour system. For two-hour system plaster mix is 1:2 by weight, gypsum to sand aggregate			1½	1			⅞[8]	¾[8]

1½″ Deep Steel Roof Deck on Steel Framing Insulation of Rigid Board Consisting of Expanded Perlite and Fibers Impregnated With Integral Asphalt Waterproofing; Density 9 to 12 Lbs./Cu. Ft. Secured to Metal Roof Deck by ½″ Wide Ribbons of Waterproof, Cold-process Liquid Adhesive Spaced 6″ Apart. Steel Joist or Light Steel Construction with Metal Roof Deck, Insulation, and Built-up Fire-retardant Roof Covering	19	Gypsum-vermiculite plaster on metal lath wire-tied at 6″ intervals to ¾″ furring channels spaced 12″ on center and wire-tied to 2″ runner channels spaced 32″ on center. Runners wire-tied to bottom chord of steel joists.			1				⅞	
Double Wood Floor Over Wood Joists [14]	20	Gypsum plaster over ⅜″ perforated gypsum lath attached to joists with 1⅛″ by No. 13 gauge by $\frac{19}{64}$″ head plasterboard blued nails at a spacing of 4″ on center. All joints reinforced with 3″ wide strips of metal lath nailed through gypsum lath to joists with 1¾″ by No. 11 gauge by ½″ head nails spaced 5″ on center along joists and with two nails per joist in the opposite direction. Plaster mixed 1:2 by weight, gypsum to sand aggregate								⅞

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

FLOOR OR ROOF CONSTRUCTION	ITEM NUMBER	CEILING CONSTRUCTION	THICKNESS OF FLOOR OR ROOF SLAB (In Inches)				MINIMUM THICKNESS OF CEILING (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.	4 Hr.	3 Hr.	2 Hr.	1 Hr.
Double Wood Floor Over Wood Joists[14] (Cont'd.)	21	Perlite or vermiculite plaster over ⅜″ perforated gypsum lath nailed with 1⅛″ by No. 13 gauge by $\frac{19}{64}$″ head plasterboard blued nails								⅞
	22	Gypsum plaster over ⅜″ Type "X" gypsum lath. Lath initially applied with not less than four 1⅛″ by No. 13 gauge by $\frac{19}{64}$″ head plasterboard blued nails per bearing. Continuous stripping over lath along all joist lines. Stripping consists of 3″ wide strips of metal lath attached by 1½″ by No. 11 gauge by ½″ head roofing nails spaced 6″ on center. Alternate stripping consists of 3″ wide .049″ diameter wire stripping weighing one pound per sq. yd. and attached by No. 16 gauge by 1½″ by ¾″ crown width staples, spaced 4″ on center. Where alternate stripping is used the								⅞

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

Double Wood Floor Over Wood Joists[14] (Cont'd.)	22	lath nailing may consist of two nails at each end and one nail at each intermediate bearing. Plaster mixed 1:2 by weight, gypsum to sand aggregate								
	23	Portland cement or gypsum plaster on metal lath. Lath fastened with 1½" by No. 11 gauge by 7/16" head barbed shank roofing nails spaced 5" on center. Plaster mixed 1:2 for scratch coat and 1:3 for brown coat, by weight, cement to sand aggregate								⅝
	24	Perlite or vermiculite gypsum plaster on metal lath secured to joists with 1½" by No. 11 gauge by 7/16" head barbed shank roofing nails spaced 5" on center								⅝
	25	⅝" Type "X" gypsum wallboard nailed to joists with 6d cooler nails spaced 6" on center. End joints of wallboard centered on joists. Joists spaced 16" maximum on center								⅝

(Continued)

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

FLOOR OR ROOF CONSTRUCTION	ITEM NUMBER	CEILING CONSTRUCTION	THICKNESS OF FLOOR OR ROOF SLAB (In Inches)				MINIMUM THICKNESS OF CEILING (In Inches)			
			4 Hr.	3 Hr.	2 Hr.	1 Hr.	4 Hr.	3 Hr.	2 Hr.	1 Hr.
Plywood Stressed Skin Panels Consisting of ⅝" Thick Interior C-D (Exterior Glue) Top Stressed Skin on 2" x 6" Nominal (Minimum) Stringers. Adjacent Panel Edges Joined with 8d Common Wire Nails Spaced 6" on Center. Stringers Spaced 12" Maximum on Center.	26	½" thick wood fiberboard weighing 15 to 18 lbs. per cu. ft. installed with long dimension parallel to stringers using 5d cooler nails spaced 12" on center. Second layer of ⅝" Type "X" gypsum wallboard applied with long dimension perpendicular to joists and attached with 8d cooler nails spaced 6" on center at end joints and 8" on center elsewhere. Wallboard joints staggered with respect to fiberboard joints								1
Vermiculite Concrete Slab Proportioned 1:4 (Portland Cement to Vermiculite Aggregate) on a 1½" Deep Steel Deck Supported on Individually Protected Steel Framing. Slab Reinforced with 4" x 8" No. 12/14 Welded Wire Mesh	27	None				3[12]				

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[1]—Continued

Perlite Concrete Slab Proportioned 1:6 (Portland Cement to Perlite Aggregate) on a 1¼" Deep Steel Deck Supported on Individually Protected Steel Framing. Slab Reinforced with 4" x 8" No. 12/14 Welded Wire Mesh	28	None				3½[12]				
Perlite Concrete Slab Proportioned 1:6 (Portland Cement to Perlite Aggregate) on a 9/16" Deep Steel Deck Supported by Steel Joists 4' on Center. Fire-retardant Roof Covering on Top	29	Perlite gypsum plaster on metal lath wire tied to ¾" furring channels attached with No. 16 gauge wire ties to lower chord of joists		2[15]	2[15]			⅞	¾	
Floor and Beam Construction Consisting of 3" Deep Cellular Steel Floor Units Mounted on Steel Members with 1:4 (Proportion of Portland Cement to Perlite Aggregate) Perlite-Concrete Floor Slab on Top	30	Suspended envelope ceiling of perlite gypsum plaster on metal lath attached to ¾" cold-rolled channels, secured to 1½" cold-rolled channels spaced 42" on center supported by No. 6 wire 36" on center. Beams in envelope with 3" minimum air space between beam soffit and lath have a 4-hour rating	2[15]				1[8]			

(Continued)

FOOTNOTES TO TABLE NO. 43-C

[1]Staples with equivalent holding power and penetration may be used as alternate fasteners to nails for attachment to wood framing.

[2]The thickness may be reduced to three inches (3") where limestone aggregate is used.

[3]Slab thickness over steel joists measured at the joists.

[4]Portland cement plaster with 40 pounds of asbestos fiber per bag of cement.

[5]Portland cement plaster with 15 pounds of hydrated lime and three pounds of asbestos fiber per bag of cement.

[6]One inch (1") by No. 20 gauge hexagonal wire mesh installed below lath and tied to each furring channel at joints between lath.

[7]No. 14 gauge wires spaced eleven and three-tenths inches (11.3") on center or ten inches (10") on center [for channel spacing of sixteen inches (16") and twelve inches (12") respectively] installed below lath sheets in a diagonal pattern. Wires tied to furring channels or clips at lath edges.

[8]Furring channels spaced twelve inches (12") on center.

[9]Allowable working stress for bulb tees to be based upon a factor of safety of four applied to the yield point for negative bending and six and five-tenths applied to the yield point for positive bending.

[10]Six-inch (6") hollow clay tile with two-inch (2") concrete slab above.

[11]Four-inch (4") hollow clay tile with one and one-half-inch (1½") concrete slab above.

[12]Thickness measured to bottom of steel form units.

[13]Five-eighths inch (⅝") of vermiculite gypsum plaster plus one-half inch (½") of approved vermiculite acoustical plastic.

[14]Double wood floor may be either of the following [see also Section 4305 (d) for conditions where flooring or ceiling may be omitted]:

(a) Subfloor of one-inch (1") nominal boarding, a layer of asbestos paper weighing not less than 14 pounds per one hundred square feet (100 sq. ft.) and a layer of one-inch (1") nominal tongue and groove finish flooring; or

(b) Subfloor of one-inch (1") nominal tongue and groove boarding or one-half-inch (½") interior type plywood with exterior glue, a layer of .010-inch thick rosin sized building paper and a layer of one-inch (1") nominal tongue and groove finish flooring or five-eighths-inch (⅝") interior type tongue and groove plywood finish flooring.

[15]Thickness measured to top of steel deck unit.

(Continued from page 465)

steel glazing angles except that in casement windows wire clips may be used.

Fire-Resistive Assemblies for Protection of Openings (Continued)

(i) **Tin-clad Doors.** If constructed as specified in U.B.C. Standard No. 43-3-67, tin-clad fire doors installed on each side of openings requiring protection shall be considered as providing a fire assembly having a three-hour fire-protection rating provided each door bears the label of an approved testing agency showing the classification thereof.

(j) **Installation.** A fire assembly shall be installed as specified in U.B.C. Standard No. 43-5-67.

(k) **Signs.** A sign shall be displayed permanently near or on each required fire door in letters not less than one inch (1") high to read as follows:

FIRE DOOR
DO NOT OBSTRUCT

Roof Coverings

Sec. 4307. Fire-retardant roof coverings shall be as specified in Section 3203.

PART IX

REGULATIONS FOR USE OF PUBLIC STREETS AND PROJECTIONS OVER PUBLIC PROPERTY

CHAPTER 44—PROTECTION OF PEDESTRIANS DURING CONSTRUCTION OR DEMOLITION

General

Sec. 4401. No person shall use or occupy a street, alley, or public sidewalk for the performance of work under a building permit except in accordance with the provisions of this Chapter.

No person shall perform any work on any building or structure adjacent to a public way in general use by the public for pedestrian travel, unless the pedestrians are protected as specified in this Chapter.

Any material or structure temporarily occupying public property, including fences and walkways, shall be adequately lighted between sunset and sunrise.

Temporary Use of Streets and Alleys

Sec. 4402. The use of public property shall meet the requirements of the public agency having jurisdiction. Whenever requested, plot plans and construction details shall be submitted for review by the agencies concerned.

Storage on Public Property

Sec. 4403. Material and equipment necessary for work to be done under a permit shall not be placed or stored on public property so as to obstruct free and convenient approach to and use of any fire hydrant, fire or police alarm box, utility box, catch basin, or manhole or so as to interfere with the free flow of water in any street or alley gutter.

Mixing Mortar on Public Property

Sec. 4404. The mixing or handling of mortar, concrete or other material on public property shall be done in a manner that will not deface public property or create a nuisance.

Protection of Utilities

Sec. 4405. A substantial protective frame and boarding shall be built around and over every street lamp, utility box, fire or police alarm box, fire hydrant, catch basin, and manhole that may be damaged by any work being done under the permit. This protection shall be maintained while such work is being done and shall not obstruct the normal functioning of the device.

Walkway

Sec. 4406. A walkway not less than four feet (4′) wide shall be maintained on the sidewalk in front of the building site during construction, alteration or demolition unless the public agency having jurisdiction authorizes the sidewalk to be fenced and closed. Adequate signs and railings shall be provided to direct pedestrian traffic. Railings shall be provided when required by Section 4407.

Walkway (Continued)

The walkway shall be capable of supporting a uniform live load of 150 pounds per square foot. A durable wearing surface shall be provided.

Pedestrian Protection

Sec. 4407. (a) **Protection Required.** Pedestrian traffic shall be protected by a railing on the street side when the walkway extends into the roadway, by a railing adjacent to excavations and by such other protection as set forth in Table No. 44-A. The construction of such protective devices shall be in accordance with the provisions of this Chapter.

(b) **Railings.** Railings shall be substantially built and when of wood shall be constructed of new material having a nominal size of at least two inches by four inches (2" x 4"). Railings shall be at least three feet six inches (3'6") in height and when adjacent to excavations shall be provided with a midrail.

(c) **Fences.** Fences shall be solid and substantially built, be not less than eight feet (8') in height above grade, and be placed on the side of the walkway nearest to the building site. Fences shall extend the entire length of the building site and each end shall be returned to the building line.

Openings in such fences shall be protected by doors which normally are kept closed.

All fences shall be provided with a two-inch by four-inch (2" x 4") plate, top and bottom, and shall be well braced. The fence material shall be a minimum of three-fourths-inch (¾") boards or one-fourth-inch (¼") plywood. Plywood fences shall conform to the following requirements:

1. Plywood panels shall be bonded with an adhesive identical to those for exterior plywood.

TABLE NO. 44-A—TYPE OF PROTECTION REQUIRED FOR PEDESTRIANS

HEIGHT OF CONSTRUCTION	DISTANCE FROM CONSTRUCTION	PROTECTION REQUIRED
Eight feet or less	Less than six feet	Railing
	Six feet or more	None
More than eight feet	Less than six feet	Fence and canopy
	Six feet or more but not more than one-fourth the height of construction	Fence and canopy
	Six feet or more, but between one-fourth to one-half the height of construction	Fence
	Six feet or more but exceeding one-half the construction height	None

Pedestrian Protection (Continued)

2. Plywood one-fourth inch (¼") or five-sixteenths inch (5/16") in thickness shall have studs spaced not more than two feet (2') on center.

3. Plywood three-eighths inch (⅜") or one-half inch (½") in thickness shall have studs spaced not more than four feet (4') on center, provided a two-inch by four-inch (2" x 4") stiffener is placed horizontally at the mid-height when the stud spacing exceeds two feet (2') on center.

4. Plywood five-eighths inch (⅝") or thicker shall not span over eight feet (8').

(d) **Canopies.** The protective canopy shall have a clear height of eight feet (8') above the walkway. The roof shall be tightly sheathed. The sheathing shall be two-inch (2") nominal wood planking or equal. Every canopy shall have a solid fence built along its entire length on the construction side.

If materials are stored or work is done on the roof of the canopy, the street sides and ends of the canopy roof shall be protected by a tight curb board not less than one foot (1') high and a railing not less than three feet six inches (3'6") high.

The entire structure shall be designed to carry the loads to be imposed on it, provided the live load shall be not less than 150 pounds per square foot. In lieu of such design a protection canopy supporting not more than 150 pounds per square foot may be constructed as follows:

1. Footings shall be continuous two-inch by six-inch (2" x 6") members with scabbed joints.

2. Posts, not less than four inches by six inches (4" x 6") in size, shall be provided on both sides of the canopy and spaced not more than twelve feet (12'), center-to-center.

3. Stringers, not less than four inches by twelve inches (4" x 12") in size, shall be placed on edge upon the posts.

4. Joists resting upon the stringers shall be at least two inches by eight inches (2" x 8") in size and shall be spaced not more than two feet (2'), center-to-center.

5. The deck shall be of planks at least two inches (2") thick nailed to the joists.

6. Each post shall be knee-braced to joists and stringers by members four feet (4') long, not less than two inches by four inches (2" x 4") in size.

7. A curb, not less than two inches by twelve inches (2" x 12") in size, shall be set on edge along the outside edge of the deck.

> EXCEPTION: Protection canopies for new, light frame construction not exceeding two stories in height may be designed for a live load of 75 pounds per square foot or the loads to be imposed on it, whichever is the greater.

Maintenance and Removal of Protective Devices

Sec. 4408. (a) **Maintenance.** Such protection shall be maintained in place and kept in good order for the entire length of time pedestrians may be endangered.

(b) **Removal.** Every protection fence or canopy shall be removed within 30 days after such protection is no longer required by this Chapter for protection of pedestrians.

Demolition

Sec. 4409. The work of demolishing any building shall not be commenced until the required pedestrian protection structures are in place.

The Building Official may require the permittee to submit plans and a complete schedule for demolition. Where such are required, no work shall be done until such plans and/or schedule are approved by the Building Official.

CHAPTER 45—PERMANENT OCCUPANCY OF PUBLIC PROPERTY

General

Sec. **4501.** No part of any structure or any appendage thereto, except signs, shall project beyond the property line of the building site, except as specified in this Chapter.

Structures or appendages regulated by this Code shall be constructed of materials as specified in Section 1710 and Chapter 35.

The projection of any structure or appendage shall be the distance measured horizontally from the property line to the outermost point of the projection.

No provisions of this Chapter shall be construed to permit the violation of other laws or ordinances regulating the use and occupancy of public property.

Projection into Alleys

Sec. **4502.** No part of any structure or any appendage thereto shall project into any alley.

A curb or buffer block may project not more than nine inches (9″) and not exceed a height of nine inches (9″) above grade.

Footings located at least eight feet (8′) below grade may project not more than twelve inches (12″).

Space Below Sidewalk

Sec. **4503.** The space adjoining a building below a sidewalk on public property may be used and occupied in connection with the building for any purpose not inconsistent with this Code or other laws or ordinances regulating the use and occupancy of such spaces on condition that the right so to use and occupy may be revoked by the city at any time and that the owner of the building will construct the necessary walls and footings to separate such space from the building and pay all costs and expenses attendant therewith.

Footings located at least eight feet (8′) below grade may project not more than twelve inches (12″).

