THE UNIFORM BUILDING CODE is dedicated to the development of better building construction and greater safety to the public by uniformity in building laws. The Code is founded on broad based performance principles that make possible the use of new materials and new construction systems.


Changes to the Code are processed each year and published in supplements in a form permitting ready adoption by local communities. These changes are carefully reviewed in public hearings by professional experts in the field of building construction and fire and life safety.
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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 29 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 29.
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

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.”

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.

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.

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-
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.

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.
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.

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.
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.

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. Whenever necessary to make an inspection to enforce any of the provisions of this Code, or whenever the Building Official or his authorized representative has reasonable cause to believe that there exists in any building or upon any premises, any condition which makes such building or premises unsafe as defined in Section 203 of this Code, the Building Official or his authorized representative may enter such building or premises at all reasonable times to inspect the same or to perform any duty imposed upon the Building Official by this Code; provided that if such building or premises be occupied, he shall first present proper credentials and demand entry; and if such building or premises be unoccupied, he shall first make a reasonable effort to locate the owner or other persons having charge or control of the building or premises and demand entry. If such entry is refused, the Building Official or his authorized representative shall have recourse to every remedy provided by law to secure entry.

"Authorized Representative" shall include the officers named in Section 202 (a) and (b) of this Code.
No owner or occupant or any other person having charge, care or control of any building or premises shall fail or neglect, after proper demand is made as herein provided, to promptly permit entry therein by the Building Official or his authorized representative for the purpose of inspection and examination pursuant to this Code. Any person violating this subdivision shall be guilty of a misdemeanor.

(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 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.

Sec. 203. 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, disaster damage, 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
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.

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

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. Indicate the use or occupancy for which the proposed work is intended.
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 600 square feet.
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.

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

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.

(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.

**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. The valuation to be used in computing the permit and plan-check fees shall be the total value of all construction work for which the permit is issued, as well as all finish work, painting, roofing, electrical, plumbing, heating, air conditioning, elevators, fire-extinguishing systems and any other permanent work or permanent equipment.
TABLE NO. 3-A—BUILDING PERMIT FEES

<table>
<thead>
<tr>
<th>TOTAL VALUATION</th>
<th>FEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.00 to $500.00</td>
<td>$5.00</td>
</tr>
<tr>
<td>$501.00 to $2,000.00</td>
<td>$5.00 for the first $500.00 plus $1.00 for each additional $100.00 or fraction thereof, to and including $2,000.00</td>
</tr>
<tr>
<td>$2,001.00 to $25,000.00</td>
<td>$20.00 for the first $2,000.00 plus $3.00 for each additional thousand or fraction thereof, to and including $25,000.00</td>
</tr>
<tr>
<td>$25,001.00 to $50,000.00</td>
<td>$89.00 for the first $25,000.00 plus $2.50 for each additional thousand or fraction thereof, to and including $50,000.00</td>
</tr>
<tr>
<td>$50,001.00 to $100,000.00</td>
<td>$131.50 for the first $50,000.00 plus $1.50 for each additional thousand or fraction thereof, to and including $100,000.00</td>
</tr>
<tr>
<td>$100,001.00 and up</td>
<td>$226.50 for the first $100,000.00 plus $1.00 for each additional thousand or fraction thereof</td>
</tr>
</tbody>
</table>

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.

(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.

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 con-
spicuous 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 written 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) Required Inspections. Reinforcing steel or structural framework of any part of any building or structure shall not be covered or concealed 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 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 this Code.

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; 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.

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'" 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.

**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.

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 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

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.

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 16 feet but not less than 10 feet 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.”)
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, education, instruction, 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.

Sec. 403. BALCONY is that portion of the seating space of an assembly room, the lowest part of which is raised 4 feet 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.”)

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.

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

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.

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.
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.

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.

DISPERAL 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.

Sec. 406. EXISTING BUILDINGS. (See “Building, Existing.”)

EXIT. See Section 3301 (e).

EXIT COURT. See Section 3301 (c).

EXIT PASSAGEWAY. See Section 3301 (c).

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).
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 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.

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 1000 square feet 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 5 feet 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 5 feet distant from said wall. In case walls are parallel to and within 5 feet of a public sidewalk, alley or other public way, the grade shall be the elevation of the sidewalk, alley or public way.
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 100 square feet of superficial floor area in a dormitory shall be considered to be a guest room.

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.

Sec. 410. No definitions.

Sec. 411. No definitions.

Sec. 412. No definitions.

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.
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 33½ 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 7 feet.

Sec. 415. NONCOMBUSTIBLE 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 shall be considered noncombustible within the meaning of this Section.

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

“Noncombustible” does not apply to surface finish materials. Material required to be noncombustible for reduced clearances to flues, heating appliances, or other materials shall refer to material conforming to Item No. 1. No material shall be classed as noncombustible 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.

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.

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

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 5 feet 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.

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.

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

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 5 feet.

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 under-floor space is more than 6 feet above grade as defined herein for more than 50 per cent of the total perimeter or is more than 12 feet above grade as defined herein at any point, such basement, cellar or unused under-floor space shall be considered as a story.
STREET is any thoroughfare or public space not less than 16 feet 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.

Sec. 421. No definitions.

Sec. 422. U.B.C. STANDARDS is the 1970 Edition of the “Uniform Building Code Standards.” (See Chapter 60.)

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).

VENUE. See Section 3002.

VENTILATING CEILING is a suspended ceiling containing many small apertures through which air, at low pressure, is forced downward from an overhead plenum dimensioned by the concealed space between suspended ceiling and the floor or roof above.

Sec. 424. WALLS shall be defined as follows:

Bearing Wall is any wall meeting either of the following classifications:
1. Any metal or wood stud wall which supports more than 100 pounds per lineal foot of superimposed load.
2. Any masonry or concrete wall which supports more than 200 pounds per lineal foot superimposed load, or any such wall supporting its own weight for more than one story.

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.
WATER HEATER is an appliance designed primarily to supply hot water and is equipped with automatic controls limiting water temperature to a maximum of 210°F.

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 12 inches 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.
3. Ceiling and roof soffits beyond a horizontal distance of 10 feet from the outer edge of the ceiling or roof soffits.

WINDOW. (See “Bay Window”; see “Oriel Window.”)

X

Sec. 425. No definitions.

Y

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.
PART III

REQUIREMENTS BASED ON OCCUPANCY

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

NOTE: Tables in Chapter 5 appear at the end of the Chapter.

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.

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.

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 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 ratios of the actual area divided by the allowable area for each separate occupancy shall not exceed one.

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

In no case shall any occupancy be located above the story or height set forth in Table No. 5-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.

Where the occupancy separation is horizontal, structural members supporting the separation shall be protected by equivalent fire-resistive construction.

(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. 43-7 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-protection 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 120 square feet.

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-protection 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-protection 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-protection 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.

EXCEPTIONS: 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. In Groups A, C and D Occupancies a three-hour occupancy separation is permitted from a Group F, Division 1 Occupancy used only as a garage for the parking of passenger motor vehicles having a capacity of not more than nine persons per vehicle and provided no repair or fueling is done.

3. In Group H Occupancies, a one-hour occupancy separation is permitted from a Group F, Division 1 Occupancy used only as a garage for the parking of passenger motor vehicles having a capacity of not more than nine persons per vehicle and provided no repair or fueling is done and the area does not exceed 3000 square feet in a building.

4. In the one-hour occupancy separation between a Group I and J Occupancy, the separation may be limited to the installation of materials approved for one-hour fire-resistant construction on the garage side and a self-closing, tight-fitting solid wood door 1⅛ inches in thickness will be permitted in lieu of a one-hour fire assembly. Fire dampers shall not be required in ducts piercing this separation for ducts constructed of not less than No. 26 gauge galvanized steel.

5. The following occupancies need not be separated from the uses to which they are accessory: assembly rooms having a floor area of not over 750 square feet; administrative and clerical offices and similar rooms which in the aggregate do not exceed 25 per cent of the floor area of the major use when not related to Group E, Division 1 and Group E, Division 2 Occupancies.

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 30 inches 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 of buildings over one story in height 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.

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 by 33 1/3 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 nor exceed the area permitted for a one-story building.

(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-resistant construction in Types I, II or III buildings and two-hour fire-resistant 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. All openings shall be protected by a fire assembly having a three-hour fire-protection rating in four-hour fire-resistant walls and one and one-half-hour fire-protection rating in two-hour fire-resistant 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-resistant construction for a width equal to the depth of the projecting elements. Wall openings within such widths shall be protected by assemblies having a three-fourths-hour fire-protection rating.

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

**EXCEPTIONS:**
1. Area separation walls may terminate at the roof soffit provided the roof is of at least two-hour fire-resistant 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-resistant time period for a width of not less than 5 feet on each side of the area separation wall termination.
3. Two-hour area separation walls may terminate at roofs of entirely noncombustible construction.

4. Where an area separation wall separates portions of a building having different heights, such wall may terminate at a point 30 inches above the lower roof level provided the exterior wall for a height of 10 feet above the lower roof is of one-hour fire-resistant construction with openings protected by assemblies having a three-fourths-hour fire-protection rating.

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

See Chapters 6 to 16 inclusive for special occupancy provisions. (See U.B.C. Standard No. 43-7 for fire dampers in air ducts piercing area separations.)

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 20 feet 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
### Allowable Area Increases (Continued)

1. **Separation on three sides.** Where public space, streets, or yards more than 20 feet 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 20 feet, but the increase shall not exceed 50 per cent.

2. **Separation on three sides.** Where public space, streets, or yards more than 20 feet 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 20 feet, but the increase shall not exceed 50 per cent.

3. **Separation on all sides.** Where public space, streets or yards, more than 20 feet 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 20 feet. 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 60 feet 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 60 feet 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. The area increases permitted in this Subsection may be compounded with that specified in paragraph No. 1, 2 or 3 of Subsection (a) of this Section. The increases permitted in this Subsection shall not apply when automatic fire-extinguishing systems are installed under the following provisions:

1. Section 507 for an increase in allowable number of stories.
2. Section 3802 (b) 6 for Group E, Divisions 1 and 2 Occupancies.
3. Substitution for one-hour fire-resistive construction pursuant to Section 508.

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### 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 and as specified in Section 503 (a) for mixed
occupancy buildings. 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 10 feet.

The limits set forth in Table No. 5-D may be increased by one story if the building is provided with an approved automatic fire-extinguishing system throughout. The increase in height for automatic fire-extinguishing systems shall not apply when the automatic fire-extinguishing systems throughout are installed under the following provisions:

1. Section 3802 (b) 6 for Group E, Divisions 1 and 2 Occupancies.
2. Section 506, for an increase in allowable area.
3. Substitution for one-hour fire-resistive construction pursuant to Section 508.

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 noncombustible materials, or may extend not to exceed 20 feet 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.

**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.

**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 noncombustible materials, or of heavy timber construction with 2-inch nominal sheathing.

**Sec. 510.** A room in which a water closet is located shall be separated from food preparation or storage rooms by a tight-fitting door.
## TABLE NO. 5-A—WALL AND OPENING PROTECTION OF OCCUPANCIES BASED ON LOCATION ON PROPERTY

**TYPE 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. For Types I, II, and III Construction see Sections 1803, 1903, and 2003.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>DESCRIPTION OF OCCUPANCY</th>
<th>FIRE RESISTANCE OF EXTERIOR WALLS</th>
<th>OPENINGS IN EXTERIOR WALLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Any assembly building with a stage and an occupant load of 1000 or more in the building</td>
<td>Not applicable [See Section 602 (a)]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1—Any assembly building with a stage and an occupant load of less than 1000 in the building</td>
<td>1</td>
<td>2 hour less than 20 feet</td>
</tr>
<tr>
<td></td>
<td>2—Any assembly building without a stage and having an occupant load of 300 or more in the building including such buildings used for educational purposes less than 12 hours per week or four hours in any one day and not classed as a Group C or Group F, Division 2 Occupancy</td>
<td>2 and 3</td>
<td>2 hour less than 10 feet</td>
</tr>
<tr>
<td>B</td>
<td>See also Section 702</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3—Any assembly building without a stage and having an occupant load of less than 300 in the building, including such buildings used for educational purposes less than 12 hours per week or four hours in any one day and not classed as a Group C or Group F, Division 2 Occupancy</td>
<td>1</td>
<td>2 hour less than 20 feet</td>
</tr>
<tr>
<td></td>
<td>4—Stadiums, reviewing stands, and amusement park structures not included within Group A nor Divisions 1, 2 and 3, Group B, Occupancies</td>
<td>2</td>
<td>2 hour less than 5 feet</td>
</tr>
<tr>
<td></td>
<td>5—Any building used for educational purposes through the 12th grade by 50 or more persons for more than 12 hours per week or four hours in any one day</td>
<td>3</td>
<td>1 hour less than 10 feet</td>
</tr>
<tr>
<td></td>
<td>6—Any building used for educational purposes through the 12th grade by less than 50 persons for more than 12 hours per week or four hours in any one day</td>
<td>1</td>
<td>2 hour less than 20 feet</td>
</tr>
<tr>
<td>C</td>
<td>See also Section 802</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1—Any building used for day care purposes for more than 6 children</td>
<td>2</td>
<td>2 hour less than 10 feet</td>
</tr>
</tbody>
</table>

### 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-protection rating.
### TABLE NO. 5-A—Continued

<table>
<thead>
<tr>
<th>D</th>
<th>See also Section 902</th>
<th>Permitted in Type I and II Buildings only [See Section 902 (b)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—Mental hospitals, mental sanitariums, jails, prisons, reformatories, houses of correction, and buildings where personal liberties of inmates are similarly restrained.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2—Nurseries for full-time care of children under kindergarten age. Hapitals, sanitariums, nursing homes with nonambulatory patients, and similar buildings (each accommodating more than five persons).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3—Nursing homes for ambulatory patients, homes for children of kindergarten age or over (each accommodating more than five persons).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>See also Section 1002</td>
<td>Not permitted in Fire Zones Nos. 1 and 2 except as set forth in Sections 1002 (e) and 1003 (e).</td>
</tr>
<tr>
<td>1—Storage and handling of hazardous and highly inflammable or explosive materials other than flammable liquids.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2—Storage and handling of Class I, II and III flammable liquids, as specified in U.B.C. Standard No. 9-1; dry cleaning plants using flammable liquids, paint stores with bulk handling; paint shops and spray painting rooms and shops.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4—Repair garages.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>See also Section 1102</td>
<td>Not permitted less than 5 feet Protected less than 20 feet</td>
</tr>
<tr>
<td>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.</td>
<td>1 2 hour less than 20 feet 1 hour elsewhere</td>
<td>Not permitted less than 5 feet Protected less than 20 feet</td>
</tr>
<tr>
<td>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.</td>
<td>2 1 hour</td>
<td></td>
</tr>
<tr>
<td>Buildings or portions of buildings having rooms used for educational purposes, beyond the 12th grade with less than 50 occupants in any room.</td>
<td>3 1 hour less than 10 feet</td>
<td>Not permitted less than 5 feet Protected less than 10 feet</td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open parking garages. (For requirements, see Section 1109.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE NO. 5-A—Continued

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

See Notes on page 50.
### TABLE NO. 5-B — REQUIRED SEPARATIONS IN BUILDINGS OF MIXED OCCUPANCY

(In Hours)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E-1</th>
<th>E-2</th>
<th>E-3</th>
<th>E-4-5</th>
<th>F-1</th>
<th>F-2</th>
<th>F-3</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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<tbody>
<tr>
<td>A</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<td>N</td>
<td>N</td>
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<td>1</td>
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<td>1</td>
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<td>1</td>
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<td>N</td>
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<td>1</td>
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<tr>
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<tr>
<td>E-1</td>
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<tr>
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</table>

*See Section 503 (d) for Exceptions.*
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 33½ PER CENT
(In Square Feet)

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Unlimited</td>
<td>22,500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B) 1-2</td>
<td>Unlimited</td>
<td>22,500</td>
<td>10,100</td>
<td>Not Permitted</td>
<td>7,900</td>
</tr>
<tr>
<td>B) 3-4</td>
<td>Unlimited</td>
<td>22,500</td>
<td>10,100</td>
<td>6,800</td>
<td>10,100</td>
</tr>
<tr>
<td>C</td>
<td>Unlimited</td>
<td>34,000</td>
<td>15,200</td>
<td>10,100</td>
<td>15,200</td>
</tr>
<tr>
<td>D) 1</td>
<td>Unlimited</td>
<td>11,300</td>
<td></td>
<td></td>
<td>Not Permitted¹</td>
</tr>
<tr>
<td>D) 2-3</td>
<td>Unlimited</td>
<td>11,300</td>
<td>5,100</td>
<td>Not Permitted</td>
<td>5,100</td>
</tr>
<tr>
<td>E) 1-2²</td>
<td>11,250</td>
<td>9,300</td>
<td>4,200</td>
<td>2,800</td>
<td>4,200</td>
</tr>
<tr>
<td>E) 3-4-5²</td>
<td>Unlimited</td>
<td>18,600</td>
<td>8,400</td>
<td>5,600</td>
<td>8,400</td>
</tr>
<tr>
<td>F) 1-2-3</td>
<td>Unlimited</td>
<td>30,000</td>
<td>13,500</td>
<td>9,000</td>
<td>13,500</td>
</tr>
<tr>
<td>G</td>
<td>Unlimited</td>
<td>45,000</td>
<td>20,300</td>
<td>13,500</td>
<td>20,300</td>
</tr>
<tr>
<td>H</td>
<td>Unlimited</td>
<td>22,500</td>
<td>10,100</td>
<td>6,800³</td>
<td>10,100</td>
</tr>
<tr>
<td>I</td>
<td>Unlimited</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>See Chapter 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.—No general requirements for fire resistance.
H.T.—Heavy Timber.
²See Section 902 (b).
²For additional limitations in Fire Zones No. 1 and No. 2 see Sections 1602 and 1603.
³Areas above the first floor shall not exceed 3000 square feet.
<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>Types of Construction</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
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<tbody>
<tr>
<td></td>
<td>1-Hr. or H.T. N</td>
<td>1-Hour N</td>
<td>1-Hour N</td>
<td></td>
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<td>Unlimited</td>
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<tr>
<td>B) 1-2</td>
<td>Unlimited</td>
<td>4</td>
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<td>Not Permitted</td>
<td>2</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>B) 3-4</td>
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<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>Unlimited</td>
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<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>D) 1</td>
<td>Unlimited</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>D) 2</td>
<td>Unlimited</td>
<td>3</td>
<td>1</td>
<td>Not Permitted</td>
<td>1</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>D) 3</td>
<td>Unlimited</td>
<td>3</td>
<td>2</td>
<td>Not Permitted</td>
<td>2</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>E) 1</td>
<td>Unlimited</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E) 2-3-4-5</td>
<td>Unlimited</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>F) 1-2-3</td>
<td>Unlimited</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>Unlimited</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
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<td>12</td>
<td>4</td>
<td>2</td>
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<tr>
<td>I</td>
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<td>See Chapter 15</td>
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</tbody>
</table>

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

N.—No general requirements for fire resistance. H.T.—Heavy Timber.
CHAPTER 6—REQUIREMENTS FOR GROUP A OCCUPANCIES

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.

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 or II construction and shall not exceed, in area or height, the limits specified in Sections 505, 506 and 507.
(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.

Sec. 603. Buildings housing Group A Occupancies shall front directly upon or have access to a public street not less than 20 feet in width. The access to the public street shall be a minimum 20-foot 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 Sections 1803 and 1903.

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

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 8 feet 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
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 water closets for each sex, and at least one drinking fountain for each floor level.

For other requirements on water closets, see Section 1711.

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 specified in Section 1706.

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

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.

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 10 feet from other doors or windows of the same building shall be protected by a fire assembly having a three-fourths-hour fire-protection 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.

Sec. 609. Gymnasiums and similar occupancies may have running tracks constructed of wood or unprotected steel or iron.
CHAPTER 7—REQUIREMENTS FOR GROUP B OCCUPANCIES

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, including such buildings used for educational purposes less than 12 hours per week or four hours in any one day and not classed as a Group C or Group F, Division 2 Occupancy.

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 educational purposes less than 12 hours per week or four hours in any one day and not classed as a Group C or Group F, Division 2 Occupancy.

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.

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-resistant construction.

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 400 square feet in area, shall be of not less than one-hour fire-resistant 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-resistant 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 reinspected at least once every six months.

Sec. 703. All buildings housing Group B Occupancies shall front directly upon or have access to a public street not less than 20 feet in width. The access to the public street shall be a minimum 20-foot 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-resistant protection of exterior walls and openings, as determined by location on property, see Section 504 and Part V.

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.

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.

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 specified in Section 1706.
CHAPTER 8—REQUIREMENTS FOR GROUP C OCCUPANCIES

Sec. 801. Group C Occupancies shall be:

Division 1. Any building used for educational purposes through the 12th grade by 50 or more persons for more than 12 hours per week or four hours in any one day.

Division 2. Any building used for educational purposes through the 12th grade by less than 50 persons for more than 12 hours per week or four hours in any one day.

Division 3. Any building used for day care purposes for more than six children.

For occupancy separations, see Table No. 5-B.

For occupant load, see Section 3301.

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, except that the area may be increased by 50 per cent when the maximum travel distance specified in Section 3302 (d) is reduced by 50 per cent.

(b) Special Provisions. Rooms in Divisions 1 and 2 Occupancies used for day care purposes, kindergarten, first or second grade pupils and Division 3 Occupancies shall not be located above the first story above grade.

Laboratories, woodworking and metalworking shops, mechanical equipment rooms, machine 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.

Janitor closets shall be of one-hour fire-resistive construction.

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

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

Sec. 803. All buildings housing Group C Occupancies shall front directly upon or have access to a public street not less than 20 feet in width. The access to the public street shall be a minimum 20-foot 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.

Sec. 804. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3317.)
Sec. 805. All portions of Group C Occupancies shall be provided with light and ventilation, either natural or artificial, as specified in Section 605.

Water closets shall be provided on the basis of the following ratio of water closets to the number of students:

<table>
<thead>
<tr>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary Schools</td>
<td>1:100</td>
</tr>
<tr>
<td>Secondary Schools</td>
<td>1:100</td>
</tr>
</tbody>
</table>

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

There shall be provided at least one lavatory for each two water closets or urinals, and at least one drinking fountain on each floor for elementary and secondary schools.

For other requirements on water closets, see Section 1711.

Sec. 806. 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 specified in Chapter 17.

Sec. 807. Where required, automatic fire-extinguishing systems and standpipes shall be installed as specified in Chapter 38.

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 rooms 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 10 feet from other doors or windows of the same building, shall be protected by a fire assembly having a three-fourths-hour fire-protection 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 openings protected by a one-hour fire-protection assembly.

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 and shall be stored within a storage cabinet for flammable liquid approved by the Fire Department.

Sec. 809. Gymnasiums and similar buildings may be constructed in the manner permitted for assembly buildings in Section 709.

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

A building housing a Group C, Division 2 or a Division 3 Occupancy for not more than 20 pupils and which will have only the first floor accessible to children may be used for school/day care purposes with the following exceptions to Code requirements:

EXCEPTIONS: 1. Exterior walls or parts of walls which are less than 3 feet 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 28 inches in clear width of opening.

Sec. 810. A Group C, Division 1 Occupancy may be constructed as an open plan educational building under the following conditions:

1. Corridor walls need not comply with the requirements of Sections 3304 and 3317.

2. The maximum distance of travel to the exterior of the building does not exceed 100 feet.

3. Partitions and room dividers need not have a fire-resistive rating, but shall meet the requirements of Section 1705 and have a Class I flame-spread rating. Where glass is used, it shall comply with the requirements of Section 5406 and Table No. 54-D.

4. Floor plan arrangements which will affect exiting conditions shall be approved by the Building Official. Copies of such approved floor plan arrangements shall be maintained available on the premises for inspection by regulatory authorities.

5. In buildings protected by an approved automatic fire-extinguishing system, the relocation of partitions and room dividers may require relocation of the fire-extinguishing system devices.

6. Industrial vocational shops shall be of one-hour construction and shall be separated from each other by a One-Hour Fire-Resistive Occupancy Separation as defined in Chapter 5.

Sec. 811. Approved fire alarms shall be provided for all Group C Occupancies with an occupant load of more than 50 persons. In every Group C Occupancy provided with an automatic fire-extinguishing system, the operation of such system shall automatically activate the school fire alarm system.
CHAPTER 9—REQUIREMENTS FOR GROUP D OCCUPANCIES

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.

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 3900 square feet between separation walls of two-hour fire-resistive construction with openings protected by fire assemblies having one and one-half-hour fire-protection rating. 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 noncombustible construction.

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

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

Sec. 904. Stairs, exits, and smokeproof enclosures shall be provided as specified in Chapter 33. (See also Section 3318.)
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 other requirements on water closets, see Section 1711.

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 specified in Section 1706.

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

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 rooms 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.

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 10 feet from the other doors or windows of the same building, shall be protected by a fire assembly having a three-fourths-hour fire-protection 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 openings protected as specified in Section 3320.

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.
Sec. 909. An approved fire alarm system shall be provided for all Group D Occupancies. Audible alarm devices shall be used in all non-patient areas. Visible alarm devices may be used in lieu of audible devices in patient occupied areas.
CHAPTER 10—REQUIREMENTS FOR GROUP E OCCUPANCIES

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; 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 for a Class III rating.

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-resistant construction or shall be surrounded by public space, streets, or yards, not less than 60 feet in width.

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

In areas where motor vehicles or airplanes are stored, repaired, or operated and where flammable liquids are stored or used, floor surfaces shall be noncombustible.

EXCEPTION: Floors may be surfaced or waterproofed with asphaltic paving materials where no repair work is done.
In buildings over 95 feet 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.

For attic space partitions and draft stops see Section 3205.

A Division 4 Occupancy having a floor area not exceeding 2500 square feet shall have exterior walls of not less than two-hour fire-resistive construction when less than 5 feet from a property line and of not less than one-hour fire-resistive construction when more than 5 feet but less than 10 feet from a property line, when located in Fire Zone No. 3.

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

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

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 5000 square feet, 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 water closet. Separate facilities shall be provided for each sex when the number of employees exceeds four and both sexes are employed. Such toilet facilities shall be located either in such building or conveniently in a building adjacent thereto on the same property.

All water closet rooms shall be provided with an exterior window at least 3 square feet in area, fully openable; or a vertical duct not less than 100 square inches in area for the
first toilet facility with an additional 50 square inches 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 5 feet from any openable window.

For other requirements on water closets, see Section 1711.

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 specified in Section 1706.

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.

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

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 7 feet 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 18 inches 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.

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 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-protection rating.
Such fire assemblies shall be fixed, automatic, or self-closing. Wall vents having an area of not less than 16 square inches each, shall be placed in the exterior walls near the floor line, not more than 6 feet 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, 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 3000 square feet may be a type conforming to the provisions of Exception 2, Section 3802.
CHAPTER 11—REQUIREMENTS FOR GROUP F OCCUPANCIES

NOTE: Tables in Chapter 11 appear at the end of the Chapter.

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.)

Buildings or portions of buildings having rooms used for educational purposes, beyond the 12th grade with less than 50 occupants in any room.

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.

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.

Other provisions of this Code notwithstanding, a Group F, Division 1 Occupancy located in the basement or first story of a building housing a Group F, Division 2 or a Group H Occupancy may be classed as a separate and distinct building for the purpose of area limitation, limitation of number of stories and Type of Construction, when all of the following conditions are met:

1. The Group F, Division 1 Occupancy is of Type I Construction;
2. There is a Three-Hour Occupancy Separation between the Group F, Division 1 Occupancy and all portions of the Group F, Division 2 or Group H Occupancy.
3. The Group F, Division 1 Occupancy is devoted to the storage of passenger vehicles (having a capacity of not more than nine persons per vehicle), but may contain laundry rooms and mechanical equipment rooms incidental to the operation of the building.
4. The maximum building height in feet shall not exceed the limits set forth in Table No. 5-D for the least type of construction involved.

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

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

In areas where motor vehicles or airplanes are stored, and in gasoline service stations, floor surfaces shall be of noncombustible materials.

EXCEPTION: Floors may be surfaced or waterproofed with asphaltic paving materials in areas where motor vehicles or airplanes are stored or operated.

Storage areas in excess of 1000 square feet 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 3000 square feet 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.

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

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.

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.
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 openings protected as specified in Section 3320.

**EXCEPTION:** Buildings not more than one story in height of Group F, Division 2 Occupancy with an occupant load of less than 30.

**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 noncombustible materials. Open parking garages shall meet the design requirements of Chapter 23. Adequate curbs and railings shall be provided at every opening.

**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 9 feet 6 inches of height or portion thereof shall be considered as a tier.

The clear height of a parking tier shall be not less than 6 feet 6 inches, 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.

(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 200 square feet per occupant. Where no persons other than parking attendants are permitted there shall be not less than two stairs 3 feet wide. Lifts may be installed for use of employees only, provided they are completely enclosed by noncombustible materials.

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

(i) **Fire-extinguishing Systems.** When required by other provisions of this Code, automatic fire-extinguishing systems and standpipes shall be installed in accordance with the provisions of Chapter 38.

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

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

(l) **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.
### TABLE NO. 11-A—OPEN PARKING GARAGES AREA AND HEIGHT

<table>
<thead>
<tr>
<th>TYPE OF CONSTRUCTION</th>
<th>AREA PER TIER (Square Feet)</th>
<th>RAMP-ACCESS</th>
<th>MECHANICAL-ACCESS</th>
<th>HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>II</td>
<td>75,000</td>
<td>10 Tiers</td>
<td>12 Tiers</td>
<td>18 Tiers</td>
</tr>
<tr>
<td>IV–1-hour</td>
<td>50,000</td>
<td>8 Tiers</td>
<td>10 Tiers</td>
<td>15 Tiers</td>
</tr>
<tr>
<td>IV–N</td>
<td>30,000</td>
<td>6 Tiers</td>
<td>8 Tiers</td>
<td>12 Tiers</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>DISTANCE FROM PROPERTY LINE TO BUILDING</th>
<th>FIRE ZONE NO. 1</th>
<th>FIRE ZONE NO. 2</th>
<th>FIRE ZONE NO. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0'-10'</td>
<td>2-hour</td>
<td>2-hour</td>
<td>1-hour</td>
</tr>
<tr>
<td>10'-20'</td>
<td>1-hour</td>
<td>1-hour</td>
<td>None</td>
</tr>
</tbody>
</table>
CHAPTER 12—REQUIREMENTS FOR GROUP G OCCUPANCIES

Sec. 1201. Group G Occupancies shall be:

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

Factories and workshops using noncombustible and nonexplosive materials.

Storage and sales rooms of noncombustible and nonexplosive materials.

For occupancy separations see Table No. 5-B.

For occupant load see Section 3301.

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.

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

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

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 water closet. Separate facilities shall be provided for each sex when the number of employees exceeds four and both sexes are employed. Such toilet facilities shall be located either in such building or conveniently in a building adjacent thereto on the same property.

For other requirements on water closets, see Section 1711.

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

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

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 openings protected as specified in Section 3320.
CHAPTER 13—REQUIREMENTS FOR GROUP H OCCUPANCIES

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.

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 3000 square feet of floor area above the first story, shall be not less than one-hour fire-resistive construction throughout.

EXCEPTION: Dwelling units within an apartment house not over two stories in height may have nonbearing walls of unprotected construction, provided the units are separated from each other and from corridors by construction having a fire-resistance rating of not less than one hour. Openings to such corridors shall be equipped with smoke or draft stop doors conforming to Section 3304 (h) or other equivalent protection.

For attic space partitions and draft stops see Section 3205.

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

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 than 4 feet 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 7 feet 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-protection assembly as specified in Section 3304.

Every sleeping room below the fourth floor shall have at least one window or exterior door approved for emergency exit or rescue. Where windows are provided they shall have a sill height not more than 48 inches above the floor.

Windows with an area of not less than 5 square feet with no dimension less than 22 inches shall be deemed to meet the requirements of this Section provided sill heights are not over 48 inches above the floor.

Sec. 1305. (a) Light and Ventilation. All guest rooms, dormitories, and habitable rooms within a dwelling unit shall be provided with natural light by means of windows or skylights with an area of not less than one-tenth of the floor area of such rooms with a minimum of 12 square feet. All bathrooms, water closet compartments, laundry rooms, and similar rooms shall be provided with natural ventilation by means of windows or skylights with an area of not less than one-tenth of the floor area of such rooms with a minimum of 3 square feet.

Not less than one-half of the required window or skylight area shall be openable to provide natural ventilation.

In lieu of openable windows for natural ventilation, a mechanical ventilation system may be provided. Such system shall be capable of providing two air changes per hour in all guest rooms, dormitories, habitable rooms, and in public corridors. One-fifth of the air supply shall be taken from the outside. In bathrooms, water closet compartments, laundry rooms, and similar rooms a mechanical ventilation system connected directly to the outside, capable of providing five air changes per hour, shall be provided.

For the purpose of determining light and ventilation requirements, any room may be considered as a portion of an adjoining room when one-half of the area of the common wall is open and unobstructed and provides an opening of not less than one-tenth of the floor area of the interior room or 25 square feet, whichever is greater.

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 7 feet; 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 water closet. Every hotel and each subdivision thereof where both sexes are accommodated shall be provided with
Light, Ventilation, and Sanitation (Continued)

at least two water closets located in such building, which shall be conspicuously marked, one for each sex.

Additional water closets 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.

Every dwelling unit shall be provided with a kitchen equipped with a kitchen sink and with bathroom facilities consisting of a water closet, lavatory and either a bathtub or shower. Each plumbing fixture shall be equipped with running water necessary for its normal operation.