Balconies and Appendages

Sec. **4504.** Oriel windows, balconies, unroofed porches, cornices, belt courses, and appendages such as water tables, sills, capitals, bases, and architectural projections, may project over the public property of the building site a distance as determined by the clearance of the lowest point of the projection above the grade immediately below, as follows:

Clearance above grade less than eight feet (8′)—no projection is permitted.

Clearance above grade over eight feet (8′)—one inch (1″) of projection is permitted for each additional inch of clearance, provided that no such projection shall exceed a distance of four feet (4′).

Marquees

Sec. 4505. (a) **General.** For the purpose of this Section a marquee shall include any object or decoration attached to or a part of said marquee.

(b) **Projection and Clearance.** The horizontal clearance between a marquee and the curb line shall be not less than two feet (2′).

A marquee projecting more than two-thirds of the distance from the property line to the curb line shall be not less than twelve feet (12′) above the ground or pavement below.

A marquee projecting less than two-thirds of the distance from the property line to the curb line shall be not less than eight feet (8′) above the ground or pavement below.

(c) **Length.** A marquee projecting more than two-thirds of the distance from the property line to the curb line shall not exceed twenty-five feet (25′) in length along the direction of the street.

(d) **Thickness.** The maximum height or thickness of a marquee measured vertically from its lowest to its highest point shall not exceed three feet (3′) when the marquee projects more than two-thirds of the distance from the property line to the curb line and shall not exceed nine feet (9′) when the marquee is less than two-thirds of the distance from the property line to the curb line.

(e) **Construction.** A marquee shall be supported entirely from the building and constructed as specified under Types of Construction and shall be of incombustible material or, when of Type V construction, of not less than one-hour fire-resistive construction.

(f) **Roof Construction.** The roof or any part thereof may be a skylight, provided wire glass is used not less than one-fourth inch (¼″) thick with no single pane more than eighteen inches (18″) wide.

Every roof and skylight of a marquee shall be sloped to downspouts which shall conduct any drainage from the marquee under the sidewalk to the curb.

(g) **Location Prohibited.** Every marquee shall be so located as not to interfere with the operation of any exterior standpipe or to obstruct the clear passage of stairways or exits from the building or the installation or maintenance of electroliers.

Movable Awnings or Hoods

Sec. 4506. (a) **Definition.** AWNING is a movable shelter supported entirely from the exterior wall of a building and of a type which can be retracted, folded or collapsed against the face of a supporting building.

Such awning or hood may extend over public property not more than seven feet (7′) from the face of a supporting building nor within two feet (2′) of the curb line measured horizontally.

Movable Awnings or Hoods (Continued)

Collapsible awnings shall be so designed that they shall not block a required exit when collapsed.

Collapsible awnings, unless cloth covered, shall be designed for a vertical live load of not less than five pounds per square foot; except that snow load shall be used, if greater.

(b) **Movable Awnings or Hoods.** Movable awnings or hoods may have combustible coverings supported on incombustible frames attached to the building.

Such awning or hood may extend over the public property not more than two-thirds the distance from the property line to the nearest curb in front of the building site.

All portions of any awning shall be at least eight feet (8') above any public walkway.

> EXCEPTION: Any valance attached to an awning shall be of cloth unless it is fabricated of the same material used for the roof of the awning. A metal valance may have a reinforcing member at or near the lower edge. The valance shall not project above the roof of the awning at the point of attachment and shall not extend more than twelve inches (12") below the roof of the awning at the point of attachment; nor shall any portion of a valance be less than seven feet (7') in height above a public way.

Doors

Sec. 4507. Doors, either fully opened or when opening, shall not project more than one foot (1') beyond the property line, except that in alleys no projection beyond the property line is permitted.

PART X

PLASTER AND WALLBOARD

CHAPTER 47—LATHING, PLASTERING AND INSTALLATION OF WALLBOARD

Sec. 4701. (a) **General.** The installation of lath, plaster and gypsum wallboard shall be done in a manner and with materials as specified in this Chapter, and when required for fire-resistive construction, also shall comply with the provisions of Chapter 43. **Scope**

(b) **Inspection.** No lath or gypsum wallboard or their attachments shall be covered or finished until it has been inspected and approved by the Building Official in accordance with Section 304 (d).

(c) **Tests.** The Building Official may require tests to be made in accordance with approved standards to determine compliance with the provisions of this Chapter, provided the permit holder has been notified 24 hours in advance of the time of making such tests.

(d) **Definitions.** For purposes of this Chapter, certain terms are defined as follows:

CORNER BEAD is a rigid formed unit or shape used at projecting or external angles to define and reinforce the corners of interior surfaces.

CORNERITE is a shaped reinforcing unit of expanded metal or wire fabric used for angle reinforcing and having minimum outstanding legs of not less than two inches (2").

CORROSION-RESISTANT MATERIALS are materials that are inherently rust-resistant or materials to which an approved rust-resistive coating has been applied either before or after forming or fabrication.

EXTERIOR SURFACES are weather-exposed surfaces as defined in Section 424.

EXTERNAL CORNER REINFORCEMENT is a shaped reinforcing unit for external corner reinforcement for portland cement plaster formed to insure mechanical bond and a solid plaster corner.

INTERIOR SURFACES are surfaces other than weather-exposed surfaces.

MOIST CURING is any method employed to retain sufficient moisture for hydration of portland cement plaster.

PORTLAND CEMENT PLASTER is a mixture of portland cement, or portland cement and lime and aggregate and other approved materials as specified in this Code.

STRIPPING is flat reinforcing units of expanded metal or wire fabric not less than three inches (3") wide to be installed as required over joints of gypsum lath.

Scope (Continued)

TIE WIRE is wire for securing together metal framing or supports, for tying metal and wire lath and gypsum lath and wallboard together and for securing accessories.

WIRE BACKING is horizontal strands of tautened wire attached to surfaces of vertical wood supports which, when covered with building paper, provide a backing for portland cement plaster.

Materials

Sec. 4702. Lathing, plastering and wallboard materials shall conform to the following Standards:

MATERIALS AND DESIGN	U.B.C. DESIGNATION
ADHESIVES	
Plaster Liquid Bonding Agents	47- 1-67
Wallboard	47- 2-67
AGGREGATE	
Sand, Perlite and Vermiculite	47- 3-67
ATTACHMENTS	
Fasteners, Gypsum Lath and Wallboard	47- 4-67
Compound, Wallboard Tape and Joint	47- 5-67
Fiber Insulation Board	22- 1-67
GYPSUM MATERIALS	
Gypsum Backing Board	47- 6-67
Gypsum Lath	47- 7-67
Gypsum Plaster	47- 8-67
Gypsum Sheathing Board	47- 9-67
Gypsum Wallboard	47-10-67
Keene's Cement	47-11-67
Molding Plaster	47-12-67
LIME	
Hydrated Finishing	47-13-67
Structural Quicklime	24-17-67
METAL LATH, WIRE LATH AND METAL ACCESSORIES	47-14-67
PORTLAND CEMENT	
Air-entrained	26- 1-67
Masonry	24-16-67
Plastic	26- 1-67
Types I, II and III	26- 1-67
WIRE	32-13-67

Vertical Assemblies

Sec. 4703. (a) **General.** In addition to the requirements of this Section, vertical assemblies of plaster or gypsum wallboard shall be designed to resist the loads specified in Chapter 23 of this Code.

EXCEPTION: Wood framed assemblies meeting the requirements of Section 2507 need not be designed.

(b) **Wood Framing.** Wood supports for lath or gypsum wallboard shall be not less than two inches (2″) nominal in least dimension. Wood stripping or furring shall be not less than two inches (2″) nominal thickness in the least dimension except that furring strips not less than one-inch by two-inch (1″ x 2″) nominal dimension may be used over solid backing.

Vertical Assemblies (Continued)

(c) **Studless Partitions.** The minimum thickness of vertically erected studless solid plaster partitions of three-eighths-inch (⅜") and three-fourths-inch (¾") rib metal lath or one-half-inch (½") thick long-length gypsum lath and gypsum wallboard partitions shall be two inches (2").

Horizontal Assemblies

Sec. 4704. (a) **General.** In addition to the requirements of this Section, supports for horizontal assemblies of plaster or gypsum wallboard shall be designed to support all loads as specified in Chapter 23 of this Code.

EXCEPTION: Wood framed assemblies meeting the requirements of Sections 2509 and 2515 need not be designed.

(b) **Wood Framing.** Wood stripping or suspended wood systems, where used, shall be not less than two inches (2") nominal thickness in the least dimension except that furring strips not less than one-inch by two-inch (1" x 2") nominal dimension may be used over solid backing.

(c) **Hangers.** Hangers for suspended ceilings shall be not less than the sizes set forth in Table No. 47-A, fastened to or embedded in the structural framing, masonry or concrete.

Hangers shall be saddle-tied around main runners to develop the full strength of the hangers. Lower ends of flat hangers shall be bolted with three-eighths-inch (⅜") bolts to runner channels or bent tightly around runners and bolted to the main part of the hanger.

(d) **Runners and Furring.** The main runner and cross-furring shall be not less than the sizes set forth in Table No. 47-A, except that other steel sections of equivalent strength may be substituted for those set forth in this Table. Cross-furring shall be securely attached to the main runner by saddle-tying with not less than one strand of No. 16 or two strands of No. 18 U. S. gauge tie wire or approved equivalent attachments.

Interior Lath

Sec. 4705. (a) **General.** Gypsum lath shall not be installed until weather protection for the installation is provided. Where wood frame walls and partitions are covered on the interior with portland cement plaster or tile or similar material and are subject to water splash, the framing shall be protected with an approved moisture barrier.

Showers and public toilet walls shall conform to Section 1711 (a) and Section 1711 (b).

(b) **Application of Gypsum Lath.** The thickness, spacing of supports, and the method of attachment of gypsum lath shall be as set forth in Tables No. 47-B and No. 47-C. Approved wire and sheet metal attachment clips may be used.

Gypsum lath shall be applied with the long dimension perpendicular to supports, and with end joints staggered in successive courses. End joints may occur on one support when the supports are wood and when stripping is applied the full length of the joints.

(Continued on page 508)

TABLE NO. 47-A—SUSPENDED AND FURRED CEILINGS
(For Support of Ceilings Weighing Not More than 10 Pounds per Square Foot)

<table>
<tr><th colspan="5">Minimum Sizes for Wire and Rigid Hangers</th></tr>
<tr><th colspan="3">SIZE AND TYPE</th><th>MAXIMUM AREA SUPPORTED (In Square Feet)</th><th>SIZE</th></tr>
<tr><td colspan="3">Hangers for Suspended Ceilings</td><td>12.5
16
18
20
22.5
25.0</td><td>No. 9 gauge wire
No. 8 gauge wire
3/16" diameter, mild steel rod[1]
7/32" diameter, mild steel rod[1]
1/4" diameter, mild steel rod[1]
1" x 3/16" mild steel flats[2]</td></tr>
<tr><td rowspan="3">Hangers for Attaching Runners and Furring Directly to Beams and Joists</td><td rowspan="2">For Supporting Runners</td><td>Single Hangers Between Beams[3]</td><td>8
12
16</td><td>No. 12 gauge wire
No. 10 gauge wire
No. 8 gauge wire</td></tr>
<tr><td>Double Wire Loops at Beams or Joists[3]</td><td>8
12
16</td><td>No. 14 gauge wire
No. 12 gauge wire
No. 11 gauge wire</td></tr>
<tr><td>For Supporting Furring without Runners[3] (Wire Loops at Supports)</td><td>Type of Support:
Concrete
Steel
Wood</td><td>8</td><td>No. 14 gauge wire
No. 16 gauge wire (2 loops)[4]
No. 16 gauge wire (2 loops)[4]</td></tr>
</table>

TABLE NO. 47-A—SUSPENDED AND FURRED CEILINGS—Continued

Minimum Sizes and Maximum Spans for Main Runners[5, 6]		
SIZE AND TYPE	MAXIMUM SPACING OF HANGERS OR SUPPORTS (ALONG RUNNERS)	MAXIMUM SPACING OF RUNNERS (TRANSVERSE)
¾"— .3 pound per foot, cold- or hot-rolled channel	2'0"	3'0"
1½"— .475 pound per foot, cold-rolled channel	3'0"	4'0"
1½"— .475 pound per foot, cold-rolled channel	3'6"	3'6"
1½"— .475 pound per foot, cold-rolled channel	4'0"	3'0"
1½"—1.12 pounds per foot, hot-rolled channel	4'0"	5'0"
2 "—1.26 pounds per foot, hot-rolled channel	5'0"	5'0"
2 "— .59 pound per foot, cold-rolled channel	5'0"	3'6"
1½" x 1½" x 3/16" angle	5'0"	3'6"

Minimum Sizes and Maximum Spans for Cross Furring[5, 6]		
SIZE AND TYPE OF CROSS FURRING	MAXIMUM SPACING OF RUNNERS OR SUPPORTS	MAXIMUM SPACING OF CROSS FURRING MEMBERS (TRANSVERSE)
⅜" diameter pencil rods	2'0"	19"
⅜" diameter pencil rods	2'6"	12"
¾"—.3 pound per foot, cold- or hot-rolled channel	3'0" 3'6" 4'0"	24" 16" 12"
1 "—.410 pound per foot, hot-rolled channel	4'0" 4'6" 5'0"	24" 19" 12"

[1]All rod hangers shall be protected with a zinc or cadmium coating or with a rust-inhibitive paint.
[2]All flat hangers shall be protected with a zinc or cadmium coating or with a rust-inhibitive paint.
[3]Inserts, special clips or other devices of equal strength may be substituted for those specified.
[4]Two loops of No. 18 gauge wire may be substituted for each loop of No. 16 gauge wire for attaching steel furring to steel or wood joists.
[5]Spans are based on webs of channels being erected vertically.
[6]Other sections of hot- or cold-rolled members of equivalent strength may be substituted for those specified.

TABLE NO. 47-B[1]—TYPES OF LATH—MAXIMUM SPACING OF SUPPORTS

TYPE OF LATH[2]	MINIMUM WEIGHT (Per Square Yard) GAUGE AND MESH SIZE	VERTICAL (In Inches)			HORIZONTAL (In Inches)	
			Metal			
		Wood	Solid Plaster Partitions	Other	Wood or Concrete	Metal
Expanded Metal Lath (Diamond Mesh)	2.5 3.4	16 16	16 16	12 16	— 16	— 13½
Flat Rib Expanded Metal Lath	2.75 3.4	16 19	16 24	16 19	16 19	12 19
Stucco Mesh Expanded Metal Lath	1.8 and 3.6	16[3]	—	—	—	—
⅜" Rib Expanded Metal Lath	3.4 4.0	24 24	24 24	24 24	24 24	24 24
Sheet Lath	4.5	24	—[4]	24	24	24

TABLE NO. 47-B[1]—TYPES OF LATH—MAXIMUM SPACING OF SUPPORTS

¾" Rib Expanded Metal Lath		5.4	—	—[4]	—	36[5]	36[5]
Wire Lath	Welded	1.95 pounds, No. 11 gauge, 2" x 2"	24	24	24	24	24
		1.4 pounds, No. 16 gauge, 2" x 2"	16	16	16	16	16
		1.4 pounds, No. 18 gauge, 1" x 1"[6]	16[3]	—	—	—	—
	Woven	1.4 pounds, No. 17 gauge, 1½" Hexagon[6]	16[3]	—	—	—	—
		1.4 pounds, No. 18 gauge, 1" Hexagonal[6]	16[3]	—	—	—	—
⅜" Gypsum Lath (perforated)			16	—	16[7]	16	16
⅜" Gypsum Lath (plain)			16	—	16[7]	16	16
½" Gypsum Lath (perforated)			16	—	16[7]	16	16
½" Gypsum Lath (plain)			24	—	24	24	16

[1]For Fire-resistive Construction, see Tables No. 43-A, No. 43-B and No. 43-C. For Shear-resisting Elements, see Table No. 47-I.

[2]Metal lath and wire lath used as reinforcement for portland cement plaster shall be furred out away from vertical supports at least one-fourth inch (¼"). Self-furring lath meets furring requirement. **Exception:** Furring is not required on steel supports having a flange width of one inch (1") or less.

[3]Wire backing required on open vertical frame construction except under expanded metal lath and paperbacked wire lath.

[4]May be for studless solid partitions.

[5]Contact or furred ceilings only. May not be used in suspended ceilings.

[6]Stucco netting, not to be used as a base for gypsum plaster.

[7]Span may be increased to twenty-four inches (24") on vertical screw or approved nailable assemblies.

TABLE NO. 47-C—TYPES OF LATH—ATTACHMENT TO WOOD SUPPORTS—MINIMUM SIZE AND MAXIMUM SPACING OF ATTACHMENTS[1]

TYPE OF LATH	NAILS			STAPLES[2] (Round or Flattened Wire)				
	Type	Maximum Spacing		Leg[3]	Wire Gauge No.	Crown	Maximum Spacing	
		Vertical	Horizontal				Vertical	Horizontal
		(In Inches)			(In Inches)			
Diamond Mesh Expanded Metal Lath and Flat Rib Metal Lath	4d blued box (clinched)[4] 1" No. 11 gauge, 7/16" head, barbed 1½" No. 11 gauge, 7/16" head, barbed	6 6 6	— — 6	⅞	16	¾	6	6
⅜" Rib Metal Lath and Sheet Lath	1½" No. 11 gauge, 7/16" head, barbed	6	6	1¼	16	¾	4½	4½
¾" Rib Metal Lath	4d Common 2", No. 11 Gauge, 7/16" head, barbed	At ribs —	— At ribs	— —	— —	— —	— —	— —
Wire Lath[5]	4d blued box (clinched)[4] 1" No. 11 gauge, 7/16" head, barbed 1½" No. 11 gauge, 7/16" head, barbed 1¼" No. 12 gauge, ⅜" head, furring	6 6 6 6	— — 6 —	⅞	16	7/16	6	6
⅜" Gypsum Lath	1⅛" No. 13 gauge, 19/64" head, blued[4]	5	5	⅞	16	¾	5	5
½" Gypsum Lath	1¼" No. 13 gauge, 19/64" head, blued[4]	5[6] 4[7]	5[6] 4[7]	1⅛	16	¾	4	4

[1]For Fire-resistive Construction, see Tables No. 43-B and No. 43-C. For Shear-resisting Elements, see Table No. 47-I. Approved wire and sheet metal attachment clips may be used.
[2]With divergent points and flattened wire for gypsum lath.
[3]When lath and stripping are stapled simultaneously, increase leg length of staple one-eighth inch (⅛").
[4]For interiors only.
[5]Attach self-furring wire fabric lath to supports at furring device.
[6]Perforated lath.
[7]Plain lath.

TABLE NO 47-D—THICKNESS OF PLASTER[1]

PLASTER BASE	FINISHED THICKNESS OF PLASTER FROM FACE OF LATH, MASONRY, CONCRETE	
	Gypsum Plaster	Portland Cement Plaster
Expanded Metal Lath	5/8" minimum[2]	5/8" minimum[2]
Wire Lath	5/8" minimum[2]	3/4" minimum (interior)[3] 7/8" minimum (exterior)[3]
Gypsum Lath	1/2" minimum	
Masonry Walls[4]	1/2" minimum	1/2" minimum
Monolithic Concrete Walls[4, 5]	5/8" maximum	7/8" maximum
Monolithic Concrete Ceilings[4, 5]	3/8" maximum[6, 7]	1/2" maximum[7]

[1]For Fire-resistive Construction, see Tables No. 43-A, No. 43-B, and No. 43-C.

[2]When measured from back plane of expanded metal lath, exclusive of ribs, or self-furring lath plaster thickness shall be three-fourths-inch (3/4") minimum.

[3]When measured from face of support or backing.

[4]Because masonry and concrete surfaces may vary in plane, thickness of plaster need not be uniform.

[5]When applied over a liquid bonding agent, finish coat may be applied directly to concrete surface.

[6]Approved acoustical plaster may be applied directly to concrete, or over basecoat plaster, beyond the maximum plaster thickness shown.

[7]On concrete ceilings, where the basecoat plaster thickness exceeds the maximum thickness shown, metal lath or wire lath shall be attached to the concrete.

(Continued from page 501)

Interior Lath (Continued)

Where electrical radiant heat cables are installed on ceilings, the stripping, if conductive, may be omitted a distance not to exceed twelve inches (12″) from the walls.

Where lath edges are not in moderate contact, and have joint gaps exceeding three-eighths inch (⅜″) the joint gaps shall be covered with stripping or cornerite. Stripping or cornerite may be omitted when the entire surface is reinforced with not less than one-inch (1″) No. 20 U. S. gauge woven wire. When lath is secured to horizontal or vertical supports not used as structural diaphragms, end joints may occur between supports when lath ends are secured together with approved fasteners. Vertical assemblies also shall comply with Section 2312 (b).

Cornerite shall be installed so as to retain position during plastering at all internal corners. Cornerite may be omitted when plaster is not continuous from one plane to an adjacent plane.

(c) **Application of Metal Plaster Bases.** The type and weight of metal lath, and the gauge and spacing of wire in welded or woven lath, the spacing of supports, and the methods of attachment to wood supports shall be as set forth in Tables No. 47-B and No. 47-C.

Metal lath or wire lath shall be attached to metal supports with not less than No. 18 U. S. gauge tie wire spaced not more than six inches (6″) apart or with approved equivalent attachments.

Metal lath or wire lath shall be applied with the long dimension of the sheets perpendicular to supports.

Metal lath shall be lapped not less than one-half inch (½″) at sides and one inch (1″) at ends. Wire lath shall be lapped not less than one mesh at sides and ends, but not less than one inch (1″). Rib metal lath, with edge ribs greater than one-eighth inch (⅛″), shall be lapped at sides by nesting outside ribs. When edge ribs are one-eighth inch (⅛″) or less, rib metal lath may be lapped one-half inch (½″) at sides, or outside ribs may be nested. Where end laps of sheets do not occur over supports, they shall be securely tied together with not less than No. 18 U. S. gauge wire.

Cornerite shall be installed at all internal corners to retain position during plastering. Cornerite may be omitted when lath is continuous or when plaster is not continuous from one plane to an adjacent plane.

Exterior Lath

Sec. 4706. (a) **General.** Exterior surfaces are weather-exposed surfaces as defined in Section 424. For eave overhangs required to be fire-resistive, see Section 1710.

(b) **Corrosion Resistance.** All lath and lath attachments shall be of corrosion-resistant materials. See Section 4701 (d).

(c) **Backing.** Backing for vertical surfaces shall consist of sheathing as specified in Section 2202 or of not less than No. 18 U. S. gauge steel wire stretched taut horizontally and spaced not more than six inches (6″) apart vertically.

Exterior Lath (Continued)

Where lath on vertical surfaces extends between rafters, or other similar projecting members, solid backing shall be installed to provide support for lath and attachments.

Gypsum lath or gypsum board shall not be used, except that on horizontal supports of ceilings or roof soffits, it may be used as backing for metal lath or wire lath and portland cement plaster.

Backing is not required under metal lath or paperbacked wire lath.

(d) **Weather Protection.** Building paper shall be installed as required in Section 1707 (a).

(e) **Application of Metal Plaster Bases.** The application of metal lath or wire lath shall be as specified in Section 4705 (c) and they shall be furred out from vertical supports or backing not less than one-fourth inch (¼″) except as set forth in footnote No. 2, Table No. 47-B.

Where no external corner reinforcement is used, lath shall be furred out and carried around corners at least one support on frame construction. Lath shall be carried down over the foundations at least two inches (2″).

When the building is of wood frame or metal stud construction with an on-grade concrete floor slab system, building paper and lath shall extend below the floor line or sill not less than two inches (2″), but shall not extend below grade. Approved drip screeds or flashing or other approved means of draining moisture to the outside may be required by the Building Official.

Interior Plaster

Sec. 4707. (a) **General.** Plastering with gypsum plaster or portland cement plaster shall be not less than three coats when applied over metal lath or wire lath and shall be not less than two coats when applied over other bases permitted by this Chapter. Showers and public toilet walls shall conform to Section 1711 (a) and Section 1711 (b).

Plaster shall not be applied directly to fiber insulation board. Portland cement plaster shall not be applied directly to gypsum lath, gypsum masonry or gypsum plaster except as specified in Section 4706 (c).

When installed, grounds shall assure the minimum thickness of plaster as set forth in Table No. 47-D. Plaster thickness shall be measured from the face of lath and other bases.

(b) **Basecoat Proportions.** Proportions of aggregate to cementitious materials shall not exceed the volume set forth in Table No. 47-E for gypsum plaster, and Table No. 47-F for portland cement and portland cement-lime plaster.

(c) **Basecoat Application.** Basecoats shall be applied with sufficient material and pressure to form a complete key or bond.

1. **Gypsum plaster.** For two-coat work, the first coat shall be brought out to grounds and straightened to a true surface

(Continued on page 513)

TABLE NO. 47-E—GYPSUM PLASTER PROPORTIONS[1]

NUMBER	COAT	PLASTER BASE OR LATH	MAXIMUM VOLUME AGGREGATE PER 100 POUNDS NEAT PLASTER[2, 3] (Cubic Feet)	
			Damp Loose Sand[4]	Perlite or Vermiculite[4]
Two-coat Work	Base Coat	Gypsum Lath	2½	2
	Base Coat	Masonry	3	3
Three-coat Work	First Coat	Lath	2[5]	2
	Second Coat	Lath	3[5]	2[6]
	First and Second Coats	Masonry	3	3

[1]Wood fibered gypsum plaster may be mixed in the proportions of 100 pounds of gypsum to not more than one cubic foot of sand where applied on masonry or concrete.

[2]For Fire-resistive Construction, see Tables No. 43-A, No. 43-B and No. 43-C.

[3]When determining the amount of aggregate in set plaster, a tolerance of 10 per cent shall be allowed.

[4]Combinations of sand and lightweight aggregate may be used provided the volume and weight relationship of the combined aggregate to gypsum plaster is maintained.

[5]If used for both first and second coats, the volume of aggregate may be two and one-half cubic feet.

[6]Where plaster is one inch (1") or more in total thickness the proportions for the second coat may be increased to three cubic feet.

TABLE NO. 47-F—PORTLAND CEMENT PLASTER

MAXIMUM VOLUME AGGREGATE PER VOLUME CEMENTITIOUS MATERIAL[1]				APPROXIMATE MINIMUM THICKNESS[4]	MINIMUM PERIOD MOIST CURING	MINIMUM INTERVAL BETWEEN COATS
	Portland Cement Plaster[2]	Portland Cement-Lime Plaster[3]				
Coat	Maximum Volume Aggregate per Volume Cement	Maximum Volume Lime per Volume Cement	Maximum Volume Sand per Volume Cement and Lime			
First	4	¾	4	⅜″[5]	48[6] Hours	48[7] Hours
Second	5	¾	5	1st and 2nd Coats ¾″	48 Hours	7 Days[8]
Finish	3[9]	—	3[9]	⅛″	—	[8]

[1]When determining the amount of aggregate in set plaster, a tolerance of 10 per cent may be allowed.

[2]From 10 to 20 pounds of dry hydrated lime (or an equivalent amount of lime putty) may be added as a plasticizing agent to each sack of Type I and Type II Standard portland cement in base coat plaster. See Section 4708 (a) for use of plastic cement.

[3]No additions of plasticizing agents shall be made.

[4]See Table No. 47-D.

[5]Measured from face of support or backing to crest of scored plaster.

[6]Twenty-four hours minimum period for moist curing of interior portland cement plaster.

[7]Twenty-four hours minimum interval between coats of interior portland cement plaster.

[8]Finish coat plaster may be applied to interior portland cement base coats after a 48-hour period.

[9]For finish coat, plaster up to an equal part of dry hydrated lime by weight (or an equivalent volume of lime putty) may be added to Type I, Type II and Type III Standard portland cement.

TABLE NO. 47-G—APPLICATION OF SINGLE-PLY GYPSUM WALLBOARD

THICKNESS OF GYPSUM WALLBOARD (Inch)	PLANE OF FRAMING SURFACE	LONG DIMENSION OF GYPSUM WALLBOARD SHEETS IN RELATION TO DIRECTION OF FRAMING MEMBERS	MAXIMUM SPACING OF FRAMING MEMBERS[1] (Center-to-center) (In Inches)	MAXIMUM SPACING OF FASTENERS (Center-to-center) (In Inches)		NAILS[2]—TO WOOD
				Nails[1, 3]	Screws[4]	
½	Horizontal	Either Direction	16	7	12	No. 13 gauge, 1⅜″ long, $\frac{19}{64}$″ head No. .098 gauge, 1¼″ long, Annular ringed 5d, cooler nail
	Horizontal	Perpendicular	24	7	12	
	Vertical	Either Direction	16	8	12	
⅝	Horizontal	Either Direction	16	7	12	No. 13 gauge, 1⅝″ long, $\frac{19}{64}$″ head No. .098 gauge, 1⅜″ long, Annular ringed 6d, cooler nail
	Horizontal	Perpendicular	24	7	12	
	Vertical	Either Direction	16	8	12	
Fastening Required with Adhesive Application						
½ or ⅝	Horizontal	Either Direction	16	16	16	As required for ½″ and ⅝″ gypsum wallboard, see above
		Perpendicular	24	12	16	
	Vertical	Either Direction	16	24	24	

[1]For Fire-resistive Construction, see Tables No. 43-B and No. 43-C. For Shear-resisting Elements, see Table No. 47-I.

[2]Where the metal framing has a clinching design formed to receive the nails by two edges of metal, the nails shall be not less than five-eighths inch (⅝″) longer than the wallboard thickness, and shall have ringed shanks. Where the metal framing has a nailing groove formed to receive the nails, the nails shall have barbed shanks or be 5d, No. 13½ gauge, one and five-eighths inches (1⅝″) long, fifteen-sixty-fourths-inch ($\frac{15}{64}$″) head for one-half-inch (½″) gypsum wallboard; 6d, No. 13 gauge, one and seven-eighths inches (1⅞″) long, fifteen-sixty-fourths-inch ($\frac{15}{64}$″) head for five-eighths-inch (⅝″) gypsum wallboard.

[3]Two nails spaced not less than two inches (2″) apart, nor more than two and one-half inches (2½″) apart and pairs of nails spaced not more than twelve inches (12″) center-to-center may be used.

[4]Screws shall be No. 6 with tapered head and long enough to penetrate into wood framing not less than five-eighths inch (⅝″) and metal framing not less than one-fourth inch (¼″).

(*Continued from page 509*)

Interior Plaster (Continued)

leaving the surface rough to receive the finish coat. For three-coat work, the surface of the first coat shall be scored sufficiently to provide adequate bond for the second coat and shall be permitted to harden and set before the second coat is applied. The second coat shall be brought out to grounds and straightened to a true surface leaving the surface rough to receive the finish coat.

2. **Portland cement plaster.** The first two coats shall be as required for the first two coats of exterior plaster, except that the moist curing time period between the first and second coats shall be not less than 24 hours and the thickness shall be as set forth in Table No. 47-D.

(d) **Finish Coat Application.** Finish coats shall be applied with sufficient material and pressure to form a complete bond. Finish coats shall be proportioned and mixed in an approved manner. Gypsum and lime and other interior finish coats shall be applied over gypsum base coats which have hardened and set. Thicknesses shall be not less than one-sixteenth inch (1/16").

Portland cement and lime finish coats may be applied over interior portland cement basecoats which have been in place not less than 48 hours.

Approved acoustical finish plaster may be applied over any basecoat plaster, over clean masonry or concrete, or other approved surfaces.

(e) **Interior Masonry or Concrete.** Condition of surfaces shall be as specified in Section 4708 (f). Approved specially prepared gypsum plaster designed for application to concrete surfaces or approved acoustical plaster may be used. The total thickness of basecoat plaster applied to concrete ceilings shall be as set forth in Table No. 47-D. Should ceiling surfaces require more than the maximum thickness permitted in Table No. 47-D, metal lath or wire lath shall be installed on such surfaces before plastering.

Exterior Plaster

Sec. 4708. (a) **General.** Plastering with portland cement plaster shall be not less than three coats when applied over metal lath or wire lath and shall be not less than two coats when applied over masonry, concrete, or gypsum backing as specified in Section 4706 (c). If plaster surface is completely covered by veneer or other facing material, or is completely concealed by another wall, plaster application need only be two coats provided the total thickness is as set forth in Table No. 47-F.

On wood frame or metal stud construction with an on-grade concrete floor slab system, exterior plaster shall be applied in such a manner as to cover, but not extend below, lath and paper. See Section 4706 (e) for the application of paper and lath, and flashing or drip screeds.

Only approved plasticity agents and approved amounts thereof may be added to portland cement. When plastic

Exterior Plaster (Continued)

cement is used, no additional lime or plasticizers shall be added. Hydrated lime or the equivalent amount of lime putty used as a plasticizer, may be added to standard portland cement in an amount not to exceed 20 per cent by weight of the portland cement.

For machine-placed plasters, asbestos fiber may be added to portland cement plaster in approved amounts. Approved portland cement plaster containing asbestos fiber, blended at the time of manufacture, and so labeled, may be used.

Gypsum plaster shall not be used on exterior surfaces. See Section 424.

(b) **Basecoat Proportions.** The proportion of aggregate to cementitious materials shall be as set forth in Table No. 47-F.

(c) **Basecoat Application.** The first coat shall be applied with sufficient material and pressure to fill solidly all openings in the lath. The surface shall be scored horizontally sufficiently rough to provide adequate bond to receive the second coat.

The second coat shall be brought out to proper thickness, rodded and floated sufficiently rough to provide adequate bond for finish coat. The second coat shall have no variation greater than one-fourth inch (¼″) in any direction under a five-foot (5′) straight edge.