A room in which a water closet is located shall be separated from food preparation or storage rooms by a tight-fitting door.

For other requirements on water closets, 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 3 feet 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 1 foot 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 3 feet in width. Courts having windows opening on opposite sides shall be not less than 6 feet in width. Courts bounded on three or more sides by the walls of the building shall be not less than 10 feet 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 1 foot in width and 2 feet 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 10 square feet 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 2 inches 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.
Sec. 1307. (a) Ceiling Heights. Habitable rooms, storage rooms and laundry rooms shall have a ceiling height of not less than 7 feet 6 inches. Hallways, corridors, bathrooms and water closet rooms shall have a ceiling height of not less than 7 feet 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 5 feet 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 7 feet.

Any portion of a garage shall have an unobstructed headroom clearance of not less than 6 feet 6 inches 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 120 square feet 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 150 square feet of superficial floor area. Other habitable rooms shall have an area of not less than 90 square feet except that there shall be no minimum area for kitchens. Where more than two persons occupy a room used for sleeping purposes, the required superficial floor area shall be increased at the rate of 50 square feet for each occupant in excess of two. 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 7 feet in any dimension.

A water closet compartment shall be not less than 30 inches in width and shall provide a clear space in front of the water closet not less than 24 inches.

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 220 square feet of superficial floor area. An additional 100 square feet 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 30 inches in front. Light and ventilation conforming to this Code shall be provided.
4. The unit shall be provided with a separate bathroom containing a water closet, lavatory, and bathtub or shower.

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 specified in Section 1706.

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

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 3 feet above the floor in all habitable rooms.

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.

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-protection rating. Such fire assembly shall be self-closing and shall be posted with a sign on each side of the door in 1-inch 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.

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

Sec. 1313. For existing buildings see Appendix, Section 1313.
CHAPTER 14—REQUIREMENTS FOR GROUP I OCCUPANCIES

Sec. 1401. Group I Occupancies shall be:
Dwellings and lodging houses.
For occupancy separations see Table No. 5-B.
For occupant load see Section 3301.

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.

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

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

Every sleeping room below the fourth floor shall have at least one window or exterior door approved for emergency exit or rescue. Where windows are provided they shall have a sill height not more than 48 inches above the floor.

Windows with an area of not less than 5 square feet with no dimension less than 22 inches shall be deemed to meet the requirements of this Section provided sill heights are not over 48 inches above the floor.

Sec. 1405. (a) Light and Ventilation. All guest rooms, dormitories and habitable rooms within a dwelling unit shall be provided with natural light by means of windows or skylights with an area of not less than one-tenth of the floor area of such rooms with a minimum of 12 square feet. All bathrooms, water closet compartments, laundry rooms, and similar rooms shall be provided with natural ventilation by means of windows or skylights with an area of not less than one-tenth of the floor area of such rooms with a minimum of 3 square feet.

Not less than one-half of the required window or skylight area shall be openable to provide natural ventilation.

In lieu of openable windows for natural ventilation, a mechanical ventilation system may be provided. Such system shall be capable of providing two air changes per hour in all guest rooms, dormitories, habitable rooms, and in public corridors. One-fifth of the air supply shall be taken from the outside. In bathrooms, water closet compartments, laundry rooms, and similar rooms a mechanical ventilation system connected directly to the outside, capable of providing five air changes per hour, shall be provided.
For the purpose of determining light and ventilation requirements, any room may be considered as a portion of an adjoining room when one-half of the area of the common wall is open and unobstructed and provides an opening of not less than one-tenth of the floor area of the interior room or 25 square feet, whichever is greater.

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

(b) **Sanitation.** A room in which a water closet is located shall be separated from food preparation or storage rooms by a tight-fitting door.

Every dwelling unit shall be provided with a kitchen equipped with a kitchen sink and with bathroom facilities consisting of a water closet, lavatory and either a bathtub or shower. Plumbing fixtures shall be provided with running water necessary for their operation.

For other requirements on water closets, see Section 1711.

**Yards and Courts**

Sec. 1406. Yards and courts having required window openings therein shall comply with the requirements for Group H Occupancies.

**Room Dimensions**

Sec. 1407. (a) **Ceiling Heights.** Habitable rooms, storage rooms and laundry rooms shall have a ceiling height of not less than 7 feet 6 inches. Hallways, corridors, bathrooms and water closet rooms shall have a ceiling height of not less than 7 feet 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 5 feet 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 7 feet.

(b) **Superficial Floor Area.** Every dwelling unit shall have at least one room which shall have not less than 120 square feet 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 150 square feet of superficial floor area. Other habitable rooms shall have an area of not less than 86
90 square feet except that there shall be no minimum area for kitchens. Where more than two persons occupy a room used for sleeping purposes the required superficial floor area shall be increased at the rate of 50 square feet for each occupant in excess of two. 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 7 feet in any dimension.

A water closet compartment shall be not less than 30 inches in width and shall provide a clear space in front of the water closet not less than 24 inches.

**Sec. 1408.** Dumbwaiter shafts, clothes chutes, and other vertical openings shall be enclosed and the enclosure shall be as specified in Section 1706.

**Sec. 1409.** Fire-extinguishing systems when installed shall conform to the requirements of Chapter 38.

**Sec. 1410.** Every dwelling unit and guest room shall be provided with heating facilities capable of maintaining a room temperature of 70°F. at a point 3 feet above the floor in all habitable rooms.

**Sec. 1411.** Chimneys and heating apparatus shall conform to the requirements of Chapter 37 of this Code and Uniform Building Code, Volume II, Mechanical.

**Sec. 1412.** 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

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.

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.) provided 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 provided the use of the building is as specified and the exterior wall and opening protection are as required for a Group H Occupancy building.

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

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.
Sec. 1505. Chimneys and heating apparatus shall conform to the requirements of Chapter 37 and Uniform Building Hazards 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.

Sec. 1506. In areas where motor vehicles are stored or operated, floor surfaces shall be of noncombustible materials or asphaltic paving materials.
PART IV

REQUIREMENTS BASED ON LOCATION IN FIRE ZONES

CHAPTER 16—RESTRICTIONS IN FIRE ZONES

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.

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.

EXCEPTIONS: 1. Open parking garages may be of Type IV-N construction as permitted by Section 1109.

2. Type IV-N buildings not exceeding one story in height or 2500 square feet in area housing a Group F, G or J Occupancy may be erected in Fire Zone No. 1 provided any
exterior wall located less than 20 feet from a property line is protected in accordance with Table No. 5-A and Section 2103 (a).

(b) Alterations. No building of Type IV construction in excess of 1000 square feet 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:

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 1500 square feet 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.

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 1000 square feet 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.

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 1500 square feet 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.

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

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-resistant protection are required, such requirements shall be the minimum requirements and any materials, types of construction, or fire-resistant 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.

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.

Sec. 1703. Usable space under the first story 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-resistant construction. Doors shall be self-closing, of noncombustible construction or solid wood core, not less than 1¾ inches in thickness.

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

<table>
<thead>
<tr>
<th>MATERIALS OF CONSTRUCTION</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Noncombustible</td>
<td>Noncombustible</td>
<td>1-Hr. or H.T.</td>
<td>N</td>
<td>1-Hour</td>
</tr>
<tr>
<td>Exterior Bearing Walls</td>
<td>4 (Sec. 1803 (a))</td>
<td>4 (Sec. 1903 (a))</td>
<td>4 (Sec. 2003 (a))</td>
<td>4 (Sec. 2003 (a))</td>
<td>1</td>
</tr>
<tr>
<td>Interior Bearing Walls</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>Exterior Non-bearing Walls</td>
<td>4 (Sec. 1803 (a))</td>
<td>4 (Sec. 1903 (a))</td>
<td>4 (Sec. 2003 (a))</td>
<td>4 (Sec. 2003 (a))</td>
<td>1</td>
</tr>
<tr>
<td>Structural Frame¹</td>
<td>3</td>
<td>2</td>
<td>1 or H.T.</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>Partitions—Permanent</td>
<td>1²</td>
<td>1²</td>
<td>1 or H.T.</td>
<td>N</td>
<td>1²</td>
</tr>
<tr>
<td>Shaft Enclosures</td>
<td>2</td>
<td>2</td>
<td>1 or H.T.</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Floors</td>
<td>2</td>
<td>2</td>
<td>1 or H.T.</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>Roofs</td>
<td>2 (Sec. 1806)</td>
<td>1 (Sec. 1906)</td>
<td>1 or H.T.</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>Exterior Doors and Windows</td>
<td>Sec. 1803 (b)</td>
<td>Sec. 1903 (b)</td>
<td>Sec. 2003 (b)</td>
<td>Sec. 2003 (b)</td>
<td>Sec. 2103 (b)</td>
</tr>
</tbody>
</table>

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

¹Structural 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.

²Fire-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.
EXCEPTION: In Fire Zone No. 3, roofs of cedar or redwood shakes and shingles constructed in accordance with requirements of U.B.C. Standard No. 32-14 for Special Purpose Roofs may be used on buildings of Types III-N and V-N construction housing Group B, Divisions 3 and 4, Group C, and Group F, Divisions 1 and 2 Occupancies, provided the horizontal clearance between cornice and property line, except street front, is not less than 10 feet.

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 3207.

Sec. 1705. (a) Fixed Partitions. Regardless of the fire-resistant 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. Noncombustible 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) Folding, Portable or Movable Partitions. Approved folding, portable or movable partitions need not have a fire-resistant rating provided:

1. They do not block required exits (without providing alternative conforming exits) and they do not establish an exit corridor.
2. Their location is restricted by means of permanent tracks, guides, or other approved methods.
3. Flammability shall be limited to materials having a flame-spread classification as set forth in Table No. 42-B for rooms or areas.

(c) Walls Fronting on Streets or Yards. Regardless of fire-resistant requirements for exterior walls, certain elements of the walls fronting on streets or yards having a width of 50 feet in Fire Zone No. 1 or 40 feet in Fire Zone No. 2 or No. 3 may be constructed as follows:

1. Show-window frames, aprons and showcases may be of combustible or noncombustible materials, provided the height of such construction does not exceed 15 feet above grade.
2. Wood veneer of not less than 1 inch nominal thickness or Exterior type plywood or particleboard not less than 3/8 inch nominal thickness may be applied to walls provided the veneer does not exceed 15 feet above grade, and further provided such wood shall be placed either directly against noncombustible surfaces or furred out from such surfaces not to exceed 1% inches with all concealed spaces firestopped as provided in Section 2517 (f).

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

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

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

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

Sec. 1706. (a) General. Openings extending vertically through floors shall be enclosed in a shaft of fire-resistive construction having the time period set forth in Table No. 17-A for “Shaft Enclosures.”

EXCEPTIONS: 1. In other than Group D Occupancies, an enclosure will not be required for an escalator, chute or conveyor serving only one adjacent floor and not connected with any other openings serving other floors.

2. In buildings housing Groups F and G Occupancies equipped with automatic fire-extinguishing systems throughout, enclosures shall not be required for escalators where the top of the escalator opening at each story is provided with a draft curtain and automatic fire sprinklers are installed around the perimeter of the opening within 2 feet of the draft curtain. The draft curtain shall enclose the perimeter of the unenclosed opening and extend from the ceiling downward at least 12 inches on all sides. The spacing between sprinklers shall not exceed 6 feet.

3. In Type V buildings, chutes and dumbwaiter shafts with a cross-sectional area of not more than 9 square feet may be unenclosed if lined on the inside with lath and plaster or gypsum wallboard, with such lining covered with not less than No. 26 galvanized sheet metal gauge with all joints in such sheet metal locklapped. All openings into any such enclosure shall be protected by metal or metal-clad doors with either metal or metal-clad jambs, casings or frames.
4. Exit enclosures shall conform to the applicable provisions of Sections 3308 and 3309.

5. Approved gas vents installed in walls of buildings three stories or less in height (four stories if equipped with an automatic fire-extinguishing system) need not be enclosed.

(b) Protection of Openings. Every opening into a shaft enclosure shall be protected by a self-closing fire assembly conforming to Section 4306 and having a fire-protection rating of one hour for openings through one-hour walls and one and one-half hours for openings through two-hour walls.

EXCEPTIONS: 1. Openings to the exterior may be unprotected when so permitted by Table No. 5-A.

2. Openings produced by air ducts piercing shaft enclosure walls may be protected by fire dampers conforming to U.B.C. Standard No. 43-7.

(c) Termination of Rubbish-Linen Chutes. 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 exit corridors or stairways.

(d) Elevator Shafts. Shafts housing elevators and extending through more than two stories shall be vented to the outside. The area of vents shall be not less than 3½ per cent of the area of the elevator shaft, with a minimum of 3 square feet per elevator.

Sec. 1707. (a) Weather Resistant Barriers. All weather exposed surfaces shall have a weather resistant barrier to protect the interior wall covering. Such barrier shall be equal to that provided for in U.B.C. Standard No. 17-1 for Kraft waterproof building paper or U.B.C. Standard No. 32-1 for asphalt saturated rag felt. Building paper and felt shall be free from holes and breaks and 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.

Weather protective barrier 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.

(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.
(c) **Weatherproofing Weather Exposed Areas.** Balconies, landings, exterior stairways and similar surfaces exposed to the weather and sealed underneath shall be waterproofed.

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.

Sec. 1709. (a) **General.** Parapets shall be provided on all exterior walls of buildings, except as follows:

1. Walls not required to be of fire-resistive construction.
2. Walls which terminate at roofs of not less than two-hour fire-resistive construction or roofs constructed entirely of noncombustible materials.
3. Walls where unprotected openings are permitted.
4. Walls on buildings having not more than 1000 square feet of floor area.

(b) **Construction.** Parapets shall have the same degree of fire resistance required for the wall upon which they are erected. They shall extend not less than 30 inches above any portion of the roof within 15 feet.

Sec. 1710. Cornices, architectural appendages, eave overhangs, exterior balconies and similar projections extending beyond the floor area, as defined in Section 407, shall be constructed of noncombustible materials. Such projections need not be protected for fire resistance regardless of the type of construction of the building to which they are attached.

**EXCEPTIONS:**

1. For Type III construction, provided such projections do not extend nearer the property line than where unprotected, noncombustible exterior nonbearing walls are first permitted in accordance with Section 2003 (a), such projections in Fire Zones No. 1 and No. 2 may be of combustible one-hour fire-resistive construction; or, such projection may be constructed of heavy timber throughout protected with an approved automatic fire sprinkler system; or, such projections may be of heavy timber throughout when the roof deck is not a weather exposed surface and is constructed of approved fire-retardant treated wood; or, may be 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 or heavy timber.

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

Sec. 1711. (a) Floors and Walls. In other than dwelling units, toilet room floors shall have a smooth, hard, nonabsorbent surface such as portland cement, concrete, ceramic tile or other approved material which extends upward onto the walls at least 5 inches. Walls within water closet compartments and walls within 2 feet of the front and sides of urinals shall be similarly finished to a height of 4 feet and, except for structural elements, the materials 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 30 inches in width and shall provide a clear space in front of the water closet not less than 24 inches.

(b) Shower Areas. Showers shall be finished as specified in Subsection (a) to a height of not less than 6 feet. 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) Glazing for Shower and Bathtub Enclosures. Glazing used in doors and panels of shower and bathtub enclosures shall be fully tempered, laminated safety glass, or approved plastic. When glass is used it shall have a minimum thickness of not less than 3/32 inch when fully tempered, or 3/16 inch when laminated and shall pass the test requirements of U.B.C. Standard No. 54-2.

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

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.

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 20 feet by 20 feet in size. The touchdown area shall be surrounded on all sides by a clear area having a minimum average width at roof level of 15 feet but with no width less than 5 feet.
(c) **Design.** Helicopter landing areas and the supports therefor on the roof of a building shall be of noncombustible 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 60 feet in length, or less than 2000 square feet in area, the second exit may be a fire escape or ladder leading to the floor below.

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

**Sec. 1714.** All unenclosed floor and roof openings; open and glazed sides of landings and stairs; balconies or porches which are more than 30 inches above grade; and roofs used for other than service of the building shall be protected by a guardrail. Guardrails shall be not less than 42 inches in height. Open guardrails and stair railings shall have intermediate rails or an ornamental pattern such that no object 9 inches in diameter can pass through. Stair railings shall be not less than 30 inches above the nosing of treads.
CHAPTER 18—TYPE I BUILDINGS

Sec. 1801. The structural elements in Type I Buildings shall be of steel, iron, concrete, or masonry. Walls and permanent partitions shall be of noncombustible 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.

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).

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 50 feet in Fire Zone No. 1 or 40 feet in Fire Zone No. 2 or No. 3 may be of unprotected noncombustible construction.

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

3. In other than Group E Occupancies, exterior nonbearing walls may be of one-hour fire-resistive noncombustible construction where unprotected openings are permitted and two-hour fire-resistive noncombustible 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-protection rating when they are less than 20 feet 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 5 feet from the property line, and no openings in Groups G, H, I, and J Occupancies less than 3 feet from the property line.

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 noncombustible material or firestopped in such a manner that there will be no open spaces under the flooring which will exceed 100 square feet in area and such space shall be filled solidly under all
permanent partitions so that there is no communication under the flooring between adjoining rooms.

**EXCEPTION:** Firestopping need not be provided in such floors when at or below grade level in gymnasiums.

(b) **Mezzanine Floors.** Mezzanine floors may be of wood or unprotected steel except that in Fire Zone No. 1 they shall be of noncombustible materials as approved for one-hour fire-resistant construction or of heavy timber construction as specified for floors in Section 2007 (e).

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

No mezzanine floor or floors shall cover more than 33 1/3 per cent of the area of any room.

**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 noncombustible materials may be used for the finish of such treads and risers.

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

**Sec. 1806.** Roofs and their members other than the structural frame more than 25 feet above any floor, balcony or gallery may be of unprotected noncombustible materials.

When every part of the structural framework of the roof of a Group A, B or C Occupancy is not less than 25 feet above any floor, balcony, or gallery, fire protection of all members of the roof construction including those of the structural frame 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 18 feet and less than 25 feet above any floor, balcony, or gallery, the roof construction shall be protected by a ceiling of not less than one-hour fire-resistant construction.

Roofs may be sheathed by wood planks of 2 1/2-inch nominal thickness when such sheathing is more than 30 feet above 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-resistant construction.

Roof covering shall be fire-retardant roofing as specified in Section 3203.
CHAPTER 19—TYPE II BUILDINGS

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

Walls and permanent partitions shall be of noncombustible 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.

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.

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 50 feet in Fire Zone No. 1 or 40 feet in Fire Zone No. 2 or No. 3 may be of unprotected noncombustible construction.

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

3. In other than Group E Occupancies, exterior nonbearing walls may be of one-hour fire-resistive noncombustible construction where unprotected openings are permitted and two-hour fire-resistive noncombustible 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-protection rating when they are less than 20 feet 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 5 feet from the property line, and no openings in Groups G, H, I, and J Occupancies less than 3 feet from the property line.

Sec. 1904. (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 noncombustible material or firestopped in such a manner that there will be no open spaces under the flooring which will exceed 100 square feet in area and such space shall be filled solidly under all permanent
partitions so that there is no communication under the flooring between adjoining rooms.

EXCEPTION: Firestopping need not be provided in such floors when at or below grade level in gymnasiums.

(b) Mezzanine Floors. Mezzanine floors may be of wood or unprotected steel except that in Fire Zone No. 1 they shall be of noncombustible materials as approved for one-hour fire-resistant construction or of heavy timber construction as specified for floors in Section 2007 (e).

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

No mezzanine floor or floors shall cover more than 33 1/3 per cent of the area of any room.

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 noncombustible materials may be used for the finish of such treads and risers.

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

Sec. 1906. Roofs and their members other than the structural frame more than 25 feet above any floor, balcony, or gallery may be of unprotected noncombustible materials.

Where every part of the structural framework of the roof of a Group A, B or C Occupancy is not less than 25 feet above any floor, balcony, or gallery, fire protection of all members of the roof construction including those of the structural frame 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 18 feet and less than 25 feet 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 2 1/2-inch nominal thickness when such sheathing is more than 30 feet above 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

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-resistant construction throughout.

Type III, Heavy Timber Construction, shall be in accordance with Section 2007 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 noncombustible fire-resistant 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.

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.

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 50 feet in Fire Zone No. 1 or 40 feet in Fire Zone No. 2 or No. 3 may be of unprotected noncombustible construction.

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

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

4. Bulkheads, not more than 30 inches high below show windows, need not be of noncombustible or fire-resistant material.

5. Wood columns and arches conforming to heavy timber sizes may be used externally where exterior walls are permitted to be of unprotected noncombustible construction or one-hour fire-resistive noncombustible 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-
protection rating when they are less than 20 feet 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 5 feet from the property line, and no openings in Groups G, H, I and J Occupancies less than 3 feet 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 1 inch nominal matched boards or laminated construction of 4 inch 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 2517 or 2518.

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 2007.

(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 2007.

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

No mezzanine floor or floors shall cover more than 33 1/3 per cent of the area of any room.

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 2 inch nominal thickness, except where built on laminated or plank inclines as required for floors, when they may be of 1 inch 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 2007. Wood joists, beams, and girders supported by masonry walls shall be anchored thereto as specified in Section 2313.

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

Sec. 2007. (a) General. The details of heavy timber construction shall be in accordance with the provisions of this Section. Unless otherwise specified, all dimensions are nominal as defined in Section 2502.

(b) Columns. Wood columns may be of sawn timber or structural glued-laminated timber not less than 8 inches in any dimension when supporting roof or floor loads, except as specified in Section 2007 (d).

Columns shall be continuous or superimposed and connected in an approved manner.

(c) Floor Framing. Beams and girders may be of sawn timber or structural glued-laminated timber and shall be not less than 6 inches in width and not less than 10 inches in depth.

Framed sawn timber or structural glued-laminated timber arches, which spring from the floor line and support floor loads, shall be not less than 8 inches nominal in any dimension.

Framed lumber or structural glued-laminated timber trusses supporting floor loads shall have members of not less than 8 inches in any dimension.

(d) Roof Framing. Framed sawn timber arches or structural glued-laminated timber arches for roof construction, which spring from the floor line and do not support floor loads, shall have members not less than 6 inches in width and not less than 8 inches in depth for the lower half of the height and not less than 6 inches in depth for the upper half.

Framed sawn timber or structural glued-laminated timber arches for roof construction which spring from the top of walls or wall abutments, framed lumber, or structural glued-laminated timber trusses, and other roof framing which do not support floor loads, shall have members not less than 4 inches in width and not less than 6 inches in depth. Spaced members may be composed of two or more pieces not less than 3 inches 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 2 inches in thickness, secured to the underside of the members. Splice plates shall be no less than 3 inches in thickness. When protected by an approved automatic fire-extinguishing system under the roof deck, framing members shall be not less than 3 inches in thickness.
(e) **Heavy Timber Floors.** Floor shall be without concealed spaces. Floors shall be of planks, splined, or tongue-and-groove, of not less than 3 inches in thickness covered with 1-inch tongue-and-groove flooring, laid crosswise or diagonally, or ½-inch plywood, or of plank not less than 4 inches in width set on edge close together and well spiked, and covered with 1-inch flooring or ½-inch plywood. The lumber shall be laid so that no continuous line of joints will occur except at points of support. Floors shall not extend closer than ½ inch to walls. Such ½-inch 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 may be used in place of such molding.

(f) **Heavy Timber Roof Decks.** Roofs shall be without concealed spaces and roof decks shall be of planks splined or tongue-and-groove not less than 2 inch thickness, or of a double thickness of 1-inch boards with tongue-and-groove joints, or with staggered joints, or of lumber not less than 3 inches nominal in width, set on edge close together and laid as required for floors.

(g) **Construction Details.** Approved wall plate boxes or hangers shall be provided where wood beams, girders or trusses rest on masonry or concrete walls.

Girders and beams shall be closely fitted around columns and adjoining ends shall be cross tied to each other, or intertwined by caps or ties, to transfer horizontal loads across the joints. 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 decks, where supported by a wall, shall be anchored to such wall at intervals not exceeding 20 feet; 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.

(h) **Mechanically Laminated Floors and Roof Decks.** Mechanically laminated floors and roof decks conforming to Section 2517 (I) may be used as heavy timber floors or roof decks provided the minimum thickness and other applicable requirements of the Section are followed.
CHAPTER 21—TYPE IV BUILDINGS

Sec. 2101. The structural elements of Type IV buildings shall be of noncombustible materials.

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

Walls and permanent partitions shall be of noncombustible materials.

Materials of construction and fire-resistant 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.

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

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 50 feet in Fire Zone No. 1 or 40 feet in Fire Zone No. 2 or No. 3 may be unprotected noncombustible construction.

2. A fire-resistant 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 2500 square feet and such wall is located not less than 20 feet from a property line in Fire Zone No. 1 and 10 feet from a property line in Fire Zone No. 2.

3. In Fire Zone No. 2 a fire-resistant 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 20 feet 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-resistant 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 1000 square feet and such wall is located not less than 5 feet 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 20 feet from the center line of the street or public space.

In Fire Zone No. 1 all openings in the exterior walls within 20 feet of a property line shall be protected by a fire assembly having a three-fourths-hour fire-protection rating.
In Fire Zone No. 2 all openings not on a street front and which are within 10 feet of an adjacent property line shall be protected by a fire assembly having a three-fourths-hour fire-protection rating.

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

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

Sec. 2106. Roofs shall be of noncombustible 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

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

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.

Sec. 2202. 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.

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 40 feet 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 10 feet of an adjacent property line shall be protected by a fire assembly having a three-fourths-hour fire-protection rating.

For shaft enclosures, see Section 1706.

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

NOTE: Tables in Chapter 23 appear at the end of the Chapter.

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. All buildings and portions thereof shall be designed and constructed to sustain, within the stress limitations specified in this Code, all dead loads and all other loads specified in this Chapter or elsewhere in this Code. Impact loads shall be considered in the design of any structure where impact loads occur.

EXCEPTION: Buildings or portions thereof which are constructed in accordance with the conventional framing requirements specified in Chapter 25 of this Code shall be deemed to meet the requirements of this Section.

(b) Special. Provisions shall be made in designing office floors for a load of 2000 pounds placed upon any space 2½ feet 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.

(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.

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.

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.

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.

(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.

(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 \( \frac{1}{2} \), 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 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.

**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 loads greater than 100 pounds per square foot, the design live load on any member supporting 150 square feet 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:

\[
R = 23.1 \left( 1 + \frac{D}{L} \right)
\]
WHERE:

\[ R = \text{Reduction in per cent} \]
\[ D = \text{Dead load per square foot of area supported by the member} \]
\[ L = \text{Unit live load per square foot of area supported by the member} \]

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.

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.

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 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 and agricultural buildings shall be designed for the horizontal wind pressures as set forth in Table No. 23-E, except that, if the height zone is 10 feet 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.

(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.
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.

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.

Sec. 2311. See Chapter 29.

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.

(b) Interior Walls. Interior walls, permanent partitions, and temporary partitions which exceed 6 feet in height shall be designed to resist all loads to which they are subjected but not less than a force of five 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.

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.

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:

**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.

**LATERAL FORCE RESISTING SYSTEM** is that part of the structural system to which the lateral forces prescribed in Section 2314 (d) 1 are assigned.

**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.

**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-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).

**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—VERTICAL LOAD-CARRYING** is a space frame designed to carry all vertical loads.

(c) Symbols and Notations. The following symbols and notations apply only to the provisions of this Section.

\[ C = \text{Numerical coefficient for base shear as specified in Section 2314 (d) 1.} \]
\[ C_p = \text{Numerical coefficient as specified in Section 2314 (d) 2 and as set forth in Table No. 23-I.} \]
\[ D = \text{The dimension of the building in feet in a direction parallel to the applied forces.} \]
\[ D_r = \text{The plan dimension of the vertical lateral force resisting system in feet.} \]
\[ F_{i, n, x} = \text{Lateral force applied to level "i," "n," or "x," respectively.} \]
\[ F_t = \text{Lateral forces on the part of the structure and in the direction under consideration.} \]
\[ F_v = \text{That portion of "V" considered concentrated at the top of the structure, at the level "n." The remaining} \]
portion of the total base shear "V" shall be distributed over the height of the structure including level "n" according to Formula (14-5).

\[ V = F_t + \sum_{i=1}^{n} F_i \]

where \( i = 1 \) designates first level above the base.

\[ W = \sum_{i=1}^{n} w_i \]

** 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.

\( W_x \) = The weight of a part or portion of a structure.

\( Z \) = Numerical coefficient dependent upon the zone as determined by Figures No. 1, No. 2 and No. 3 in this
Chapter. 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:

\[ V = ZKCW \] (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:

\[ C = \frac{0.05}{\sqrt{T}} \] (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:

\[ T = \frac{0.05h_a}{\sqrt{D}} \] (14-3)

EXCEPTION: In all buildings in which the lateral force 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:

\[ T = 0.10N \] (14-3A)

The total lateral force "V" shall be distributed in the height of the structure in the following manner:

\[ F_h = .004V \left( \frac{h_a}{D_e} \right)^2 \] (14-4)

"F_h" need not exceed 0.15 "V" and may be considered as 0 for values \( \left( \frac{h_a}{D_e} \right) \) of 3 or less, and
\[
F_i = \frac{(V - F_i) \cdot w_i \cdot h_i}{\sum_{i=1}^{n} w_i \cdot h_i} \quad \text{(14-5)}
\]

**EXCEPTION:** One- and two-story buildings shall have uniform distribution.

At each level designated as "x," the force "F_i" 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:

\[
F_p = ZC_p W_p \quad \text{............... (14-6)}
\]

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.

(c) **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.

(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.
SEISMIC RISK MAP OF THE UNITED STATES

ZONE 0 - No damage

ZONE 1 - Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 seconds. Corresponds to intensities V and VI of the M M * Scale.

ZONE 2 - Moderate damage. Corresponds to intensity VIII and higher of the M M * Scale.

ZONE 3 - Major damage. Corresponds to intensity VIII and higher of the M M * Scale.

This map is based on the known distribution of damaging earthquakes and the M M * intensities associated with these earthquakes, evidence of strain release, and consideration of major geologic structures and provinces believed to be associated with earthquake activity. The probable frequency of occurrence of damaging earthquakes in each zone was not considered in assigning ratings to the various zones.

*Mapped Mercalli Intensity Scale of 1931
(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:

   \[ M = J(F_i h_i + \sum_{i=1}^{n} F_i h_i) \]  

   \[ J = \frac{0.6}{\sqrt{T}} \]

   \[ (14-7) \]

   \[ (14-8) \]

   The value of "J" need not be more than 1.00. For structures other than buildings the value of "J" shall be not less than 0.45.

2. The overturning moment, "M_x", at any level designated as "x" shall be determined in accordance with the following:

   \[ M_x = J_x [F_r (h_x - h_r) + \sum_{i=x}^{n} F_i (h_i - h_r)] \]  

   \[ (14-9) \]

   \[ J_x = J + (1 - J) \left( \frac{h_r}{h_x} \right)^3 \]  

   \[ (14-10) \]

   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 redistribution 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) **Setbacks.** Buildings having setbacks 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 setbacks for the purpose of determining seismic forces.

For other conditions of setbacks 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.

**EXCEPTION:** Nothing in this subsection shall be deemed to prohibit the submission of properly substantiated technical data for establishing the lateral design forces by a dynamic analysis.

(j) **Structural Systems.** 1. **Design requirements.** Buildings more than 160 feet 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 Section 2722 for buildings in Seismic Zones No. 2 and No. 3 or Section 2723 for buildings in Seismic Zone No. 1) or of 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 160 feet 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 structural steel with moment-resisting connections (complying with Section 2722 for buildings in Seismic Zones No. 2 and No. 3 or Section 2723 for buildings in Seismic Zone No. 1) or by a reinforced concrete frame (complying with Section 2630 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 $K = 0.80$ shall be composed of axially loaded bracing members of A36, A440, A441, A572
Earthquake Regulations (Continued)

(continued) or A588 Grades A, B or C structural steel; or reinforced concrete bracing members or walls conforming with the requirements of Section 2632.

Reinforced concrete shear walls and reinforced concrete braced frames for all buildings shall conform to the requirements of Section 2632. In buildings where \( K = 0.67 \) and \( K = 0.80 \), all structural elements below the base required to transmit seismic forces to the foundation shall be composed of structural steel (complying with Section 2722 for buildings in Seismic Zones No. 2 and No. 3 or Section 2723 for buildings in Seismic Zone No. 1) or by reinforced concrete (complying with Section 2630 for buildings in Seismic Zones No. 2 and No. 3 or with Section 2631 for buildings in Seismic Zone No. 1 and with Section No. 2632 for buildings in Seismic Zones Nos. 1, 2, and 3).

(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 2 feet maximum on center in buildings using a 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 \( \frac{1}{4} \) inch 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.

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.

(1) Earthquake Recording Instrumentations. For earthquake recording instrumentations see Appendix, Section 2314 (1).