(d) **Curing and Interval.** First and second coats of plaster shall be applied and moist-cured as set forth in Table No. 47-F.

When applied over gypsum backing as specified in Section 4706 (c) or directly to unit masonry surfaces, the second coat may be applied as soon as the first coat has attained sufficient hardness.

(e) **Finish Coats.** Finish coats shall be proportioned and mixed in an approved manner and in accordance with Table No. 47-F.

Portland cement and lime finish coats shall be applied over basecoats which have been in place for the time periods set forth in Table No. 47-F. Thickness shall be at least one-eighth inch (⅛″).

(f) **Preparation of Masonry and Concrete.** Surfaces shall be clean, free from efflorescence, sufficiently damp and rough to assure proper bond. If surface is insufficiently rough, approved bonding agents or a portland cement dash bond coat mixed in the proportions of one and one-half cubic feet of sand to one cubic foot of portland cement shall be applied. Dash bond coat shall be left undisturbed and shall be moist cured not less than 24 hours. When dash bond is applied, first coat of basecoat plaster may be omitted. See Table No. 47-D for thickness.

Pneumatically Placed Plaster (Gunite)

Sec. 4709. Pneumatically placed portland cement plaster shall be a mixture of portland cement and sand, mixed dry, conveyed by air through a pipe or flexible tube, hydrated at the nozzle at the end of the conveyor, and deposited by air pressure in its final position.

Pneumatically Placed Plaster (Gunite) (Continued)

Rebound material may be screened and reused as sand in an amount not greater than 25 per cent of the total sand in any batch.

Pneumatically placed portland cement plaster shall consist of a mixture of one part cement to not more than five parts sand. Plasticity agents may be used as specified in Section 4708 (a). Except when applied to concrete or masonry, such plaster shall be applied in not less than two coats to a minimum total thickness of seven-eighths inch (⅞"). The first coat shall be rodded as specified in Section 4708 (c) for the second coat. The curing period and time interval shall be as set forth in Table No. 47-F.

Gypsum Wallboard

Sec. 4710. (a) **General.** All gypsum wallboard shall be installed in accordance with the provisions of this Section. Gypsum wallboard shall not be installed on exterior surfaces. See Section 424. For use as backing under stucco, see Section 4706 (c).

Gypsum wallboard shall not be installed until weather protection for the installation is provided.

Shower and public toilet walls shall conform to Section 1711 (a) and Section 1711 (b).

(b) **Supports.** Supports shall be spaced not to exceed the spacing set forth in Table No. 47-G for single-ply application and Table No. 47-H for two-ply application. Vertical assemblies shall comply with Section 4703. Horizontal assemblies shall comply with Section 4704.

(c) **Single-ply Application.** All edges and ends of gypsum wallboard shall occur on the framing members, except those edges and ends which are perpendicular to the framing members. All edges and ends of gypsum wallboard shall be in moderate contact except in concealed spaces where fire-resistive construction or diaphragm action is not required.

The size and spacing of fasteners shall comply with Table No. 47-G. Fasteners shall be spaced not less than three-eighths inch (⅜") from edges and ends of gypsum wallboard. Fasteners at the top and bottom plates of vertical assemblies, or the edges and ends of horizontal assemblies perpendicular to supports, and at the wall line may be omitted except on shear-resisting elements, or fire-resistive assemblies. Fasteners shall be applied in such a manner as to not fracture the face paper with the fastener head.

Gypsum wallboard may be applied to wood framing members with an approved adhesive. A continuous bead of the adhesive shall be applied to the face of all framing members, except top and bottom plates, of sufficient size as to spread to an average width of one inch (1") and thickness of one-

Gypsum Wallboard (Continued)

sixteenth inch ($\frac{1}{16}$") when the gypsum wallboard is applied. Where the edges or ends of two pieces of gypsum wallboard occur on the same framing member, two continuous parallel beads of adhesive shall be applied to the framing member. Fasteners shall be used with adhesive application in accordance with Table No. 47-G.

(d) **Two-ply Application.** The base ply of gypsum wallboard shall be applied with fasteners of the type and size as required for the nonadhesive application of single-ply gypsum wallboard. Fastener spacings shall be in accordance with Table No. 47-H.

The face ply of gypsum wallboard may be applied with gypsum wallboard joint compound or approved adhesive furnishing full coverage between the plies, or with fasteners in accordance with Table No. 47-H. When the face ply is installed with joint compound or adhesive, the joints of the face ply need not occur on supports. Temporary nails or shoring shall be used to hold face ply in position until the joint compound or adhesive develops adequate bond.

(e) **Joint Treatment.** Gypsum wallboard single layer fire-rated assemblies shall have joints treated except where the wallboard is to receive a decorative finish such as wood paneling, battens, acoustical finishes, or any similar application which would be equivalent to the joint treatment.

EXCEPTION: Assemblies tested without joint treatment.

Shear-resisting Construction with Wood Frame

Sec. 4711. (a) **General.** Gypsum lath and plaster, gypsum sheathing board, and gypsum wallboard may be used on wood studs for vertical diaphragms if applied in accordance with this Section. Shear-resisting values shall not exceed those set forth in Table No. 47-I.

The shear values tabulated shall not be cumulative with the shear value of other materials applied to the same wall. The shear values may be doubled when the identical materials applied as specified in this Section are applied to both sides of the wall.

(b) **Masonry and Concrete Construction.** Gypsum lath and plaster, gypsum sheathing board, and gypsum wallboard shall not be used in vertical diaphragms to resist forces imposed by masonry or concrete construction.

(c) **Wall Framing.** Framing for vertical diaphragms shall comply with Section 2507 (b) for bearing walls, and studs shall be spaced not further apart than sixteen inches (16") center-to-center. Marginal studs and plates shall be anchored to resist all design forces.

(d) **Height to Length Ratio.** The maximum allowable height to length ratio for the construction in this Section shall be 1½ to 1.

(Continued on page 519)

TABLE NO. 47-H—APPLICATION OF TWO-PLY GYPSUM WALLBOARD[1]

<table>
<tr><th colspan="9">Fasteners Only</th></tr>
<tr><th rowspan="3">THICKNESS OF GYPSUM WALLBOARD (Each Ply) (Inch)</th><th rowspan="3">PLANE OF FRAMING SURFACE</th><th rowspan="3">LONG DIMENSION OF GYPSUM WALLBOARD SHEETS</th><th rowspan="3">MAXIMUM SPACING OF FRAMING MEMBERS (Center-to-center) (In Inches)</th><th colspan="5">MAXIMUM SPACING OF FASTENERS (Center-to-Center) (In Inches)</th></tr>
<tr><th colspan="3">Base Ply</th><th colspan="2">Face Ply</th></tr>
<tr><th>Nails[2]</th><th>Screws[3]</th><th>Staples[4]</th><th>Nails[2]</th><th>Screws[3]</th></tr>
<tr><td rowspan="2">3/8</td><td>Horizontal</td><td>Perpendicular only</td><td>16</td><td rowspan="6">16</td><td rowspan="6">24</td><td rowspan="6">16</td><td>7</td><td rowspan="6">12</td></tr>
<tr><td>Vertical</td><td>Either Direction</td><td>16</td><td>8</td></tr>
<tr><td rowspan="2">1/2</td><td>Horizontal</td><td>Perpendicular only</td><td>24</td><td>7</td></tr>
<tr><td>Vertical</td><td>Either Direction</td><td>24</td><td>8</td></tr>
<tr><td rowspan="2">5/8</td><td>Horizontal</td><td>Perpendicular only</td><td>24</td><td>7</td></tr>
<tr><td>Vertical</td><td>Either Direction</td><td>24</td><td>8</td></tr>
<tr><th colspan="9">Fasteners and Adhesives</th></tr>
<tr><td rowspan="2">3/8 Base Ply</td><td>Horizontal</td><td>Perpendicular only</td><td>16</td><td>7</td><td rowspan="6">12</td><td>5</td><td colspan="2" rowspan="6">Temporary Nailing or Shoring to Comply with Section 4710 (d)</td></tr>
<tr><td>Vertical</td><td>Either Direction</td><td>16</td><td>8</td><td>7</td></tr>
<tr><td rowspan="2">1/2 Base Ply</td><td>Horizontal</td><td>Perpendicular only</td><td>16</td><td>7</td><td>5</td></tr>
<tr><td>Vertical</td><td>Either Direction</td><td>16</td><td>8</td><td>7</td></tr>
<tr><td rowspan="2">5/8 Base Ply</td><td>Horizontal</td><td>Perpendicular only</td><td>24</td><td>7</td><td>5</td></tr>
<tr><td>Vertical</td><td>Either Direction</td><td>24</td><td>8</td><td>7</td></tr>
</table>

[1]For Fire-resistive Construction, see Tables No. 43-B and No. 43-C. For Shear-resisting Elements, see Table No. 47-I.

[2]*Nails for wood framing shall be long enough to penetrate into wood members not less than three-fourths inch (3/4") and the sizes shall comply with the provisions of Table No. 47-G.* For nails not included in Table No. 47-G, use the appropriate size cooler nail as set forth in Table No. 25-24-A of U.B.C. Standard No. 25-24-67. Nails for metal framing shall comply with the provisions of Table No. 47-G.

[3]*Screws shall comply with the provisions of Table No. 47-G.*

[4]Staples shall be not less than 16 gauge by three-fourths-inch (3/4") crown width with leg length of seven-eighths-inch (7/8"), one and one-eighths-inch (1 1/8") and one and three-eighths inch (1 3/8") for gypsum wallboard thicknesses of three-eighths inch (3/8"), one-half-inch (1/2") and five-eighths-inch (5/8") respectively.

TABLE NO. 47-I—ALLOWABLE SHEAR FOR WIND OR SEISMIC FORCES IN POUNDS PER FOOT FOR VERTICAL DIAPHRAGMS OF GYPSUM LATH AND PLASTER, GYPSUM SHEATHING BOARD, AND GYPSUM WALLBOARD WOOD FRAMED WALL ASSEMBLIES[1]

TYPE OF MATERIAL	THICKNESS OF MATERIAL	WALL CONSTRUCTION	NAIL SPACING[2] MAXIMUM (In Inches)	SHEAR VALUE	MINIMUM NAIL SIZE
Gypsum Lath, Plain or Perforated	3/8" Lath and 1/2" Plaster	Unblocked	5	100	No. 13 gauge, 1 1/8" long, 19/64" head, plasterboard blued nail
Gypsum Sheathing Board	1/2" x 2' x 8'	Unblocked	4	75	No. 11 gauge, 1 3/4" long, 7/16" head, diamond-point, galvanized
	1/2" x 4'	Blocked	4	175	
Gypsum Wallboard	1/2"	Unblocked	7	100	5d cooler nails
			4	125	
		Blocked	7	125	
			4	150	
	5/8"	Blocked	4	175	6d cooler nails
		Blocked Two-ply	Base Ply 9 Face Ply 7	250	Base Ply—6d cooler nails Face Ply—8d cooler nails

[1]These vertical diaphragms shall not be used to resist loads imposed by masonry or concrete walls. Values are for short-time loading due to wind or earthquake and must be reduced 25 per cent for normal loading.

[2]Applies to nailing at all studs, top and bottom plates, and blocking.

(Continued from page 516)

Shear-resisting Construction with Wood Frame (Continued)

(e) **Application.** End joints of adjacent courses of gypsum lath, gypsum sheathing board or gypsum wallboard sheets shall not occur over the same stud.

Where required in Table No. 47-I, blocking having the same cross-sectional dimensions as the studs shall be provided at all joints that are perpendicular to the studs.

The size and spacing of nails shall be as set forth in Table No. 47-I. Nails shall be spaced not less than three-eighths inch (⅜") from edges and ends of gypsum lath, gypsum sheathing board, gypsum wallboard or sides of studs, blocking, and top and bottom plates.

1. **Gypsum lath.** Gypsum lath shall be applied perpendicular to the studs. Maximum allowable shear values shall be as set forth in Table No. 47-I.

2. **Gypsum sheathing board.** Four-foot (4') wide pieces may be applied parallel or perpendicular to studs. Two-foot (2') wide pieces shall be applied perpendicular to the studs. Maximum allowable shear values shall be as set forth in Table No. 47-I.

3. **Gypsum wallboard.** Gypsum wallboard may be applied parallel or perpendicular to studs. Maximum allowable shear values shall be as set forth in Table No. 47-I.

PART XI

SPECIAL SUBJECTS

CHAPTER 48—FILM STORAGE

Film Storage

Secs. 4801, 4802, and 4803. Where it is desired to regulate film storage, complete provisions covering handling and storage of photographic and X-ray nitrocellulose films may be found in Appendix Chapter 48.

CHAPTER 50—PREFABRICATED CONSTRUCTION

General

Sec. 5001. (a) **Purpose.** The purpose of this Chapter is to regulate materials and establish methods of safe construction where any structure or portion thereof is wholly or partially prefabricated.

(b) **Scope.** Unless otherwise specifically stated in this Chapter, all prefabricated construction and all materials used therein shall conform to all the requirements of this Code. (See Section 106.)

(c) **Definition. PREFABRICATED ASSEMBLY** is a structural unit, the integral parts of which have been built up or assembled prior to incorporation in the building.

Tests of Materials

Sec. 5002. Every approval of a material not specifically mentioned in this Code shall incorporate as a proviso the kind and number of tests to be made during prefabrication.

Tests of Assemblies

Sec. 5003. The Building Official may require special tests to be made on assemblies to determine their durability and weather resistance.

Connections

Sec. 5004. Every device designed to connect prefabricated assemblies shall be capable of developing the strength of the members connected, except in the case of members forming part of a structural frame designed as specified in Chapter 23. The connection device shall be designed as required by the other Chapters in this Code. Connections between roofs and the supporting walls shall be capable of withstanding an uplift equal to five pounds per square foot of roof.

Pipes and Conduits

Sec. 5005. In structural design, due allowance shall be made for any material to be removed for the installation of pipes, conduits, or other equipment.

Certificate and Inspection

Sec. 5006. (a) **Materials.** Materials and the assembly thereof shall be inspected to determine compliance with this Code. Every material shall be grade marked or labeled where required elsewhere in this Code.

Certificate and Inspection (Continued)

(b) **Certificate.** A certificate of approval shall be furnished with every prefabricated assembly, except where the assembly is readily accessible to inspection at the site. The certificate of approval shall certify that the assembly in question has been inspected and meets all the requirements of this Code. When mechanical equipment is installed so that it cannot be inspected at the site, the certificate of approval shall certify that such equipment complies with the laws applying thereto.

(c) **Certifying Agency.** To be acceptable under this Code, every certificate of approval shall be made by an approved agency.

(d) **Field Erection.** Placement of prefabricated assemblies at the building site shall be inspected by the Building Official to determine compliance with this Code.

(e) **Continuous Inspection.** If continuous inspection is required for certain materials where construction takes place on the site, it shall also be required where the same materials are used in prefabricated construction.

> EXCEPTION: Continuous inspection will not be required during prefabrication if the approved agency certifies to the construction and furnishes evidence of compliance.

CHAPTER 52—PLASTICS

General

Sec. 5201. (a) **Material.** Plastic materials may be of any plastic defined in this Chapter.

(b) **Approval for Use.** The Building Official shall require that sufficient technical data be submitted to substantiate the proposed use of any plastic material and, if it is determined that the evidence submitted is satisfactory for the use intended, he may approve its use subject to the requirements of this Chapter.

(c) **Identification.** Each sheet, roll or piece of plastic for which a building permit is required shall be identified with a mark or decal satisfactory to the Building Official showing its intended use.

Definitions

Sec. 5202. APPROVED PLASTICS. Approved plastic materials shall be those specified in U.B.C. Standard No. 52-1-67 which have a flame-spread rating of 225 or less and a smoke density not greater than that obtained from the burning of untreated wood under similar conditions when tested in accordance with U.B.C. Standard No. 42-1-67 in the way intended for use. The products of combustion shall be no more toxic than the burning of untreated wood under similar conditions.

Installation

Sec. 5203. (a) **General.** All plastics shall be approved plastics and those used as interior finish or trim shall comply with the requirements specified in Chapter 42.

> EXCEPTION: Approved plastics are not required to be used in occupancies not restricted by Table No. 42-B.

(b) **Structural Requirements.** All plastic materials and their assemblies shall be of adequate strength and durability to withstand the design loads as prescribed elsewhere in this Code. Sufficient and substantial technical data shall be submitted to the Building Official by an approved testing agency to establish stresses, maximum unsupported spans, and such other information as may be deemed necessary by the Building Official for the various thicknesses and forms used.

(c) **Fastenings.** Fastenings shall be adequate to withstand design loads as prescribed elsewhere in this Code. Proper allowance shall be made for expansion and contraction of plastic materials in accordance with accepted data on coefficient of expansion of the material and any material in conjunction with which it is employed.