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

*See also Subsection 2302 (b).*
TABLE NO. 23-B—MINIMUM ROOF LIVE LOADS
(IN POUNDS PER SQUARE FOOT)

<table>
<thead>
<tr>
<th>ROOF SLOPE</th>
<th>TRIBUTARY LOADED AREA IN SQUARE FEET FOR ANY STRUCTURAL MEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 TO 200</td>
</tr>
<tr>
<td>Flat or rise less than 4 inches per foot. Arch or dome with rise less than 1/8 of span.</td>
<td>20</td>
</tr>
<tr>
<td>Rise 4 inches per foot to less than 12 inches per foot. Arch or dome with rise 1/8 of span to less than 3/8 of span.</td>
<td>16</td>
</tr>
<tr>
<td>Rise 12 inches per foot and greater. Arch or dome with rise 3/8 of span or greater.</td>
<td>12</td>
</tr>
</tbody>
</table>

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

TABLE NO. 23-C—MAXIMUM ALLOWABLE DEFLECTION FOR STRUCTURAL MEMBERS

<table>
<thead>
<tr>
<th>TYPE OF MEMBER</th>
<th>MEMBER LOADED WITH LIVE LOAD ONLY (L.L.)</th>
<th>MEMBER LOADED WITH LIVE LOAD PLUS DEAD LOAD (L.L. + K D.L.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Member Supporting Plaster or Floor Member</td>
<td>L/360</td>
<td>L/240</td>
</tr>
</tbody>
</table>

*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"

<table>
<thead>
<tr>
<th>WOOD</th>
<th>REINFORCED CONCRETE</th>
<th>STEEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unseasoned</td>
<td>Seasoned</td>
<td>A's = 0</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>HEIGHT ZONES (IN FEET)</th>
<th>WIND-PRESSURE-MAP AREAS (Pounds per square foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Less than 30</td>
<td>15</td>
</tr>
<tr>
<td>30 to 49</td>
<td>20</td>
</tr>
<tr>
<td>50 to 99</td>
<td>25</td>
</tr>
<tr>
<td>100 to 499</td>
<td>30</td>
</tr>
<tr>
<td>500 to 1199</td>
<td>35</td>
</tr>
<tr>
<td>1200 and over</td>
<td>40</td>
</tr>
</tbody>
</table>

*See Figure No. 4. 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

<table>
<thead>
<tr>
<th>HORIZONTAL CROSS SECTION</th>
<th>FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square or rectangular</td>
<td>1.00</td>
</tr>
<tr>
<td>Hexagonal or octagonal</td>
<td>0.80</td>
</tr>
<tr>
<td>Round or elliptical</td>
<td>0.60</td>
</tr>
</tbody>
</table>

TABLE NO. 23-G—SHAPE FACTORS FOR RADIO TOWERS AND TRUSSED TOWERS

<table>
<thead>
<tr>
<th>TYPE OF EXPOSURE</th>
<th>FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind normal to one face of tower</td>
<td></td>
</tr>
<tr>
<td>Four-cornered, flat or angular sections, steel or wood</td>
<td>2.20</td>
</tr>
<tr>
<td>Three-cornered, flat or angular sections, steel or wood</td>
<td>2.00</td>
</tr>
<tr>
<td>Wind on corner, four-cornered tower, flat or angular sections</td>
<td>2.40</td>
</tr>
<tr>
<td>Wind parallel to one face of three-cornered tower, flat or angular sections</td>
<td>1.50</td>
</tr>
<tr>
<td>Factors for towers with cylindrical elements are approximately two-thirds of those for similar towers with flat or angular sections</td>
<td></td>
</tr>
<tr>
<td>Wind on individual members</td>
<td></td>
</tr>
<tr>
<td>Cylindrical members</td>
<td></td>
</tr>
<tr>
<td>Two inches or less in diameter</td>
<td>1.00</td>
</tr>
<tr>
<td>Over two inches in diameter</td>
<td>0.80</td>
</tr>
<tr>
<td>Flat or angular sections</td>
<td>1.30</td>
</tr>
</tbody>
</table>
ALLOWABLE RESULTANT WIND PRESSURES
COMBINED INWARD AND OUTWARD PRESSURES ON EXTERIOR SURFACES OF ORDINARY SQUARE BUILDINGS AT 30 FEET ABOVE GROUND

FIGURE NO. 4
### TABLE NO. 23-H—HORIZONTAL FORCE FACTOR "K" FOR BUILDINGS OR OTHER STRUCTURES

<table>
<thead>
<tr>
<th>TYPE OR ARRANGEMENT OF RESISTING ELEMENTS</th>
<th>VALUE OF K</th>
</tr>
</thead>
<tbody>
<tr>
<td>All building framing systems except as hereinafter classified</td>
<td>1.00</td>
</tr>
<tr>
<td>Buildings with a box system as specified in Section 2314 (b)</td>
<td>1.33</td>
</tr>
<tr>
<td>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</td>
<td>0.80</td>
</tr>
<tr>
<td>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</td>
<td>0.67</td>
</tr>
<tr>
<td>Elevated tanks plus full contents, on four or more cross-braced legs and not supported by a building</td>
<td>3.00&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Structures other than buildings and other than those set forth in Table No. 23-I</td>
<td>2.00</td>
</tr>
</tbody>
</table>

<sup>1</sup>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.

<sup>2</sup>See maps on pages 122 and 123 for seismic probability zones and definition of "Z" as specified in Subsection (c).

<sup>3</sup>The minimum value of "KC" shall be 0.12 and the maximum value of "KC" need not exceed 0.25.

<sup>4</sup>For overturning, the factor "J" as specified in Section 2314 (h) shall be 1.00.

<sup>5</sup>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 "Ct" = .2.
### TABLE NO. 23-I—HORIZONTAL FORCE FACTOR "CP" FOR PARTS OR PORTIONS OF BUILDINGS OR OTHER STRUCTURES

<table>
<thead>
<tr>
<th>PART OR PORTION OF BUILDINGS</th>
<th>DIRECTION OF FORCE</th>
<th>VALUE OF ( C_P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior bearing and nonbearing walls, interior bearing walls and partitions, interior nonbearing walls and partitions over 10 feet in height, masonry or concrete fences over 6 feet in height(^1)</td>
<td>Normal to flat surface</td>
<td>0.20</td>
</tr>
<tr>
<td>Cantilever parapet and other cantilever walls, except retaining walls</td>
<td>Normal to flat surface</td>
<td>1.00</td>
</tr>
<tr>
<td>Exterior and interior ornamentations and appendages</td>
<td>Any direction</td>
<td>1.00</td>
</tr>
<tr>
<td>When connected to or a part of a building: towers, tanks, towers and tanks plus contents, chimneys, smokestacks, and penthouses</td>
<td>Any direction</td>
<td>0.20(^2)</td>
</tr>
<tr>
<td>When resting on the ground, tank plus effective mass of its contents</td>
<td>Any direction</td>
<td>0.10</td>
</tr>
<tr>
<td>Floors and roofs acting as diaphragms(^3)</td>
<td>Any direction</td>
<td>0.10</td>
</tr>
<tr>
<td>Connections for exterior panels or for elements complying with Section 2314 (k) 5</td>
<td>Any direction</td>
<td>2.00</td>
</tr>
<tr>
<td>Connections for prefabricated structural elements other than walls, with force applied at center of gravity of assembly(^4)</td>
<td>Any horizontal direction</td>
<td>0.30</td>
</tr>
</tbody>
</table>

\(^1\)See also Section 2312 (b) for minimum load on deflection criteria for interior partitions.

\(^2\)When "\(h_e/D\)" 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 \(V = ZK CW\).

\(^4\)The "\(W_{p}\)" shall be equal to the total load plus 25 per cent of the floor live load in storage and warehouse occupancies.
CHAPTER 24 — MASONRY

NOTE: Tables in Chapter 24 appear at the end of the Chapter.

**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 $\frac{1}{2}$ inch.

**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:

<table>
<thead>
<tr>
<th>MATERIALS AND DESIGN</th>
<th>U.B.C. DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUILDING AND FACING BRICK</strong></td>
<td></td>
</tr>
<tr>
<td>Clay or Shale</td>
<td>24- 1</td>
</tr>
<tr>
<td>Sand-Lime</td>
<td>24- 2</td>
</tr>
<tr>
<td>Concrete</td>
<td>24- 3</td>
</tr>
<tr>
<td><strong>CONCRETE MASONRY UNITS</strong></td>
<td></td>
</tr>
<tr>
<td>Hollow Load-Bearing</td>
<td>24- 4</td>
</tr>
<tr>
<td>Solid Load-Bearing</td>
<td>24- 5</td>
</tr>
<tr>
<td>Hollow Nonload-Bearing</td>
<td>24- 6</td>
</tr>
<tr>
<td>Method of Test</td>
<td>24- 7</td>
</tr>
<tr>
<td><strong>STRUCTURAL CLAY TILE</strong></td>
<td></td>
</tr>
<tr>
<td>For Walls—Load-Bearing</td>
<td>24- 8</td>
</tr>
<tr>
<td>For Walls—Nonbearing</td>
<td>24- 9</td>
</tr>
<tr>
<td>For Floors</td>
<td>24-10</td>
</tr>
<tr>
<td><strong>GYPSUM</strong></td>
<td></td>
</tr>
<tr>
<td>Partition Tile or Block</td>
<td>24-11</td>
</tr>
<tr>
<td>General</td>
<td>24-12</td>
</tr>
<tr>
<td>Reinforced, Precast and Roof Diaphragms</td>
<td>24-13</td>
</tr>
</tbody>
</table>

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(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. 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. 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.
(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 or No. 24-5 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 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.

(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, 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 when used for interior nonload-bearing purposes; or equal to the requirements set forth in U.B.C. Standard No. 24-10 when used for floor construction.


(h) Cast Building Stones. Cast building stone shall be equal to the requirements set forth in U.B.C. Standard No. 24-14. Every concrete unit more than 18 inches 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 U.B.C. Standard No. 24-15.

(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.
(n) Masonry Joint Reinforcement. Wire reinforcement shall conform to U.B.C. Standard No. 24-16.

(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.


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 except in respect to the limitations on insoluble residue, air-entrainment, and additions subsequent to calcination.


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.

Processed pulverized quicklime conforming to U.B.C. Standard No. 24-20 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. 24-21. Tests made to classify mortar by compressive strength shall be as set forth in U.B.C. Standard No. 24-21, using the proportions and materials proposed for use. Aggregates for mortar shall conform to the provisions set forth in U.B.C. Standard No. 24-22.

2. Admixtures. Admixtures shall not be added to the mortar unless approved by the Building Official.

Only pure mineral oxide colors shall be used.
3. 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. 24-23.

(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. 24-24.

2. Type. Fine 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 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 2 inches or more in horizontal dimension and in grout spaces in filled-cell construction 4 inches 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. 24-23.

(t) Mortar Limitations. Masonry units used in foundation walls and footings shall be laid up in Type S or Type M mortar. Type O mortar may be used only in interior nonstructural walls. See Sections 2413 (b), 2415 (a), and 2419 (a).

(u) Aggregates. Aggregates for mortar shall be of a quality at least equal to that set forth in U.B.C. Standard No. 24-22.

(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 \( \frac{3}{8} \) inch 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. Such units may not be used under the provisions of Section 2419 (c) 2 B.

**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

\[
\frac{L}{200} \text{ nor } \frac{L^2}{4000t}
\]

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. When
approved by the Building Official, assembly or unit strength tests may be analyzed statistically considering the variability of test results.

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 5000 square feet 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.

B. Prisms. Prisms shall be not less than 12 inches high and shall have a height-to-thickness minimum dimension ratio of not less than 1.5 nor more than 5. Hollow masonry unit prisms shall be not less than one masonry unit in length and solid masonry unit prisms or solid filled prisms shall be not less than 4 inches in length. The thickness and type of construction of the specimen shall be representative of the masonry element under consideration. Cores in hollow masonry shall not be filled, except for solid filled construction. The strength “f’m” shall be taken as the compressive strength of the specimens multiplied by the following correction factor:

<table>
<thead>
<tr>
<th>Ratio of h/d</th>
<th>1.5</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correction Factor</td>
<td>0.86</td>
<td>1.00</td>
<td>1.20</td>
<td>1.30</td>
<td>1.37</td>
</tr>
</tbody>
</table>

WHERE:

- h = height of specimen in inches.
- d = minimum dimension of specimen in inches.

Intermediate values may be interpolated.

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 5 degrees, at a relative humidity of 30 per cent to 50 per cent until tested. Prisms shall be capped and tested in compression

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 Clay Units — 14,000 p.s.i. gross .......... $f_m = 5300$
Solid Clay Units — 10,000 p.s.i. gross .......... $f_m = 4000$
Solid Clay Units — 6,000 p.s.i. gross .......... $f_m = 2600$
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
(1½" minimum face shell) ....................... $f_m = 1350$
Hollow Clay Units — Grade LB
(1½" minimum face shell) grouted
solid ................................................. $f_m = 1500$

For solid units, intermediate values may be interpolated.

Compressive tests of solid clay units shall be conducted in accordance with U.B.C. Standard No. 24-25.

Where the assumed "$f_m\) exceeds 2600 pounds per square inch, field tests in accordance with Section 2404 (c) 2 shall be required.

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 16 inches. All footing walls which support masonry of unburned clay units shall extend to an elevation not less than 6 inches above the adjacent ground at all points.

(b) Units. At the time of laying, all units shall be clean and damp at the surface.
(c) Laying. All joints shall be solidly filled with Type M or S 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.

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 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 2 inches in diameter and 4 inches long or on 2-inch cubes.


For special inspection, see Section 305 (a).

(b) Design. The minimum thickness of reinforced gypsum concrete shall be 2 inches except the thickness may be reduced to 1 1/2 inches provided all of the following conditions are satisfied:

1. The over-all thickness including the formboard is not less than 2 inches.
2. The clear span of the gypsum concrete between supports does not exceed 2 feet 9 inches.
3. Diaphragm action is not required.
4. The design live load does not exceed 40 pounds per square foot.

(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.

Allowable shear in poured-in-place reinforced gypsum concrete diaphragms using standard hot-rolled bulb tee subpurlins shall be determined by U.B.C. Standard No. 24-26. (See Table No. 24-26 in the Standard for values for commonly used roof systems.)

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 (3/8") 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.

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.
Stone Masonry  
(Continued)

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.

(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.

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 (\(\frac{3}{16}\"\)) diameter steel rods or metal ties of equivalent strength and stiffness embedded in the horizontal joints. There shall be one metal tie for not more than each four and one-half square feet (4 1/2 sq. ft.) of wall area for cavity widths up to three and one-half-inches (3 1/2") net in width. Where the cavity exceeds three and one-half-inches (3 1/2") 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.

**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 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.

**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 (I) for masonry laid in stack bond. Adjacent wythes in bearing and nonbearing walls shall be bonded by either of the following methods:
Solid Masonry (Continued)

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 approved 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").

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 M or Type S mortar consisting of a mixture of portland cement, hydrated lime and aggregate 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 (\( \frac{3}{4}" \)) 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.** Requirements for construction shall be as follows:

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 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.

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.

(b) Construction. The thickness of grout or mortar between masonry units and reinforcement shall be not less than one-fourth inch (\( \frac{1}{4}'' \)), except that one-fourth-inch (\( \frac{1}{4}'' \)) bars may be laid in horizontal mortar joints at least one-half inch (\( \frac{1}{2}'' \)) 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 2418 (a).

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 M or Type S mortar consisting of a mixture of portland cement, hydrated lime and aggregate 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.

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 (1 1/2") below the top of the uppermost unit.

(c) Stresses. See Section 2418 (a).

Sec. 2416. (a) Cold Weather Construction. No masonry shall be laid when the temperature of the outside air is below 40° F., unless approved methods are used during construction to prevent damage to the masonry. Such methods shall include protection of the masonry for a period of at least 48 hours where masonry cement or Type I portland cement is used in the mortar and grout and for a period of at least 24 hours where Type III portland cement is used. Materials to be used and materials to be built upon shall be free from ice or snow.

(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 2516.

(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 with-
out 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 (\(\frac{5}{8}\)") 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 (\(\frac{3}{4}\)"") except where exposed to weather or soil in which cases the minimum coverage shall be two inches (2"").

Sec. 2417. (a) **General.** Masonry shall be designed to withstand all vertical and horizontal loads as specified in Chapter 23, and with due allowance for the effect of eccentric loads.

(b) **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 \(\frac{1}{2}\) inches.

(c) **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 reduction 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.
(d) **Piers.** Every structural pier whose width is less than three times its thickness shall be designed and constructed as required for columns.

(e) **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.

(f) **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.

(g) **Arches and Lintels.** Members supporting masonry shall be of noncombustible materials.

(h) **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.

(i) **End Support.** Beams, girders, or other concentrated loads supported by a wall or pier shall have bearing at least 3 inches in length upon solid masonry not less than 4 inches thick or upon a metal bearing plate of adequate design and dimensions to distribute the loads safely on the wall or pier, or upon a continuous reinforced masonry member projecting not less than 3 inches from the face of the wall, or by other approved methods.

Joists shall have bearing at least 3 inches in length upon solid masonry at least 2\(\frac{1}{4}\) inches thick; or other provisions shall be made to distribute safely the loads on the wall or pier.

(j) **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.
(k) Bolt Values. The allowable loads on bolts shall not exceed the values set forth in Table No. 24-G.

(1) Stack Bond. In unreinforced masonry where masonry units are laid in stack bond, longitudinal reinforcement consisting of not less than two continuous wires each with a minimum aggregate cross-sectional area of .017 square inch shall be provided in horizontal bed joints spaced not more than 16 inches on center vertically.

Sec. 2418. (a) General. 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.

(b) Allowable Steel Stresses. Stresses in reinforcement shall not exceed the following:

<table>
<thead>
<tr>
<th>TENSILE STRESS:</th>
<th>POUNDS PER SQUARE INCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>For billet-steel or axle steel reinforcing bars of structural grade</td>
<td>18,000</td>
</tr>
<tr>
<td>For deformed bars with a yield strength of 60,000 pounds per square inch or more and in sizes No. 11 and smaller</td>
<td>24,000</td>
</tr>
<tr>
<td>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</td>
<td>30,000</td>
</tr>
<tr>
<td>For all other reinforcement</td>
<td>20,000</td>
</tr>
</tbody>
</table>

| 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. |

(c) Symbols and Notations. The symbols and notations used in this Section are defined as follows:

\[ \alpha = \text{Angle between inclined web bars and axis of beam.} \]
\[ A_v = \text{Total area of web reinforcement in tension within a distance of "$s"}, \text{or the total area of all bars bent up in any one plane.} \]
(d) 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 completely surrounded by and bonded to masonry material so that they will work together as a homogenous material within the range of working stresses.

(e) 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 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.

(f) 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.

(g) Combined Axial and Flexural Stresses. Members subject to combined axial and flexural stresses shall be so proportioned that the quantity

\[ \frac{f_a}{F_a} + \frac{f_b}{F_b} \]

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.

(h) Shear and Diagonal Tension. 1. Shearing unit stress.
The shearing unit stress \( v \) in reinforced masonry flexural members shall be computed by

\[ v = \frac{V}{bd} \]  

WHERE:

- \( b \) = The width of a rectangular section or the width of the web in I- or T- sections.

Where the values 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, or
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, or
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, or
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):
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):

\[ A_v = \frac{V}{f_v \sin \alpha} \]  \hspace{1cm} (3)

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):

\[ A_v = \frac{V_s}{f_v jd (\sin \alpha + \cos \alpha)} \]  \hspace{1cm} (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.

(i) 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):

\[ u = \frac{V}{\Sigma ojd} \]  \hspace{1cm} (5)

in which “V” is the shear at that section and “\( \Sigma o \)” 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.

No flexural bar shall be terminated in a tension zone unless one of the following conditions is satisfied:

A. The shear is not over one-half that normally permitted, including allowance for shear reinforcement, if any.

B. Additional stirrups in excess of those required are provided each way from the cutoff, a distance equal to the depth of the beam.

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.

C. The continuing bars provide double the area required for flexure at that point or double the perimeter required for flexural bond.

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 6 inches.

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 6 inches.

Compression steel in beams and girders shall be anchored by ties or stirrups not less than $\frac{3}{4}$ inch 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.

   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 term “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 hooks 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.

(j) **Reinforced Masonry Walls.**

1. **Minimum thickness.** The minimum nominal thickness of reinforced masonry bearing walls shall be 6 inches, and the ratio of height or length to thickness shall not exceed 25, except as specified in Section 2417 (c).

2. **Stresses.** The axial stress in reinforced masonry bearing walls shall not exceed the value determined by the following formula:

\[
f_m = 0.20 f'_m \left[ 1 - \left( \frac{h}{40t} \right)^3 \right]
\]

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 6000 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 area of horizontal reinforcement shall be not less than 0.0013 and that of vertical reinforcement shall be not less than 0.0007 times the gross cross-sectional area of the wall. Wall steel shall be limited to a maximum of 4 feet on center. The minimum diameter shall be % inch except that joint reinforcement may be considered as part of the required reinforcement.

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 % inch bar or two % inch bars on all sides of, and adjacent to, every opening which exceeds 24 inches in either direction, and such bars shall extend not less than 40 diameters, but in no case less than 24 inches beyond the corners of the opening. The bars required by this paragraph shall be in addition to the minimum reinforcement elsewhere required.

When the reinforcement in bearing walls is designed, placed and anchored in position as for columns, the allowable stresses shall be as for columns. The length of the wall to be considered effective shall not exceed the center-to-center distance between loads nor shall it exceed the width of the bearing plus four times the wall thickness.

(k) Reinforced Masonry Columns. 1. Limiting dimensions. The least dimension of every reinforced masonry column shall be not less than 12 inches unless designed for one-half the allowable stresses, in which case the minimum least dimensions shall be 8 inches. No masonry columns shall have an unsupported length greater than 20 times its least dimension.

2. Allowable loads. The axial load on columns shall not exceed:

\[ P = A_g \left( 0.18 f_m + 0.65 p_g f_s \right) \left[ 1 - \left( \frac{h}{40t} \right)^3 \right] \]
WHERE:

\[ P = \text{Maximum concentric column axial load.} \]

\[ A_g = \text{The gross area of the column.} \]

\[ f'_m = \text{Ultimate compressive masonry strength as determined by Section 2404 (c).} \]

\[ \text{The value of } f'_m \text{ shall not exceed 6000 pounds per square inch.} \]

\[ p_g = \text{Ratio of the effective cross-sectional area of vertical reinforcement to } A_g. \]

\[ f_s = \text{Allowable stress in reinforcement [see Section 2418 (b)].} \]

\[ t = \text{Least thickness of column in inches.} \]

\[ h = \text{Clear height in inches.} \]

3. Reinforcement. A. Vertical reinforcement. The ratio \( p_g \) shall be not less than 0.5 per cent nor more than 4 per cent. The number of bars shall be not less than four, nor the diameter less than ¾ inch.

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.

B. Ties. Lateral ties shall be at least ¼ inch 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 1½ inches and not more than 5 inches from the surface of the column, and may be against the vertical bars, or placed in the horizontal bed joints.

Sec. 2419. (a) Partially Reinforced Masonry. Partially reinforced masonry shall be designed as unreinforced masonry, except that 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 M or S mortar shall be used.

The minimum area of reinforcement required in Section 2418 (j) 3 shall not apply to partially reinforced masonry walls. Maximum spacing of vertical reinforcement in exterior partially reinforced masonry walls shall be 8 feet. Reinforcement shall be provided each side of each opening and at each corner of all walls. Horizontal reinforcement not less than 0.2 square inch 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.

Partially reinforced masonry walls shall be considered as reinforced masonry for the purpose of applying Table No. 24-I.
(b) Unreinforced Masonry. 1. General. Except for brick masonry designed in accordance with the applicable requirements of Subsection (c) of this Section, unreinforced masonry walls shall comply with the empirical requirements set forth in this Subsection and Table No. 24-1.

2. Empirical requirements. A. 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.

B. Minimum thickness. The minimum thickness of bearing walls of plain masonry shall be 12 inches for the uppermost 35 feet of their height, and shall be increased 4 inches in thickness for each successive 35 feet or fraction thereof measured downward from the top of the wall.

EXCEPTIONS: 1. The thickness of unreinforced grouted brick masonry walls may be 2 inches less than required by this Subsection, but in no case less than 6 inches.

2. In buildings not more than three stories or 35 feet in height, masonry walls may be of 8 inches nominal thickness. Solid masonry walls in one-story buildings may be of 6 inch nominal thickness when not over 9 feet in height, provided that when gable construction is used an additional 6 feet are 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.

C. Stresses. The 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.

(c) Engineered Brick Masonry. 1. General. A. Design. The design of unreinforced brick masonry walls or columns constructed of solid masonry units made from clay or shale may be based on a general structural analysis and the requirements of this Subsection. Where required there shall be special inspection as specified in Section 305 to insure that the construction and workmanship requirements of this Subsection and Chapter are satisfied.

In determining the stresses in brick masonry, the effects of all dead and live loads shall be taken into account. Eccentric-
ity of vertical load, the effects of lateral load, temperature changes and other forces shall be considered. Stresses shall be calculated on actual rather than nominal dimensions.

B. Combination of dissimilar units. In composite or faced walls or other structural members composed of different kinds or grades of units or mortars, the maximum stresses shall not exceed the allowable for the weakest of the combination of units and mortars of which the member is composed.

In cavity walls composed of different kinds or grades of units or mortars, the maximum stress shall not exceed the allowable stresses for the weaker of the combinations of units and mortars where both wythes support vertical load; where only one wythe supports vertical load, maximum stresses shall not exceed the allowable stresses for the units and mortars of that wythe.

2. Materials. Except as may be otherwise provided herein, materials used in brick masonry shall conform to the standards and requirements specified in this Subsection.

A. Brick and solid clay or shale masonry units. Brick and solid clay or shale masonry units shall comply with the requirements of Section 2403 (b).

Brick used in load bearing or shear walls shall comply with the dimension and distortion tolerances specified for type FBS of U.B.C. Standard No. 24-1. Where such bricks do not comply with these requirements, the compressive strength of brick masonry shall be determined by prism tests. See Section 2419 (c) 3 B.

B. Used brick. Used or salvaged brick shall not be permitted under the provisions of this Subsection.

C. Mortar. Mortar for use in engineered brick masonry shall conform to U.B.C. Standard No. 24-20, Type M, S or N, except that it shall consist of a mixture of portland cement (Type I, II or III), hydrated lime (Type S) and aggregate where values given in Tables No. 24-J and No. 24-K are used.

3. Brick masonry strength. A. General. The value of \( f'_m \) used for determining the allowable stresses shall be based on the specified minimum 28-day compressive strength of the masonry or on the specified minimum compressive strength at the earlier age at which the masonry may be expected to receive its full load. All plans, submitted for approval or used on the job, shall clearly show the specified strength of masonry \( \left(f'_m\right) \) at an age for which all parts of the structure were designed.
B. Determination of brick masonry strength. The determination of the compressive strength of brick masonry ("f' m") shall be made by one of the following methods:

Method No. 1 — Prism Tests. When the compressive strength of brick masonry is to be established by tests, the tests shall be made in accordance with the requirements of Section 2404 (c) 2. In no case, however, shall a value of "f' m" in excess of 6000 pounds per square inch be used in the design.

Method No. 2 — Brick Tests. When the compressive strength of the brick masonry is not determined by prism tests and the units, mortar and workmanship conform to all applicable requirements of this Subsection, the allowable stresses may be based upon an assumed value of "f' m" interpolated from the values in Table No. 24-J. Compressive strength tests of brick shall be conducted in accordance with U.B.C. Standard No. 24-25.

4. Allowable stresses. A. Compressive stresses. Except as provided elsewhere in this Code, the allowable compressive stresses due to axial loads in unreinforced brick masonry shall not exceed 0.20 f' m for walls and 0.18 f' m for columns.

B. Tensile and shearing stresses. Except as provided elsewhere in this Code, the allowable stresses in tension in flexure and shear in unreinforced brick masonry shall not exceed the values set forth in Table No. 24-K.

5. Design. A. Slenderness ratio. The slenderness ratio of a load-bearing wall shall be taken as the ratio of its effective height to the effective thickness and shall not exceed 25.

The slenderness ratio of a column shall be the greater value obtained by dividing the effective height in any direction by the effective thickness in the corresponding direction and shall not exceed 20.

Where walls or columns meet all other requirements of this Code, limits on slenderness ratios may be waived when approved after a review of a written justification.

B. Effective height of columns. Where a column is provided with lateral supports in the directions of both principal axes at both its top and bottom, the effective height in any direction shall be taken as the actual height.

Where a column is provided with lateral support in the directions of both principal axes at the bottom and in the direction of one principal axis at the top, its effective height relative to the direction of the top support shall be taken as the height between supports and its effective height at right angles to this shall be taken as twice its height above the lower support.
In the absence of lateral support at the top, the effective height of a column relative to both principal axes shall be taken as twice its height above the lower support.

C. **Effective height of walls.** Where a wall is laterally supported top and bottom, its effective height shall be taken as the actual height of the wall.

Where there is no lateral support at the top of a wall, its effective height shall be taken as twice the height of the wall above the bottom lateral support.

D. **Effective thickness.** For solid walls, the effective thickness shall be taken as the actual thickness.

For cavity walls loaded on both wythes, the effective thickness shall be taken as the square root of the sum of the squares of the actual thicknesses of both wythes.

For cavity walls loaded on one wythe only, the effective thickness may be determined as for cavity walls loaded on both wythes, except that the effective thickness shall not exceed 1.5 times the actual thickness of the loaded wythe.

For columns, the effective thickness shall be taken as its actual thickness in the direction considered.

E. **Eccentricity normal to plane of member.** In calculating the virtual eccentricity of loads on walls or columns, consideration shall be given to the effects of lateral load, eccentricity of vertical load, and the deflection, thermal and other movements of members.

In solid walls, columns and cavity walls loaded on both wythes, the eccentricity of the load shall be considered with respect to the centroidal axis of the member.

In cavity walls loaded on one wythe, the eccentricity of the load shall be considered with respect to the centroidal axis of the loaded wythe.

F. **Allowable vertical loads: Axial loads on walls.** Allowable axial loads on unreinforced brick masonry walls shall be computed by the following formula:

\[ P = c (0.20 f'_m) A_g \]

**WHERE:**

- \( c \) = Stress reduction factor given in Table No. 24-L corresponding to the slenderness ratio and
- \( A_g \) = Actual gross cross-sectional area of the wall.

Where both wythes of a cavity wall support vertical load “\( A_g \)” shall be taken as gross cross-sectional area of wall minus area of cavity between wythes.
Where only one wythe supports vertical load, "A₀" shall be taken as gross cross-sectional area of the loaded wythe.

**Axial loads on columns.** Allowable axial loads on unreinforced brick masonry columns shall be computed by the following formula:

\[ P = c \times (0.18 \times f'_m) \times A₀ \]

**WHERE:**

- \( c \) = Stress reduction factor given in Table No. 24-L corresponding to the slenderness ratio and
- \( A₀ \) = Actual gross cross-sectional area of the column.

**Eccentric load.** Where the virtual eccentricity of vertical and horizontal loads normal to the plane of the member does not exceed one-third the thickness, the allowable vertical load on unreinforced brick masonry walls and columns shall be computed in accordance with this Subsection, where the stress reduction factor corresponds to the slenderness ratio and eccentricity.

Where virtual eccentricity exceeds one-third the thickness, the maximum tensile stress in the masonry, assuming linear stress distribution, shall not exceed the values given in Table No. 24-K or the member shall be designed in accordance with the requirements of Section 2418.

**G. Concentrated loads.** The bearing stress under beams, lintels and girders and from similar concentrated loads supported on unreinforced masonry shall not exceed the values set forth in Table No. 24-H for reinforced masonry.

**H. Shear walls: Eccentricity parallel to plane of wall.** The eccentricity parallel to the plane of the wall of vertical and horizontal loads acting on shear walls shall not exceed an amount which will produce tension in unreinforced brick masonry. Where the eccentricity exceeds this amount, the wall shall be designed in accordance with the requirements of Section 2418.

**Allowable horizontal shear.** The horizontal component of forces acting on a shear wall shall not exceed the product of the actual gross cross-sectional area of the wall parallel to the horizontal force times the allowable shear given in Table No. 24-K. The overhanging portion of the flange of the shear wall shall not be considered to be effective in computing the shear resistance of the wall.

**Allowable compressive stress.** The maximum allowable flexural compressive stress in shear walls resulting from horizontal and vertical loads shall not exceed \( 0.25 \times f'_m \) multiplied by the stress reduction factor of Table No. 24-L for an eccentricity of zero.
Anchorage of diaphragms. Anchorage of diaphragms to walls shall be in accordance with Section 2313 and shall be sufficient to transmit all forces.

6. Construction. A. General. In addition to the construction requirements of Sections 2410 (b), 2412 (b) and (c), and 2416, unreinforced brick masonry designed in accordance with Section 2419 (c) shall also comply with the requirements of this Subsection.

B. Mortar joints. All brick shall be laid with full head and bed joints and all interior joints that are designed to receive mortar shall be filled. The average thickness of head and bed joints shall not exceed ½ inch.

C. Bonding unreinforced load-bearing walls and shear walls. Where two unreinforced load-bearing walls meet or intersect, or where shear walls intersect a wall [see Section 2419 (c) 5 H], the intersections shall be bonded by laying in a true bond at least 50 per cent of the units at the intersection or the intersecting walls shall be regularly toothed or blocked with 8-inch maximum offsets and the joints provided with metal anchors having a minimum section of ¼-inch by 1 1/8-inches with ends bent up at least 2 inches, or with cross pins to form anchorage. Such anchors shall be at least 2 feet long and the maximum spacing shall be 4 feet.

Sec. 2420. (a) General. Nonbearing walls may be constructed of any masonry as specified in this Chapter. Reinforced masonry nonbearing walls shall be reinforced as specified in Section 2418 (j) 3.