Glazing of Openings

Sec. 5204. Doors, sash and framed openings in exterior walls of all buildings except Types I and II construction may be glazed or equipped with approved plastic provided:

1. The wall in which such glazing is installed is so located that openings are not required to be fire-protected.

TABLE NO. 52-A—INSTALLATION OF GLAZED OPENINGS IN ANY ONE EXTERIOR WALL AND ANY ONE STORY[1]

Glazing of Openings (Continued)

DISTANCE OF EXTERIOR WALL FROM PROPERTY LINE OR WIDTH OF ADJOINING PUBLIC WAY IN FEET	MAXIMUM PER CENT OF EXTERIOR WALL AREA PERMITTED TO BE OF PLASTIC PANELS	MAXIMUM AREA OF INDIVIDUAL PLASTIC PANEL IN SQUARE FEET	MINIMUM SEPARATION BETWEEN PLASTIC PANELS IN FEET	
			Vertical	Horizontal
10-20	10	50	8	4
20-30	20	80	6	3
30-more	30	100	4	2

[1]Not permitted in Types I and II buildings.

2. Except for Type V-N buildings, the location, size and spacing of such glazed openings do not exceed the values set forth in Table No. 52-A.

3. Plastics used in glazed openings of Type IV-N buildings are Class I or II materials as set forth in Table No. 42-A and the location, size and spacing of the openings do not exceed the values set forth in Table No. 52-A.

Skylights

Sec. 5205. (a) **General.** Regardless of the provisions of Chapter 34, approved plastics may be used in skylights installed on roofs of Type III-N, IV-N or V-N buildings and all buildings equipped with an approved automatic fire-extinguishing system in Groups B-3, B-4, C, F, G, H, I and J Occupancies.

EXCEPTIONS: 1. Approved plastics may be used in any type of construction or occupancy as a fire venting system when approved by the Building Official.

2. Plastics may be used in approved skylights in Type V One-Hour constructions which are located twelve inches (12") or more above the lower plane of the ceiling. The walls of the skylight well shall be no less fire-resistive than the adjacent ceiling.

3. Where a fire-resistive ceiling is not required in one-story buildings, approved plastics may be used in skylights.

(b) **Installation Requirements.** 1. Except in Group I Occupancies, no skylight shall be installed within ten feet (10′) of a property line.

2. The edges of dome-type skylights shall be properly flashed.

3. Plastic skylights shall be separated from each other by at least eight feet (8′) laterally and ten feet (10′) along the slope of the roof.

(c) **Allowable Areas.** The area of individual plastic skylights shall not exceed one hundred square feet (100 sq. ft.).

The total aggregate area of plastics used in skylights, monitors and sawtooth glazing shall not exceed 20 per cent of the floor area of the room or occupancy sheltered.

Skylights (Continued)

(d) **Curb Requirements.** Plastic skylights in roofs having a slope of less than four in 12 shall have a four-inch (4") high curb.

EXCEPTION: The curb may be omitted where skylights are provided with a screen constructed of wire not smaller than No. 12 U. S. gauge with a mesh not larger than one inch (1") immediately below the skylight. The screen shall be substantially mounted below the skylight.

Light-Transmitting Panels in Monitors and Sawtooth Roofs

Sec. 5206. (a) **General.** Where a fire-resistive rating is not required for the roof structure, and in all buildings provided with an approved automatic fire-extinguishing system, approved plastics may be used with or without sash as the light-transmitting medium in monitors and sawtooth roofs.

EXCEPTION: Plastics used in monitors or sawtooth roofs of Type IV-N buildings shall be of Class I or II material as set forth in Table No. 42-A.

(b) **Allowable Areas.** The area of individual plastic glazing used in monitors and sawtooth glazing shall not exceed one hundred and fifty square feet (150 sq. ft.). The total aggregate area of plastics used in skylights, monitors and sawtooth glazing shall not exceed 20 per cent of the floor area of the room or occupancy sheltered.

(c) **Area Separations.** The areas of such plastic panels shall be separated from each other by a section of incombustible material or by a section of the roofing material of the structure not less than five feet (5') in length. The lower edge of the plastic material shall be at least six inches (6") above the surface of the adjoining roof surface.

Plastic Light Diffusers in Ceilings

Sec. 5207. (a) **General.** Ceiling light diffusers having an area greater than 10 per cent of any one hundred square feet (100 sq. ft.) of room area shall be of approved plastics conforming to the requirements specified in Chapter 42.

(b) **Installation.** Plastic light diffusers shall be installed in such a manner that they will not readily become detached when subjected to room temperatures of 300°F. for 25 minutes.

EXCEPTIONS: 1. Plastic light diffusers which are installed in the first floor areas of Group C Occupancies having egress directly to the exterior of the building.

2. Plastic light diffusers which are located between an approved automatic fire-extinguishing system and the areas to be protected other than public corridors or Groups A, B, C, D and E Occupancies if tests by an approved agency have established that such installation will not interfere with the efficient operation of such automatic fire-extinguishing systems.

Partitions

Sec. 5208. Where partitions are not required to be of fire-resistive or incombustible construction, approved plastics conforming to the requirements specified in Chapter 42 and Section 1705 (a) 4 may be used.

Exterior Veneer

Sec. 5209. (a) **General.** Exterior veneer may be of approved plastic materials and shall conform to the provisions of this Section.

(b) **Height.** Plastic veneer shall not be attached to any exterior wall above the first story.

EXCEPTION: Plastic veneer may be attached to exterior walls above the first story of buildings located outside of Fire Zones No. 1 and No. 2 provided the height of veneer is not in excess of thirty-five feet (35') above the adjacent grade elevation.

(c) **Area.** Sections of plastic veneer shall not exceed one hundred and fifty square feet (150 sq. ft.) in area.

EXCEPTION: In Fire Zone No. 3 the area may be increased by 50 per cent.

(d) **Separation.** Sections of plastic veneer shall be separated by a minimum of four feet (4') vertically and two feet (2') horizontally.

Awnings and Canopies

Sec. 5210. Class I and II plastics may be used in awnings and canopies, and all such awnings and canopies shall be constructed in accordance with provisions governing projections and appendages as specified in Section 4506.

Approved plastics may be used in awnings where untreated canvas is permitted.

Greenhouses

Sec. 5211. Approved plastics may be used in lieu of plain glass in greenhouses in Fire Zone No. 3.

CHAPTER 53—SHEET METAL PAINT SPRAY BOOTHS

General

Sec. 5301. (a) **General.** Paint spray booths shall be constructed of steel of not less than No. 18 U. S. gauge in thickness and shall be designed in accordance with Section 2722.

(b) **Area.** The area of a paint spray booth shall not exceed fifteen hundred square feet (1500 sq. ft.) nor 10 per cent of the basic area permitted for the major use of the building as set forth in Table No. 5-C.

(c) **Floor Construction.** The floor shall be constructed of incombustible material.

(d) **Interior Surfaces.** Paint spray booths shall be designed to permit the free passage of exhaust air from all parts of the interior and all interior surfaces shall be smooth and continuous without outstanding edges.

Fire Protection

Sec. 5302. Every spray booth having an open front elevation larger in area than nine square feet (9 sq. ft.) and which is not equipped with doors, shall have a fire curtain or metal deflector not less than four inches (4″) deep installed at the upper outer edge of the booth opening.

Light

Sec. 5303. Paint spray booths shall be illuminated through hammered wire or heat-treated glass panels. The glass panels shall be located in such a manner as to reduce the hazard of ignition caused by paint spray deposit.

Ventilation

Sec. 5304. (a) **General.** Mechanical ventilation shall be provided direct to the exterior of the building. The mechanical exhaust system shall be designed to move the air through any portion of the paint spray area at the rate of not less than 100 lineal feet (100 lin. ft.) per minute. The blades of the exhaust fan shall be constructed of nonferrous material and shall be mounted in such a manner as to prevent contact with the exhaust duct. The motor shall not be mounted in the spray booth or the duct system and belts shall be enclosed where they enter the booth or duct system.

(b) **Exhaust Ducts.** Exhaust ducts shall be constructed of steel having a thickness not less than the values set forth in Table No. 53-A.

The discharge point for ducts in a paint spray booth shall be not less than six feet (6′) from adjoining combustible construction nor less than twenty-five feet (25′) from adjoining exterior wall openings.

EXCEPTION: The discharge point for exhaust ducts is not regulated in a waterwash spray booth.

TABLE NO. 53-A—MINIMUM THICKNESS OF EXHAUST DUCTS

DIAMETER OF DUCT (In Inches)	MINIMUM THICKNESS (In U. S. Standard Gauge)
8″ or less	24
Over 8″ to 18″ Inclusive	22
Over 18″ to 30″ Inclusive	20
Over 30″	18

Electrical Equipment

Sec. 5305. All electrical equipment shall be installed in accordance with U.B.C. Standard No. 53-1-67. Other sources of ignition shall also meet the requirements of this Standard.

CHAPTER 54—GLASS AND GLAZING

Scope

Sec. 5401. (a) **General.** The provisions of this Chapter apply to:

1. Exterior glass and glazing in all occupancies except Groups H, I and J not over three stories in height; and
2. Interior and exterior glass and glazing in all occupancies subject to human impact as specified in Section 5406.

(b) **Standards.** Standards for materials shall be as specified in this Chapter and U.B.C. Standard No. 54-1-67.

(c) **Other Provisions.** See Part V of this Code for additional glass requirements where openings are required to be fire protected and Section 5204 for openings glazed with plastics.

Identification

Sec. 5402. Each light shall bear the manufacturer's label designating the type and thickness of glass. Each light with special performance characteristics such as laminated, heat-strengthened, fully tempered, or insulated shall bear the manufacturer's identification showing the special characteristic and thickness by etching or other permanent identification that shall be visible after the glass is glazed.

EXCEPTION: When approved by the Building Official labels may be omitted from other than special performance glass provided an affidavit is furnished by the glazing contractor certifying that each light is glazed in accordance with approved plans and specifications.

Area Limitations

Sec. 5403. Exterior glass and glazing shall be capable of safely withstanding the loads set forth in Table No. 23-E, acting inward or outward. The area of individual lights shall

TABLE NO. 54-A—MAXIMUM ALLOWABLE AREA OF GLASS (In Square Feet)[1]

WIND LOAD (In Pounds per Square Foot)	THICKNESS (In Inches)										
	SS	DS	3/16	7/32	13/64	1/4	5/16	3/8	1/2	5/8	3/4
10	25	37	72	84	72	114	156	198	270	365	465
15	16	25	48	58	48	72	104	131	192	260	330
20	12	19	36	43	36	54	78	98	144	195	245
25	10	15	29	35	29	43	62	78	115	156	195
30	8	12	24	29	24	36	52	65	96	130	165
35	7	11	21	25	21	31	45	56	82	112	140
40	6	9	18	22	18	27	39	49	72	98	124
45	5	8	16	19	16	24	35	44	64	87	110
50	4	7	14	17	14	22	31	39	58	78	98
60	—	6	12	15	12	18	25	32	48	65	81
70	—	—	10	12	10	15	22	28	40	55	70
80	—	—	9	11	9	13	19	24	35	47	61
90	—	—	8	9	8	12	17	22	32	42	55
100	—	—	7	8	7	11	16	20	29	39	50

[1]Maximum areas apply for rectangular lights of annealed glass firmly supported on all four sides in a vertical position. Glass mounted at a slope not to exceed one horizontal to five verticals may be considered vertical. Maximum areas based on minimum thicknesses set forth in Table No. 54-1-A, Uniform Building Code Standards, No. 54-1-67.

be not more than set forth in Table No. 54-A or as adjusted by Table No. 54-B.

Area Limitations (Continued)

TABLE NO. 54-B—ADJUSTMENT FACTORS—RELATIVE RESISTANCE TO WIND LOAD[1]

GLASS TYPE	APPROXIMATE RELATIONSHIP
Laminated	0.6
Wired	0.5
Heat-strengthened	2.0
Fully tempered	4.0
Factory-fabricated Double Glazing[2]	1.5
Rough Rolled Plate	1.0
Sandblasted	Varies[3]
Regular Plate or Sheet	1.0

[1]To determine the maximum allowable area for glass types listed in Table No. 54-B multiply the allowable area established in Table No. 54-A by the appropriate adjustment factor. Example: For one-fourth-inch (¼") heat strengthened glass determine the maximum allowable area for a 30-pound per square foot wind load requirement. Solution procedure: Use Table No. 54-A to determine the established allowable area for one-fourth-inch (¼") annealed glass. Answer: Thirty-six square feet (36 sq. ft.), then multiply thirty-six square feet (36 sq. ft.) by two – the heat-strengthened glass adjustment factor. Answer: Seventy-two square feet (72 sq. ft.).

[2]Use thickness of the thinner of the two lights, not thickness of the unit.

[3]To be approved by the Building Official since adjustment factor varies with amount of depreciation and type of glass.

TABLE NO. 54-C—MINIMUM GLAZING REQUIREMENTS*

Fixed Windows and Openable Windows Other Than Horizontal Sliding

GLASS AREA	UP TO 6 SQ. FT.	6 TO 14 SQ. FT.	14 TO 32 SQ. FT.	32 TO 50 SQ. FT.	OVER 50 SQ. FT.
Minimum Frame Lap	¼"	¼"	$\frac{5}{16}$"	⅜"	½"
Minimum Glass Edge Clearance	⅛"[1,2]	⅛"[1,2]	$\frac{3}{16}$"[1]	¼"[1]	¼"[1]
Continuous Glazing Rabbet and Glass Retainer[3]	Required				
Resilient Setting Material[4]	Not Required	Required			

Sliding Doors and Horizontal Sliding Windows

GLASS AREA	UP TO 14 SQ. FT.	14 TO 32 SQ. FT.	32 TO 50 SQ. FT.	OVER 50 SQ. FT.
Minimum Glass Frame Lap	¼"	$\frac{5}{16}$"	⅜"	½"
Minimum Glass Edge Clearance	⅛"[2]	$\frac{3}{16}$"	¼"	¼"
Continuous Glazing Rabbet and Glass Retainer[3]	Required above third story	Required		
Resilient Setting Material[4]	Not Required		Required	

*Footnotes on page 530.

FOOTNOTES TO TABLE NO. 54-C

[1]Glass edge clearance in fixed openings shall be not less than required to provide for wind and earthquake drift.

[2]Glass edge clearance at all sides of pane shall be a minimum of three-sixteenths inch ($\frac{3}{16}''$) where height of glass exceeds three feet (3').

[3]Glass retainers such as metal, wood, or vinyl face stops, glazing beads, gaskets, glazing clips, and glazing channels shall be of sufficient strength and fixation to serve this purpose.

[4]Resilient setting material shall include preformed rubber or vinyl plastic gaskets or other materials which are proved to the satisfaction of the Building Official to remain resilient.

Glazing

Sec. 5404. Glass firmly supported on all four edges shall be glazed with minimum laps and edge clearances set forth in Table No. 54-C. For glass not firmly supported on all four edges, design shall be submitted to Building Official for approval. Glass supports shall be considered firm when deflection of the support at design load does not exceed 1/175 of the span.

Windows Louvered

Sec. 5405. Regular plate, sheet, or patterned glass in jalousies and louvered windows shall be no thinner than nominal seven-thirty seconds inch ($\frac{7}{32}''$) and no longer than forty-eight inches (48"). When other glass types are used, design shall be submitted to the Building Official for approval. Exposed glass edges shall be smooth.

Impact

Sec. 5406. Frameless glass doors, glass in doors, fixed glass panels and similar glazed openings which may be subject to accidental human impact shall comply with Table No. 54-D.

EXCEPTIONS: 1. Bathtub and shower enclosures need only conform to the requirements of Section 1711.

2. Glass lights located not less than eighteen inches (18") above the adjacent finished floor or walking surface.

3. Glass lights when the least dimension is no greater than eighteen inches (18").

4. Glass lights six square feet (6 sq. ft.) or less in area.

TABLE NO. 54-D—IMPACT LOADS—GLASS[1, 2]

GLASS TYPE	INDIVIDUAL OPENING AREA	REQUIREMENTS
Regular plate, sheet or rolled (annealed)[3]	Over 6 square feet	Not less than 3/16" thick. Must be protected by a push-bar or protective screen firmly attached on each exposed side, if not divided by a muntin, or decorated[4]
Regular plate, sheet or rolled (annealed), surfaced sandblasted, etched, or otherwise depreciated[3]	Over 6 square feet	Not less than 7/32" thick. Must be protected by a push-bar or protective screen firmly attached on each exposed side, or decorated[4]
Regular plate, sheet or rolled (annealed) obscure[3]	Over 6 square feet	Not less than 3/16" thick. Must be protected by a push-bar or screen firmly attached on each exposed side, or decorated[4]
Laminated	Over 6 square feet	Not less than ¼" thick
Fully Tempered	Over 6 square feet	Not less than 3/16" thick
Wired	Over 6 square feet	Not less than ¼" thick
Frameless All Glass Doors	—	Shall be fully tempered glass

[1]Glass less than single strength (SS) in thickness shall not be used.
[2]If short dimension is larger than twenty-four inches (24"), glass must be double strength (DS) or thicker.
[3]Not permitted for bathtub and shower enclosures.
[4]Decoration shall be sufficient to make glass plainly visible.

PART XII—LEGISLATIVE

CHAPTER 60—LEGISLATIVE

Validity

Sec. 6001. If any section, subsection, sentence, clause, or phrase of this Ordinance is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this Ordinance. The City Council hereby declares that it would have passed this Ordinance, and each section, subsection, clause, or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses, and phrases be declared unconstitutional.

Uniform Building Code Standards

Sec. 6002. The U.B.C. Standards which are referred to in various parts of this Ordinance shall be the Uniform Building Code Standards, 1967 Edition, and are hereby declared to be a part of this Ordinance.

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
CHAPTER 4	
4- 1-67 410	Incombustible Material—Tests. Standard Specification E136 of the ASTM.*
CHAPTER 6	
6- 1-67 608	Proscenium Curtains. Recommended Standards of International Conference of Building Officials.
CHAPTER 9	
9- 1-67 908	Storage and Handling of Flammable Liquids. Pamphlet 30. National Fire Protection Association.
CHAPTER 10	
10- 1-67 1001	Class III Dry Cleaning Systems. Pamphlet 32—Dry Cleaning Plants. National Fire Protection Association.
10- 2-67 1008	Blower and Exhaust System for Dust, Stock and Vapor Control. Pamphlet 91. National Fire Protection Association.
CHAPTER 22	
22- 1-67 2202	Fiberboard; Insulating. Federal Specifications. LLL-I-535 and D2277-64T of the ASTM.
CHAPTER 24	
24- 1-67 2403	Building Brick (Made from Clay or Shale). Standard Specification C62-58 of the ASTM.
24- 2-67 2403	Sand-Lime Building Brick. Standard Specification C73-51 of the ASTM.
24- 3-67 2403	Concrete Building Brick. Standard Specification C55-55 of the ASTM.

*ASTM refers to American Society for Testing and Materials.

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
24- 4-67 2403	Hollow Load-Bearing Concrete Masonry Units. Standard Specification C90-59 of the ASTM.
24- 5-67 2403	Solid Load-Bearing Concrete Masonry Units. Standard Specification C145-59 of the ASTM.
24- 6-67 2403	Hollow Nonload-Bearing Concrete Masonry Units. Standard Specification C129-59 of the ASTM.
24- 7-67 2403	Method of Test for Concrete Masonry Units. Standard Specification C140-63T of the ASTM.
24- 8-67 2403	Structural Clay Load-Bearing Wall Tile. Standard Specifications C34-62 and C112-60 of the ASTM.
24- 9-67 2403	Structural Clay Nonload-Bearing Tile. Standard Specification C56-57 of the ASTM.
24-10-67 2403	Structural Clay Floor Tile. Standard Specification C57-57 of the ASTM.
24-11-67 2403	Gypsum Partition Tile or Block. Standard Specification C52-54 of the ASTM.
24-12-67 2403	Gypsum. Standard Specification C22-50 of the ASTM.
24-13-67 2403	Reinforced Gypsum Concrete and Precast Reinforced Gypsum Slabs. Standard Specifications C317-55 and C377-58T of the ASTM.
24-14-67 2403	Cast Stone. Specification ACI 704-44 of the American Concrete Institute.
24-15-67 2403	Cold-Drawn Steel Wire for Concrete Reinforcement. Standard Specification A82 of the ASTM.
24-16-67 2403	Cement, Masonry. Standard Specification C91-60 of the ASTM.
24-17-67 2403	Quicklime for Structural Purposes. Standard Specification C5-59 of the ASTM.
24-18-67 2403	Hydrated Lime for Masonry Purposes. Standard Specification C207-49 of the ASTM.
24-19-67 2403	Processed Pulverized Quicklime. Standard Specification C51-47 of the ASTM.
24-20-67 2403	Mortar for Masonry Other than Gypsum. Specifications C161-44T and C270-59T of the ASTM.
24-21-67 2403	Aggregate for Masonry Mortar. Specification C144-52T of the ASTM.
24-22-67 2403	Field Tests for Grout and Mortar. Recommended Standards of International Conference of Building Officials.
24-23-67 2403	Aggregates for Grout. Standard Specification C404 of the ASTM.
24-24-67 2405	Sampling and Testing Brick. Standard Methods C67-60 of the ASTM.
24-25-67 2407	Testing Gypsum and Gypsum Products. Standard Specification C472-61 of the ASTM.

Uniform Building Code Standards (Continued)

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
CHAPTER 25	
25- 1-67 2501	Classification Definition and Methods of Grading for all Species of Lumber. Tentative Standard D245-64T of the ASTM; Handbook No. 72 of the U. S. Department of Agriculture, and Simplified Practice Recommendation 16-53 of the U. S. Department of Commerce.
25- 2-67 2501	Cypress — Tidewater Red. Standard Specifications, Southern Cypress Manufacturers' Association.
25- 3-67 2501	Douglas Fir, Coast Region, West Coast Hemlock, and Sitka Spruce, Western Red Cedar; White Fir. Grading and Dressing Rules No. 15. West Coast Lumber Inspection Bureau.
25- 4-67 2501	Douglas Fir, Larch, Ponderosa Pine, Idaho White Pine, Sugar Pine, White Fir, Engelmann Spruce, Lodgepole Pine, Incense Cedar, Red Cedar and Western Hemlock. Standard Grading Rules, Western Wood Products Association.
25- 5-67 2501	Hemlock, Eastern; and Pine, Norway. Grading Rules, Northern Hardwood and Pine Manufacturers Association.
25- 6-67 2501	Pine, Southern. Grading Rules, Southern Pine Inspection Bureau.
25- 7-67 2501	Redwood. Specifications for Grades of California Redwood Lumber of the Redwood Inspection Service.
25- 8-67 2501	Spruce, Eastern; and Fir, Balsam. Grading Rules, Northeastern Lumber Manufacturers Association, Inc.
25- 9-67 2501	Softwood Plywood — Construction and Industrial Product Standard PS 1-66 of the U. S. Department of Commerce, Bureau of Standards.
25-10-67 2501	Structural Glued-Laminated Timber. U. S. Commercial Standard CS 253-63 of the U. S. Department of Commerce and Technical Bulletin 1069, Forest Products Laboratory, U. S. Department of Agriculture.
25-11-67 2501	Structural Glued-Laminated Wood — Douglas Fir; Southern Pine, Hardwood, West Coast Hemlock, and Larch. Standard Specifications of West Coast Lumber Inspection Bureau; Southern Pine Association; Western Wood Products Association; Southern Hardwood Producers; Appalachian Hardwood Manufacturers; Northern Hardwood and Pine Manufacturers and U. S. Forest Products Laboratory.
25-12-67 2501 2806 2810	Preservative Treatment by Pressure Processes. Standard Specifications C1-63, C2-63, C3-63, C4-63, C9-62, C12-51 and C28-60, American Wood Preservers Association.
25-13-67 2501	Wood Poles. Specifications and Dimensions for Wood Poles, USASI 05.1-1963 of the United States of America Standards Institute.

Uniform Building Code Standards (Continued)

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
25-14-67 2501	Round Timber Piles. Standard Specification D25-58 of the ASTM.
25-15-67 2501	Spaced Columns. National Design Specification for Stress-Grade Lumber and Fastenings (1962), National Forest Products Association.
25-16-67 2501	Flexural and Axial Loading. National Design Specification for Stress-Grade Lumber and Fastenings (1962), National Forest Products Association.
25-17-67 2501	Timber Connector Joints, Bolted Joints, Drift Bolts and Wood Screws, Lag Screws. National Design Specification for Stress-Grade Lumber and its Fastenings (1962), National Forest Products Association.
25-18-67 2501	Structural Glued Built-up Members—Plywood Components. Design and Fabrication Specifications of American Plywood Association.
25-19-67 2501	Adhesives. Specification MMM-A-125, U. S. Federal Government. Joint Military Specification MIL-A-397B, U. S. Federal Government. Joint Military Specification MIL-A-5534A, U. S. Federal Government.
25-20-67 2501	Test for Glue Joints in Laminated Wood Products. Standard Method of Testing D1101-59 of the ASTM.
25-21-67 2501	General Design Criteria. Recommended Standards of International Conference of Building Officials.
25-22-67 2501	Plank-and-Beam Framing. Wood Construction Data No. 4, National Forest Products Association.
25-23-67 2501	Tests for Structural Glued-Laminated Lumber, Inspection Manual, AITC 200-63 of American Institute of Timber Construction.
25-24-67 2501	Nails and Staples. Federal Specification No. FFN-105A.
CHAPTER 26	
26- 1-67 2604	Portland Cement. Standard Specifications C150-62 and C175-66 of the ASTM.
26- 2-67 2604	Portland Blast Furnace Slag Cement. Specification C205-62T of the ASTM.
26- 3-67 2604	Portland Pozzolan Cement. Specification C340-62T of the ASTM.
26- 4-67 2604	Concrete Aggregates. Specification C33-61T of the ASTM.
26- 5-67 2604	Lightweight Aggregates for Structural Concrete. Standard Specification C330-60T of the ASTM.
26- 6-67 2604	Concrete Proportions. ACI 613-54 and 613A-59 of the American Concrete Institute.
26- 7-67 2604	Concrete Reinforcement. Specifications A15-62T, A16-63T, A61-63T, A82-62T, A160-62T, A305-56T, A408-62T and A432-62T of the ASTM.
26- 8-67 2604	Prestressed Steel Strand for Concrete. Standard Specification A416-59T of the ASTM.
26- 9-67 2604	Prestressed Steel Wire for Concrete. Specification A421-59T of the ASTM.

Uniform Building Code Standards (Continued)

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
26-10-67 2604	Steel Bar Mats. Standard Specification A184-37 of the ASTM.
26-11-67 2604	Welded Steel Wire Fabric. Specification A185-61T of the ASTM.
26-12-67 2604	Admixtures for Concrete. Standard Specification C494-62T of the ASTM.
26-13-67 2604	Concrete Tests. Part I — Making and Curing Concrete Compression and Flexture Specimens in the Laboratory. Part II — Making and Curing Concrete Compression and Flexure Test Specimens in the Field. Part III — Test for Compressive and Flexural Strengths. Part IV — Compressive Strength of Molded Concrete Cylinders. Standard Specifications C31-62, C39-61, C42-61 and C192-62 of the ASTM.
26-14-67 2604	Splitting Tensile Strength. Specification C496-62T of the ASTM.
26-15-67 2604	Ready-Mixed Concrete. Standard Specification C94-62 of the ASTM.
26-16-67 2604	Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction. AWS D12.1-61 of the American Welding Society.
26-17-67 2604	Design of Two-Way Slabs. Standard 318-63 of the American Concrete Institute.
CHAPTER 27	
27- 1-67 2701	Material Specifications for Structural Steel. Standard Specifications A7, A27, A36, A48, A53, A141, A195, A242, A245, A252, A303, A307, A325, A333, A354, A373, A375, A406, A440 and A441 of the ASTM.
27- 2-67 2701	Erection, Fabrication, Identification and Painting of Structural Steel. Specifications of American Institute of Steel Construction, Inc.
27- 3-67 2701	Stress Variation or Stress Reversal Design. Specifications of American Institute of Steel Construction, Inc.
27- 4-67 2701	Open Web Steel Joist Design. Specifications of American Institute of Steel Construction, Inc.
27- 5-67 2701	Structural Rivet Steel. Standard Specification A141 of the ASTM.
27- 6-67 2701	Design of Welded Connections. Specifications of the American Welding Society.
27- 7-67 2701	High Strength Steel Bolts. Specifications of the American Institute of Steel Construction, Inc.
27- 8-67 2701	Shear Connectors for Composite Construction. Specifications of the American Institute of Steel Construction, Inc.
27- 9-67 2701	Flat-Rolled Carbon Steel Sheets and Hot-Rolled Carbon Steel Strips. Standard Specifications A245 and A303 of the ASTM.
27-10-67 2701	Design of Light Gauge Steel Structural Members. Specification of the American Iron and Steel Institute Specification Manual (1960).

Uniform Building Code Standards (Continued)

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
CHAPTER 29	
29- 1-67 2905 2906	Veneer Application. Recommended Standards of International Conference of Building Officials.
CHAPTER 30	
30- 1-67 3004	Dampers. Pamphlet 90A, National Fire Protection Association.
CHAPTER 32	
32- 1-67 3203	Composition Roofing. Standard Specification 55-A, Underwriters' Laboratories, Inc.
32- 2-67 3203	Roofing Asphalt. Standard Specification D312-44 of the ASTM.
32- 3-67 3203	Composition Roofing. Standard Specification 55-B, Underwriters' Laboratories, Inc.
32- 4-67 3203	Sheet Metals. Standard Specifications A245-62aT, A361-63T and B209-63 of the ASTM.
32- 5-67 3203	Roofing Aggregates. Recommended Standards of International Conference of Building Officials.
32- 6-67 3203	Corrosion-Resistant Metals. Standard Specifications A219 and A239 of the ASTM.
32- 7-67 3203	Composition Roofing Testing. Standard Specification 790, Underwriters' Laboratories, Inc.
32- 8-67 3203	Hand-Split Shakes. Grading and Packing Rules, Hand-Split Red Cedar Shakes (1963), Red Cedar Shingle and Hand-Split Shake Bureau.
32- 9-67 3203	Asbestos-Cement Shingles. Standard Specification C222-60 of the ASTM.
32-10-67 3203	Slate Shingles. Standard Specification C406-57T of the ASTM.
32-11-67 3203	Wood Shingles. Commercial Standard CS31-52, U. S. Department of Commerce, National Bureau of Standards.
32-12-67 3203	Roofing Tile. Recommended Standards of International Conference of Building Officials.
32-13-67 3203	Wire. Standard Specifications B134-62, B211-63 and B250-62 of the ASTM.
CHAPTER 37	
37- 1-67 3701	Fire Clay Refractories. Standard Specification C27-60 of the ASTM.
CHAPTER 38	
38- 1-67 3802	Automatic Fire-Extinguishing Systems. Pamphlet 13 (1960), National Fire Protection Association.
38- 2-67 3802	Carbon Dioxide Fire-Extinguishing Systems. Pamphlet 12 (1957), National Fire Protection Association.
CHAPTER 42	
42- 1-67 4202	Test Method for Fire Hazard Classification of Building Materials. Standard Test Method, Subject 723 (1960).
CHAPTER 43	
43- 1-67 4302	Fire Tests of Building Construction and Materials. Standard Method E119-58 of the ASTM.

Uniform Building Code Standards (Continued)

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
43- 2-67 4306	Fire Tests of Door Assemblies. Standard Method E152-58 of the ASTM.
43- 3-67 4306	Tin-Clad Fire Doors and Shutters. Standard Subject 10 (A) (1965), Underwriters' Laboratories, Inc.
43- 4-67 4302	Fire Tests of Window Assemblies. Standard Specification E163-60T of the ASTM.
43- 5-67 4302	Fire Doors and Fire Windows. Pamphlet 80 (1965), National Fire Protection Association.
43- 6-67 4302	Smoke Detectors for Fire Protective Signaling Systems. Standard Subject 168, Underwriters' Laboratories, Inc.
CHAPTER 47	
47- 1-67 4702	Plaster Liquid Bonding Agents. U. S. Government Military Specification MIL-B-19235 (Docks) 1965, and Standard Specifications of the California Lathing and Plastering Contractors Association (1965), and Recommendations of the Gypsum Association.
47- 2-67 4702	Adhesives for Fastening Gypsum Wallboard to Wood Framing. Specification C557-65T of the ASTM.
47- 3-67 4702	Perlite, Vermiculite and Sand Aggregates for Gypsum and Portland Cement Plaster. Standard Specification C35-62 of the ASTM.
47- 4-67 4702	Fasteners for Gypsum Wallboard. Standard Specifications C514-64 and C380-63 of the ASTM.
47- 5-67 4702	Gypsum Wallboard Tape and Joint Compound. Standard Specifications C475-64 and C474-64 of the ASTM.
47- 6-67 4702	Gypsum Backing Board. Standard Specification C442-63 of the ASTM.
47- 7-67 4702	Gypsum Lath. Standard Specification C37-54 of the ASTM.
47- 8-67 4702	Gypsum Plasters. Standard Specification C28-63 of the ASTM.
47- 9-67 4702	Gypsum Sheathing Board. Standard Specification C79-54 of the ASTM.
47-10-67 4702	Gypsum Wallboard. Standard Specification C36-64 of the ASTM.
47-11-67 4702	Keene's Cement. Standard Specification C61-64 of the ASTM.
47-12-67 4702	Gypsum Molding Plaster. Standard Specification C59-50 of the ASTM.
47-13-67 4702	Lime. Standard Specifications C206-49 and C6-49 of the ASTM.
47-14-67 4702	Metal and Wire Lath. Approved Standard A42.4-1955, of the United States of America Standards Institute.
CHAPTER 48	
48- 1-67 4802	Storage and Handling of Photographic and X-Ray Nitrocellulose Films. Pamphlet 41 of the National Fire Protection Association.