(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) 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.
TABLE NO. 24-A — MORTAR PROPORTIONS
(Parts by Volume)

<table>
<thead>
<tr>
<th>MORTAR TYPE</th>
<th>MINIMUM COMPRESSIVE STRENGTH AT 28 DAYS (p.s.i.)</th>
<th>PORTLAND CEMENT</th>
<th>HYDRATED LIMES OR LIME PUTTY1</th>
<th>MASONRY CEMENTS</th>
<th>DAMP LOOSE AGGREGATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>2500</td>
<td>1</td>
<td>—</td>
<td>¼</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>1800</td>
<td>1</td>
<td>¼</td>
<td>½</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>750</td>
<td>1</td>
<td>½</td>
<td>1½</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>O</td>
<td>350</td>
<td>1</td>
<td>1½</td>
<td>2½</td>
<td>—</td>
</tr>
</tbody>
</table>

1When 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.

TABLE NO. 24-B — ALLOWABLE WORKING STRESSES IN UNREINFORCED UNIT MASONRY

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>Type M</th>
<th>Type S</th>
<th>Type M or Type S Mortar</th>
<th>Type N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Inspection Required</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Solid Brick Masonry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4500 plus p.s.i.</td>
<td>250</td>
<td>225</td>
<td>20 10 40 20</td>
<td>200</td>
</tr>
<tr>
<td>2500-4500 p.s.i.</td>
<td>175</td>
<td>160</td>
<td>20 10 40 20</td>
<td>140</td>
</tr>
<tr>
<td>1500-2500 p.s.i.</td>
<td>125</td>
<td>115</td>
<td>20 10 40 20</td>
<td>100</td>
</tr>
<tr>
<td>Solid Concrete Unit Masonry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade A</td>
<td>175</td>
<td>160</td>
<td>12 6 24 12</td>
<td>140</td>
</tr>
<tr>
<td>Grade B</td>
<td>125</td>
<td>115</td>
<td>12 6 24 12</td>
<td>100</td>
</tr>
<tr>
<td>Grouted Masonry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4500 plus p.s.i.</td>
<td>350</td>
<td>275</td>
<td>25 12.5 50 25</td>
<td></td>
</tr>
<tr>
<td>2500-4500 p.s.i.</td>
<td>275</td>
<td>215</td>
<td>25 12.5 50 25</td>
<td></td>
</tr>
<tr>
<td>1500-2500 p.s.i.</td>
<td>225</td>
<td>175</td>
<td>25 12.5 50 25</td>
<td></td>
</tr>
<tr>
<td>Hollow Unit Masonry²</td>
<td>170</td>
<td>150</td>
<td>12 6 24 12</td>
<td>140</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE NO. 24-B — ALLOWABLE WORKING STRESSES IN UNREINFORCED UNIT MASONRY — Continued

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>Type M</th>
<th>Type S</th>
<th>Type S Mortar</th>
<th>Type N</th>
</tr>
</thead>
</table>
| Cavity Wall Masonry Solid Units
grade A or 2500 p.s.i. plus
Grade B or 1500-2500 p.s.i.
Hollow Units | 140 | 130 | 12 6 | 30 15 | 110 10 5 |
| |||||
| Stone Masonry
Cast Stone
Natural Stone | 400 | 360 | 8 4 | — — | 320 8 4 |
| |||||
| Gypsum Masonry | 20 | 20 | — — | — — | 20 |
| |||||
| Unburned Clay Masonry | 30 | 30 | 8 4 | — — |

1. Allowable axial or flexural compressive stresses in 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.

### TABLE NO. 24-C—ALLOWABLE SHEAR ON BOLTS
Masonry of Unburned Clay Units

<table>
<thead>
<tr>
<th>DIAMETER OF BOLTS (Inches)</th>
<th>EMBEDMENTS (Inches)</th>
<th>SHEAR (Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5/8</td>
<td>12</td>
<td>200</td>
</tr>
<tr>
<td>3/4</td>
<td>15</td>
<td>300</td>
</tr>
<tr>
<td>7/8</td>
<td>18</td>
<td>400</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>500</td>
</tr>
<tr>
<td>1 1/8</td>
<td>24</td>
<td>600</td>
</tr>
</tbody>
</table>

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### TABLE NO. 24-D — MINIMUM ULTIMATE COMPRESSIVE STRENGTH AND MODULUS OF ELASTICITY AND OF RIGIDITY OF REINFORCED GYPSUM CONCRETE

| CLASS | COMPRESSIVE STRENGTH P.S.I. ($f_p$) | MODULUS OF ELASTICITY P.S.I. ($E$) | $E_s/E_g$ | MODULUS OF RIGIDITY ($G$) |
|-------|-----------------------------------|-------------------------------|--------|----------------|------------------|
| A     | 500                               | 200,000                       | 150    | .36E            |
| B     | 1,000                             | 600,000                       | 50     | .40E            |

### TABLE NO. 24-E — ALLOWABLE UNIT WORKING STRESS REINFORCED GYPSUM CONCRETE

<table>
<thead>
<tr>
<th>TYPE OF STRESS</th>
<th>FACTOR</th>
<th>CLASS A</th>
<th>CLASS B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Compression</td>
<td>$0.25f_e$</td>
<td>125</td>
<td>250</td>
</tr>
<tr>
<td>Axial Compression or Bearing</td>
<td>$0.20f_e$</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Bond for Plain Bars and Shear</td>
<td>$0.02f_e$</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Bond for Deformed Bars and</td>
<td>$0.03f_e$</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Electrically Welded Wire Mesh</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Electrically welded wire mesh reinforcement shall be considered as meeting the bond and shear requirements of this Section. In no case shall the area of principal reinforcement be less than .026 square inch per foot of slab width.

### TABLE NO. 24-F — SHEAR ON ANCHOR BOLTS AND DOWELS — REINFORCED GYPSUM CONCRETE

<table>
<thead>
<tr>
<th>BOLT OR DOWEL SIZE (Inches)</th>
<th>EMBEDMENT (Inches)</th>
<th>SHEAR (Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 Bolt</td>
<td>4</td>
<td>325</td>
</tr>
<tr>
<td>1/2 Bolt</td>
<td>5</td>
<td>450</td>
</tr>
<tr>
<td>5/8 Bolt</td>
<td>5</td>
<td>650</td>
</tr>
<tr>
<td>3/4 Deformed Dowel</td>
<td>6</td>
<td>325</td>
</tr>
<tr>
<td>1/2 Deformed Dowel</td>
<td>6</td>
<td>450</td>
</tr>
</tbody>
</table>

1The bolts or dowels shall be spaced not closer than 6 inches on center.

### TABLE NO. 24-G—ALLOWABLE SHEAR ON BOLTS FOR ALL MASONRY EXCEPT GYPSUM AND UNBURNED CLAY UNITS

<table>
<thead>
<tr>
<th>DIAMETER OF BOLT (Inches)</th>
<th>EMBEDMENT (Inches)</th>
<th>SOLID MASONRY (Shear in Pounds)</th>
<th>GRouted MASONRY (Shear in Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>4</td>
<td>350</td>
<td>550</td>
</tr>
<tr>
<td>3/8</td>
<td>4</td>
<td>500</td>
<td>750</td>
</tr>
<tr>
<td>5/8</td>
<td>5</td>
<td>750</td>
<td>1100</td>
</tr>
<tr>
<td>3/4</td>
<td>6</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>1250</td>
<td>1850</td>
</tr>
<tr>
<td>1 1/8</td>
<td>8</td>
<td>1500</td>
<td>2250</td>
</tr>
</tbody>
</table>

1Permitted only with not less than 2500 pounds per square inch units.
<table>
<thead>
<tr>
<th>TYPE OF STRESS</th>
<th>SPECIAL INSPECTION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Compression—Axial, Walls</td>
<td>See Section 2418</td>
</tr>
<tr>
<td>Compression—Axial, Columns</td>
<td>See Section 2418</td>
</tr>
<tr>
<td>Compression—Flexural Shear: No shear reinforcement</td>
<td>$0.33 f_m$ but not to exceed 900</td>
</tr>
<tr>
<td>Reinforcement taking entire shear: Flexural members</td>
<td>$0.02 f_m$ but not to exceed 50</td>
</tr>
<tr>
<td>Shear Walls</td>
<td>$0.05 f_m$ but not to exceed 120</td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>$1000 f_m$ but not to exceed 3,000,000</td>
</tr>
<tr>
<td>Modulus of Rigidity</td>
<td>$400 f_m$ but not to exceed 1,200,000</td>
</tr>
<tr>
<td>Bearing on full Area</td>
<td>$0.25 f_m$ but not to exceed 900</td>
</tr>
<tr>
<td>Bearing on $\frac{1}{3}$ or less of area</td>
<td>$0.30 f_m$ but not to exceed 1200</td>
</tr>
<tr>
<td>Bond—Plain bars</td>
<td>60</td>
</tr>
<tr>
<td>Bond—Deformed</td>
<td>140</td>
</tr>
</tbody>
</table>

1Stresses for hollow unit masonry are based on net section.

2Web 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.

3Where 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.

4This 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.
### TABLE NO. 24-I — MINIMUM THICKNESS OF MASONRY WALLS

<table>
<thead>
<tr>
<th>TYPE OF MASONRY</th>
<th>MAXIMUM RATIO UNSUPPORTED HEIGHT OR LENGTH TO THICKNESS</th>
<th>NOMINAL MINIMUM THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEARING WALLS:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unburned Clay Masonry</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Stone Masonry</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Cavity Wall Masonry</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Hollow Unit Masonry</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Solid Masonry</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Grouted Masonry</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Reinforced Grouted Masonry</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>Reinforced Hollow Unit Masonry</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td><strong>NONBEARING WALLS:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior Unreinforced Walls</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Exterior Reinforced Walls</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>Interior Partitions Unreinforced</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Interior Partitions Reinforced</td>
<td>48</td>
<td>2</td>
</tr>
</tbody>
</table>

### TABLE NO. 24-J — ASSUMED COMPRESSIVE STRENGTH OF BRICK MASONRY

<table>
<thead>
<tr>
<th>COMPRESSIVE STRENGTH OF UNITS, P.S.I.</th>
<th>ASSUMED COMPRESSIVE STRENGTH OF BRICK MASONRY (f' m, P.S.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Inspection Required</td>
<td>TYPE M MORTAR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>14,000 plus</td>
<td>4600</td>
</tr>
<tr>
<td>10,000</td>
<td>3400</td>
</tr>
<tr>
<td>6,000</td>
<td>2200</td>
</tr>
<tr>
<td>2,000</td>
<td>1000</td>
</tr>
</tbody>
</table>

1. See Section 2419 (c) 1.
2. See Section 2419 (c) 2.

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### TABLE NO. 24-K — ALLOWABLE STRESSES IN TENSION IN FLEXURE AND SHEAR IN UNREINFORCED BRICK MASONRY

<table>
<thead>
<tr>
<th>CONSTRUCTION</th>
<th>ALLOWABLE STRESSES, P.S.I.</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TENSION IN FLEXURE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NORMAL TO BED JOINTS¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PARALLEL TO BED JOINTS²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MORTAR TYPE¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M or S</td>
<td>N</td>
<td>M or S</td>
<td>N</td>
</tr>
<tr>
<td>Special Inspection Required</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Brick Masonry⁴</td>
<td>36 18 28 14</td>
<td>72 36 56 28</td>
<td>50 25 40 20</td>
<td></td>
</tr>
</tbody>
</table>

¹Direction of stress is normal to bed joints; vertically in normal masonry construction.

²Direction of stress is parallel to bed joints; horizontally in normal masonry construction. If masonry is laid in stack bond, tensile stresses in the horizontal direction shall not be permitted in the masonry. See Section 2417 (1).

³See Section 2419 (c) 2.

⁴For computing flexural resistance, the section modulus of a cavity wall shall be assumed to be equal to the sum of the section moduli of each wythe.

### TABLE NO. 24-L — STRESS REDUCTION FACTORS, c, FOR UNREINFORCED MASONRY¹

<table>
<thead>
<tr>
<th>SLENDERNESS RATIO²</th>
<th>VIRTUAL ECCENTRICITY NORMAL TO PLANE OF MEMBER AS A PROPORTION OF THE THICKNESS OF THE MEMBER³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 to 1/20</td>
</tr>
<tr>
<td>5</td>
<td>1.00</td>
</tr>
<tr>
<td>10</td>
<td>0.92</td>
</tr>
<tr>
<td>15</td>
<td>0.79</td>
</tr>
<tr>
<td>20</td>
<td>0.64</td>
</tr>
<tr>
<td>25</td>
<td>0.49</td>
</tr>
<tr>
<td>30</td>
<td>0.38</td>
</tr>
</tbody>
</table>

¹Linear interpolation between values for the stress factors is permissible.

²Except as provided in Section 2419 (c) 5 A, the slenderness ratios of walls and columns shall be limited to 25 and 20, respectively.

³See Section 2419 (c) 5 E.
Sec. 707. When required by other provisions of this Code, automatic fire-extinguishing systems and standpipes shall be installed as specified in Chapter 38.

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 rooms 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.

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 10 feet from other doors or windows of the same building shall be protected by a fire assembly having a three-fourths-hour fire-protection 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 openings protected as specified in Section 3320.

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 3200 square feet, 1-inch nominal tight tongue-and-grooved or ¾-inch plywood wall covering may be used on the inner side in lieu of fire-resistive plaster.
**EXCEPTION:** In storage garages and aircraft hangars not exceeding an area of 5000 square feet, 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 water closet. Separate facilities shall be provided for each sex when the number of employees exceeds four and both sexes are employed. Such toilet facilities shall be located either in such building or conveniently in a building adjacent thereto on the same property.

Such water closet 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 water closet rooms shall be provided with an exterior window at least 3 square feet in area, fully openable; or a vertical duct not less than 100 square inches in area for the first toilet facility with an additional 50 square inches 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 5 feet from any openable window.

For other requirements on water closets, see Section 1711.

**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 specified in Section 1706.

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

**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.

Devices generating a glow or flame capable of igniting gasoline vapor shall not be installed or used within 18 inches
Chapter 25 — Wood

NOTE: Tables in Chapter 25 appear at the end of the Chapter.

Sec. 2501. (a) Quality and Design. The quality and design of wood members and their fastenings shall conform to the provisions of this Chapter, and to the following Standards:

<table>
<thead>
<tr>
<th>Materials or Design</th>
<th>U.B.C. Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grading — Light Framing, Joists and Planks, Decking, Beams and Stringers, Posts and Timbers</td>
<td></td>
</tr>
<tr>
<td>All Species of Lumber</td>
<td>25-1</td>
</tr>
<tr>
<td>Cedar, Incense and Western Red</td>
<td>25-3</td>
</tr>
<tr>
<td>Cypress — Tidewater Red</td>
<td>25-2</td>
</tr>
<tr>
<td>Douglas Fir, Coast Region</td>
<td>25-3</td>
</tr>
<tr>
<td>Douglas Fir</td>
<td>25-4</td>
</tr>
<tr>
<td>Fir, White</td>
<td>25-3</td>
</tr>
<tr>
<td>Fir, Balsam</td>
<td>25-4</td>
</tr>
<tr>
<td>Hemlock, Eastern</td>
<td>25-5</td>
</tr>
<tr>
<td>Hemlock, West Coast</td>
<td>25-3</td>
</tr>
<tr>
<td>Hemlock, Western</td>
<td>25-4</td>
</tr>
<tr>
<td>Larch</td>
<td>25-4</td>
</tr>
<tr>
<td>Pine (Idaho White, Lodgepole, Ponderosa and Sugar)</td>
<td>25-4</td>
</tr>
<tr>
<td>Pine, Norway</td>
<td>25-5</td>
</tr>
<tr>
<td>Pine, Southern</td>
<td>25-6</td>
</tr>
<tr>
<td>Redwood</td>
<td>25-7</td>
</tr>
<tr>
<td>Spruce, Eastern</td>
<td>25-8</td>
</tr>
<tr>
<td>Spruce, Engelmann</td>
<td>25-4</td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>25-3</td>
</tr>
</tbody>
</table>

Plywood

Construction and Industrial Softwood | 25-9 |
Calculation of Diaphragm Deflection | 25-9 |

Structural Glued-Laminated Timber

All Species of Lumber | 25-10 |
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Pine, Southern | 25-11 |
Hardwood | 25-11 |

Preservative Treatment by Pressure Processes | 25-12 |

Wood Poles | 25-13 |
Round Timber Piles | 25-14 |
Spaced Columns | 25-15 |
Flexural and Axial Loading | 25-16 |
(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 their fastenings shall conform to accepted 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 such a combination that they affect the serviceability of the member.

(e) Minimum Quality. Minimum capacity of structural framing members may be established by performance tests. When tests are not made, capacity shall be based upon allowable stresses and design criteria specified in this Code.

Studs, joists, rafters, foundation plates or sills, planking 2 inches 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-1 or No. 25-A-2, and in Groups I, II and III set forth in Table No. 25-F. Lumber set forth in Group IV of Table No. 25-F may be used only under conditions specifically approved by the Building Official.

(f) Shrinkage. Consideration shall be given in the design to the possible effect of cross grain dimensional changes considered vertically which may occur in lumber fabricated in a green condition.
Sec. 2502. (a) Definitions. The following terms used in this Chapter shall have the meanings indicated in this Section:

**FIBERBOARD** is a fibrous-felted, homogeneous panel made from lignocellulosic fibers (usually wood or cane) and having a density of less than 31 pounds per cubic foot but more than 10 pounds per cubic foot, conforming to U.B.C. Standard No. 25-24.

**GLUED BUILT-UP MEMBERS** are structural elements, the sections of which are composed of built-up lumber, plywood or plywood in combination with lumber; all parts bonded together with adhesives.

**GRADE (Lumber)**, the classification of lumber in regard to strength and utility in accordance with the grading rules of an approved lumber grading agency.

**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 for sawn lumber and U.B.C. Standard No. 25-10 for structural glued-laminated timber.

**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 load may be applied for the remainder of the life of the member or fastening.

**PARTICLEBOARD**, a mat-formed panel manufactured from lignocellulosic materials in the form of discrete pieces or particles, as distinguished from fibers, combined with a binder and bonded together under heat and pressure in accordance with U.B.C. Standard No. 25-25.

**PLYWOOD**, a built-up panel of laminated veneers conforming to U.B.C. Standard No. 25-9.

**STRUCTURAL GLUED-LAMINATED TIMBER**, 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 or No. 25-11.

**TREATED WOOD**, wood treated with approved preservatives in accordance with U.B.C. Standard No. 25-12.
WOOD OF NATURAL RESISTANCE TO DECAY, the heartwood of bald cypress, black locust, black walnut, the cedars and redwood.

(b) Symbols. The symbols used in this Chapter have the following definitions:

\[ A = \text{area of cross section.} \]
\[ b = \text{breadth (width) of rectangular member.} \]
\[ C = \text{coefficient, constant, or factor.} \]
\[ C_c = \text{curvature factor.} \]
\[ C_d = \text{depth effect factor.} \]
\[ C_f = \text{form factor.} \]
\[ C_s = \text{slenderness factor.} \]
\[ c = \text{distance from neutral axis to extreme fiber.} \]
\[ D = \text{diameter.} \]
\[ d = \text{depth of rectangular member, or least dimension of compression member.} \]
\[ E = \text{modulus of elasticity.} \]
\[ e = \text{eccentricity.} \]
\[ F_b = \text{allowable unit stress for extreme fiber in bending.} \]
\[ F_b' = \text{allowable unit stress for extreme fiber in bending, adjusted for slenderness.} \]
\[ f_b = \text{actual unit stress for extreme fiber in bending.} \]
\[ F_c = \text{allowable unit stress in compression parallel to grain.} \]
\[ F_c' = \text{allowable unit stress in compression parallel to grain adjusted for } \frac{L}{d} \text{ ratio where } d \text{ is the least dimension.} \]
\[ f_c = \text{actual unit stress in compression parallel to grain.} \]
\[ F_{c\perp} = \text{allowable unit stress in compression perpendicular to grain.} \]
\[ f_{c\perp} = \text{actual unit stress in compression perpendicular to grain.} \]
\[ F_n = \text{allowable unit stress acting perpendicular to the inclined surface p.s.i. (Hankinson's Formula).} \]
\[ F_r = \text{allowable unit radial stress.} \]
\[ f_r = \text{actual unit radial stress.} \]
\[ F_{rc} = \text{allowable unit radial stress in compression.} \]
\[ f_{rc} = \text{actual unit radial stress in compression.} \]
\[ F_{rt} = \text{allowable unit radial stress in tension.} \]
\[ f_{rt} = \text{actual unit radial stress in tension.} \]
\[ F_t = \text{allowable unit stress in tension parallel to grain.} \]
\[ f_t = \text{actual unit stress in tension parallel to grain.} \]
Definitions and Symbols (Continued)

\[ F_v = \text{allowable unit horizontal shear stress.} \]
\[ f_v = \text{actual unit horizontal shear stress.} \]
\[ h = \text{rise.} \]
\[ I = \text{moment of inertia.} \]
\[ L = \text{span length of beam, or unsupported length of column, feet.} \]
\[ l = \text{span length of beam, or unsupported length of column, inch.} \]
\[ M = \text{bending moment.} \]
\[ m = \text{unit bending moment.} \]
\[ N = \text{acting perpendicular to the inclined surface "lb" (Hankinson's Formula).} \]
\[ P = \text{total concentrated load, or axial compression load.} \]
\[ P/A = \text{induced axial load per unit of cross-sectional area.} \]
\[ Q = \text{statical moment of an area about the neutral axis.} \]
\[ R = \text{radius of curvature.} \]
\[ R_H = \text{horizontal reaction.} \]
\[ R_V = \text{vertical reaction.} \]
\[ r = \text{radius of gyration.} \]
\[ S = \text{section modulus.} \]
\[ T = \text{total axial tension load.} \]
\[ t = \text{thickness.} \]
\[ V = \text{total vertical shear.} \]
\[ W = \text{total uniform load.} \]
\[ w = \text{uniform load per unit of length.} \]
\[ \Delta_A = \text{allowable deformation or deflection.} \]
\[ \Delta_a = \text{actual deformation or deflection.} \]
\[ \theta = \text{angle between the direction of load and the direction of grain, degrees (Hankinson's Formula).} \]

Sec. 2503. Sizes of lumber, structural glued-laminated timber and plywood referred to in this Code are nominal sizes. Computations to determine the required sizes of members shall be based on the net dimensions (actual sizes) and not the nominal sizes.

Sec. 2504. (a) General. Except as hereinafter provided, stresses shall not exceed the allowable unit stresses for the respective species and grades or fabricated products as set forth in Tables No. 25-A-1 and No. 25-A-2 for lumber, and...
The values for $F_b$ and $F_c$ tabulated in Table No. 25-A-1 for visually stress-rated lumber and in Table No. 25-A-2 for machine stress-rated lumber are for the design of structures when the strength of an individual member is premised on the assumption that each individual piece carries its design load.

The values for $F_b$ tabulated in Table No. 25-A-1 may be increased 15 per cent for the design of an assembly of repetitive framing such as tongue-and-groove planks and decking, or members such as joists, rafters, and studs not over 4 inches in thickness spaced not more than 24 inches, not less than three in number and joined by transverse load distributing elements adequate to support the design load.

Values for species and grades not tabulated shall be approved by the Building Official.

Values for plywood shall be in accordance with Table No. 25-B. All plywood when designed to be exposed in outdoor applications shall be of the exterior type.

(b) Wood Poles or Piles. The values tabulated in Table No. 25-E shall be used for the design of round timber poles and piles.

Poles and piles shall conform to the requirements set forth in U.B.C. Standards No. 25-13 and No. 25-14.

(c) Adjustment of Stresses. 1. General. The allowable unit stresses specified in this Chapter shall be subject to the adjustments set forth in the footnotes to the appropriate stress tables and to the requirement of this Subsection.

2. Preservative treatment. The values for wood pressure impregnated with an approved process and preservative need no adjustment for treatment but are subject to other adjustments.

3. Fire-retardant treatment. The values shall be reduced 10 per cent for lumber pressure impregnated with approved fire-retardant chemicals. The values for plywood so treated shall be reduced 16 per cent except for modulus of elasticity which shall be reduced 10 per cent. Other adjustments are applicable.

Where structural glued-laminated timber is fire-retardant treated, values shall be reduced as approved by the Building Official.
4. **Duration of load.** Values for wood and mechanical fastenings (when the wood determines the load capacity) are subject to the following adjustments for the various durations of loading:

i. Where a member is fully stressed to the maximum allowable stress, either continuously or cumulatively, for more than 10 years under the conditions of maximum design load, the values shall not exceed 90 per cent of those in the tables.

ii. When the duration of the full maximum load during the life of the member does not exceed the period indicated below, the values may be increased in the tables as follows:

- 15 per cent for two months duration as for snow
- 25 per cent for seven days duration as for roof loads
- 33½ per cent for wind or earthquake
- 100 per cent for impact

The foregoing increases are not cumulative. For combined duration of loadings the resultant structural members shall not be smaller than required for the longer duration of loading.

iii. Values for normal loading conditions may be used without regard to impact if the stress induced by impact does not exceed the values for normal loading.

**Sec. 2505.** All lumber, plywood, particleboard, structural glued-laminated timber, piles and poles regulated by this Chapter shall conform to the applicable standards or grading rules specified in this Code and shall be so identified by the grade mark or a Certificate of Inspection issued by an approved agency.

**Sec. 2506.**

(a) **Beam Span.** For simple beams, the span shall be taken as the distance from face to face of supports, plus one-half the required length of bearing at each end; for continuous beams, the span is the distance between centers of bearings on supports over which the beam is continuous.

(b) **Flexure.**

1. **Circular cross section.** A beam of circular cross section may be assumed to have the same strength in flexure as a square beam having the same cross-sectional area. If a circular beam is tapered, it shall be considered a beam of variable cross section.
2. Notching. If possible, notching of beams should be avoided. For a beam notched at or near the middle of the span, the net depth shall be taken when determining the flexural strength. For effect of notch on shear strength, see Section 2506 (d).

3. Lateral moment distribution. Lateral moment distribution of a concentrated load from a critically loaded beam to adjacent parallel beams shall be calculated.

(c) Horizontal Shear. The maximum horizontal shear stress in a solid-sawn or glued-laminated wood beam shall not exceed that calculated by means of the formula:

\[ f_v = \frac{3V}{2bd} \]

The actual unit shear stress, \( f_v \), shall not exceed the allowable for the species and grade, as given in Table No. 25-A for solid-sawn lumber, and in Tables No. 25-C and No. 25-D for glued-laminated lumber, adjusted for duration of loading, as provided in Section 2504 (c).

When calculating the total vertical shear, \( V \), distribution of load to adjacent parallel beams by flooring or other members may be considered and all loads within a distance from either support equal to the depth of the beam may be neglected.

(d) Horizontal Shear in Notched Beams. 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:

\[ V = \left( \frac{2bd'}{3} \right) \left( \frac{d'}{d} \right) \]

WHERE:

\( d' = \) actual depth of beam at the notch.

\( d = \) 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.
(e) Design of Eccentric Joints and of Beams Supported by Fastenings. Eccentric connector and bolted joints, and beams supported by connectors or bolts, shall be designed so that $f_v$ in the following formula does not exceed the allowable unit stresses in horizontal shear.

$$f_v = \frac{3V}{2bd_e}$$

in which

$d_e$ (with connectors) = the depth of the member, less the distance from the unloaded edge of the member to the nearest edge of the nearest connector.

$d_e$ (with bolts only) = the depth of the member, less the distance from the unloaded edge of the member to the center of the nearest bolt.

Allowable unit stresses in shear for such joint details shall be 150 per cent of the horizontal shear values as set forth in Tables No. 25-A, No. 25-C and No. 25-D.

(f) Compression Perpendicular to Grain. The allowable unit stresses for compression perpendicular to grain, in Tables No. 25-A, No. 25-C and No. 25-D apply to bearings of any length at the ends of the beam, and to all bearings 6 inches or more in length at any other location.

For bearings of less than 6 inches in length and not nearer than 3 inches to the end of a member, the maximum allowable load per square inch may be obtained by multiplying the allowable unit stresses in compression perpendicular to grain by the following factor:

$$\frac{l_b + .375}{l_b}$$

in which $l_b$ is the length of bearing in inches measured along the grain of the wood.

The multiplying factors for indicated lengths of bearing on such small areas as plates and washers may be:

<table>
<thead>
<tr>
<th>LENGTH OF BEARING (IN INCHES)</th>
<th>$\frac{1}{4}$</th>
<th>1</th>
<th>$1\frac{1}{4}$</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6 OR MORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
<td>1.75</td>
<td>1.38</td>
<td>1.25</td>
<td>1.19</td>
<td>1.13</td>
<td>1.10</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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In using the preceding formula and table for round washers or bearing areas, use a length equal to the diameter.

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.

(g) Lateral Support. 1. Floor joists. Floor joists, having a depth-to-thickness ratio of 6 or more, shall be supported laterally by bridging installed at intervals not exceeding 8 feet. Bridging may be omitted at the ends of joists which are nailed or otherwise fastened to framing members.

EXCEPTION: Bridging between supports may be omitted for 2 x 12 floor joists where live loads do not exceed 40 pounds per square foot.

2. Beams and roof joists. For solid sawn rectangular beams and roof joists, the following rules, based on nominal dimensions, shall apply to provide lateral restraint:

If the ratio of depth to thickness is 2 to 1, no lateral support is needed.

If the ratio is 3 to 1, the ends shall be held in position.

If the ratio is 4 to 1, the piece shall be held in line as in a well-bolted chord member in a truss.

If the ratio is 5 to 1, one edge shall be held in line.

If the ratio is 6 to 1, the provisions of paragraph 1 may be applied.

If the ratio is 7 to 1, both edges shall be held in line.

If a beam is subject to both flexure and compression parallel to grain, the ratio may be as much as 5 to 1, if one edge is held firmly in line; e.g., by rafters (or by roof joists) and diagonal sheathing. If the dead load is sufficient to induce tension on the underside of the rafters, the ratio for the beam may be 6 to 1.

(h) Lateral Deflection—Arches and Top Chords of Trusses. Where roof joists, not purlins, are used between arches or the top chords of trusses, the depth, rather than the breadth, of the arch or top chord member (compression member) may be taken as its least dimension in determining the l/d. The roof joists shall be placed so that their upper edges are at least ½ inch above the tops of the arch or chord, but also placed low enough to provide adequate lateral support.

When roof joists or planks are placed on top of an arch or top chord of a truss, and are well spiked or otherwise securely fastened to the arch or top chord and to blocking placed be-
tween the joists, or when sheathing is nailed properly to the top chord of trussed rafters, the depth of the arch or individual chord members may be used as the least dimension \( d \) in determining \( l/d \).

Sec. 2507. (a) Column Classifications. 1. Simple solid wood columns. Simple columns consist of a single piece or of pieces properly glued together to form a single member.

2. Spaced columns, connector joined. Spaced columns are formed of two or more individual members with their longitudinal axes parallel, separated at the ends and middle points of their length by blocking and joined at the ends by timber connectors capable of developing the required shear resistance. See U.B.C. Standard No. 25-15 for design.

3. Built-up columns. Built-up columns, other than connector-joined spaced columns and glued-laminated columns, shall not be designed as solid columns.

(b) Limitation on \( l/d \) Ratios. For simple solid columns \( l/d \) shall not exceed 50.

For individual members of a spaced column, \( l/d \) shall not exceed 80, nor shall \( l_2/d \) exceed 40.

(c) Simple Solid-Column Design. These formulas for simple solid columns are based on pin-end conditions but shall be applied also to square-end conditions.

Allowable unit stresses in pounds per square inch of cross-sectional area of simple solid columns shall be determined by the following formula, but such unit stresses shall not exceed the values for compression, parallel to grain \( F_c \) in Tables No. 25-A, No. 25-C and No. 25-D, adjusted in accordance with the provisions of Section 2504.

\[
F_c' = \frac{n^2 E}{2.727 (l/r)^2} = \frac{3.619 E}{(l/r)^2}
\]

For columns of square or rectangular cross section this formula becomes:

\[
F_c' = \frac{0.30 E}{(l/d)^2}
\]

(d) Tapered Columns. In determining the \( d \) for tapered column design, the diameter of a round column or the least
Column Design (Continued) 

Flexural and Axial Loading Combined

Sec. 2508. (a) Flexure and Axial Tension. Members subjected to both flexure and axial tension, shall be so proportioned that

\[
\frac{P/A}{F_t} + \frac{M/S}{F_b} \text{ does not exceed } ONE
\]

(b) Flexure and Axial Compression. Members subjected to both flexure and axial compression, shall be so proportioned that

\[
\frac{P/A}{F_c} + \frac{M/S}{F_{cb}} \text{ does not exceed } ONE
\]

(c) Spaced Columns. In the case of spaced columns, this combined stress formula may be applied only if the bending is in a direction parallel to the greater \( d \) of the individual member.

Compression at Angle to Grain

Sec. 2509. The allowable unit stress in compression at an angle of load to grain between \( 0^\circ \) and \( 90^\circ \) shall be computed from the Hankinson formula as follows:

\[
F_n = \frac{F_c F_{c\perp}}{F_c \sin^2 \theta + F_{c\perp} \cos^2 \theta}
\]

Timber Connections and Fastenings

Sec. 2510. (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.

Safe loads and design practices for types of connectors not mentioned or fully covered in U.B.C. Standard No. 25-17 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. 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 ex-
ceed values set forth in Tables No. 25-G and No. 25-H. (For other species see U.B.C. Standard No. 25-17.)

(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.

(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.

(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.

(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-I.

   A wire nail driven parallel to the grain of the wood or toenailed 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-J.

   Nails driven parallel to grain of the wood shall not be allowed for resisting withdrawal forces.

3. **Spacing and penetration.** Common wire nails shall have penetration into the piece receiving the point as set forth in Table No. 25-I. Nails or spikes for which the wire gauges or lengths are not set forth in Table No. 25-I 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.

(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.

(h) Metal Plate Connector. Metal plate connector employed as joint connector in light wood trusses shall conform to U.B.C. Standard No. 25-17.

Sec. 2511. (a) General Provisions. 1. Design requirements. Except as otherwise provided in this Section, structural glued-laminated timber members shall be designed in accordance with the applicable engineering formulas used for sawn members.

2. Fastenings. The pertinent provisions and allowable loads for fastenings, given in this Chapter, shall apply to structural glued-laminated timber members.

3. Allowable unit stresses. The allowable unit stresses for structural glued-laminated timber shall be in accordance with Tables No. 25-C and No. 25-D and as modified by this Section.


Depth of straight and curved members, length of all members and net dimensions shall be specified on the plans.

(c) Specifications. For structural glued-laminated timber, the following shall be specified on the plans:

Whether for dry or wet conditions of use.
Species and applicable standard.
Stress requirements.
If the temperature of the timber exceeds 150°F. in service.

(d) Design Stresses. 1. Dry conditions of use. 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.

2. Wet conditions of use. Allowable stress values for wet conditions of use shall be applicable for normal loading when the moisture content in service is 16 per cent or more, as may occur in exterior and submerged construction.

3. Curvature factor. For the curved portion of members, the allowable unit stress in bending shall be modified by multiplication by the following curvature factor:

\[ C_c = 1 - 2000 \left( \frac{t}{R} \right)^2 \]
in which

\[ t = \text{thickness of lamination in inches.} \]

\[ R = \text{radius of curvature of inside face of lamination in inches, and } t/R \text{ shall not exceed } 1/100 \text{ for hardwoods and Southern pine, or } 1/125 \text{ for other softwoods.} \]

No curvature factor shall be applied to stress in the straight portion of an assembly, regardless of curvature elsewhere.

4. Radial tension or compression. The maximum radial stress induced in a curved member of rectangular cross section by a bending moment is:

\[ f_r = \frac{3M}{2Rbd} \]

in which

\[ f_r = \text{radial stress in pounds per square inch.} \]

\[ M = \text{bending moment in inch pounds.} \]

\[ R = \text{radius of curvature at center line of member in inches.} \]

\[ b = \text{width of cross section in inches.} \]

\[ d = \text{depth of cross section in inches.} \]

When \( M \) is in the direction tending to decrease curvature (increase the radius), the radial stress is in tension. For Douglas fir and larch, the radial tension stress shall not exceed one-third the allowable stress for horizontal shear for wind or earthquake loads, nor 15 pounds per square inch for other types of load. For other species of wood, the radial tension stress shall not exceed one-third the allowable stress for horizontal shear. Where mechanical reinforcement is provided to resist all radial tension stress, the foregoing limits do not apply.

When \( M \) is in the direction tending to increase curvature (decrease the radius) the radial stress is in compression and shall be limited to the allowable stress in compression perpendicular to the grain.

5. Slenderness factor for beams. When the depth of a beam exceeds its breadth, lateral support is required and the slenderness factor shall be calculated by the following formula:

\[ C_s = \sqrt{\frac{Ld}{b^2}} \]
in which

\[ C_s = \text{slenderness factor.} \]
\[ l_e = \text{effective length of beam, inches, from the following table.} \]
\[ l_u = \text{unsupported length of beam, inches.} \]
\[ d = \text{depth of beam, inches.} \]
\[ b = \text{breadth of beam, inches.} \]

**EFFECTIVE LENGTH OF GLUED-LAMINATED BEAMS**

<table>
<thead>
<tr>
<th>TYPE OF BEAM SPAN AND NATURE OF LOAD</th>
<th>VALUE OF EFFECTIVE LENGTH, ( l/e )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single span beam, load concentrated at center</td>
<td>1.61( l_u )</td>
</tr>
<tr>
<td>Single span beam, uniformly distributed load</td>
<td>1.92( l_u )</td>
</tr>
<tr>
<td>Single span beam, equal end moments</td>
<td>1.84( l_u )</td>
</tr>
<tr>
<td>Cantilever beam, load concentrated at unsupported end</td>
<td>1.69( l_u )</td>
</tr>
<tr>
<td>Cantilever beam, uniformly distributed load</td>
<td>1.06( l_u )</td>
</tr>
<tr>
<td>Single span or cantilever beam, any load</td>
<td>1.92( l_u )</td>
</tr>
</tbody>
</table>

When the slenderness factor \( C_s \) does not exceed 10, the full allowable unit stress in bending, \( F_b \), may be used.

When the slenderness factor \( C_s \) is greater than 10, but does not exceed \( C_k \), the allowable unit stress in bending \( F'_b \) shall be determined from the following formula:

\[ F'_b = F_b \left[ 1 - \frac{1}{3} \left( \frac{C_s}{C_k} \right)^4 \right] \]

in which

\[ C_k = \sqrt{3E/5F_b} \]
\[ E = \text{modulus of elasticity.} \]

When the slenderness factor \( C_s \) is greater than \( C_k \), but less than 50, the allowable unit stress in bending \( F'_b \) shall be determined by the following formula:

\[ F'_b = \frac{0.40E}{(C_s)^2} \]

In no case shall \( C_s \) exceed 50.

When the compression edge of a beam is supported throughout its length to prevent its lateral displacement, and the ends at points of bearing have lateral support to prevent rotation, the unsupported length \( l_u \) may be taken as zero.

When lateral support is provided to prevent rotation at the points of end bearing, but no other lateral support is provided
throughout the length of the beam, the unsupported length $l_u$ is the distance between such points of end bearing, or the length of a cantilever.

When a beam is provided with lateral support to prevent rotational and lateral displacement at intermediate points as well as at the ends, the unsupported length $l_u$ is the distance between such points of intermediate lateral support.

6. **Depth factor for beams.** When the depth of a rectangular beam exceeds 12 inches, the allowable unit stress in bending $F_b$ shall be multiplied by the depth factor determined by the following formula:

$$C_d = 0.81 \frac{(d^2 + 143)}{(d^2 + 88)}$$

in which

- $C_d = \text{depth factor}$.
- $d = \text{depth of beam in inches}$.

7. **Combined slenderness and depth factors.** Adjustment of bending stress for depth factor is cumulative with adjustment for slenderness factor.

(e) **Tapered Faces.** No sawn tapered cuts shall be permitted on the tension face of any simple beam. Pitched or curved beams shall be so fabricated that the laminations are parallel to the tension face. Straight, pitched or curved beams may have sawn tapered cuts on the compression face.

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.

(f) **Manufacture and Fabrication.** The manufacture and fabrication of structural glued-laminated timber shall be in accordance with U.B.C. Standard No. 25-10. All work shall be under the supervision of qualified personnel.

Sec. 2512. 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:

<table>
<thead>
<tr>
<th>Beam Section</th>
<th>Form Factor $(C_f)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular</td>
<td>1.180</td>
</tr>
<tr>
<td>Square (with diagonal vertical)</td>
<td>1.414</td>
</tr>
<tr>
<td>Lumber I and Box Beams</td>
<td>$0.81 + C_d (C_d - .81)$</td>
</tr>
</tbody>
</table>
WHERE:

\[ C_f = \text{form factor.} \]
\[ C_d = \text{depth factor determined in accordance with Section 2511 (d) 6.} \]
\[ C_u = \text{support factor} = p^2 (6 - 8p + 3p^2) (1 - q) + q. \]

\[ p = \text{ratio of depth of compression flange to full depth of beam.} \]
\[ q = \text{ratio of thickness of web or webs to the full width of beam.} \]

Sec. 2513. Plywood components shall be designed, fabricated and identified in accordance with U.B.C. Standard No. 25-18.

Sec. 2514 (a) General. Lumber 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. See U.B.C. Standard No. 25-9 for a method of calculating the deflection of a blocked plywood diaphragm.

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-K.

In buildings of wood frame construction where rotation is provided for, the depth of the diaphragm normal to the open side shall not exceed 25 feet nor two-thirds the diaphragm width, whichever is the smaller depth. Straight sheathing shall not be permitted to resist shears in diaphragms acting in rotation.

EXCEPTIONS: 1. One-story, wood-framed structures with the depth normal to the open side not greater than 25 feet, may have a depth equal to the width.

2. Where calculations show that diaphragm deflections can be tolerated, the depth normal to the open end may be increased to a depth to width ratio not greater than 1 1/2:1 for diagonal sheathing or 2:1 for special diagonal sheathed or plywood diaphragms.

In masonry or concrete buildings lumber and plywood diaphragms shall not be considered as transmitting lateral forces by rotation.
(b) Diagonally Sheathed Diaphragms. 1. Conventional construction. Such lumber diaphragms shall be made up of 1-inch 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 1-inch by 6-inch nominal boards and three 8d nails for boards 8 inches, or wider; and in addition three 8d nails and four 8d nails shall be used for 6-inch and 8-inch 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 lumber diaphragms may be used to resist shear, 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.

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-L for horizontal diaphragms, and Table No. 25-M for vertical diaphragms, or may be calculated by principles of mechanics without limitation by using values of nail strength and plywood shear values as specified elsewhere in this Code. Plywood for horizontal diaphragms shall be as set forth in Table No. 25-Q for corresponding joist spacing and loads. Maximum spans for plywood subfloor-underlayment shall be as set forth
Wood Diaphragms
(Continued)

Fiberboard Sheathing Diaphragms

in Table No. 25-R. Plywood used for horizontal and vertical diaphragms shall conform to U.B.C. Standard No. 25-9.

All boundary members shall be proportioned and spliced where necessary to transmit direct stresses. Framing members shall be at least 2-inch nominal in the dimension to which the plywood is attached and such members shall be limited to a maximum spacing of 16 inches 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 3/8 inch in from the panel edge, nor more than 12 inches apart along intermediate supports and 6 inches along panel edge bearings, and shall be firmly driven into the framing members. No unblocked panels less than 12 inches wide shall be used.

Sec. 2515. Wood stud walls sheathed with fiberboard sheathing complying with U.B.C. Standard No. 25-24 may be used to resist horizontal forces not exceeding those set forth in Table No. 25-N. The fiberboard sheathing, 4 feet by 8 feet, shall be applied vertically to wood studs not less than 2-inch nominal in thickness spaced 16 inches on centers. Nailing shown in Table No. 25-N shall be provided at the perimeter of the sheathing board, and at intermediate studs. Blocking not less than 2-inch nominal in thickness shall be provided at horizontal joints when wall height exceeds length of sheathing panel and nail sheathing with nails shown in Table No. 25-N spaced 3 inches on centers each side of joint. Nails shall be spaced not less than 3/8 inch 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.

Sec. 2516. (a) Dead Load. Wood members shall not be used to permanently support the dead load of any masonry or concrete.

EXCEPTIONS: 1. Masonry or concrete nonstructural floor or roof surfacing not more than 4 inches thick may be supported by wood members.

2. Any structure may rest upon wood piles constructed in accordance with the requirements of Chapter 28.

3. Masonry or concrete fireplace with a factory built chimney conforming to Chapter 37 of the Code may be supported by wood framing.

(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.

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Sec. 2517. (a) General. The requirements in this Section apply to all wood frame construction.

(b) Preparation of Building Site. All stumps and roots shall be removed from the soil to a depth of at least 12 inches 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.

(c) Protection against Decay and Termites. 1. Wood support embedded in ground. Wood embedded in the ground or in direct contact with the earth and used for the support of permanent structures, shall be treated wood unless continuously below the ground waterline or continuously submerged in fresh water.

2. Underfloor clearance. Wood joists or the bottom of wood floors closer than 18 inches, or wood girders closer than 12 inches to the ground underfloor areas and their supports, shall be of treated wood or all heartwood of approved naturally durable species as listed in Section 2517 (c) 3.

Accessible underfloor areas shall be provided with an 18-inch by 24-inch access crawl hole.

3. Plates, sills and sleepers. 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 treated wood 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 permitted by this Code may be used for sills when specifically approved by the Building Official.

4. Columns and posts. All wood columns and posts shall be framed to true end bearings. Supports shall be designed to hold the column or post securely in position and to protect its base from deterioration. In areas exposed to water splash and in exterior locations, wood columns and posts shall be supported by piers projecting at least 2 inches above the finished floor and shall bear on a metal base plate or a foundation plate or sill as specified in Subsection (c) 3. Posts or columns of treated wood or of Foundation grade redwood or cedar may be placed directly on concrete, solid masonry or grouted masonry.
5. Girders entering masonry or concrete walls. Ends of wood girders entering masonry or concrete walls shall be provided with a \( \frac{1}{2} \)-inch air space on tops, sides and ends unless approved wood of natural resistance to decay or treated wood is used.

6. Foundation ventilation. Underfloor areas shall be ventilated by an approved mechanical means or by openings in the foundation walls. Such wall openings shall have a net area of not less than \( 1\frac{1}{2} \) square feet for each 25 linear feet of exterior wall. Openings shall be arranged to provide cross ventilation on at least two approximately opposing sides and shall be covered with corrosion resistant wire mesh of not less than \( \frac{1}{4} \) inch nor more than \( \frac{1}{2} \) inch in any dimension.

7. Wood and earth separation. No wood other than that permitted in paragraph 3 above shall be nearer than 6 inches to any earth unless separated by concrete at least 3 inches in thickness with an impervious membrane installed between the earth and concrete.

Where planter boxes are installed adjacent to wood frame walls a 2-inch wide air space shall be provided between the planter and the wall. Flashings shall be installed when the air space is less than 6 inches in width. Where flashing is used provisions shall be made to permit circulation of air in the air space. The wood frame wall shall be provided with an exterior wall covering conforming to the provisions of Subsection (g) of this Section.

(d) Wall Framing. The framing of exterior and interior walls shall be in accordance with provisions specified in Section 2518 unless a specific design is furnished.

(e) Floor Framing. 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 1000 square feet in a manner required for partitioning attic space in Section 3205.

(f) Firestopping. Firestopping shall be provided to cut off all concealed draft openings (both vertical and horizontal) and shall 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 10 feet.

3. Between stair stringers 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 noncombustible materials shall be placed in noncombustible 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 2-inch nominal thickness. If the width of opening is such that more than one piece of lumber is necessary, there shall be two thicknesses of 1-inch nominal material with joints broken or 3/4-inch thick plywood.

Firestops may also be of gypsum board, cement asbestos board, mineral wool or other approved noncombustible materials, securely fastened in place.

(g) 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 or elsewhere in this Code. Studs or sheathing shall be covered on the outside face with a weather resistive barrier when required by Section 1707 (a). Exterior wall coverings of the minimum thickness specified in this Section are based upon a maximum stud spacing of 16 inches.

2. Siding. Siding shall have a minimum thickness of 3/8 inch unless placed over sheathing permitted by this Code.

Siding patterns known as rustic, drop siding, or shiplap, shall have an average thickness in place of not less than 3/8 inch and shall have a minimum thickness of not less than 3/8 inch. Bevel siding shall have a minimum thickness measured at the butt section of not less than 1/16 inch and a tip thickness of not less than 1/16 inch. Siding of lesser dimensions may be used, provided such wall covering is placed over sheathing which conforms to the provisions specified elsewhere in this Code.

All weatherboarding or siding shall be securely nailed to each stud with not less than one nail, or to solid 1-inch nominal wood sheathing or 1/2-inch plywood sheathing with not less than one line of nails spaced not more than 24 inches on center in each piece of the weatherboarding or siding.

3. Plywood. Where plywood is used for covering the exterior of outside walls, it shall be of the Exterior type not less than 3/8 inch thick. Unless applied over 1-inch wood sheathing or 1/2-inch plywood sheathing, joints shall occur over framing members and shall be covered with a continuous wood batt; or joints shall be 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 sheathing other than wood sheathing shall be secured with approved corrosion-resistant fasteners or 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 5/8 inch. Wood shingles or shakes and asbestos shingles or siding may be nailed directly to approved fiberboard nailbase sheathing not less than ½-inch nominal thickness with approved corrosion-resistant annular grooved nails. Fiberboard nailbase sheathing and shingle backer shall comply with U.B.C. Standard No. 25-24.

5. Particleboard. Where particleboard is used for covering the exterior of outside walls, it shall be of the Exterior type 2-B-1 conforming to U.B.C. Standard No. 25-25, not less than 5/8 inch thick and not less than 3/8 inch thick when applied directly to framing spaced 24 inches on center. Unless applied over 1-inch wood sheathing or ½-inch plywood sheathing joints shall occur over framing members and shall be covered with a continuous wood batt; or joints shall be lapped horizontally or otherwise made waterproof to the satisfaction of the Building Official.

6. Nailing. All fasteners used for the attachment of siding shall be of a corrosion-resistant type.

(h) Structural Floor Sheathing. Structural floor sheathing shall be designed in accordance with the general provisions of this Code and the special provisions in this Subsection.

Sheathing used as subflooring shall be designed to support all loads specified in this Code and shall be capable of supporting concentrated loads of not less than 300 pounds without failure. The concentrated load shall be applied by a loaded disc, 3 inches or smaller in diameter.

Flooring, including the finish floor, underlayment and subfloor, where used, shall meet the following requirements:

Deflection under uniform design load limited to 1/360 of the span between supporting joists or beams.

Deflection of flooring relative to joists under a 1-inch diameter concentrated load of 200 pounds limited to 0.125 inch or less when loaded midway between supporting joints or beams not over 24 inches on center and 1/360 of the span for spans over 24 inches.
Floor sheathing conforming to the provisions of Table No. 25-Q or No. 25-P shall be deemed to meet the requirements of this Subsection.

(i) Structural Roof Sheathing. Structural roof sheathing shall be designed in accordance with the general provisions of this Code and the special provisions in this Subsection. Structural roof sheathing shall be designed to support all loads specified in this Code and shall be capable of supporting concentrated loads of not less than 300 pounds without failure. The concentrated load shall be applied by a loaded disc, 3 inches or smaller in diameter. Structural roof sheathing shall meet the following requirement:

Deflection under uniform design live and dead load limited to 1/180 of the span between supporting rafters or beams and 1/240 under live load only.

Roof sheathing conforming to the provisions of Table No. 25-P or No. 25-Q shall be deemed to meet the requirements of this Subsection.

Plywood roof sheathing shall be bonded by intermediate or exterior glue.

(j) Fastenings. 1. Nailing requirements. The number and size of nails connecting wood members shall be not less than that set forth in Table No. 25-O. Other connections shall be fastened so as to provide equivalent strength. End and edge distances and nail penetrations shall be in accordance with the applicable provisions of Section 2510.

2. 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.

(k) Water Splash. 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 approved waterproof paper conforming to Section 1707 (a).

(l) 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.

Nail length shall be not less than two and one-half times the net thickness of each lamination. When deck supports are 4 feet on center or less, side nails shall be spaced not more
than 30 inches on center and staggered one-third of the spacing in adjacent laminations. When supports are spaced more than 4 feet on center, side nails shall be spaced not more than 18 inches on center alternately near top and bottom edges, and also staggered one-third of the spacing in adjacent laminations. Two side nails shall be used at each end of butt jointed pieces.

Laminations shall be toe-nailed to supports with 20d or larger common nails. When the supports are 4 feet on center or less, alternate laminations shall be toe-nailed to alternate supports; when supports are spaced more than 4 feet on center alternate laminations shall be toe-nailed to every support.

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.

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.

(m) Post-beam Connections. Where post and beam or girder construction is used, the design shall be in accordance with the provisions of this Code. Positive connection shall be provided to ensure against uplift and lateral displacement.

Sec. 2518. (a) General. The requirements contained in this Section are intended for light-frame construction. Other methods may be used provided a satisfactory design is submitted showing compliance with other provisions of this Code.

(b) Foundation Plates or Sills. Foundation plates or sills shall be bolted to the foundation or foundation wall with not less than 1/2-inch diameter steel bolts embedded at least 7 inches into concrete or reinforced masonry, or 15 inches into unreinforced grouted masonry and shall be spaced not more than 6 feet apart. There shall be a minimum of two bolts per piece with one bolt located within 12 inches of each end of each piece.

(c) Girders. Girders shall be designed to support all loads and when supporting first floor joists shall be not less than 4 inches by 4 inches for spans 5 feet or less, or not less than 4 inches by 6 inches placed on edge for spans not more than 7 feet. Laminated built-up beams with laminations not less than 2 inches in thickness may be used for girders when the laminations are parallel to applied load (see Table No. 25-O for nailing requirements). The end joints shall occur over supports. Where a girder is spliced over a support, an adequate tie shall be provided.

The ends of beams or girders supported on masonry or concrete shall have not less than 4 inches of bearing.
(d) **Floor Joists.** 1. **General.** Spans for joists shall be in accordance with Table No. 25-T.

2. **Bearing.** Except where supported on a 1-inch by 4-inch ribbon strip and nailed to the adjoining stud, the ends of each joist shall have not less than 1½ inches of bearing on wood or metal, nor less than 3 inches on masonry.

3. **Framing details.** Joists shall be supported laterally at the ends and at each support by solid blocking except where the ends of joists are nailed to a header, band or rim joist or to an adjoining stud or by other approved means. Solid blocking shall be not less than 2 inches in thickness and the full depth of joist.

Notches on the ends of joists shall not exceed one-fourth the joist depth. Holes bored in joists shall not be within 2 inches of the top or bottom of the joist and the diameter of any such hole shall not exceed one-third the depth of the joist. Notches in the top or bottom of joists shall not exceed one-sixth the depth and shall not be located in the middle third of the span.

Joists framing from opposite sides of a beam, girder or partition shall be lapped at least 4 inches or the opposing joists shall be tied together in an approved manner.

Joists framing into the side of a wood girder shall be supported by framing anchors or on ledger strips not less than 2 inches by 2 inches.

Joists under bearing partitions shall be doubled.

4. **Framing around openings.** Trimmer and header joists shall be doubled, or of lumber of equivalent cross section, when the span of the header exceeds 4 feet. The ends of header joists more than 6 feet long shall be supported by framing anchors or joist hangers unless bearing on a beam, partition or wall. Tail joists over 12 feet long shall be supported at header by framing anchors or on ledger strips not less than 2 inches by 2 inches.

5. **Supporting bearing partitions.** Bearing partitions perpendicular to joists shall not be offset from supporting girders, walls or partitions more than the joist depth.

6. **Blocking.** Floor joists shall be blocked when required by the provisions of Sections 2506 (g) and 2518 (d) 3.

(e) **Subflooring.** 1. **Lumber subfloor.** Sheathing used as a structural subfloor shall conform to the limitations set forth in Table No. 25-P.

Joints in subflooring shall occur over supports unless end-matched lumber is used, in which case each piece shall bear on at least two joists.

Subflooring may be omitted when joist spacing does not exceed 16 inches and 1-inch nominal tongue-and-grooved wood strip flooring is applied perpendicular to the joists.
2. Plywood. Where used as structural subflooring, plywood shall be as set forth in Table No. 25-Q. Plywood combination subfloor-underlayment shall have maximum spans as set forth in Table No. 25-R.

3. Plank flooring. Plank flooring shall be designed in accordance with the general provisions of this Code.

In lieu of such design, 2-inch tongue-and-groove planking may be used in accordance with Table No. 25-S. Joints in such 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 24 inches in adjacent pieces. One-inch nominal strip square edged flooring, ½-inch tongue-and-groove flooring, or ¾-inch 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 ¾-inch plywood shall be applied with the face grain at right angles to the span of the planks.

(f) Wall Framing. 1. Size. Studs in exterior walls and interior bearing walls of buildings not more than two stories in height shall be not less than 2 inches by 4 inches in size. For three-story buildings such studs shall be not less than 3 inches by 4 inches or 2 inches by 6 inches to the bottom of the second floor joists, and 2 inches by 4 inches for the two upper stories. Interior nonbearing partitions may be framed with 2-inch by 3-inch studs.

2. Height. Unless supported laterally by adequate framing, the maximum allowable height for studs shall be 10 feet for 2-inch by 3-inch studs; 14 feet for 2-inch by 4-inch and 3-inch by 4-inch studs; and 20 feet for 2-inch by 6-inch studs.

When Group IV studs (as set forth in Table No. 25-F) are permitted to be used by the Building Official, the maximum allowable height shall be 8 feet for load-bearing and exterior wall studs and 10 feet for interior nonload-bearing studs. When used in bearing walls, Group IV studs shall support not more than a roof and ceiling load.

3. Spacing. Studs supporting floors shall be spaced not more than 16 inches. Two by 4 studs of Group I, II or III lumber (as set forth in Table No. 25-F) not more than 10 feet in length may be spaced not more than 24 inches on center when supporting only a ceiling and roof. The spacing of studs on nonbearing walls shall not exceed 24 inches.

When bearing studs are spaced at 24-inch intervals, care shall be exercised to insure centering of roof trusses over studs or, in lieu thereof, solid blocking equal in size to the studs shall be installed to reinforce the double plate above.
4. **Framing details.** Studs shall be placed with their wide dimension perpendicular to the wall. Not less than three studs shall be installed at every corner of an exterior wall.

Studs shall be capped with double top plates installed to provide overlapping at corners and at intersections with bearing partitions. End joints in double top plates shall be offset at least 48 inches.

5. **Bracing.** All exterior walls and main cross stud partitions shall be effectively and thoroughly braced at each end, or as near thereto as possible, and at least every 25 feet of length by one of the following methods:

A. Nominal 1-inch by 4-inch continuous diagonal braces let into studs spaced not over 16 inches on center and placed at an angle not steeper than 60° from the horizontal so as to engage at least three stud spaces.

B. Wood boards of 5%-inch net minimum thickness applied diagonally on studs spaced not over 24 inches on center.

C. Plywood sheathing with a thickness not less than 1/8 inch for 16-inch stud spacing and not less than 3/8 inch for 24-inch stud spacing.

D. Fiberboard sheathing 4-foot by 8-foot panels not less than 1/8 inch thick applied vertically on studs spaced not over 16 inches on center.

E. Gypsum sheathing panels not less than 1/2 inch thick on studs spaced not over 16 inches on center when installed in accordance with Table No. 47-I.

F. Particleboard Exterior Type 2-B-1 sheathing panels not less than 3/8 inch thick on studs spaced not more than 16 inches on center.

For methods B, C, D, E and F, the braced panel must be at least 48 inches in width, covering three stud spaces where studs are spaced 16 inches apart and covering two stud spaces where studs are spaced 24 inches apart.

Solid sheathing of one of the materials specified in subparagraphs B through F above shall be applied on the exterior walls of the first story of all wood framed buildings three stories in height.

All vertical joints of panel sheathing shall occur over studs. Horizontal joints shall occur over blocking equal in size to the studding unless panels are at least 4 feet by 8 feet in size and applied vertically.

6. **Cripple walls.** Cripple walls shall be framed of studs not less in size than the studding above with a minimum length of 14 inches, or shall be framed of solid blocking. When exceeding 4 feet in height, such walls shall be framed of studs having the size required for an additional story.

Such walls under bearing walls and partitions shall be thoroughly and effectively braced.
7. **Headers.** All openings 4 feet wide or less in bearing walls shall be provided with headers consisting of either two pieces of 2-inch framing lumber placed on edge and securely fastened together or 4-inch lumber of equivalent cross section. All openings more than 4 feet wide shall be provided with headers or lintels. Such headers or lintels shall have not less than 2-inch solid bearing at each end to the floor or bottom plate, unless other approved framing methods or joint devices are used.

8. **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 \( \frac{3}{8} \) inch thick and 1\(\frac{1}{2} \) inches wide shall be fastened to the plate across and to each side of the opening with not less than four 16d nails.

9. **Bridging.** Unless covered by interior or exterior wall coverings or sheathings meeting the minimum requirements of this Code, all stud partitions or walls with studs having a height to least thickness ratio exceeding 50 shall have bridging not less than 2 inches in thickness and of the same width as the studs fitted snugly and nailed thereto to provide adequate lateral support.

(g) **Roof and Ceiling Framing.** 1. **General.** The framing details required in this subsection apply to roofs having a minimum pitch of 3:12 or greater. When the roof pitch is less than 3:12 members supporting rafters and ceiling joists such as ridge boards, hips and valleys shall be designed as beams.

2. **Spans.** Allowable spans for ceiling joists shall be in accordance with Table No. 25-U. Allowable spans for rafters shall be in accordance with Table No. 25-V or No. 25-W where applicable.

3. **Framing.** Rafters shall be framed directly opposite each other at the ridge. There shall be a ridge board at least 1-inch nominal thickness at all ridges and not less in depth than the cut end of the rafter. At all valleys and hips there shall be a single valley or hip rafter not less than 2 inches nominal thickness and not less in depth than the cut end of the rafter.

4. **Rafter ties.** Rafters shall be nailed to adjacent ceiling joists to form a continuous tie between exterior walls when such joists are parallel to the rafters. Where not parallel, rafters shall be tied to 1-inch by 4-inch (nominal) minimum sized cross ties. Rafter ties shall be spaced not more than 4 feet on center.
5. **Purlins.** Purlins to support roof loads may be installed to reduce the span of rafters within allowable limits and shall be supported by struts to bearing walls. The maximum span of 2-inch by 4-inch purlins shall be 4 feet. The maximum span of the 2-inch by 6-inch purlin shall be 6 feet but in no case shall the purlin be smaller than the supported rafter. Struts shall be not smaller than 2-inch by 4-inch members. The unbraced length of struts shall not exceed 8 feet and the minimum slope of the struts shall be not less than 45° from the horizontal.

6. **Blocking.** Rafters more than 8 inches in depth shall be supported laterally at the ends and at each support by solid blocking not less than 2 inches in thickness and the full depth of the rafter unless nailed to a header, band or rim joist or to an adjoining stud.

7. **Roof sheathing.** Roof sheathing shall be in accordance with Table No. 25-Q for plywood or No. 25-P for lumber.

   Joints in lumber sheathing shall occur over supports unless approved end matched lumber is used in which case each piece shall bear on at least two supports.

   Plywood used for roof sheathing shall be bonded by intermediate or exterior glue.

8. **Roof planking.** Planking shall be designed in accordance with the general provisions of this Code.