U.B.C. STD. AND SEC. NO.	TITLE AND SOURCE
48- 2-67 4803	Nitrocellulose Motion Picture Film. Pamphlet 40, National Fire Protection Association.
CHAPTER 52	
52- 1-67 5201	Plastic Materials. Specifications of the Manufacturing Chemists Association.
CHAPTER 53	
53- 1-67 5305	Spray Finishing Using Flammable Materials. Pamphlet 33, National Fire Protection Association.
CHAPTER 54	
54- 1-67 5401	Glass. Federal Specification DD-G-451 (a), U. S. Federal Government.
CHAPTER 70	
70- 1-67 7012	Moisture-Density Relations of Soils. Tentative Methods of Test D1557-58T of the ASTM.
70- 2-67 7012	In-Place Density of Soils. Tentative Methods of Test D1556-58T of the ASTM.

Uniform Building Code Standards (Continued)

Ordinances Repealed

Sec. 6003. Ordinance No.................................and all ordinances amendatory thereto, and all ordinances or parts of ordinances in conflict with this Ordinance are hereby repealed.

Date Effective

Sec. 6004. This Ordinance shall be, and is hereby declared to be in full force and effect, from and after 30 days from this date of final passage and approval.

APPENDIX

CHAPTER 13—EXISTING BUILDINGS

Existing Buildings

Sec. 1313. (a) **Purpose.** The purpose of this Section is to provide a reasonable degree of safety to persons living and sleeping in apartment houses and hotels through providing for alterations to such existing buildings as do not conform with the minimum safety requirements of this Code.

(b) **Scope.** The provisions of this Section shall apply exclusively to existing nonconforming Group H Occupancies more than two stories in height.

(c) **Effective Date.** Eighteen months after the effective date of this Section, every building falling within its scope shall be vacated until made to conform to the requirements of this Section.

(d) **Number of Exits.** Every apartment and every other sleeping room shall have access to not less than two exits. A fire escape as specified herein may be used as one required exit.

(e) **Stair Construction.** All stairs shall have a minimum run of nine inches (9″) and a maximum rise of eight inches (8″) and a minimum width exclusive of handrails of thirty inches (30″). Every stairway shall have at least one handrail. A landing having a minimum horizontal dimension of thirty inches (30″) shall be provided at each point of access to the stairway.

(f) **Interior Stairways.** Every interior stairway shall be enclosed with walls of not less than one-hour fire-resistive construction.

Where existing partitions form part of a stairwell enclosure, wood lath and plaster in good condition will be acceptable in lieu of one-hour fire-resistive construction. Doors to such enclosures shall be protected by a self-closing door equivalent to a solid wood door not less than one and three-fourths inches (1¾″) thick. Enclosures shall include landings between flights and any corridors, passageways, or public rooms necessary for continuous exit to the exterior of the building.

The stairway need not be enclosed in a continuous shaft if cut off at each story by the fire-resistive construction required by this Subsection for stairwell enclosures.

Enclosures shall not be required if an automatic fire-extinguishing system is provided for all portions of the building except bedrooms, apartments, and rooms accessory thereto.

(g) **Exterior Stairways.** Exterior stairs shall be incombustible or of wood of not less than two-inch (2″) nominal thickness with solid treads and risers.

Existing Buildings (Continued)

(h) **Fire Escapes.** Fire escapes may be used as one means of egress, if the pitch does not exceed 60 degrees, the width is not less than eighteen inches (18″), the treads are not less than four inches (4″) wide, and they extend to the ground or are provided with counterbalanced stairs reaching to the ground. Access shall be by an opening having a minimum dimension of twenty-nine inches (29″) when open. The sill shall be not more than thirty inches (30″) above the floor and landing.

(i) **Doors and Openings.** Exit doors shall swing in the direction of exit travel, shall be self-closing, and shall be openable from the inside without the use of key or any special knowledge or effort. Doors shall not reduce the required width of stairway more than six inches (6″) when open. Transoms, and openings other than doors, from corridors to rooms shall be fixed closed and shall be covered with a minimum of three-fourths-inch (¾″) plywood.

(j) **Exit Signs.** Every exit doorway or change of direction of a corridor shall be marked with a well-lighted exit sign having letters at least five inches (5″) high.

(k) **Enclosure of Vertical Openings.** Elevators, shafts, ducts, and other vertical openings shall be enclosed as required for stairways in Subsection (f) or by wired glass set in metal frames. Doors shall be incombustible, or as regulated in Subsection (f).

(l) **Separation of Occupancies.** Occupancy separations shall be provided as specified in Section 503. Lobbies, and public dining rooms not including cocktail lounges, shall not require a separation if the kitchen is so separated from the dining room. Boiler rooms or heater rooms containing a central heating plant using solid or liquid fuel shall be separated from the rest of the building by a One-Hour Fire-Resistive Occupancy Separation as specified in Chapter 5.

(m) **Alternates.** No alternate method of obtaining the fire protection and safety required by this Section may be used unless the Board of Appeals, including as a voting member for this purpose the Chief of the Fire Department, finds that such alternate method provides protection and safety equivalent to that required herein.

CHAPTER 23

Refer to Sec. 2301.

Weights of Building Materials

WEIGHTS OF BUILDING MATERIALS

MATERIAL	LBS. PER CU. FT.
BRICK—	
Common	125
Common, laid ⅜″ joints	120
Pressed	150
Soft, laid ⅜″ joints	100

Weights of Building Materials (Continued)

CAST IRON	450
CINDERS, DRY, BITUMINOUS, IN BULK	45
CONCRETE—	
Cinder, structural	110
Stone or gravel	144
Concrete building tile, 60 per cent solid	87
Concrete building tile, 55 per cent solid	79
EARTH—	
Common loam, dry and loose	76
Clay and gravel, dry and loose	100
Common earth, dry and packed	100
Wet mud	120
GLASS	157
GRANITE	170
GRANITE MASONRY, DRESSED	165
GRANITE MASONRY, RUBBLE	155
GRAVEL, DRY	120
LIMESTONE MASONRY, DRESSED	162
MARBLE MASONRY, DRESSED	170
MORTAR, HARD, CEMENT	135
MORTAR, HARD, LIME	105
SAND, DRY	100
SAND, WET	120
SLAG (BLAST FURNACE)	130
STEEL	490
TERRA COTTA, FILLED WITH BRICKWORK	120
TERRA COTTA, DENNISON INTERLOCK TILE, LAID	65
TIMBER—	
Fir, dry	32
Fir, wet	44
Oak	46
WATER, FRESH AT 60°F.	62.5

MATERIAL	LBS. PER SQ. FT.
CEILINGS—	
Wood, lath and plaster	8
Metal lath and plaster suspended	10
PARTITIONS—	
2″ x 4″ studs, plasterboard, ⅝″ plaster, both sides	16
2″ x 4″ studs, wood lath, ⅝″ plaster, both sides	16
Channel studs, metal lath, cement plaster, solid 2″ thick	20
PLASTER ON HOLLOW CLAY TILE (ONE SIDE)	5
2″ hollow clay tile	13
3″ hollow clay tile	16
4″ hollow clay tile	18
5″ hollow clay tile	20
6″ hollow clay tile	25
8″ hollow clay tile	30
12″ hollow clay tile	45

Weights of Building Materials (Continued)

MATERIAL	LBS. PER SQ. FT.
PLASTER ON PLASTER-BLOCK PARTITIONS (ONE SIDE)	5
2" plaster blocks	7
2½" plaster blocks	8.5
3" plaster blocks	9.5
3½" plaster blocks	10.5
4" plaster blocks	12
5" plaster blocks	15
6" plaster blocks	18
8" plaster blocks	22
ROOFINGS—	
Wood shingles	3
Slate 3/16"	7
Slate ¼"	10
Tile and clay shingles	11 to 14
Roman tile, clay	12
Spanish tile, clay	19
Ludowici tile, Spanish	10
Tile roof laid in mortar, add	10
Copper (if no weight is specified)	1.5
Tin	1
Corrugated iron	2
Tar and gravel	6
Prepared composition	1
Skylights, metal-covered, wire glass	5

Refer to Sec. 2314 (l).

Earthquake Recording Instrumentations

Sec. 2314 (l) 1. **General.** In Seismic Zone No. 3 every building over six stories in height with an aggregate floor area of sixty thousand square feet (60,000 sq. ft.) or more, and every building over 10 stories in height regardless of floor area, shall be provided with not less than three approved recording accellerographs.

2. **Location.** The instruments shall be located in the basement, mid-portion, and near the top of the building. Each instrument shall be located in an accessible position.

3. **Maintenance.** Maintenance and service of the instruments shall be provided by the owner of the building subject to the approval of the Building Official. Data produced by the instruments shall be made available to the Building Official upon his request.

CHAPTER 48—PHOTOGRAPHIC AND X-RAY FILMS

Photographic and X-ray Films

Refer to Chapter 48. The following provisions are recommended for inclusion in the Code where provisions covering the handling and storage of photographic and X-ray nitrocellulose films are desired:

Classes of Film Excepted

Sec. 4801. The provisions of this Chapter do not apply to:

1. Film for amateur photographic use in original packages of "roll" and "film pack" films in quantities of less than 50 cubic feet.
2. Safety film (cellulose acetate base).
3. Dental X-ray film.
4. Establishments manufacturing photographic films and storage incidental thereto.
5. Films stored or being used in standard motion picture booths (see Chapter 40).

Safety photographic and X-ray film (cellulose acetate base) may be identified by the marking on the edge of the film. This marking shows plainly before and after developing. Where film is not so marked it shall be inspected to determine whether it is of the safety acetate or nitrate type.

General Regulations

Sec. 4802. All regulations for the storage and handling of photographic and X-ray nitrocellulose films shall conform to the requirements set forth in U.B.C. Standard No. 48-1-67.

> EXCEPTION: Where definite fire-resistive materials are specified, materials of equal fire resistance as specified in this Code may be used.

Motion Picture Film

Sec. 4803. The storage and handling of nitrocellulose motion picture film shall conform to the requirements set forth in U.B.C. Standard No. 48-2-67.

CHAPTER 70—EXCAVATION AND GRADING

Purpose

Sec. 7001. The purpose of this Chapter is to safeguard life, limb, property, and public welfare by establishing minimum requirements for regulating grading and procedures by which these requirements may be enforced.

Scope

Sec. 7002. This Chapter sets forth rules and regulations to control excavation, grading, and earthwork construction, including fills or embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

Permits Required and Exceptions

Sec. 7003. No person shall do any grading without first having obtained a grading permit from the Building Official, except for the following:

1. An excavation which (a) is less than two feet (2') in depth, or (b) which does not create a cut slope greater than five feet (5') in height and steeper than one and one-half horizontal to one vertical.
2. A fill less than one foot (1') in depth, and placed on natural terrain with a slope flatter than five horizontal to one vertical, or less than three feet (3') in depth, not intended to support structures, which does not exceed 50 cubic yards on any one lot and does not obstruct a drainage course.
3. An excavation below finished grade for basements and footings of a building, retaining wall, or other structure authorized by a valid building permit. This shall not exempt any fill made with the material from such excavation nor exempt any excavation having an unsupported height greater than five feet (5') after the completion of such structure.
4. Excavation or deposition of earth materials within a property which is dedicated or used, or to be used for cemetery purposes, except where such grading is within one hundred feet (100') of the property line or intended to support structures.
5. Mining, quarrying, excavating, processing, stockpiling of rock, sand, gravel, aggregate, or clay where established and provided for by law provided that such operations do not affect the lateral support or unduly increase the stresses in or pressure upon any adjacent or contiguous property.
6. Grading in an isolated, self-contained area if the Building Official finds that no danger to private or public property can now or thereafter result from the grading operations.

Hazardous Conditions

Sec. 7004. Whenever the Building Official determines that any existing excavation or embankment or fill has become a hazard to life and limb, or endangers property, or adversely affects the safety, use, or stability of a public way or drainage channel, the owner of the property upon which the excavation or fill is located, or other person or agent in control of said

Hazardous Conditions (Continued)

property, upon receipt of notice in writing from the Building Official shall within the period specified therein repair or eliminate such excavation or embankment so as to eliminate the hazard and be in conformance with the requirements of this Code.

Definitions

Sec. 7005. BEDROCK is the solid, undisturbed rock in place either at the ground surface or beneath surficial deposits of gravel, sand, or soil.

CERTIFY OR CERTIFICATION shall mean the specific inspections and tests where required have been performed and that such tests comply with the applicable requirements of this Chapter.

ENGINEERING GEOLOGY is the application of geological data and principles to engineering problems dealing with naturally occurring rock and soil for the purpose of assuring that geological factors are recognized and adequately interpreted in engineering practice.

EXISTING GRADE is the vertical location of the existing ground surface prior to excavating or filling.

FILL is deposits of soil, rock, or other materials placed by man.

FINISH GRADE is the final grade or elevation of the building site.

GRADING is any excavating or filling or combination thereof.

ROUGH GRADE is an approximate elevation of the ground surface conforming to the proposed design.

SITE is any lot or parcel of land or contiguous combination thereof, under the same ownership, where grading is performed or permitted.

SOIL is all earth material of whatever origin that overlies bedrock.

SOILS ENGINEERING shall mean the application of the principles of soils mechanics in the investigation and analysis of the engineering properties of earth material.

Grading Permit Requirements

Sec. 7006. (a) **Permits Required.** Except as exempted in Section 7003 of this Code, no person shall do any grading without first obtaining a grading permit from the Building Official. A separate permit shall be required for each site, and may cover both excavations and fills.

(b) **Plans and Specifications.** With each application for a grading permit and when required by the Building Official for enforcement of any provisions of this Code, two sets of plans and specifications shall be submitted. Except as waived by the Building Official for small and unimportant work, the plans shall be prepared and signed by a civil engineer licensed by the state and shall show the following:

Grading Permit Requirements (Continued)

1. A vicinity sketch or other data adequately indicating the site location.

2. Property lines of the property on which the work is to be performed.

3. Location of any buildings or structures on the property where the work is to be performed, and the location of any building or structure on land of adjacent property owners which are within fifteen feet (15′) of the property.

4. Accurate contours showing the topography of the existing ground.

5. Elevations, dimensions, location, extent and the slopes of all proposed grading shown by contours and other means.

6. A certification of the quantity of excavation and fill involved and estimated starting and completion dates.

7. Detailed plans of all drainage devices, walls, cribbing, dams, or other protective devices to be constructed in connection with, or as a part of, the proposed work, together with a map showing the drainage area and estimated runoff of the area served by any drains.

8. Any additional plans, drawings, or calculations required by the Building Official.

(c) **Engineering Geological Reports.** Prior to issuance of a grading permit, the Building Official may require an engineering geological investigation, based on the most recent grading plan. The engineering geological report shall include an adequate description of the geology of the site, and conclusions and recommendations regarding the effect of geologic conditions on the proposed development.

All reports shall be subject to approval by the Building Official, and supplemental reports and data may be required as he may deem necessary. Recommendations included in the report and approved by the Building Official shall be incorporated in the grading plan.

(d) **Soils Engineering Reports.** The Building Official may require a soils engineering investigation, based on the most recent grading plan. Such reports shall include data regarding the nature, distribution, and strength of existing soils, conclusions and recommendations for grading procedures, and design criteria for corrective measures.

Recommendations included in the report and approved by the Building Official shall be incorporated in the grading plan or specifications.

Permit Limitations and Conditions

Sec. 7007. (a) **General.** The issuance of a grading permit shall constitute an authorization to do only that work which is described or illustrated on the application for the permit, or on the site plans and specifications approved by the Building Official.

(b) **Jurisdiction of Other Agencies.** Permits issued under the requirements of this Code shall not relieve the owner of

Permit Limitations and Conditions (Continued)

responsibility for securing required permits for work to be done which is regulated by any other code, department or division of the governing agency.

(c) **Time Limits.** The permittee shall fully perform and complete all of the work required to be done pursuant to the grading permit within the time limit specified. If no time limit is specified, the permittee shall complete the work within 180 days after the date of the issuance of the grading permit.

If the permittee is unable to complete the work within the specified time, he shall, prior to the expiration of the permit, present in writing to the Building Official a request for an extension of time, setting forth the reasons for the requested extension. If, in the opinion of the Building Official, such an extension is warranted, he may grant additional time for the completion of the work.

(d) **Storm Damage Precautions.** All persons performing any grading operations shall put into effect all safety precautions which are necessary in the opinion of the Building Official and shall remove all loose dirt from the grading site and provide adequate anti-erosion and/or drainage devices, debris basins, or other safety devices to protect the life, limb, health, and welfare of private and public property of others from damage of any kind.

(e) **Conditions of Approval.** In granting any permit under this Code, the Building Official may attach such conditions as may be reasonably necessary to prevent creation of a nuisance or hazard to public or private property. Such conditions may include, but shall not be limited to:

1. Improvement of any existing grading to bring it up to the standards of this Code.
2. Requirements for fencing of excavations or fills which otherwise would be hazardous.