   In lieu of such design, 2-inch tongue-and-groove planking may be used in accordance with Table No. 25-S. Joints in such 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 24 inches in adjacent pieces.
### Table No. 25-A-1 — Allowable Unit Stresses for Visually Stress-Rated Lumber

**Normal Loading — See also Section 2504**

**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

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<td>1,600,000</td>
</tr>
<tr>
<td>1750f. Industrial Dry</td>
<td>L.F.</td>
<td>1200</td>
<td>1800</td>
<td>90</td>
<td>330</td>
<td>1350</td>
<td>1,500,000</td>
</tr>
<tr>
<td>1750f. Industrial</td>
<td>L.F.</td>
<td>1100</td>
<td>1700</td>
<td>85</td>
<td>330</td>
<td>1300</td>
<td>1,300,000</td>
</tr>
<tr>
<td>1500f. Industrial MC15</td>
<td>L.F.</td>
<td>1100</td>
<td>1700</td>
<td>95</td>
<td>280</td>
<td>1350</td>
<td>1,500,000</td>
</tr>
<tr>
<td>1500f. Industrial Dry</td>
<td>L.F.</td>
<td>1000</td>
<td>1550</td>
<td>90</td>
<td>280</td>
<td>1150</td>
<td>1,400,000</td>
</tr>
<tr>
<td>1500f. Industrial</td>
<td>L.F.</td>
<td>950</td>
<td>1450</td>
<td>85</td>
<td>280</td>
<td>1100</td>
<td>1,300,000</td>
</tr>
<tr>
<td>1200f. Industrial MC15</td>
<td>L.F.</td>
<td>900</td>
<td>1450</td>
<td>65</td>
<td>280</td>
<td>1150</td>
<td>1,300,000</td>
</tr>
<tr>
<td>1200f. Industrial Dry</td>
<td>L.F.</td>
<td>850</td>
<td>1300</td>
<td>90</td>
<td>280</td>
<td>1000</td>
<td>1,200,000</td>
</tr>
<tr>
<td>1200f. Industrial</td>
<td>L.F.</td>
<td>800</td>
<td>1150</td>
<td>85</td>
<td>280</td>
<td>950</td>
<td>1,100,000</td>
</tr>
<tr>
<td>Dense Select Structural MC15</td>
<td>J. &amp; P.</td>
<td>1150</td>
<td>2150</td>
<td>95</td>
<td>330</td>
<td>1800</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Dense Select Structural Dry</td>
<td>J. &amp; P.</td>
<td>1050</td>
<td>2000</td>
<td>90</td>
<td>330</td>
<td>1550</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Select Structural MC15</td>
<td>J. &amp; P.</td>
<td>1050</td>
<td>2000</td>
<td>95</td>
<td>280</td>
<td>1650</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Dense Select Structural</td>
<td>J. &amp; P.</td>
<td>1000</td>
<td>1850</td>
<td>85</td>
<td>330</td>
<td>1450</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Dense Construction MC15</td>
<td>J. &amp; P.</td>
<td>950</td>
<td>1700</td>
<td>85</td>
<td>330</td>
<td>1550</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Select Structural Dry</td>
<td>J. &amp; P.</td>
<td>1000</td>
<td>1850</td>
<td>90</td>
<td>280</td>
<td>1400</td>
<td>1,400,000</td>
</tr>
<tr>
<td>Select Structural</td>
<td>J. &amp; P.</td>
<td>950</td>
<td>1700</td>
<td>85</td>
<td>280</td>
<td>1350</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Dense Construction Dry</td>
<td>J. &amp; P.</td>
<td>750</td>
<td>1700</td>
<td>90</td>
<td>330</td>
<td>1300</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Dense Construction</td>
<td>J. &amp; P.</td>
<td>700</td>
<td>1550</td>
<td>85</td>
<td>330</td>
<td>1250</td>
<td>1,300,000</td>
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</table>

(Continued)
### Table NO. 25-A-1 — Allowable Unit Stresses for Visually Stress-Rated Lumber — Continued

<table>
<thead>
<tr>
<th>Species and Commercial Grade</th>
<th>Tension Parallel to Grain (TI)</th>
<th>Maximum Horizontal Shear (FM)</th>
<th>Compression Perpendicular to Grain (Fp)</th>
<th>Compression Parallel to Grain (Fp)</th>
<th>Modulus of Elasticity (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction MC15</td>
<td>650</td>
<td>1550</td>
<td>95</td>
<td>280</td>
<td>1300</td>
</tr>
<tr>
<td>Construction Dry</td>
<td>600</td>
<td>1450</td>
<td>90</td>
<td>280</td>
<td>1150</td>
</tr>
<tr>
<td>Construction</td>
<td>600</td>
<td>1350</td>
<td>85</td>
<td>280</td>
<td>1050</td>
</tr>
<tr>
<td>Standard MC15</td>
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<td>1300</td>
<td>95</td>
<td>280</td>
<td>1200</td>
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<tr>
<td>Standard Dry</td>
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<td>1200</td>
<td>90</td>
<td>280</td>
<td>1000</td>
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<tr>
<td>Standard</td>
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<td>85</td>
<td>280</td>
<td>950</td>
</tr>
<tr>
<td>Dense Select Structural</td>
<td>B &amp; S.</td>
<td>900</td>
<td>1800</td>
<td>85</td>
<td>330</td>
</tr>
<tr>
<td>Select Structural</td>
<td>B &amp; S.</td>
<td>850</td>
<td>1650</td>
<td>85</td>
<td>280</td>
</tr>
<tr>
<td>Dense Construction</td>
<td>B &amp; S.</td>
<td>600</td>
<td>1500</td>
<td>85</td>
<td>330</td>
</tr>
<tr>
<td>Construction</td>
<td>B &amp; S.</td>
<td>550</td>
<td>1250</td>
<td>85</td>
<td>280</td>
</tr>
<tr>
<td>Dense Select Structural</td>
<td>P &amp; T.</td>
<td>1100</td>
<td>1650</td>
<td>85</td>
<td>330</td>
</tr>
<tr>
<td>Select Structural</td>
<td>P &amp; T.</td>
<td>1000</td>
<td>1550</td>
<td>85</td>
<td>280</td>
</tr>
<tr>
<td>Dense Construction</td>
<td>P &amp; T.</td>
<td>850</td>
<td>1250</td>
<td>85</td>
<td>330</td>
</tr>
<tr>
<td>Construction</td>
<td>P &amp; T.</td>
<td>750</td>
<td>1100</td>
<td>85</td>
<td>280</td>
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</table>

#### Hemlock, Western and West Coast

<table>
<thead>
<tr>
<th>Species and Commercial Grade</th>
<th>Tension Parallel to Grain (TI)</th>
<th>Maximum Horizontal Shear (FM)</th>
<th>Compression Perpendicular to Grain (Fp)</th>
<th>Compression Parallel to Grain (Fp)</th>
<th>Modulus of Elasticity (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Structural MC15</td>
<td>L.F.</td>
<td>650</td>
<td>1800</td>
<td>80</td>
<td>365</td>
</tr>
<tr>
<td>Select Structural Dry</td>
<td>L.F.</td>
<td>550</td>
<td>1500</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>Select Structural</td>
<td>L.F.</td>
<td>550</td>
<td>1500</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>1500f. Industrial MC15</td>
<td>L.F.</td>
<td>950</td>
<td>1650</td>
<td>80</td>
<td>365</td>
</tr>
<tr>
<td>1500f. Industrial Dry</td>
<td>L.F.</td>
<td>900</td>
<td>1550</td>
<td>75</td>
<td>365</td>
</tr>
<tr>
<td>1500f. Industrial</td>
<td>L.F.</td>
<td>850</td>
<td>1400</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>1200f. Industrial MC15</td>
<td>L.F.</td>
<td>800</td>
<td>1400</td>
<td>80</td>
<td>365</td>
</tr>
<tr>
<td>1200f. Industrial Dry</td>
<td>L.F.</td>
<td>750</td>
<td>1300</td>
<td>75</td>
<td>365</td>
</tr>
<tr>
<td>1200f. Industrial</td>
<td>L.F.</td>
<td>700</td>
<td>1200</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>Select Structural MC15</td>
<td>J &amp; P.</td>
<td>800</td>
<td>1550</td>
<td>80</td>
<td>365</td>
</tr>
<tr>
<td>Select Structural Dry</td>
<td>J &amp; P.</td>
<td>750</td>
<td>1400</td>
<td>75</td>
<td>365</td>
</tr>
<tr>
<td>Select Structural</td>
<td>J &amp; P.</td>
<td>700</td>
<td>1300</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>Construction MC15</td>
<td>J &amp; P.</td>
<td>750</td>
<td>1450</td>
<td>80</td>
<td>365</td>
</tr>
<tr>
<td>Construction Dry</td>
<td>J &amp; P.</td>
<td>700</td>
<td>1350</td>
<td>75</td>
<td>365</td>
</tr>
<tr>
<td>Construction</td>
<td>J. &amp; P.</td>
<td>700</td>
<td>1250</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------</td>
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<td>------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Standard MC15</td>
<td>J. &amp; P.</td>
<td>550</td>
<td>1200</td>
<td>80</td>
<td>365</td>
</tr>
<tr>
<td>Standard Dry</td>
<td>J. &amp; P.</td>
<td>500</td>
<td>1100</td>
<td>75</td>
<td>365</td>
</tr>
<tr>
<td>Standard</td>
<td>J. &amp; P. 5</td>
<td>500</td>
<td>1050</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>Construction</td>
<td>B. &amp; S.</td>
<td>600</td>
<td>1200</td>
<td>70</td>
<td>365</td>
</tr>
<tr>
<td>Construction</td>
<td>P. &amp; T.</td>
<td>700</td>
<td>1100</td>
<td>70</td>
<td>365</td>
</tr>
</tbody>
</table>

**DOUGLAS FIR AND LARCH**

<table>
<thead>
<tr>
<th>DOUGLAS FIR AND LARCH</th>
<th>Select Dex &amp; Selected Decking</th>
<th>-</th>
<th>1500</th>
<th>-</th>
<th>390</th>
<th>-</th>
<th>1,600,000^4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial Dex &amp; Commercial Decking</td>
<td>-</td>
<td>1200</td>
<td>-</td>
<td>390</td>
<td>-</td>
<td>1,500,000^4</td>
</tr>
</tbody>
</table>

**DOUGLAS FIR (SOUTH)^3**

<table>
<thead>
<tr>
<th>DOUGLAS FIR (SOUTH)^3</th>
<th>Select Dex &amp; Selected Decking</th>
<th>-</th>
<th>1450</th>
<th>-</th>
<th>330</th>
<th>-</th>
<th>1,300,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial Dex &amp; Commercial Decking</td>
<td>-</td>
<td>1150</td>
<td>-</td>
<td>330</td>
<td>-</td>
<td>1,100,000</td>
</tr>
</tbody>
</table>

**HEMLOCK, WESTERN AND WEST COAST**

<table>
<thead>
<tr>
<th>HEMLOCK, WESTERN AND WEST COAST</th>
<th>Select Dex &amp; Selected Decking</th>
<th>-</th>
<th>1100</th>
<th>-</th>
<th>365</th>
<th>-</th>
<th>1,400,000^4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial Dex &amp; Commercial Decking</td>
<td>-</td>
<td>850</td>
<td>-</td>
<td>365</td>
<td>-</td>
<td>1,200,000^4</td>
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**SPRUCE, SITKA**

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<th>Select Dex Decking</th>
<th>-</th>
<th>1100</th>
<th>-</th>
<th>305</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial Dex Decking</td>
<td>-</td>
<td>850</td>
<td>-</td>
<td>305</td>
<td>-</td>
<td>1,200,000^4</td>
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**WHITE FIR**

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<th>1100</th>
<th>-</th>
<th>365</th>
<th>-</th>
<th>1,400,000^4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial Dex &amp; Commercial Decking</td>
<td>-</td>
<td>850</td>
<td>-</td>
<td>365</td>
<td>-</td>
<td>1,200,000^4</td>
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</tbody>
</table>

**PINE, NORWAY**

<table>
<thead>
<tr>
<th>PINE, NORWAY</th>
<th>Prime Structural Decking</th>
<th>-</th>
<th>1200</th>
<th>75</th>
<th>360</th>
<th>900</th>
<th>1,200,000</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Common Structural Decking</td>
<td>-</td>
<td>1100</td>
<td>75</td>
<td>360</td>
<td>775</td>
<td>1,200,000</td>
</tr>
<tr>
<td></td>
<td>Utility Structural Decking</td>
<td>-</td>
<td>950</td>
<td>75</td>
<td>360</td>
<td>650</td>
<td>1,200,000</td>
</tr>
</tbody>
</table>

**PINE, (IDAHO WHITE, LODGEPOLE, PONDEROSA AND SUGAR)**

<table>
<thead>
<tr>
<th>PINE, (IDAHO WHITE, LODGEPOLE, PONDEROSA AND SUGAR)</th>
<th>Selected Decking</th>
<th>-</th>
<th>900</th>
<th>-</th>
<th>305</th>
<th>-</th>
<th>1,100,000^4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commercial Decking</td>
<td>-</td>
<td>700</td>
<td>-</td>
<td>305</td>
<td>-</td>
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</tr>
</tbody>
</table>

(Continued)

---

^4: Select Dex & Selected Decking

^3: DOUGLAS FIR (SOUTH)

25-3: DOUGLAS FIR AND LARCH

25-4: DOUGLAS FIR (SOUTH)
### TABLE NO. 25-A-1 — ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-RATED LUMBER — Continued

Normal Loading — See also Section 2504

<table>
<thead>
<tr>
<th>SPECIES AND COMMERCIAL GRADE</th>
<th>SYMBOL:</th>
<th>Tension Parallel to Grain</th>
<th>Extreme Fiber in Bending</th>
<th>Maximum Horizontal Shear</th>
<th>Compression Perpendicular to Grain</th>
<th>Compression Parallel to Grain</th>
<th>Modulus of Elasticity</th>
<th>U.B.C. STDS. UNDER WHICH GRADED</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEDAR, INCENSE AND WESTERN RED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select Deck &amp; Selected Commercial Deck &amp; Commercial</td>
<td>Decking</td>
<td>-</td>
<td>900</td>
<td>-</td>
<td>240</td>
<td>-</td>
<td>-</td>
<td>1,000,000† &amp; 900,000†</td>
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<tr>
<td>SPRUCE, ENGMELMANN</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,000,000†</td>
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<tr>
<td>Selected Commercial Decking</td>
<td>Decking</td>
<td>-</td>
<td>750</td>
<td>-</td>
<td>215</td>
<td>-</td>
<td>-</td>
<td>25-4</td>
</tr>
<tr>
<td>HEMLOCK, EASTERN</td>
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</tr>
<tr>
<td>SOUTHERN PINE†</td>
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</tr>
<tr>
<td>(Moisture content not over 15 per cent)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No. 1 KD No. 1 Dense KD No. 2 KD No. 2 Dense KD Special KD No. 3 KD No. 3 MG KD No. 3 Dense KD KD Stud</td>
<td>1150 1350 1000 1150 800 475 550 650 475</td>
<td>1700 2000 1500 1750 1200 1200 825 975 700</td>
<td>105 105 90 90 75 80 90 90 80</td>
<td>405 475 405 475 305 335 405 475 335</td>
<td>1350 1600 1150 1400 950 550 650 775 550</td>
<td>1,900,000,000 2,000,000,000 1,700,000,000 1,800,000,000 1,300,000,000 1,300,000,000 1,500,000,000 1,600,000,000 1,300,000,000</td>
<td>25-6</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Density</th>
<th>Thickness</th>
<th>2½&quot; to 4&quot;</th>
<th>4&quot; Thick</th>
<th>3½&quot; to 5&quot;</th>
<th>6&quot; to 8&quot;</th>
<th>9&quot; to 12&quot;</th>
<th>13&quot; to 16&quot;</th>
<th>17&quot; to 20&quot;</th>
<th>21&quot; to 24&quot;</th>
<th>25&quot; to 28&quot;</th>
<th>29&quot; to 32&quot;</th>
<th>33&quot; to 36&quot;</th>
<th>37&quot; to 40&quot;</th>
<th>41&quot; to 44&quot;</th>
<th>45&quot; to 48&quot;</th>
<th>49&quot; to 52&quot;</th>
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</thead>
<tbody>
<tr>
<td>No. 1 SR KD</td>
<td>1150</td>
<td>1700</td>
<td>125</td>
<td>405</td>
<td>1600</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1 Dense SR KD</td>
<td>1350</td>
<td>2000</td>
<td>125</td>
<td>475</td>
<td>1850</td>
<td>2,000,000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No. 2 SR KD</td>
<td>1000</td>
<td>1500</td>
<td>105</td>
<td>405</td>
<td>1150</td>
<td>1,700,000</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No. 2 Dense SR KD</td>
<td>1150</td>
<td>1750</td>
<td>105</td>
<td>475</td>
<td>1400</td>
<td>1,800,000</td>
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<td>475</td>
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<tr>
<td>No. 2 KD (DT&amp;G)</td>
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<td>1500</td>
<td>90</td>
<td>405</td>
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</tr>
<tr>
<td>SOUTHERN PINE (Moisture content not over 19 per cent)</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>100</td>
<td>405</td>
<td>1150</td>
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<tr>
<td>No. 2 Dry</td>
<td>925</td>
<td>1350</td>
<td>90</td>
<td>405</td>
<td>1000</td>
<td>1,800,000</td>
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</tr>
<tr>
<td>No. 2 Dense Dry</td>
<td>1050</td>
<td>1600</td>
<td>90</td>
<td>475</td>
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<td>1,700,000</td>
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<td></td>
</tr>
<tr>
<td>Special Dry</td>
<td>725</td>
<td>1100</td>
<td>70</td>
<td>305</td>
<td>800</td>
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</tr>
<tr>
<td>No. 3 Dry</td>
<td>425</td>
<td>650</td>
<td>75</td>
<td>335</td>
<td>475</td>
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<td></td>
<td></td>
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</tr>
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<td>No. 3 MG Dry</td>
<td>500</td>
<td>775</td>
<td>60</td>
<td>405</td>
<td>575</td>
<td>1,400,000</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No. 3 Dense Dry</td>
<td>600</td>
<td>900</td>
<td>90</td>
<td>475</td>
<td>650</td>
<td>1,500,000</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Stud Dry</td>
<td>425</td>
<td>650</td>
<td>75</td>
<td>335</td>
<td>475</td>
<td>1,300,000</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

(Continued)
### TABLE NO. 25-A-1 — ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-RATED LUMBER — Continued

**Normal Loading — See also Section 2504**

**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

<table>
<thead>
<tr>
<th>SPECIES AND COMMERCIAL GRADE</th>
<th>ALLOWABLE UNIT STRESSES, POUNDS PER SQUARE INCH</th>
<th>U.B.C. STRENGTH UNDER WHICH GRADED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Symbol</td>
<td>Tension Parallel to Grain</td>
</tr>
<tr>
<td>No. 1 SR Dry</td>
<td></td>
<td>(F_{P} )</td>
</tr>
<tr>
<td>No. 1 Dense SR Dry</td>
<td>2(\frac{3}{4})&quot; to 4&quot;</td>
<td>1050</td>
</tr>
<tr>
<td>No. 2 SR Dry</td>
<td>4&quot; Thick</td>
<td>1250</td>
</tr>
<tr>
<td>No. 2 Dense SR Dry</td>
<td></td>
<td>925</td>
</tr>
<tr>
<td>Dense Structural 86 Dry</td>
<td>2&quot; to 4&quot;</td>
<td>1850</td>
</tr>
<tr>
<td>Dense Structural 72 Dry</td>
<td>Thick</td>
<td>1550</td>
</tr>
<tr>
<td>Dense Structural 65 Dry</td>
<td></td>
<td>1400</td>
</tr>
<tr>
<td>Dense Std. Factory Dry</td>
<td>2&quot; to 4&quot;</td>
<td>1250</td>
</tr>
<tr>
<td>No. 1 Dense Factory Dry</td>
<td></td>
<td>1050</td>
</tr>
<tr>
<td>No. 1 Factory Dry</td>
<td>925</td>
<td>1350</td>
</tr>
<tr>
<td>No. 2 Dense Factory Dry</td>
<td></td>
<td>1050</td>
</tr>
<tr>
<td>No. 2 Factory Dry</td>
<td>925</td>
<td>1350</td>
</tr>
<tr>
<td>SOUTHERN PINE (Over 19 per cent moisture content)</td>
<td></td>
<td>850</td>
</tr>
<tr>
<td>No. 1 SR</td>
<td></td>
<td>1000</td>
</tr>
<tr>
<td>No. 1 Dense SR</td>
<td>2(\frac{3}{4})&quot; and</td>
<td>725</td>
</tr>
<tr>
<td>No. 2 SR</td>
<td>Thicker</td>
<td>850</td>
</tr>
<tr>
<td>No. 2 Dense SR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2½&quot; and Thicker</td>
<td>2½&quot; to 5&quot; Thick</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Dense Structural 86</strong></td>
<td>1450</td>
<td>1250</td>
</tr>
<tr>
<td><strong>Dense Structural 72</strong></td>
<td>1900</td>
<td>1650</td>
</tr>
<tr>
<td><strong>Dense Structural 65</strong></td>
<td>1450</td>
<td>1250</td>
</tr>
<tr>
<td><strong>Dense Std. Factory</strong></td>
<td>1000</td>
<td>850</td>
</tr>
<tr>
<td>No. 1 Dense Factory</td>
<td>1500</td>
<td>1300</td>
</tr>
<tr>
<td>No. 1 Factory</td>
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<td>1100</td>
<td>95</td>
</tr>
<tr>
<td>No. 2 Factory</td>
<td>1100</td>
<td>95</td>
</tr>
<tr>
<td><strong>CALIFORNIA REDWOOD®</strong></td>
<td>1300</td>
<td>1200</td>
</tr>
<tr>
<td>Clear Heart — Clear Structural</td>
<td>1950</td>
<td>1750</td>
</tr>
<tr>
<td>Select Heart — Select Structural</td>
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<td>Construction Heart —</td>
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</tr>
<tr>
<td>Construction Structural</td>
<td>1600</td>
<td>1250</td>
</tr>
<tr>
<td><strong>SPRUCE, EASTERN</strong></td>
<td>1450f.-Structural Grade</td>
<td>J. &amp; P.®</td>
</tr>
<tr>
<td>1300f.-Structural Grade</td>
<td>1300f.-Structural Grade</td>
<td>J. &amp; P.®</td>
</tr>
<tr>
<td>1200f.-Structural Grade</td>
<td>1200f.-Structural Grade</td>
<td>J. &amp; P.®</td>
</tr>
</tbody>
</table>

See Footnotes on page 212.
TABLE NO. 25-A-1 — ALLOWABLE UNIT STRESSES FOR VISUALLY STRESS-RATED LUMBER — Continued

1If lumber is in service under wet conditions of use, or where the moisture content is at or above the fiber saturation point, as when continuously submerged, (a) the allowable unit stresses for \( F_t \), \( F_c \), \( F_r \) and modulus of elasticity shall be limited in all thicknesses to the stresses listed for the corresponding unseasoned grade; (b) the allowable unit stress for \( F_c \) shall be limited in all thicknesses to the stresses listed for the corresponding unseasoned grade; and (c) the allowable unit stresses for \( F_{c\perp} \) shall be reduced one third.

2Where members are specially graded so that the slope of grain limitations applicable to the middle portion applies throughout the full length of the piece and are so identified by appropriate marking, the allowable stress in tension parallel to the grain may be increased in accordance with the procedures set forth in U.B.C. Standard No. 25-1.

3Douglas fir (South) indicates Douglas fir produced in the States of Utah, Colorado, New Mexico, Arizona and Nevada and allowable unit stresses are shown thereunder. Douglas fir (South) shall be identified to indicate its origin by the use of the symbol \( S \) as part of the species identification on the grade stamp. Allowable unit stresses for Douglas fir produced in other states are shown under Douglas fir and larch.

4The value of \( E \) may be increased 17 per cent where the lumber is manufactured at a maximum moisture content of 15 per cent.

5These grades applicable to 2-inch thickness only.

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 6 inches 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 6 inches of length of any face.

All stress-rated grades for Southern pine lumber are established on a basis that permits cutting graded members to shorter lengths without impairment of stress ratings in the shorter pieces. In addition, the stresses apply to members used either flat or on edge. Grade restrictions apply the entire length of each piece, and each piece is suitable for use in continuous spans, over double spans, or under concentrated loads, without the necessity of regrading for shear or other stress requirements.

For lumber seasoned below the fiber saturation point (approximately 30 per cent moisture content) before full design load is applied, and which will remain dry in service, the tabulated modulus of elasticity may be increased 2 per cent, and the tabulated \( F_r \) values may be increased 10 per cent.

For lumber 4 inches and thinner, where the moisture content in service will not exceed 19 per cent, the tabulated values may be increased as follows:
- Fiber stress in bending, \( F_s \) and tension parallel to grain, \( F_t \) 24 per cent
- Horizontal shear, \( F_r \) None*
- Compression perpendicular to grain, \( F_c \) 50 per cent
- Compression parallel to grain, \( F_{c\perp} \) 45 per cent
- Modulus of elasticity 11 per cent

*For lumber manufactured at or below 19 per cent moisture content, the tabulated \( F_r \) values may be increased 8 per cent.
**TABLE NO. 25-A-2 — ALLOWABLE UNIT STRESSES FOR MACHINE STRESS-RATED LUMBER NORMAL LOADING**¹ (in p.s.i.)

<table>
<thead>
<tr>
<th>EXTREME FIBER IN BENDING ($F_0$)</th>
<th>MODULUS OF ELASTICITY ($E$)</th>
<th>TENSION ($F_1$)</th>
<th>COMPRESSION PARALLEL TO GRAIN ($F_c$)</th>
<th>COMPRESSION PERPENDICULAR TO GRAIN ($F_p$)</th>
<th>HORIZONTAL SHEAR ($F_s$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>1,000,000</td>
<td>350</td>
<td>725</td>
<td>390</td>
<td>70</td>
</tr>
<tr>
<td>1200</td>
<td>1,200,000</td>
<td>600</td>
<td>950</td>
<td>390</td>
<td>75</td>
</tr>
<tr>
<td>1500</td>
<td>1,400,000</td>
<td>900</td>
<td>1200</td>
<td>365</td>
<td>60</td>
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<td>1800</td>
<td>1,600,000</td>
<td>1175</td>
<td>1450</td>
<td>390</td>
<td>70</td>
</tr>
<tr>
<td>2100</td>
<td>1,800,000</td>
<td>1575</td>
<td>1700</td>
<td>415</td>
<td>75</td>
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<tr>
<td>2400</td>
<td>2,000,000</td>
<td>1925</td>
<td>1925</td>
<td>455</td>
<td>60</td>
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</table>

¹For visual grading rules which also apply, see U.B.C. Standard No. 25-1, Section 25.113.

The above stresses are for lumber used on edge. When loaded flatwise $F_s$ may be increased 18 per cent.

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 33% per cent for compression perpendicular to the grain and 10 per cent for compression parallel to the grain.
<table>
<thead>
<tr>
<th>TYPE OF STRESS</th>
<th>SPECIES GROUP</th>
<th>EXTERIOR A-A, A-C, C-C</th>
<th>STRUCTURAL I A-C, C-C (Use Group 1 Stresses)</th>
<th>EXTERIOR A-B, B-B, B-C, C-C (Plugged)</th>
<th>STRUCTURAL II A-C, C-C (Use Group 2 Stresses)</th>
<th>STANDARD SHEATHING (Exterior Grade)</th>
<th>ALL OTHER GRADES OF INTERIOR INCLUDING STANDARD SHEATHING</th>
</tr>
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<tbody>
<tr>
<td>Extreme fiber in bending</td>
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<tr>
<td>Tension</td>
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<td>2000</td>
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<td>1650</td>
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<tr>
<td>Face grain parallel or perpendicular to span</td>
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<td>1400</td>
<td></td>
<td>1200</td>
<td></td>
<td></td>
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<tr>
<td>(at 45° to face grain use 1/6)</td>
<td>4</td>
<td>1200</td>
<td></td>
<td>1000</td>
<td></td>
<td></td>
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<td>Compression</td>
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<tr>
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<td>1550</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at 45° to face grain use 1/6)</td>
<td>2, 3</td>
<td>1200</td>
<td></td>
<td>1100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1000</td>
<td></td>
<td>950</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing (on face)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>340</td>
<td></td>
<td>340</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2, 3</td>
<td>220</td>
<td></td>
<td>220</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>160</td>
<td></td>
<td>160</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear in plane perpendicular to plies^3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel or perpendicular to face grain</td>
<td>1</td>
<td>250</td>
<td></td>
<td>250</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at 45° increase 100 per cent)</td>
<td>2, 3</td>
<td>185</td>
<td></td>
<td>185</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>175</td>
<td></td>
<td>175</td>
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<td></td>
</tr>
</tbody>
</table>

TABLE NO. 25-B — 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)
Shear, rolling in plane of plies, parallel or perpendicular to face grain (at 45° increase 1/4)

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>53</th>
<th>53</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus of Elasticity in bending, Face grain parallel or perpendicular to span</td>
<td>1</td>
<td>1,800,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,500,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>900,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1See U.B.C. Standard No. 25-9 for plywood species groups.
2Exterior 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:
   All other combinations—use Group 4 working stresses.
3Shear 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.
4For 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>
<thead>
<tr>
<th>COMBINATION SYMBOL</th>
<th>NUMBER OF LAMINATIONS</th>
<th>FIBER BENDING $(F_1)$</th>
<th>LOAD PARALLEL TO WIDE FACE OF LAMINATIONS</th>
<th>LOAD PERPENDICULAR TO WIDE FACE OF LAMINATIONS</th>
<th>TENSION PARALLEL TO GRAIN $(F_t)$</th>
<th>COMPRESSION PARALLEL TO GRAIN $(F_c)$</th>
<th>COMPRESSION PERPENDICULAR TO GRAIN $(F_{cp})$</th>
<th>HORIZONTAL SHEAR $(F_s)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ALLOWABLE UNIT STRESSES IN POUNDS PER SQUARE INCH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 — DRY CONDITIONS OF USE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Douglas Fir &amp; Larch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A₁</td>
<td>4 or more</td>
<td></td>
<td>2400</td>
<td>1600</td>
<td>1500</td>
<td>165</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>B₁</td>
<td>4 or more</td>
<td></td>
<td>2200</td>
<td>1600</td>
<td>1500</td>
<td>165</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>C₁</td>
<td>4 or more</td>
<td></td>
<td>2000</td>
<td>1600</td>
<td>1500</td>
<td>165</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>E⁽²⁾</td>
<td>4 or more</td>
<td></td>
<td>2400</td>
<td>2400</td>
<td>1900</td>
<td>2200</td>
<td>145⁽⁸⁾</td>
<td>450</td>
</tr>
<tr>
<td>F⁽²⁾</td>
<td>4 or more</td>
<td></td>
<td>2000</td>
<td>2000</td>
<td>1600</td>
<td>2100</td>
<td>145⁽⁸⁾</td>
<td>450</td>
</tr>
<tr>
<td>G⁽²⁾</td>
<td>4 or more</td>
<td></td>
<td>1600</td>
<td>1600</td>
<td>1200</td>
<td>1800</td>
<td>145⁽⁸⁾</td>
<td>385</td>
</tr>
<tr>
<td>H⁽²⁾</td>
<td>4 or more</td>
<td></td>
<td>1100</td>
<td>1100</td>
<td>900</td>
<td>1500</td>
<td>145⁽⁸⁾</td>
<td>385</td>
</tr>
<tr>
<td><strong>Southern Pine</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-1</td>
<td>9 or more</td>
<td></td>
<td>2400</td>
<td>1900</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>A-2</td>
<td>14 to 21</td>
<td></td>
<td>2400</td>
<td>1900</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>A-3</td>
<td>22 or more</td>
<td></td>
<td>2400</td>
<td>1900</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>A-4</td>
<td>13 or more</td>
<td></td>
<td>2400</td>
<td>1900</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>B-1</td>
<td>4 or more</td>
<td></td>
<td>2200</td>
<td>1700</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>B-2</td>
<td>12 or more</td>
<td></td>
<td>2200</td>
<td>1700</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>B-3</td>
<td>25 or more</td>
<td></td>
<td>2200</td>
<td>1700</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>B-4</td>
<td>9 or more</td>
<td></td>
<td>2200</td>
<td>1700</td>
<td>2000</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>C-1</td>
<td>6 or more</td>
<td></td>
<td>2000</td>
<td>1600</td>
<td>1900</td>
<td>200</td>
<td>450</td>
<td>385</td>
</tr>
<tr>
<td>C-2</td>
<td>14 or more</td>
<td></td>
<td>2000</td>
<td>1600</td>
<td>1900</td>
<td>200</td>
<td>450</td>
<td>385</td>
</tr>
<tr>
<td>C-3</td>
<td>18 or more</td>
<td></td>
<td>2000</td>
<td>1600</td>
<td>1900</td>
<td>200</td>
<td>450</td>
<td>385</td>
</tr>
<tr>
<td>D-1</td>
<td>10 or more</td>
<td></td>
<td>1800</td>
<td>1400</td>
<td>1900</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>D-2</td>
<td>10 or more</td>
<td></td>
<td>1800</td>
<td>1400</td>
<td>1900</td>
<td>200</td>
<td>385</td>
<td>385</td>
</tr>
</tbody>
</table>
### 1 – DRY CONDITIONS OF USE (Continued)

<table>
<thead>
<tr>
<th>California Redwood&lt;sup&gt;3&lt;/sup&gt; – Modulus of Elasticity: 1,300,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>B</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>C</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>D</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>E</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>F</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

### 2 – WET CONDITIONS OF USE

<table>
<thead>
<tr>
<th>Douglas Fir &amp; Larch&lt;sup&gt;3&lt;/sup&gt; – Modulus of Elasticity: 1,600,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>B</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>C</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>E</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>F</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>G</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>H</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Southern Pine&lt;sup&gt;4&lt;/sup&gt; – Modulus of Elasticity: 1,600,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>A</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>A</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>A</strong>&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>B</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>B</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>B</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>B</strong>&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>C</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>C</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>C</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE NO 25-C — ALLOWABLE UNIT STRESSES FOR STRUCTURAL GLUED-LAMINATED SOFTWOOD TIMBER FOR NORMAL LOADING DURATION

(Continued)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COMBINATION SYMBOL</strong></td>
<td><strong>NUMBER OF LAMINATIONS</strong></td>
<td><strong>LOAD PARALLEL TO WIDE FACE OF LAMINATIONS</strong></td>
<td><strong>LOAD PERPENDICULAR TO WIDE FACE OF LAMINATIONS</strong></td>
<td><strong>TENSION PARALLEL TO GRAIN ((F_t))</strong></td>
<td><strong>COMPRESSION PARALLEL TO GRAIN ((F_c))</strong></td>
<td><strong>HORIZONTAL SHEAR ((F_s))</strong></td>
<td><strong>COMPRESSION PERPENDICULAR TO GRAIN ((F_s'))</strong></td>
</tr>
<tr>
<td>D-1</td>
<td>10 or more</td>
<td>1400</td>
<td>1100</td>
<td>1400</td>
<td>175</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>D-2</td>
<td>10 or more</td>
<td>1400</td>
<td>1100</td>
<td>1400</td>
<td>175</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>E-1</td>
<td>4 or more</td>
<td>1300</td>
<td>1000</td>
<td>1400</td>
<td>175</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>E-2</td>
<td>12 or more</td>
<td>1300</td>
<td>1000</td>
<td>1400</td>
<td>175</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>California Redwood (^3) — Modulus of Elasticity: 1,200,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A(^1)</td>
<td>4 or more</td>
<td>1600</td>
<td>1200</td>
<td>1600</td>
<td>110</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>B(^1)</td>
<td>4 or more</td>
<td>1600</td>
<td>1200</td>
<td>1500</td>
<td>110</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>C(^1)</td>
<td>4 or more</td>
<td>1600</td>
<td>1200</td>
<td>1500</td>
<td>110</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>D(^2)</td>
<td>4 or more</td>
<td>1600 (^5)</td>
<td>1200</td>
<td>1600</td>
<td>110</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>E(^2)</td>
<td>4 or more</td>
<td>1000 (^5)</td>
<td>1100</td>
<td>1500</td>
<td>110</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>F(^2)</td>
<td>4 or more</td>
<td>700 (^5)</td>
<td>800</td>
<td>1300</td>
<td>110</td>
<td>215</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)For members stressed principally in bending.
\(^2\)For members stressed principally in axial tension or axial compression.
\(^3\)For more details see U.B.C. Standards No. 25-10 and No. 25-11. This does not include Douglas fir (South) as defined in footnote 3 of Table No. 25-A-1.
\(^5\)For more details see U.B.C. Standards No. 25-10 and No. 25-11. In addition to the combination symbol, it is necessary to specify the required unit stresses in bending, tension and compression parallel to grain since the allowable slope of grain in individual laminations varies with the type of unit stress.