(f) **Liability.** Neither the issuance of a permit under the provisions of this Code, nor the compliance with the provisions hereof or with any conditions imposed in the permit issued hereunder, shall relieve any person from responsibility for damage to other persons or property, nor impose any liability upon the city for damage to other persons or property.

Denial of Permit

Sec. 7008. (a) **Hazardous Grading.** The Building Official shall not issue a permit in any case where he finds that the work as proposed by the applicant is liable to endanger any private property or result in the deposition of debris on any public way or interfere with any existing drainage course.

If it can be shown to the satisfaction of the Building Official that the hazard can be essentially eliminated by the construction of retaining structures, buttress fills, drainage devices or by other means, the Building Official may issue the permit with the condition that such work be performed.

(b) **Geological or Flood Hazard.** If, in the opinion of the Building Official, the land area for which grading is proposed is subject to geological or flood hazard to the extent that no reasonable amount of corrective work can eliminate or sufficiently reduce the hazard to human life or property, the grading permit and building permits for habitable structures shall be denied.

Denial of Permit (Continued)

Sec. 7009. (a) **Plan-checking Fee.** For excavation and fill on the same site, the fee shall be based on the volume of the excavation or fill, whichever is greater. Before accepting a set of plans and specifications for checking, the Building Official shall collect a plan-checking fee. Separate permits and fees shall apply to retaining walls or major drainage structures as indicated elsewhere in this Code. There shall be no separate charge for standard terrace drains and similar facilities. The amount of the plan-checking fee for grading plans shall be as set forth in Table No. 70-A.

Fees

The fee for a grading permit authorizing additional work to that under a valid permit shall be the difference between the fee paid for the original permit and the fee shown for the entire project.

TABLE NO. 70-A—PLAN-CHECKING FEES

50 cubic yards or less	No Fee
50 to 100 cubic yards	**$10.00**
101 to 1000 cubic yards	**15.00**
1001 to 10,000 cubic yards	**20.00**

10,001 to 100,000 cubic yards—**$20.00** for the first 10,000 cubic yards plus **$10.00** for each additional 10,000 cubic yards or fraction thereof.

100,001 to 200,000 cubic yards—**$110.00** for the first 100,000 cubic yards plus **$6.00** for each additional 10,000 cubic yards or fraction thereof.

200,001 cubic yards or more—**$170.00** for the first 200,000 cubic yards, plus **$3.00** for each additional 10,000 cubic yards or fraction thereof.

(b) **Grading Permit Fees.** A fee for each grading permit shall be paid to the Building Official as set forth in Table No. 70-B.

TABLE NO. 70-B—GRADING PERMIT FEES

50 cubic yards or less	**$10.00**
50 to 100 cubic yards	**15.00**

101 to 1000 cubic yards—**$15.00** for the first 100 cubic yards, plus **$7.00** for each additional 100 cubic yards or fraction thereof.

1001 to 10,000 cubic yards—**$78.00** for the first 1000 cubic yards, plus **$6.00** for each additional 1000 cubic yards or fraction thereof.

10,001 to 100,000 cubic yards—**$132.00** for the first 10,000 cubic yards, plus **$27.00** for each additional 10,000 cubic yards or fraction thereof.

100,001 cubic yards or more—**$375.00** for the first 100,000 cubic yards, plus **$15.00** for each additional 10,000 cubic yards or fraction thereof.

Fees (Continued)

The fee for a grading permit authorizing additional work to that under a valid permit shall be the difference between the fee paid for the original permit and the fee shown for the entire project.

Bonds

Sec. 7010. (a) **Bonds Required.** A permit shall not be issued for more than 1000 cubic yards unless the permittee shall first post with the Building Official a bond executed by the owner and a corporate surety authorized to do business in this state as a surety in an amount sufficient to cover the cost of the project, including corrective work necessary to remove and eliminate geological hazards.

The bond shall include penalty provisions on a form approved by counsel for the governing agency, for failure to complete the work on schedule.

In lieu of a surety bond the applicant may file a cash bond with the Building Official in an amount equal to that which would be required in the surety bond.

(b) **Conditions.** Every bond shall include the conditions that the permittee shall:

1. Comply with all of the provisions of the Code, applicable laws, and ordinances;
2. Comply with all of the terms and conditions of the permit for excavation or fill to the satisfaction of the Building Official;
3. Complete all of the work contemplated under the permit within the time limit specified in the permit. (The Building Official may, for sufficient cause, extend the time specified in the permit, but no such extension shall release the surety upon the bond.)

(c) **Failure to Complete Work.** The term of each bond shall begin upon the date of filing and shall remain in effect until the completion of the work to the satisfaction of the Building Official. In the event of failure to complete the work and failure to comply with all of the conditions and terms of the permit, the Building Official may order the work required by the permit to be completed to his satisfaction. The surety executing such bond or deposit shall continue to be firmly bound under a continuing obligation for the payment of all necessary costs and expenses that may be incurred or expended by the governing agency in causing any and all such required work to be done. In the case of a cash deposit, said deposit or any unused portion thereof shall be refunded to the permittee.

Design Standards for Cuts

Sec. 7011. (a) **Maximum Slope.** Cuts shall not be steeper in slope than one and one-half horizontal to one vertical unless the owner furnishes a soils engineering or an engineering geology report certifying that the site has been investigated and indicating that the proposed deviation will not endanger any private property or result in the deposition of debris on any public way or interfere with any existing drainage course. **Design Standards for Cuts (Continued)**

The Building Official may require the excavation to be made with a cut face flatter in slope than one and one-half horizontal to one vertical if he finds it necessary for stability and safety.

(b) **Drainage Terraces.** Cut slopes exceeding forty feet (40′) in vertical height shall be terraced at their approximate mid-height. Drainage terraces are to be a minimum of six feet (6′) wide, paved and must carry water to a safe disposal area. Terraces shall be cut every thirty feet (30′) vertically, except that where only one terrace is required, it shall be at mid-height.

Design Standards for Fills

Sec. 7012. (a) **Compaction.** All fills shall be compacted to a minimum of 90 per cent of maximum density as determined by U.B.C. Standard No. 70-1-67. Field density shall be determined by U.B.C. Standard No. 70-2-67 or equivalent as approved by the Building Official. If the Building Official determines that the strict enforcement of this Section is unduly restrictive or imposes an undue hardship on the permittee, this requirement may be waived by the Building Official. This requirement shall not be waived when structures are to be supported by the fill or where the Building Official determines that compaction is necessary as a safety measure to aid in preventing the saturation, slipping, or erosion of the fill.

(b) **Preparation of Ground.** The natural ground surface shall be prepared to receive fill by removing vegetation, noncomplying fill, top soil, and, where slopes are five horizontal to one vertical or steeper, by benching into sound bedrock or other competent material. Five feet (5′) of the lowermost bench shall be exposed beyond the toe of the fill. The bench shall be sloped for sheet overflow or a paved drain shall be provided.

(c) **Fill Slope.** No compacted fill shall be made which creates an exposed surface steeper in slope than one and one-half horizontal to one vertical. The Building Official may require that the fill be constructed with an exposed surface flatter than one and one-half horizontal to one vertical if he finds this necessary for stability and safety.

Slopes of fills which are not compacted in accordance with Section 7012 (a) may not exceed two horizontal to one vertical.

(d) **Fill Material.** No organic material shall be permitted in fills. Except as permitted by the Building Official, no rock or similar irreducible material with a maximum dimension greater than eight inches (8″) shall be buried or placed in fills.

(e) **Drainage Terraces.** All fill slopes in excess of thirty feet (30′) vertical height shall have paved drainage terraces

Design Standards for Fills (Continued)

at vertical intervals not exceeding twenty-five feet (25') except that where only one terrace is required it shall be at mid-height. Such terraces shall drain into a paved gutter, pipe or other watercourse adequate to convey the water to a safe disposal area. The terrace shall be at least six feet (6') wide.

(f) **Slopes to Receive Fill.** Fills toeing out on natural slopes which are steeper than two horizontal to one vertical will not be permitted.

Design Standards for Setbacks

Sec. 7013. Cuts and fills shall be set back from property lines and buildings shall be set back from cut or fill slopes in accordance with Figure No. 1. Retaining walls may be used to reduce the required setback when approved by the Building Official.

Fill placed on or above the top of an existing or proposed cut or natural slope steeper than three horizontal to one vertical shall be set back from the edge of the slope a minimum distance of six feet (6').

Building foundations shall be set back from the top of slope a minimum distance of six feet (6') for all cut slopes steeper than two horizontal to one vertical. No buildings shall be constructed on cut or fill slopes steeper than two horizontal to one vertical.

The setbacks given in this Section are minimum and may be increased by the Building Official if considered necessary for safety or stability or to prevent possible damage from water, soil, or debris.

Design Standards for Drainage

Sec. 7014. (a) **Disposal.** All drainage facilities shall be designed to carry surface waters to the nearest practical street, storm drain, or natural watercourse approved by the Building Official and/or other appropriate governmental agency, as a safe place to deposit such waters. At least two per cent grade toward the approved disposal area will be required for building pads, except as waived by the Building Official for nonhilly terrain.

(b) **Erosion Prevention.** Adequate provision shall be made to prevent any surface waters from damaging the face of an excavation or fill. All slopes shall be protected from surface water runoff from above by berms or swales.

(c) **Terrace Drains.** All swales or ditches on drainage terraces shall have a minimum grade of five per cent and must be paved. Drainage devices shall be paved with concrete with a minimum thickness of three inches (3") or approved equal. They shall have a minimum depth at the deepest point of one foot (1').

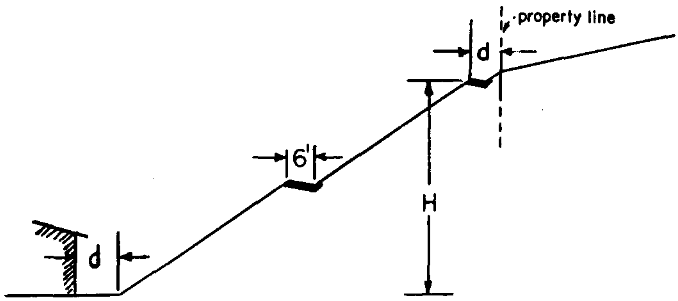
If the drain discharges onto natural ground riprap may be required.

Planting

Sec. 7015. The face of all cut and fill slopes shall be planted and maintained with a ground cover approved by the

Figure No. 1

EXCAVATED SLOPE



REQUIRED SETBACKS			
	FILL SLOPES		CUT SLOPES
H FEET	a	b	d
0-15	1'6"	3'	3'
15-50	H/10	H/5	H/5
Over 50	H/10	H/5	10'

COMPACTED FILL SLOPE

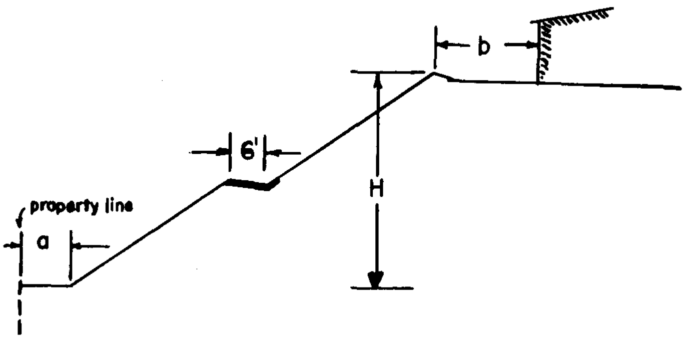


FIGURE NO. 1—REQUIRED SETBACKS

Planting (Continued)

Building Official to protect the slopes against erosion as soon as practical and prior to the final approval of the grading. Where cut slopes are not subject to erosion due to their rocky character, this requirement may be waived by the Building Official.

An irrigation system or watering facilities may be required by the Building Official.

Grading Inspection and Supervision

Sec. 7016. (a) **Supervised Grading Required.** All grading in excess of 5000 cubic yards shall be performed under the supervision of a civil engineer and shall be designated "supervised grading." Grading not supervised in accordance with this Section shall be designated "regular grading." For grading involving less than 5000 cubic yards the permittee may elect to have the grading performed as either supervised grading or regular grading.

(b) **Regular Grading Requirements.** The Building Official shall inspect the work, and require adequate inspection and compaction control by a soils testing agency. The soils testing agency shall be approved by the Building Official.

Periodic reports certifying the compaction or acceptability of all fills shall be required except as exempted by Section 7012 (a). These shall include but need not be limited to inspection of cleared areas and benches prepared to receive fill and removal of all soil and unsuitable materials; the placement and compaction of fill materials; the bearing capacity of the fill to support structures, and the inspection or review of the construction of retaining walls, subdrains, drainage devices, buttress fills, and other similar measures.

The Building Official may require sufficient inspection to assure that all geologic conditions have been adequately considered. Where geologic conditions warrant, the Building Official may require periodic geologic reports. These inspections may be required to include, but need not be limited to inspection of cut slopes, canyons during clearing operations for ground water and earth material conditions; benches prior to placement of fill; and possible spring locations.

(c) **Supervised Grading Requirements.** For supervised grading it shall be the responsibility of the civil engineer to supervise and coordinate all site inspection and testing during grading operations. Soils and geology reports shall also be required as specified in Section 7006. All necessary reports, compaction data, and soils engineering and engineering geological recommendations shall be submitted to the Building Official by the supervising civil engineer.

(d) **Notification of Noncompliance.** If in the course of fulfilling his responsibility under this Chapter, the supervising civil engineer finds that the work is not being done in conformance with this Chapter or the plans approved by the Building Official, or in accordance with accepted practices, he shall immediately notify the person in charge of the grading work and the Building Official in writing of the nonconformity and of the corrective measures to be taken.

Safety Precautions

Sec. 7017. If at any stage of the work the Building Official determines by inspection that further grading as authorized is likely to endanger any private property or result in the deposition of debris on any public way or interfere with any

Safety Precautions (Continued)

existing drainage course, the Building Official may require, as a condition to allowing the work to be completed, that such reasonable safety precautions be taken as he considers advisable to avoid such likelihood of danger.

Notice to comply shall be submitted to the permittee in writing. After a notice to comply is written, a period of 10 days shall be allowed for the contractor to begin to make the corrections, unless an imminent hazard exists, in which case the corrective work shall begin immediately.

If the Building Official finds any existing conditions not as stated in the grading permit or approved plans, he may refuse to approve further work until approval is obtained for a revised grading plan which will conform to the existing conditions.

Responsibility of Permittee

Sec. 7018. (a) **Compliance with Plans and Requirements.** All permits issued hereunder shall be presumed to include the provision that the applicant, his agent, contractors or employees, shall carry out the proposed work in accordance with the approved plans and specifications and in compliance with all the requirements of this Chapter.

(b) **Protection of Utilities.** During grading operations the permittee shall be responsible for the prevention of damage to any public utilities or services. This responsibility applies within the limits of grading and along any routes of travel of equipment.

(c) **Protection of Adjacent Property.** The permittee is responsible for the prevention of damage to adjacent property and no person shall excavate on land sufficiently close to the property line to endanger any adjoining public street, sidewalk, alley, or other public or private property without supporting and protecting such property from settling, cracking, or other damage which might result.

Modification of Approved Plans

Sec. 7019. All modifications of the approved grading plans must be approved by the Building Official. All necessary soils and geological reports shall be submitted with the plans.

No grading work in connection with the proposed modifications will be permitted without the approval of the Building Official. If, in the opinion of the Building Official, the strict enforcement of Section 7007 (d) 1 will create an undue hardship on the permittee, or a hazard to the safety of operations, this requirement may be waived. Such a waiver shall not relieve the permittee of responsibility for compliance with the design standards of this Code.

Modifications which affect basic tract design or land use must have the approval of the appropriate control agency.

Completion of Work

Sec. 7020. (a) **Final Reports.** Upon completion of the work, the Building Official may require the following reports:

Completion of Work (Continued)

1. The supervising civil engineer shall certify that all grading, lot drainage, and drainage facilities have been completed in conformance with the approved plans and this Chapter, and shall furnish a final contour map of the completed work.
2. The soils engineering reports shall include certification of soil bearing capacity, summaries of field and laboratory tests, locations of tests, and shall show limits of compacted fill on an "as built" plan.
3. The engineering geology reports shall be based on the final contour map and shall include specific approval of the grading as affected by geological factors. Where necessary, a revised geologic map and cross sections, and any recommendations regarding building restrictions or foundation setbacks shall be included.

(b) **Notification of Completion.** The permittee or his agent shall notify the Building Official when the grading operation is ready for final inspection. Final approval shall not be given until all work including installation of all drainage structures and their protective devices, has been completed and the final contour map and required reports have been submitted.

INDEX

For Index by Parts, Chapters, and Sections, see Pages 7 to 18

A

Section

Section

D

G

H

M

N

O

Section

Section

T

Section

U

X