2. -- WET CONDITIONS OF USE (Continued)

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For members stressed principally in bending.
For members stressed principally in axial tension or axial compression.
For more details see U.B.C. Standards No. 25-10 and No. 25-11. This does not include Douglas fir (South) as defined in footnote 3 of Table No. 25-A-1.
For more details see U.B.C. Standards No. 25-10 and No. 25-11. In addition to the combination symbol, it is necessary to specify the required unit stresses in bending, tension and compression parallel to grain since the allowable slope of grain in individual laminations varies with the type of unit stress.
When loaded perpendicular to wide face of laminations, these values may be increased to 165 p.s.i.
When loaded perpendicular to wide face of laminations, these values may be increased to 165 p.s.i.
### TABLE NO. 25-D — PART A — ALLOWABLE UNIT STRESSES FOR GLUED HARDWOOD LAMINATED LUMBER

**FOR NORMAL LOADING DURATION — DRY CONDITIONS OF USE**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>Extreme Fiber in Bending f or Tension Parallel to Grain</th>
<th>Compression Parallel to Grain</th>
<th>Horizontal Shear</th>
<th>Compression Perpendicular to Grain</th>
<th>Modulus of Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hickory, true and pecan</td>
<td>3.90</td>
<td>3.05</td>
<td>260</td>
<td>730</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Beech, American</td>
<td>3.05</td>
<td>2.45</td>
<td>230</td>
<td>610</td>
<td>1,800,000</td>
</tr>
<tr>
<td>Birch, sweet and yellow</td>
<td>3.05</td>
<td>2.45</td>
<td>230</td>
<td>610</td>
<td>1,800,000</td>
</tr>
<tr>
<td>Elm, rock</td>
<td>3.05</td>
<td>2.45</td>
<td>230</td>
<td>610</td>
<td>1,400,000</td>
</tr>
<tr>
<td>Maple, black and sugar (hard maple)</td>
<td>3.05</td>
<td>2.45</td>
<td>230</td>
<td>610</td>
<td>1,800,000</td>
</tr>
<tr>
<td>Ash, commercial white</td>
<td>2.85</td>
<td>2.20</td>
<td>230</td>
<td>610</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Oak, commercial red and white</td>
<td>2.85</td>
<td>2.05</td>
<td>230</td>
<td>610</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Elm, American and slippery (white or soft elm)</td>
<td>2.20</td>
<td>1.60</td>
<td>190</td>
<td>310</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Sweet gum (red or sap gum)</td>
<td>2.20</td>
<td>1.60</td>
<td>190</td>
<td>370</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Tupelo, black (black gum)</td>
<td>2.20</td>
<td>1.60</td>
<td>190</td>
<td>370</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Tupelo, water</td>
<td>2.20</td>
<td>1.60</td>
<td>190</td>
<td>370</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Ash, black</td>
<td>2.00</td>
<td>1.30</td>
<td>170</td>
<td>370</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Poplar, yellow</td>
<td>1.80</td>
<td>1.45</td>
<td>150</td>
<td>270</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Cottonwood, Eastern</td>
<td>1.55</td>
<td>1.20</td>
<td>110</td>
<td>180</td>
<td>1,100,000</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE NO. 25-D — 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

<table>
<thead>
<tr>
<th>Ratio of Size of Maximum Permitted Knot to Finished Width of Lamination</th>
<th>Number of Laminations</th>
<th>Extreme Fiber in Bending</th>
<th>Tension Parallel to Grain</th>
<th>Compression Parallel to Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>4 to 14</td>
<td>800</td>
<td>1:16</td>
<td>1:10</td>
</tr>
<tr>
<td>.1</td>
<td>15 or more</td>
<td>800</td>
<td>1:16</td>
<td>1:10</td>
</tr>
<tr>
<td>.2</td>
<td>4 to 14</td>
<td>800</td>
<td>1:16</td>
<td>1:10</td>
</tr>
<tr>
<td>.2</td>
<td>15 or more</td>
<td>800</td>
<td>1:16</td>
<td>1:10</td>
</tr>
<tr>
<td>.3</td>
<td>4 to 14</td>
<td>670</td>
<td>1:12</td>
<td>1:8</td>
</tr>
<tr>
<td>.3</td>
<td>15 or more</td>
<td>770</td>
<td>1:16</td>
<td>1:10</td>
</tr>
<tr>
<td>.4</td>
<td>4 to 14</td>
<td>520</td>
<td>1:8</td>
<td>1:5</td>
</tr>
<tr>
<td>.4</td>
<td>15 or more</td>
<td>660</td>
<td>1:12</td>
<td>1:8</td>
</tr>
<tr>
<td>.5</td>
<td>4 to 14</td>
<td>390</td>
<td>1:8</td>
<td>1:5</td>
</tr>
<tr>
<td>.5</td>
<td>15 or more</td>
<td>550</td>
<td>1:10</td>
<td>1:15</td>
</tr>
</tbody>
</table>

1. The allowable unit stresses in bending obtained from Table No. 25-D 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:
   - $F_b$ (bending) and $F_t$ (tension) 80 per cent
   - $F_c$ (horizontal shear) and $E$ (modulus of elasticity) 90 per cent
   - $F_c$ (compression parallel to grain) 70 per cent
   - $F_c \perp$ (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-E — ALLOWABLE UNIT STRESSES FOR ROUND TIMBER POLES AND PILES
(In p.s.i. and for Normal Duration of Load)

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>EXTREME FIBER IN BENDING&lt;sup&gt;1&lt;/sup&gt;</th>
<th>COMPRESSION PARALLEL TO GRAIN (L/D = 11 OR LESS)</th>
<th>COMPRESSION PERPENDICULAR TO GRAIN</th>
<th>HORIZONTAL SHEAR</th>
<th>AVERAGE MODULUS OF ELASTICITY (In Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Pine</td>
<td>2150</td>
<td>1200</td>
<td>260</td>
<td>130</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Douglas Fir (Coast)</td>
<td>2150</td>
<td>1200</td>
<td>260</td>
<td>110</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Western Larch</td>
<td>2150</td>
<td>1200</td>
<td>260</td>
<td>110</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Red Oak</td>
<td>2000</td>
<td>1100</td>
<td>400</td>
<td>150</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>1200</td>
<td>830</td>
<td>200</td>
<td>100</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>1200</td>
<td>800</td>
<td>180</td>
<td>80</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Red (Norway) Pine</td>
<td>1550</td>
<td>850</td>
<td>180</td>
<td>100</td>
<td>1,200,000</td>
</tr>
</tbody>
</table>

*Extreme fiber in bending values include 18 per cent increase allowed for round shape.*
### TABLE NO. 25-F — GROUP CLASSIFICATION — NONSTRESS-GRADED LUMBER

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>MINIMUM GRADE</th>
<th>UNIFORM BUILDING CODE STANDARD NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUP I</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Douglas Fir &amp; Larch&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Construction</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-4</td>
</tr>
<tr>
<td><strong>GROUP II</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bald Cypress (Tidewater Red Cypress)</td>
<td>No. 2</td>
<td>25-2</td>
</tr>
<tr>
<td>Douglas Fir (South)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Construction</td>
<td>25-4</td>
</tr>
<tr>
<td>Fir, White</td>
<td>Construction</td>
<td>25-3</td>
</tr>
<tr>
<td>Hemlock, Eastern</td>
<td>No. 1</td>
<td>25-5</td>
</tr>
<tr>
<td>Hemlock, West Coast &amp; Western&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Construction</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-4</td>
</tr>
<tr>
<td>Pine, Red (Norway Pine)</td>
<td>No. 1</td>
<td>25-5</td>
</tr>
<tr>
<td>Redwood, California</td>
<td>Select Heart</td>
<td>25-7</td>
</tr>
<tr>
<td>Spruce, Eastern</td>
<td>No. 1</td>
<td>25-8</td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>Construction</td>
<td>25-3</td>
</tr>
<tr>
<td>Spruce, White and Western White</td>
<td>Construction</td>
<td>25-4</td>
</tr>
<tr>
<td><strong>GROUP III</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar, Western</td>
<td>Construction</td>
<td>25-3</td>
</tr>
<tr>
<td>West Coast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar, Western Red and Incense</td>
<td>Construction</td>
<td>25-4</td>
</tr>
<tr>
<td>Douglas Fir &amp; Larch&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Standard</td>
<td>25-3</td>
</tr>
<tr>
<td>West Coast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Douglas Fir (South)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Standard</td>
<td>25-4</td>
</tr>
<tr>
<td>Fir, Balsam</td>
<td>No. 1</td>
<td>25-8</td>
</tr>
<tr>
<td>Fir, White</td>
<td>Standard</td>
<td>25-3</td>
</tr>
<tr>
<td>West Coast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GROUP III (Continued)**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>MINIMUM GRADE</th>
<th>UNIFORM BUILDING CODE STANDARD NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemlock, Eastern</td>
<td>No. 2</td>
<td>25-5</td>
</tr>
<tr>
<td>Hemlock, West Coast &amp; Western&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Standard</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-4</td>
</tr>
<tr>
<td>Pine, Ponderosa, Lodgepole, Sugar, Idaho White</td>
<td>Construction</td>
<td>25-4</td>
</tr>
<tr>
<td>Redwood, California</td>
<td>Construction</td>
<td>25-7</td>
</tr>
<tr>
<td>Redwood, California (studs only)</td>
<td>Two Star</td>
<td>25-7</td>
</tr>
<tr>
<td>Spruce, Engelmann</td>
<td>Construction</td>
<td>25-4</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>25-3</td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>West Coast</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td>Studs</td>
<td>25-4</td>
</tr>
<tr>
<td>Spruce, White and Western White</td>
<td>Standard</td>
<td>25-4</td>
</tr>
</tbody>
</table>

**GROUP IV** [See Section 2501 (e)]

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>MINIMUM GRADE</th>
<th>UNIFORM BUILDING CODE STANDARD NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar, Western</td>
<td>Utility</td>
<td>25-3</td>
</tr>
<tr>
<td>Cedar, Western Red and Incense</td>
<td>Utility</td>
<td>25-4</td>
</tr>
<tr>
<td>Douglas Fir &amp; Larch&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Utility</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-4</td>
</tr>
<tr>
<td>Douglas Fir (South)</td>
<td>Utility</td>
<td>25-4</td>
</tr>
<tr>
<td>Fir, White</td>
<td>Utility</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-4</td>
</tr>
<tr>
<td>Hemlock, West Coast &amp; Western</td>
<td>Utility</td>
<td>25-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-4</td>
</tr>
<tr>
<td>Pine, Ponderosa, Lodgepole, Sugar, Idaho White</td>
<td>Utility</td>
<td>25-4</td>
</tr>
<tr>
<td>Redwood, California</td>
<td>Merchantable</td>
<td>25-7</td>
</tr>
<tr>
<td>Redwood, California (studs only)</td>
<td>One Star</td>
<td>25-7</td>
</tr>
<tr>
<td>Spruce, Engelmann</td>
<td>Utility</td>
<td>25-4</td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>Utility</td>
<td>25-3</td>
</tr>
<tr>
<td>Spruce, White and Western White</td>
<td>Utility</td>
<td>25-4</td>
</tr>
</tbody>
</table>

<sup>1</sup>Two-inch by 4-inch only.
<sup>2</sup>Spruce (White and Western White) shall be graded under the requirements of Section 25.409 of U.B.C. Standard No. 25-4.
### TABLE NO. 25-G — 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 for values in other species.)

<table>
<thead>
<tr>
<th>LENGTH OF BOLT IN MAIN MEMBER (Inches)</th>
<th>DIAMETER OF BOLT (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>½</td>
</tr>
<tr>
<td>1⅛</td>
<td>1010</td>
</tr>
<tr>
<td>2⅛</td>
<td>1280</td>
</tr>
<tr>
<td>3⅛</td>
<td>1290</td>
</tr>
<tr>
<td>4⅛</td>
<td>1290</td>
</tr>
<tr>
<td>5⅛</td>
<td>2010</td>
</tr>
<tr>
<td>6⅛</td>
<td>2010</td>
</tr>
<tr>
<td>7⅛</td>
<td>2010</td>
</tr>
<tr>
<td>9⅛</td>
<td>2890</td>
</tr>
</tbody>
</table>

*This assumes dressed size lumber. Safe loads for other lengths of bolt in main member may be obtained by interpolation.

### TABLE NO. 25-H — 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 for values in other species.)

<table>
<thead>
<tr>
<th>LENGTH OF BOLT IN MAIN MEMBER (Inches)</th>
<th>DIAMETER OF BOLT (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>½</td>
</tr>
<tr>
<td>1⅛</td>
<td>480</td>
</tr>
<tr>
<td>2⅛</td>
<td>780</td>
</tr>
<tr>
<td>3⅛</td>
<td>1020</td>
</tr>
<tr>
<td>4⅛</td>
<td>1020</td>
</tr>
<tr>
<td>5⅛</td>
<td>1020</td>
</tr>
<tr>
<td>6⅛</td>
<td>1300</td>
</tr>
<tr>
<td>7⅛</td>
<td>1300</td>
</tr>
<tr>
<td>9⅛</td>
<td>1690</td>
</tr>
<tr>
<td>11⅛</td>
<td>2850</td>
</tr>
</tbody>
</table>

*This assumes dressed size lumber. Safe loads for other lengths of bolt in main member may be obtained by interpolation.
TABLE NO. 25-I — SAFE LATERAL STRENGTH AND REQUIRED
PENETRATION OF COMMON WIRE NAILS
DRIVEN PERPENDICULAR TO GRAIN OF WOOD

<table>
<thead>
<tr>
<th>SIZE OF NAIL</th>
<th>STANDARD LENGTH (INCHES)</th>
<th>WIRE GAUGE</th>
<th>PENETRATION REQUIRED (INCHES)</th>
<th>LOADS (POUNDS)</th>
<th>Douglas Fir or Southern Pine</th>
<th>Other Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>6d</td>
<td>2</td>
<td>11½</td>
<td>1½</td>
<td>63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8d</td>
<td>2½</td>
<td>10¼</td>
<td>1½</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10d</td>
<td>3</td>
<td>9</td>
<td>1%</td>
<td>94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12d</td>
<td>3½</td>
<td>9</td>
<td>1%</td>
<td>94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16d</td>
<td>3½</td>
<td>8</td>
<td>1½</td>
<td>107</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20d</td>
<td>4</td>
<td>6</td>
<td>2½</td>
<td>139</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30d</td>
<td>4½</td>
<td>5</td>
<td>2¼</td>
<td>154</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40d</td>
<td>5</td>
<td>4</td>
<td>2½</td>
<td>176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50d</td>
<td>5½</td>
<td>3</td>
<td>2¼</td>
<td>202</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60d</td>
<td>6</td>
<td>2</td>
<td>2½</td>
<td>223</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.)

TABLE NO. 25-J — 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

<table>
<thead>
<tr>
<th>KIND OF WOOD</th>
<th>SIZE OF NAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6d 8d 10d 12d 16d 20d 30d 40d 50d 60d</td>
</tr>
<tr>
<td>Douglas Fir, Larch or Southern Pine</td>
<td>33 39 44 44 48 57 61 67 72 78</td>
</tr>
<tr>
<td>Other Species</td>
<td>See U.B.C. Standard No. 25-17</td>
</tr>
</tbody>
</table>

TABLE NO. 25-K — MAXIMUM DIAPHRAGM DIMENSION RATIOS

<table>
<thead>
<tr>
<th>HORIZONTAL DIAPHRAGMS</th>
<th>VERTICAL DIAPHRAGMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Span-Width Ratios</td>
<td>Maximum Height-Width Ratios</td>
</tr>
<tr>
<td>1. Diagonal sheathing, conventional</td>
<td>3:1</td>
</tr>
<tr>
<td>2. Diagonal sheathing, special</td>
<td>4:1</td>
</tr>
<tr>
<td>3. Plywood, nailed all edges</td>
<td>4:1</td>
</tr>
<tr>
<td>4. Plywood, blocking omitted at intermediate joints</td>
<td>4:1</td>
</tr>
<tr>
<td>PLYWOOD GRADE</td>
<td>Common Nail Size</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>STRUCTURAL I</td>
<td></td>
</tr>
</tbody>
</table>
| 6d            | 1¼               | ½                                            | 2                                            | 3                                              | 185              | 165
|               | 1½               | %                                            | 2                                            | 3                                              | 210              | 185
|               | 1¾               | %                                            | 2                                            | 3                                              | 270              | 210
|               |                  |                                              |                                              |                                                | 300              | 265
|               | 1½               | %                                            | 2                                            | 3                                              | 320              | 285
|               |                  |                                              |                                              |                                                | 360              | 320
| 8d            | 1¼               | %                                            | 2                                            | 3                                              | 170              | 150
|               | 1½               | %                                            | 2                                            | 3                                              | 190              | 170
|               |                  |                                              |                                              |                                                | 210              | 185
|               | 1¾               | %                                            | 2                                            | 3                                              | 240              | 215
|               |                  |                                              |                                              |                                                | 270              | 240
| 10d           | 1¾               | %                                            | 2                                            | 3                                              | 290              | 285
|               |                  |                                              |                                              |                                                | 320              | 320

(Continued)
TABLE NO. 25-L (Continued)

1These values are for short time loads due to wind or earthquake and must be reduced 25 per cent for normal loading. Space nails 12 inches on center along intermediate framing members.

2Reduce tabulated allowable shears 10 per cent when boundary members provide less than 3-inch nominal nailing surface.

NOTE: Framing may be located in either direction for blocked diaphragms.
<table>
<thead>
<tr>
<th>Plywood Grade</th>
<th>Nail Size (Common or Galvanized Casing)</th>
<th>Minimum Nail Penetration in Framing (Inches)</th>
<th>Minimum Nominal Plywood Thickness (Inches)</th>
<th>Plywood Applied Direct to Framing</th>
<th>Nail Spacing at Plywood Panel Edges</th>
<th>Nail Size (Common or Galvanized Casing)</th>
<th>Plywood Applied Over 1/2-Inch Gypsum Sheathing</th>
<th>Nail Spacing at Plywood Panel Edges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural I</td>
<td>6d</td>
<td>1 1/2</td>
<td>1/2</td>
<td>200</td>
<td>300</td>
<td>450</td>
<td>510</td>
<td>8d</td>
</tr>
<tr>
<td></td>
<td>8d</td>
<td>1 3/4</td>
<td>1/2</td>
<td>280</td>
<td>430</td>
<td>640</td>
<td>730</td>
<td>10d</td>
</tr>
<tr>
<td></td>
<td>10d</td>
<td>1 1/2</td>
<td>1/2</td>
<td>340</td>
<td>510</td>
<td>770</td>
<td>870</td>
<td>8d</td>
</tr>
<tr>
<td>Structural II, C-C Exterior, Standard Sheathing, Panel Siding Plywood and Other Grades Covered in U.B.C. Standard No. 25-9</td>
<td>6d</td>
<td>1 1/2</td>
<td>1/2</td>
<td>180</td>
<td>270</td>
<td>400</td>
<td>450</td>
<td>8d</td>
</tr>
<tr>
<td></td>
<td>8d</td>
<td>1 3/4</td>
<td>1/2</td>
<td>260</td>
<td>380</td>
<td>570</td>
<td>640</td>
<td>10d</td>
</tr>
<tr>
<td></td>
<td>10d</td>
<td>1 1/2</td>
<td>1/2</td>
<td>310</td>
<td>460</td>
<td>690</td>
<td>770</td>
<td>8d</td>
</tr>
<tr>
<td>Plywood Panel Siding in Grades Covered in U.B.C. Standard No. 25-9</td>
<td>6d</td>
<td>1 1/2</td>
<td>1/2</td>
<td>140</td>
<td>210</td>
<td>320</td>
<td>360</td>
<td>8d</td>
</tr>
<tr>
<td></td>
<td>8d</td>
<td>1 3/4</td>
<td>1/2</td>
<td>160</td>
<td>240</td>
<td>360</td>
<td>410</td>
<td>10d</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 All panel edges backed with 2-inch nominal or wider framing. Plywood installed either horizontally or vertically. Space nails at 12 inches 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.

2 Reduce tabulated allowable shears 10 per cent when boundary members provide less than 3-inch nominal nailing surface.
### TABLE NO. 25-N—ALLOWABLE SHEARS FOR WIND OR SEISMIC LOADING ON VERTICAL DIAPHRAGMS OF FIBERBOARD SHEATHING BOARD CONSTRUCTION FOR TYPE V CONSTRUCTION ONLY

<table>
<thead>
<tr>
<th>SIZE AND APPLICATION</th>
<th>NAIL SIZE</th>
<th>SHEAR VALUE 3-INCH NAIL SPACING AROUND PERIMETER AND 6-INCH AT INTERMEDIATE POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{7}{8} )&quot; x 4' x 8'</td>
<td>No. 11 ga. roofing nail 1( \frac{1}{2} )&quot; long, ( \frac{7}{8} )&quot; head</td>
<td>125²</td>
</tr>
<tr>
<td>( \frac{11}{16} )&quot; x 4' x 8'</td>
<td>No. 11 ga. roofing nail 1( \frac{1}{2} )&quot; long, ( \frac{7}{8} )&quot; head</td>
<td>175</td>
</tr>
</tbody>
</table>

¹Fiberboard sheathing diaphragms shall not be used to brace concrete or masonry walls.
²The shear value may be 175 for \( \frac{1}{2} \)-inch x 4 foot x 8 foot fiberboard nailing base sheathing.

---

### TABLE NO. 25-O—NAILING SCHEDULE

<table>
<thead>
<tr>
<th>CONNECTION</th>
<th>NAILING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joist to sill or girder, toe nail</td>
<td>3-8d</td>
</tr>
<tr>
<td>Bridging to joist, toe nail each end</td>
<td>2-8d</td>
</tr>
<tr>
<td>1&quot; x 6&quot; subfloor or less to each joist, face nail</td>
<td>2-8d</td>
</tr>
<tr>
<td>Wider than 1&quot; x 6&quot; subfloor to each joist, face nail</td>
<td>3-8d</td>
</tr>
<tr>
<td>2&quot; subfloor to joist or girder, blind and face nail</td>
<td>2-16d</td>
</tr>
<tr>
<td>Sole plate to joist or blocking, face nail</td>
<td>16d at 16&quot; o.c.</td>
</tr>
<tr>
<td>Top plate to stud, end nail</td>
<td>2-16d</td>
</tr>
<tr>
<td>Stud to sole plate, toe nail</td>
<td>4-8d</td>
</tr>
<tr>
<td>Doubled studs, face nail</td>
<td>16d at 24&quot; o.c.</td>
</tr>
<tr>
<td>Doubled top plates, face nail</td>
<td>16d at 16&quot; o.c.</td>
</tr>
<tr>
<td>Top plates, laps and intersections, face nail</td>
<td>2-16d</td>
</tr>
<tr>
<td>Continuous header, two pieces</td>
<td>16d at 16&quot; o.c. along each edge</td>
</tr>
<tr>
<td>Ceiling joists to plate, toe nail</td>
<td>3-8d</td>
</tr>
<tr>
<td>Continuous header to stud, toe nail</td>
<td>4-8d</td>
</tr>
<tr>
<td>Ceiling joists, laps over partitions, face nail</td>
<td>3-16d</td>
</tr>
<tr>
<td>Ceiling joists to parallel rafters, face nail</td>
<td>3-16d</td>
</tr>
<tr>
<td>Rafter to plate, toe nail</td>
<td>3-8d</td>
</tr>
<tr>
<td>1&quot; brace to each stud and plate, face nail</td>
<td>2-8d</td>
</tr>
<tr>
<td>1&quot; x 8&quot; sheathing or less to each bearing, face nail</td>
<td>2-8d</td>
</tr>
<tr>
<td>Wider than 1&quot; x 8&quot; sheathing to each bearing, face nail</td>
<td>3-8d</td>
</tr>
<tr>
<td>Built-up corner studs</td>
<td>16d at 24&quot; o.c.</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>CONNECTION</th>
<th>NAILING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-up girder and beams</td>
<td>20d at 32&quot; o.c. at top and bottom and staggered 2-20d at ends and at each splice</td>
</tr>
<tr>
<td>2&quot; planks</td>
<td>2-16d at each bearing</td>
</tr>
<tr>
<td>Particleboard: 5</td>
<td></td>
</tr>
<tr>
<td>Wall Sheathing (to framing):</td>
<td>8d³</td>
</tr>
<tr>
<td>Plywood: 5</td>
<td></td>
</tr>
<tr>
<td>Subfloor, roof and wall sheathing (to framing):</td>
<td></td>
</tr>
<tr>
<td>½&quot; and less</td>
<td>6d²</td>
</tr>
<tr>
<td>⅞&quot;-¾&quot;</td>
<td>8d³ common or 6d⁴</td>
</tr>
<tr>
<td>¾&quot;-1&quot;</td>
<td>8d³</td>
</tr>
<tr>
<td>1¼&quot;-1¼&quot;</td>
<td>10d³ or 8d⁴</td>
</tr>
<tr>
<td>Combination Subfloor-underlayment (to framing):</td>
<td></td>
</tr>
<tr>
<td>¾&quot; and less</td>
<td>6d⁴</td>
</tr>
<tr>
<td>¾&quot;-1&quot;</td>
<td>8d⁴</td>
</tr>
<tr>
<td>1¾&quot;-1¾&quot;</td>
<td>10d³ or 8d⁴</td>
</tr>
<tr>
<td>Fiberboard Sheathing: 7</td>
<td></td>
</tr>
<tr>
<td>½&quot;</td>
<td>No. 11 ga.⁶</td>
</tr>
<tr>
<td></td>
<td>6d³</td>
</tr>
<tr>
<td></td>
<td>No. 16 ga.⁸</td>
</tr>
<tr>
<td>⅝&quot;</td>
<td>No. 11 ga.⁶</td>
</tr>
<tr>
<td></td>
<td>8d³</td>
</tr>
<tr>
<td></td>
<td>No. 16 ga.⁸</td>
</tr>
</tbody>
</table>

1Common box nails may be used except where otherwise stated.
2Common or deformed shank.
3Common.
4Deformed shank.
5Nails spaced at 6 inches on center at edges, 12 inches at intermediate supports (10 inches at intermediate supports for floors), except 6 inches at all supports where spans are 48 inches or more. For nailing of plywood diaphragms and shear walls refer to Section 2514 (c).
6Galvanized roofing nails with ⅜-inch diameter head and 1½-inch length for ½-inch sheathing and 1¾-inch length for ⅝-inch sheathing.
7Fasteners spaced 3 inches on center at exterior edges and 6 inches on center at intermediate supports.
8Galvanized staple with ⅜-inch crown and 1½-inch length for ½-inch sheathing and 1¾-inch length for ⅝-inch sheathing.
TABLE NO. 25-P — ALLOWABLE SPANS FOR LUMBER FLOOR AND ROOF SHEATHING¹

<table>
<thead>
<tr>
<th>SPAN (Inches)</th>
<th>MINIMUM NET THICKNESS (Inches) OF LUMBER PLACED</th>
<th>PERPENDICULAR TO SUPPORTS</th>
<th>DIAGONALLY TO SUPPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLOORS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>1%</td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>16</td>
<td>5/8</td>
<td></td>
<td>1/8</td>
</tr>
<tr>
<td></td>
<td>ROOFS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>5/8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Installation details shall conform to Sections 2518 (e) 1 and 2518 (g) 7 for floor and roof sheathing, respectively. Sheathing lumber shall meet the following minimum grade requirements:

**BOARD GRADE**

<table>
<thead>
<tr>
<th>SOLID FLOOR OR ROOF SHEATHING</th>
<th>SPACED ROOF SHEATHING</th>
<th>U.B.C. STANDARD NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>Standard</td>
<td>25-3</td>
</tr>
<tr>
<td>Utility</td>
<td>Standard</td>
<td>25-4</td>
</tr>
<tr>
<td>No. 3</td>
<td>No. 2</td>
<td>25-5</td>
</tr>
<tr>
<td>Merchantable</td>
<td>Construction</td>
<td>25-7</td>
</tr>
</tbody>
</table>

TABLE NO. 25-Q — ALLOWABLE SPANS FOR PLYWOOD FLOOR AND ROOF SHEATHING CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PERPENDICULAR TO SUPPORTS²

<table>
<thead>
<tr>
<th>PANEL IDENTIFICATION INDEX³</th>
<th>MAXIMUM SPAN (In Inches)</th>
<th>ROOF²</th>
<th>FLOOR MAXIMUM SPAN⁴ (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Edges Blocked</td>
<td>Edges Unblocked</td>
<td>Total Load</td>
</tr>
<tr>
<td>12/0</td>
<td>12</td>
<td></td>
<td>130</td>
</tr>
<tr>
<td>16/0</td>
<td>16</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>20/0</td>
<td>20</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>24/0</td>
<td>24</td>
<td>16</td>
<td>60</td>
</tr>
<tr>
<td>30/12</td>
<td>30</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td>32/16</td>
<td>32</td>
<td>28</td>
<td>50⁷</td>
</tr>
<tr>
<td>36/16</td>
<td>36</td>
<td>30</td>
<td>50⁷</td>
</tr>
<tr>
<td>42/20</td>
<td>42</td>
<td>32</td>
<td>45⁷</td>
</tr>
<tr>
<td>48/24</td>
<td>48</td>
<td>36</td>
<td>40⁷</td>
</tr>
</tbody>
</table>

²These values apply for Structural I and II, Standard Sheathing and C-C grades only. Spans shall be limited to values shown because of possible effect of concentrated loads.

³Uniform load deflection limitation: 1/180th of roof under live load plus dead load, 1/240th under live load only. Edges may be blocked with lumber or other approved type of edge support.

⁴Identification index appears on all panels in the construction grades listed in Footnote No. 1.

⁵Plywood edges shall have approved tongue and groove joints or shall be supported with blocking, unless 7/8-inch minimum thickness underlayment is installed, or finish floor is 7/8-inch wood strip. Allowable uniform load based on deflection of 1/360 of span is 100 pounds per square foot.

⁶May be 16-inch if 7/8-inch wood strip flooring is installed at right angles to joists.

(Continued)
One-half inch 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 24 inches on center, and the live load does not exceed 30 pounds per square foot. For other grades, a thickness of 5/8-inch is required.

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.

May be 24 inch if 3/4-inch wood strip flooring is installed at right angles to joists.

**TABLE NO. 25-R — ALLOWABLE SPAN FOR PLYWOOD COMBINATION SUBFLOOR-UNDERLAYMENT**

<table>
<thead>
<tr>
<th>SPECIES GROUPS</th>
<th>MAXIMUM SPACING OF JOISTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>2, 3</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>4</td>
<td>3/4&quot;</td>
</tr>
</tbody>
</table>

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 1/4-inch minimum thickness underlayment is installed, or finish floor is 3/8-inch wood strip. If wood strips are perpendicular to supports, thicknesses shown for 16 and 20-inch spans may be used on 24-inch span.

2 See U.B.C. Standard No. 25-9 for plywood species groups.

**TABLE NO. 25-S — ALLOWABLE SPANS FOR TWO-INCH TONGUE-AND-GROOVE DECKING**

<table>
<thead>
<tr>
<th>SPAN (in Feet)</th>
<th>LIVE LOAD</th>
<th>DEFLECTION LIMIT</th>
<th>f (p.s.i.)</th>
<th>E (p.s.i.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1/240</td>
<td>160</td>
<td>170,000</td>
<td>256,000</td>
</tr>
<tr>
<td>1/360</td>
<td>210</td>
<td>256,000</td>
<td>384,000</td>
<td>512,000</td>
</tr>
<tr>
<td>30</td>
<td>1/240</td>
<td>270</td>
<td>340,000</td>
<td>484,000</td>
</tr>
<tr>
<td>1/360</td>
<td>350</td>
<td>512,000</td>
<td>725,000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1/240</td>
<td>200</td>
<td>242,000</td>
<td>305,000</td>
</tr>
<tr>
<td>1/360</td>
<td>270</td>
<td>363,000</td>
<td>405,000</td>
<td>582,000</td>
</tr>
<tr>
<td>4.5</td>
<td>1/240</td>
<td>350</td>
<td>484,000</td>
<td>725,000</td>
</tr>
<tr>
<td>1/360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1/240</td>
<td>350</td>
<td>484,000</td>
<td>725,000</td>
</tr>
<tr>
<td>1/360</td>
<td>350</td>
<td>725,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>1/240</td>
<td>250</td>
<td>332,000</td>
<td>500,000</td>
</tr>
<tr>
<td>1/360</td>
<td>330</td>
<td>495,000</td>
<td>742,000</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
**TABLE NO. 25-S (Continued)**

<table>
<thead>
<tr>
<th>SPAN (In Feet)</th>
<th>LIVE LOAD</th>
<th>DEFLECTION LIMIT</th>
<th>f (p.s.i.)</th>
<th>E (p.s.i.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>1/240</td>
<td>1/360</td>
<td>420</td>
<td>660,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>300</td>
<td>442,000</td>
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<td>5.5</td>
<td>20</td>
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<td>1/240</td>
<td>1/360</td>
<td>500</td>
<td>884,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1/240</td>
<td>600</td>
<td>1,000,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
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<td></td>
<td>40</td>
<td>1/240</td>
<td>800</td>
<td>1,330,000</td>
</tr>
<tr>
<td>6.0</td>
<td>20</td>
<td>1/240</td>
<td>360</td>
<td>575,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>480</td>
<td>862,000</td>
</tr>
<tr>
<td></td>
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<td>1/240</td>
<td>600</td>
<td>1,150,000</td>
</tr>
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<td>1/240</td>
<td>700</td>
<td>1,730,000</td>
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<tr>
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<td>20</td>
<td>1/240</td>
<td>420</td>
<td>595,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>560</td>
<td>892,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1/240</td>
<td>650</td>
<td>1,340,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>810</td>
<td>1,920,000</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>1/240</td>
<td>700</td>
<td>1,730,000</td>
</tr>
<tr>
<td>7.0</td>
<td>20</td>
<td>1/240</td>
<td>490</td>
<td>910,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>650</td>
<td>1,360,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1/240</td>
<td>810</td>
<td>1,820,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>930</td>
<td>2,725,000</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>1/240</td>
<td>810</td>
<td>1,820,000</td>
</tr>
<tr>
<td>7.5</td>
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<td>1/240</td>
<td>560</td>
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<td>1/360</td>
<td>750</td>
<td>1,685,000</td>
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<td>1/240</td>
<td>930</td>
<td>2,530,000</td>
</tr>
<tr>
<td></td>
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<td>8.0</td>
<td>20</td>
<td>1/240</td>
<td>640</td>
<td>1,360,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>850</td>
<td>2,040,000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1/240</td>
<td>950</td>
<td>1,300,000</td>
</tr>
<tr>
<td></td>
<td>1/240</td>
<td>1/360</td>
<td>1,300,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>1/360</td>
<td>840</td>
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<td></td>
<td>4.5</td>
<td>1/360</td>
<td>950</td>
<td>1,300,000</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>1/360</td>
<td>1060</td>
<td>1,600,000</td>
</tr>
</tbody>
</table>

FLOORS

<table>
<thead>
<tr>
<th>Floors</th>
<th>Live Load</th>
<th>Deflection Limit</th>
<th>f (p.s.i.)</th>
<th>E (p.s.i.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1/360</td>
<td>840</td>
<td></td>
<td>1,000,000</td>
</tr>
<tr>
<td>4.5</td>
<td>1/360</td>
<td>950</td>
<td></td>
<td>1,300,000</td>
</tr>
<tr>
<td>5.0</td>
<td>1/360</td>
<td>1060</td>
<td></td>
<td>1,600,000</td>
</tr>
</tbody>
</table>

*Spans are based on simple beam action with 10 pounds per square foot dead load and provisions for a 300-pound concentrated load on a 12-inch width of floor decking. Random lay-up permitted in accordance with the provisions of Section 251S (e). Lumber thickness assumed at 1 1/2 inches, net.*
TABLE NO. 25-T—ALLOWABLE SPANS FOR FLOOR JOISTS USING NONSTRESS-GRADED LUMBER

<table>
<thead>
<tr>
<th>Size of Floor Joists (Inches)</th>
<th>Spacing of Floor Joists (Inches)</th>
<th>Maximum Allowable Span (Feet and Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Group I Plastered Ceiling Below</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group I Without Plastered Ceiling Below</td>
</tr>
<tr>
<td>2 x 6</td>
<td>12</td>
<td>10-6</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>9-6</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>7-6</td>
</tr>
<tr>
<td>2 x 8</td>
<td>12</td>
<td>14-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>12-6</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>10-0</td>
</tr>
<tr>
<td>2 x 10</td>
<td>12</td>
<td>17-6</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>15-6</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>13-0</td>
</tr>
<tr>
<td>2 x 12</td>
<td>12</td>
<td>21-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>18-0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>15-0</td>
</tr>
</tbody>
</table>

**Design Loading and Deflection Criteria:**

- **Live load:** Forty pounds per square foot.
- **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-F. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21. Span lengths for stress-graded lumber as set forth in Tables No. 25-A-1 and No. 25-A-2 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-1 or No. 25-A-2 which has a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1,100 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.
### TABLE NO. 25-U

**ALLOWABLE SPANS FOR CEILING JOISTS USING NONSTRESS-GRADED LUMBER**

<table>
<thead>
<tr>
<th>Size of Ceiling Joists (Inches)</th>
<th>Spacing of Ceiling Joists (Inches)</th>
<th>Maximum Allowable Span (Feet and Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GROUP I</td>
<td>GROUP II</td>
</tr>
<tr>
<td>2 x 4</td>
<td>12</td>
<td>11-6</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>10-6</td>
</tr>
<tr>
<td>2 x 6</td>
<td>12</td>
<td>18-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>16-0</td>
</tr>
<tr>
<td>2 x 8</td>
<td>12</td>
<td>24-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>21-6</td>
</tr>
</tbody>
</table>

**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.

¹Species of lumber are divided into groups as set forth in Table No. 25-F. Span lengths for stress-graded lumber as set forth in Tables No. 25-A-1 and No. 25-A-2 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-1 or No. 25-A-2 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.

²Lumber in Group IV may be used only under conditions specifically approved by the Building Official.
### TABLE NO. 25-V — ALLOWABLE SPANS FOR RAFTERS
(Slopes 4:12 or greater)

<table>
<thead>
<tr>
<th>SIZE OF RAFTER (Inches)</th>
<th>SPACING OF RAFTER (Inches)</th>
<th>MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LIVE LOAD 16 POUNDS³</td>
</tr>
<tr>
<td></td>
<td>Group I</td>
<td>Group II</td>
</tr>
<tr>
<td>2 x 4</td>
<td>12</td>
<td>10-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>9-0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>7-6</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>6-6</td>
</tr>
<tr>
<td>2 x 6</td>
<td>12</td>
<td>17-6</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>15-6</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>12-6</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>11-0</td>
</tr>
<tr>
<td>2 x 8</td>
<td>12</td>
<td>23-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>20-0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>17-0</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>14-6</td>
</tr>
<tr>
<td>2 x 10</td>
<td>12</td>
<td>28-6</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>25-6</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>21-0</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>18-6</td>
</tr>
</tbody>
</table>

**DESIGN LOADING CRITERIA**

Dead Load — Weight of roof equals seven pounds per square foot plus weight of rafters. All loads applied on horizontal projection.

¹Span lengths for stress-graded lumber set forth in Table No. 25-A-1 or 25-A-2 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-1 or 25-A-2 which has a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1,100 pounds per square inch. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21. Species of lumber are divided into groups as set forth in Table No. 25-F.

²Allowable stresses increased 25 per cent for roof loading [Section 2504 (c) 4].

³Allowable stresses are increased 15 per cent for roof loading [Section 2504 (c) 4].

⁴Lumber in Group IV may be used only under conditions specifically approved by the Building Official.
<table>
<thead>
<tr>
<th>SIZE OF ROOF RAFTERS (Inches)</th>
<th>SPACING OF ROOF RAFTERS (Inches)</th>
<th>TABLE NO. 25-W—ALLOWABLE SPANS FOR ROOF RAFTERS USING NONSTRESS-GRADED LUMBER¹ (Slopes less than 4:12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GROUP I                  GROUP II                  GROUP III                 GROUP IV²</td>
</tr>
<tr>
<td></td>
<td>Supporting Ceiling</td>
<td>Net Supporting Ceiling</td>
</tr>
<tr>
<td>2 x 4</td>
<td>12</td>
<td>8-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>7-0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>5-6</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>5-0</td>
</tr>
<tr>
<td>2 x 6</td>
<td>12</td>
<td>13-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>11-6</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>10-0</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>8-6</td>
</tr>
<tr>
<td>2 x 8</td>
<td>12</td>
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</tr>
<tr>
<td></td>
<td>16</td>
<td>15-6</td>
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<tr>
<td></td>
<td>24</td>
<td>13-6</td>
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<tr>
<td></td>
<td>32</td>
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<tr>
<td>2 x 10</td>
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<td></td>
<td>16</td>
<td>19-6</td>
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<tr>
<td></td>
<td>24</td>
<td>16-6</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>14-6</td>
</tr>
</tbody>
</table>
### TABLE NO. 25-W—ALLOWABLE SPANS FOR ROOF RAFTERS USING NONSTRESS-GRADED LUMBER

<table>
<thead>
<tr>
<th>Size of Roof Rafters (Inches)</th>
<th>Spacing of Roof Rafters (Inches)</th>
<th>Maximum Allowable Span (Feet and Inches Measured Along the Horizontal Projection)</th>
<th>Design Loading and Deflection Criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>GROUP I</strong></td>
<td><strong>GROUP II</strong></td>
</tr>
<tr>
<td></td>
<td>Supporting Ceiling</td>
<td>Not Supporting Ceiling</td>
<td>Supporting Ceiling</td>
</tr>
<tr>
<td>2 x 12</td>
<td>12</td>
<td>25-6</td>
<td>32-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>23-6</td>
<td>28-0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>20-0</td>
<td>23-6</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>17-6</td>
<td>20-6</td>
</tr>
</tbody>
</table>

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.

1Species of lumber are divided into groups as set forth in Table No. 25-F. Allowable stresses are increased 25 per cent for roof loading [Section 2504 (c) 4]. Span lengths for stress-graded lumber set forth in Tables No. 25-A-1, No. 25-A-2 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 Tables No. 25-A-1 and No. 25-A-2 or No. 25-B which have a modulus of elasticity of 1,600,000 pounds per square inch and an allowable extreme fiber stress in bending of 1,100 pounds per square inch. The allowable spans are based upon stress and deflection criteria set forth in U.B.C. Standard No. 25-21.

Lumber in Group IV may be used only under conditions specifically approved by the Building Official.
### TABLE NO. 25-W-SL-30' — ALLOWABLE SPANS FOR ROOF RAFTERS, USING NONSTRESS-GRADED LUMBER
(Slopes less than 4:12)

<table>
<thead>
<tr>
<th>SIZE OF ROOF RAFTERS (Inches)</th>
<th>SPACING OF ROOF RAFTERS (Inches)</th>
<th>MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GROUP I</td>
</tr>
<tr>
<td></td>
<td>Supporting Ceiling</td>
<td>Not Supporting Ceiling</td>
</tr>
<tr>
<td>2 x 4 12</td>
<td>7-0</td>
<td>8-0</td>
</tr>
<tr>
<td>16</td>
<td>6-0</td>
<td>7-0</td>
</tr>
<tr>
<td>24</td>
<td>5-0</td>
<td>5-6</td>
</tr>
<tr>
<td>32</td>
<td>4-0</td>
<td>5-0</td>
</tr>
<tr>
<td>2 x 6 12</td>
<td>12-0</td>
<td>13-6</td>
</tr>
<tr>
<td>16</td>
<td>10-6</td>
<td>12-0</td>
</tr>
<tr>
<td>24</td>
<td>8-6</td>
<td>9-6</td>
</tr>
<tr>
<td>32</td>
<td>7-6</td>
<td>8-6</td>
</tr>
<tr>
<td>2 x 8 12</td>
<td>16-0</td>
<td>18-0</td>
</tr>
<tr>
<td>16</td>
<td>13-0</td>
<td>15-6</td>
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<tr>
<td>24</td>
<td>11-6</td>
<td>13-0</td>
</tr>
<tr>
<td>32</td>
<td>10-0</td>
<td>11-0</td>
</tr>
<tr>
<td>2 x 10 12</td>
<td>20-0</td>
<td>22-6</td>
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<tr>
<td>16</td>
<td>17-6</td>
<td>19-6</td>
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<tr>
<td>24</td>
<td>14-6</td>
<td>16-0</td>
</tr>
<tr>
<td>32</td>
<td>12-6</td>
<td>14-0</td>
</tr>
<tr>
<td>2 x 12 12</td>
<td>24-0</td>
<td>27-0</td>
</tr>
<tr>
<td>16</td>
<td>20-0</td>
<td>23-6</td>
</tr>
<tr>
<td>24</td>
<td>17-6</td>
<td>19-6</td>
</tr>
<tr>
<td>32</td>
<td>15-0</td>
<td>17-0</td>
</tr>
</tbody>
</table>

**DESIGN LOADING AND DEFLECTION CRITERIA:**

Snow load—30 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 snow load nor $1/240$ of the span with dead and snow load—Without plastered ceiling—not considered.

SEE FOOTNOTES ON PAGE 240.
<table>
<thead>
<tr>
<th>SIZE OF ROOF RAFTERS (Inches)</th>
<th>SPACING OF ROOF RAFTERS (Inches)</th>
<th>MAXIMUM ALLOWABLE SPAN (Feet and Inches Measured Along the Horizontal Projection)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GROUP I</td>
<td>GROUP II</td>
</tr>
<tr>
<td></td>
<td>Supporting Ceiling</td>
<td>Not Supporting Ceiling</td>
</tr>
<tr>
<td>2x4</td>
<td>12</td>
<td>6-0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>5-6</td>
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<td></td>
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<td>19-0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>16-0</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>13-6</td>
</tr>
</tbody>
</table>

**DESIGN LOADING AND DEFLECTION CRITERIA:**

Snow load—40 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 snow load nor 1/240 of the span with dead and snow load—Without plastered ceiling—not considered.

SEE FOOTNOTES ON PAGE 240.
FOOTNOTES TO TABLES NO. 25-W-SL-30 AND NO. 25-W-SL-40

Species of lumber are divided into groups as set forth in Table No. 25-F. Allowable stresses are increased 15 per cent for roof loading [Section 2504 (c) 4]. Span lengths for stress-graded lumber set forth in Table No. 25-A-1 or 25-A-2 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-1 or 25-A-2 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.

Lumber in Group IV may be used only under conditions specifically approved by the Building Official.
CHAPTER 26—CONCRETE

NOTE: Tables in Chapter 26 appear at the end of the Chapter.

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.

Sec. 2602. (a) Notations. The notations used in these regulations are defined as follows:

- $D$ = dead load.
- $L$ = live load.
- $\Delta$ = 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.
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, \( \Delta \), of a reinforced concrete beam, floor or roof exceeds \( \frac{P}{20,000t} \), 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, \( \Delta \), is less than \( \frac{P}{20,000t} \), the requirement on recovery of deflection in item No. 1 may be waived.

3. In determining the limiting deflection for a cantilever, \( P \) 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.

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.
COMPRESSIVE STRENGTH OF CONCRETE "f_c", specified compressive strength of concrete in pounds per square inch. Compressive strength shall be determined by tests of standard 6-inch by 12-inch 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. Welded wire fabric with welded intersections not farther apart than 12 inches 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.

1Wherever this quantity appears under a radical sign, the root of only the numerical value is intended; all values are in pounds per square inch.
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.

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:

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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 or No. 26-3.

(c) Concrete Aggregates. Concrete aggregates shall conform to U.B.C. Standard No. 26-4 or No. 26-5, 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.

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.

Wire for concrete reinforcement shall conform to U.B.C. Standard No. 26-7.

Welded wire fabric for concrete reinforcement shall conform to U.B.C. Standard No. 26-11 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.


Structural steel shall conform to U.B.C. Standard No. 27-1.

Steel pipe for concrete-filled pipe columns shall conform to Grade B of U.B.C. Standard No. 27-1.

Cast-iron pipe for composite columns shall conform to U.B.C. Standard No. 27-1.

(f) Admixtures. Admixtures, if used, shall conform to U.B.C. Standard No. 26-12.
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.

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.

(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).
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.

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.

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 and tested in accordance with the requirements set forth in U.B.C. Standard No. 26-13. Samples from which compression test specimens are molded shall be secured in accordance with U.B.C. Standard No. 26-13. 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. 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.

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, \( f' \), and not more than 20 per cent of the strength tests shall have values less than the specified strength.

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, \( f' \), 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 serv-
ice. 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 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, \( F_{tp}\), for a particular aggregate, tests of concrete shall be made as follows:

1. Twenty-four 6-inch by 12-inch cylinders shall be made in accordance with U.B.C. Standard No. 26-13, 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.


The ratio, \( F_{tp}\), 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.

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.

(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.

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 1 inch.

(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.

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 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.
UNIFORM BUILDING CODE

(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 2 inches 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.

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 1 inch.

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 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.

Sec. 2608. (a) Hooks and Bends.

HOOKS. The term “standard hook” as used herein shall mean:

1See also Section 2609 (q) and (r).
1. A semicircular turn plus an extension of at least four bar diameters but not less than $2\frac{1}{2}$ inches 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 $2\frac{1}{2}$ inches 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.

(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 24 inches or less: plus or minus $\frac{1}{4}$ inch.

Depth, $"d"$, in flexural members and columns where $"d"$ is more than 24 inches: plus or minus $\frac{1}{2}$ inch.
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.

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:

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 hori-
zontal 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 com-
posite columns shall be accurately milled at splices and posi-
tive provision shall be made for alignment of one core above
another. At the column base, provision shall be made to trans-
fer 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 permis-
sible 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
Details of Reinforcement (Continued)

inches (30") in diameter, and four for spirals more than thirty inches (30") in diameter. When spiral rods are five-eighths inch (5/8") 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 (1/4") 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 (1 3/8") 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.

All bars for tied columns shall be enclosed by lateral ties at least one-fourth inch (1/4") 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 corner and alternate longitudinal bar shall have lateral support provided by the corner of a tie having an included angle of not more than 135 degrees and no bar shall be farther than six inches (6") from such a laterally supported bar. 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 (1/4") 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”).

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 inches (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 third 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.
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.
\( p_s \) = 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 \( \Sigma K \) of columns to \( \Sigma K \) 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 sec-
tions the maximum effects of the prescribed loads as determined by the theory of elastic frames in which the simplifying assumptions of Section 2609 (d) 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 \( w l^2 \)
If discontinuous end is integral with support ...... 1/14 \( w l^2 \)
Interior spans ..................................................... 1/16 \( w l^2 \)

Negative moment at exterior face of first interior support
Two spans .............................................................. 1/9 \( w l^2 \)
More than two spans ............................................ 1/10 \( w l^2 \)

Negative moment at other faces of interior supports . 1/11 \( w l^2 \)

Negative moment at face of all supports for, (a) slabs with spans not exceeding 10 feet 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 \( w l^2 \)

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 \( w l^2 \)
Where the support is a column ........................................ 1/16 \( w l^2 \)

Shear in end members at first interior support...... 1.15 \( \frac{w l}{2} \)

Shear at all other supports ........................................ \( \frac{w l}{2} \)

(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 10 feet 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 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.

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 18 inches.
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 ½ inch 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.

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 “pfy” is equal to or less than 500 and on the transformed cracked section when “pfy” 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
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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 \( \frac{200}{f_y} \), 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 10 inches, or in the case of rectangular columns, a thickness of at least 8 inches, and a gross area not less than 96 square inches.

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 1\(\frac{1}{2}\) inches outside the column spiral or as a square or rectangle, the sides of which are at least 1\(\frac{1}{2}\) inches 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

\[
p_s = 0.45 \left( \frac{A_g}{A_c} - 1 \right) \frac{f'_c}{f_y} \ldots \ldots \ldots \ldots \ldots (9-1)
\]

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.

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:

\[ h' = 2h (0.78 + 0.22r') \leq 2h \]

WHERE:
\[ r' = \text{the value at the restrained end.} \]

3. For columns restrained against rotation at both ends the effective length "h'" shall be taken as

\[ h' = h (0.78 + 0.22r') \leq h \]

WHERE:
\[ r' = \text{the average of the values at the two ends of the column.} \]

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

\[ R = 1.32 - 0.006 \frac{h}{r} \leq 1.0 \] 

\[ (9-2) \]
If \( \frac{h}{r} \) 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

\[
R = \frac{h}{R} = 1.07 - 0.008\frac{r}{R} \leq 1.0 \quad (9-3)
\]

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 \( h \).

\[
R = \frac{h'}{R} = 1.07 - 0.008\frac{r}{R} \leq 1.0 \quad (9-4)
\]

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

\[
R = \frac{h'}{R} = 1.18 - 0.009\frac{r}{R} \leq 1.0 \quad (9-5)
\]

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
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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.

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 6 inches.

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.

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 percent 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 sub-
jected, 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 rein-
forcement 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 regu-
lations 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 earth-
quake cause transfer of bending moment between column
and slab, the additional shears on the critical section shall
be investigated by a rational analysis.

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 cov-
ered 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 pro-
vided 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 \( \frac{3}{2} \) inch whichever is
larger.

Sec. 2610. (a) Notations. The notations used in these
regulations are defined as follows:

\[ f_c = \text{compressive stress in concrete.} \]
\[ f'_c = \text{compressive strength of concrete (see Section 2603).} \]
\[ n = \text{ratio of modulus of elasticity of steel to that of con-

\[ v = \text{shear stress.} \]
\[ v_c = \text{shear stress carried by the concrete.} \]
\[ w = \text{weight of concrete, pounds per cubic foot.} \]

(b) General. For structures to be designed with reference
to allowable stresses, service loads, and the accepted straight-
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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 main reinforcement, \( \frac{3}{8} \) inch or less diameter, in one-way slabs of not more than 12-foot span, 50 per cent of the minimum yield strength specified in the U.B.C. Standards for the 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 \( 10,000 \) p.s.i.

In compression, flexural members

For compression in flexural members see Section 2611 (c).

Spirals [yield strength for use in Formula (9-1)]

Hot-rolled bars Grade 40 \( 40,000 \) p.s.i.

Hot-rolled bars Grade 50 \( 50,000 \) p.s.i.

Hot-rolled bars of minimum yield strength of 60,000 p.s.i., and cold-drawn wire \( 60,000 \) p.s.i.
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; strains 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.

(c) Modulus of Elasticity of Concrete. The modulus of elasticity, \( "E_c" \), for concrete may be taken as \( w^{1.533} \sqrt{f'_c} \), 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:

\[ n = \frac{E_s}{E_c} \]

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.

Sec. 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.


\[ A_v = \text{total area of web reinforcement in tension within a distance, } s, \text{ measured in a direction parallel to the longitudinal reinforcement.} \]

\[ a = \text{angle between inclined web bars and longitudinal axis of member.} \]

\[ b = \text{width of compression face of flexural member.} \]

\[ b' = \text{width of web in I- and T-sections.} \]

\[ b_o = \text{periphery of critical section for slabs and footings.} \]

\[ d = \text{distance from extreme compression fiber to centroid of tension reinforcement.} \]

\[ f_c' = \text{compressive strength of concrete (see Section 2603).} \]

\[ f_v = \text{tensile stress in web reinforcement.} \]

\[ F_{sp} = \text{ratio of splitting tensile strength to the square root of compressive strength [see Section 2605 (f)].} \]

\[ M = \text{bending moment.} \]

\[ M' = \text{modified bending moment.} \]

\[ N = \text{load normal to the cross section, to be taken as positive for compression, negative for tension, and to include the effects of tension due to shrinkage and creep.} \]

\[ p_w = A_v/b'd. \]

\[ s = \text{spacing of stirrups or bent bars in a direction parallel to the longitudinal reinforcement.} \]

\[ t = \text{total depth of section.} \]

\[ v = \text{shear stress.} \]

\[ v_c = \text{shear stress carried by concrete.} \]

\[ V = \text{total shear.} \]

\[ V' = \text{shear carried by web reinforcement.} \]

(b) Shear Stress\(^1\). The nominal shear stress, as a measure of diagonal tension, in reinforced concrete members shall be computed by:

\[ v = V/bd \hspace{1cm} (12-1) \]

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 \(1.1V/f_c'\) 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

\(^1\) Special provisions for lightweight aggregate concretes are given in Section 2612 (i).

\(^2\) This provision does not apply to brackets and other short cantilevers.
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:

\[
v_c = \sqrt{f_c'} + 1300 \frac{p_wVd}{M} \quad \text{(12-2)}
\]

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. \(V\) and \(M\) are the shear and bending moment at the section considered, but \(M\) shall not be 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:

\[
M' = \frac{(4t - d)}{8} \quad \text{(12-3)}
\]

and \(v_c\) shall not exceed

\[
v_c = 1.75 \sqrt{f_c'} \left(1 + 0.004 \frac{N}{A_g}\right) \quad \text{(12-4)}
\]

When all longitudinal reinforcement at a section acts in compression, use Formula (12-4). [See Section 2612 (i) for Lightweight Aggregate Concretes.]

(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 an 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).

\(^1\)This provision does not apply to brackets and other short cantilevers.
(d) Stirrups. The area of steel required in stirrups placed perpendicular to the longitudinal reinforcement shall be computed by:

\[ A_v = \frac{V'}{f_v d} \] ........................ (12-5)

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:

\[ A_v = \frac{V'}{f_v \sin \alpha} \] ........................ (12-6)

WHERE:

\[ V' \] shall not exceed 1.5 \( bd \sqrt{\frac{f_v}{f_c}} \).

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:

\[ A_v = \frac{V's}{f_v d (\sin \alpha + \cos \alpha)} \] ............... (12-7)

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, \( \frac{V'}{f_c} \), 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, \( \sigma \), shall not exceed \( 5\sqrt{\frac{f_c}{f_v}} \) 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 \( 3\sqrt{\frac{f_c}{f_v}} \), 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:

\[
v = V/b_o d
\]  

(12-8)

where "V" and "b_o" are taken at the critical section specified in this Subsection. The shear stress, "v", so computed shall not exceed \(2\sqrt{T_c}\), unless shear reinforcement is provided in accordance with the following paragraph, in which case "v" shall not exceed \(3\sqrt{T_c}\).

When "v" exceeds \(2\sqrt{T_c}\), 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 10 inches.

(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

\[
0.17 F_{sp} \sqrt{T_c}
\]  

(12-9)

2. Formula (12-2) shall be replaced by:

\[
v_c = 0.15 F_{sp} \sqrt{T_c} + 1300 \frac{p_w Vd}{M}
\]  

(12-10)

\(^1\)For transfer of moments and effects of openings see Section 2609 (s).
3. The limiting value for shear stress in slabs and footings, "v_c", in Section 2612 (h) shall be:

\[ 0.3F_{sp} \sqrt{f_c} \] \[ (12-11) \]

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

\[ v_c = \left( 3.7 - \frac{H}{D} \right) 1.1 \sqrt{f_c} \] \[ (12-12) \]

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

\[ A_v = \frac{V's}{f_o d \left( \frac{H}{D} - 1 \right)} \] \[ (12-13) \]

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

\[ v = \left( 1 + 2 \frac{H}{D} \right) \sqrt{f_c} \] \[ (12-14) \]

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.

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).

$i$ = ratio of distance between centroid of compression and centroid of tension to the depth, “d”.

$\Sigma o$ = 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 shear.

(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

$$u = \frac{V}{\Sigma o d}$$

(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, 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 “$\Sigma o$” 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, except for those designated as Special Large Size Deformed Reinforcing Bars:

   Top bars
   $$\frac{3.4 \sqrt{f_c'}}{D} \text{ nor } 350 \text{ p.s.i.}$$

   Bars other than top bars
   $$\frac{4.8 \sqrt{f_c'}}{D} \text{ nor } 500 \text{ p.s.i.}$$

---

1Top bars, in reference to bond, are horizontal bars so placed that more than 12 inches of concrete is cast in the member below the bar.
2. For tension bars designated as Special Large Size Deformed Reinforcing Bars in U.B.C. Standard No. 26-7.
   Top bars  $2.1 \sqrt{f_c}$
   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, 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.

Sec. 2614. (a) Notations. The notations used in these regulations are defined as follows:

- $A_c = \text{area of concrete within a pipe column.}$
- $A_g = \text{gross area of spirally reinforced or tied column.}$
- $A_t = \text{the total area of the concrete encasement of combination column.}$
- $A_r = \text{area of concrete of a composite column.}$
- $A_s = \text{area of tension reinforcement.}$
- $A_{st} = \text{total area of longitudinal reinforcement.}$
- $b = \text{width of compression face of flexural member.}$
- $d = \text{distance from extreme compression fiber to centroid of tension reinforcement.}$
- $d' = \text{distance from extreme compression fiber to centroid of compression reinforcement.}$
- $D_s = \text{diameter of circle through centers of the longitudinal reinforcement in spiral columns.}$
- $e = \text{eccentricity of the resultant load on a column, measured from the gravity axis.}$
- $e_b = \text{maximum permissible eccentricity of "$N_b".}$
- $F_b = \text{allowable bending stress that would be permitted for bending alone.}$
- $f_a = \text{axial load divided by area of member, "$A_g".}$
- $f_c' = \text{compressive strength of concrete (see Section 2603).}$
- $f_r = \text{allowable stress in the metal core of a composite column.}$
- $f_r' = \text{allowable stress on unencased metal columns and pipe columns.}$
- $f_s = \text{allowable stress in column vertical reinforcement.}$
- $f_y = \text{yield strength of reinforcement (see Section 2603).}$
- $h = \text{unsupported length of column.}$
- $j = \text{ratio of distance between centroid of compression and centroid of tension to the depth, "$d'".}$
Reinforced Concrete Columns—Working Stress Design (Continued)

\[ K_c = \text{radius of gyration of concrete in pipe columns.} \]
\[ K_s = \text{radius of gyration of metal pipe in pipe columns.} \]
\[ m = \frac{f_y}{0.85 f'_c}. \]
\[ n = \text{ratio of modulus of elasticity of steel to that of concrete.} \]
\[ N = \text{eccentric load normal to the cross section of a column.} \]
\[ N_b = \text{the value of "N" below which the allowable eccentricity is controlled by tension, and above which by compression.} \]
\[ p = \text{ratio of area of tension reinforcement to effective area of concrete.} \]
\[ p' = \text{ratio of area of compression reinforcement to effective area of concrete.} \]
\[ p_a = \text{ratio of area of vertical reinforcement to the gross area, "A_g".} \]
\[ P = \text{allowable axial load on a reinforced concrete column without reduction for length or eccentricity.} \]
\[ = \text{allowable axial load on combination, composite, or pipe column without reduction for eccentricity.} \]
\[ t = \text{over-all depth of rectangular column or the diameter of a round column.} \]

(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.]

(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

\[ P = A_g (0.25 f'_c + f_s p_g) \quad \text{.........(14-1)} \]

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
\[ P = 0.225 A_{ofc'} + f_{st} A_{st} + f_{r} A_{r} \quad \text{(14-2)} \]

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 3 inches 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 2 inches.

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.

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 2½ inches thick over all metal (except rivet heads), reinforced as hereinafter specified, shall be computed by

\[ P = A_{ofc'} \left[ 1 + \frac{A_{g}}{100A_{r}} \right] \quad \text{(14-3)} \]

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 4 inches apart and those parallel to the column axis not more than 8 inches apart. This fabric shall extend entirely around the column at a distance of 1 inch 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

\[ P = 0.25 f'_c \left( 1 - 0.000025 \frac{h^2}{K_s^2} \right) A_c + f'_r A_r \]  \hspace{1cm} (14-4)

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.

\[ f'_r = 17,000 - 0.485 \frac{h^2}{K_s^2} \]  \hspace{1cm} (14-5)

(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:

\[ e_b = 0.43 \rho y m D_s + 0.14 t \]  \hspace{1cm} (14-6)

For symmetrical tied columns:

\[ e_b = (0.67 \rho y m + 0.17) d \]  \hspace{1cm} (14-7)

For unsymmetrical tied columns:

\[ e_b = \frac{p' m (d - d') + 0.1 d}{(p' - p) m + 0.6} \]  \hspace{1cm} (14-8)

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.

\[ \frac{f_a}{F_a} + \frac{f_{bz}}{F_b} + \frac{f_{by}}{F_b} \text{ not greater than unity} \]  \hspace{1cm} (14-9)

where “\( f_{bz} \)” 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

\[ F_a = 0.34 \left( 1 + \rho y m \right) f'_c \]  \hspace{1cm} (14-10)

The allowable bending moment “\( M \)” on columns controlled by tension shall be considered to vary linearly with axial
load, from "M₀" when the section is in pure flexure, to "Mₘₜₜ" when the axial load is equal to "Nₜ"; "Mₘₜₜ" and "Nₜ" shall be determined from "εₜ" and Formula (14-9); "M₀" from Formula (14-11), (14-12), or (14-13).

For spiral columns:

\[ M₀ = 0.12AₜₜₜₜDₜ \] .................................. (14-11)

For symmetrical tied columns:

\[ M₀ = 0.40Aₜₜₜₜ(d - d') \] .................................. (14-12)

For unsymmetrical tied columns:

\[ M₀ = 0.40Aₜₜₜₜd \] .................................. (14-13)

For bending about two axes

\[ \frac{Mₓ}{Mₘₜₜ} + \frac{Mᵧ}{Mₘₜₜₜₜ} \text{ not greater than unity} \] .................................. (14-14)

where "Mₓ" and "Mᵧ" are bending moments about the "X" and "Y" principal axes, and "Mₓₘₜₜ" and "Mᵧₘₜₜₜₜ" are the values of "M₀" for bending about these axes.

Sec. 2615. (a) Notations. The notations used in these regulations shall be defined as follows:

- \( Aₜ \) = area of tension reinforcement.
- \( Aₜ' \) = area of compression reinforcement.
- \( Aₜₜₜₜ \) = area of reinforcement to develop compressive strength of overhanging flanges in I- and T-sections.
- \( a \) = depth of equivalent rectangular stress block = \( k₁c \).
- \( b \) = 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.
- \( D \) = dead load.
- \( d \) = distance from extreme compression fiber to centroid of tension reinforcement.
- \( E \) = earthquake load.
- \( fₜ' \) = compressive strength of concrete (see Section 2603).
- \( fₜ \) = yield strength of reinforcement (see Section 2603).
- \( k₁ \) = a factor defined in Section 2615 (d) 6.
- \( L \) = specified live load plus impact.
- \( p \) = \( Aₜ/ bd \).
- \( p' \) = \( Aₜ'/ bd \).
- \( p₁ \) = \( Aₜₜₜₜ/ bd \).
- \( pₜ \) = \( Aₜₜₜₜ/ bd \).
- \( U \) = 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, con-
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 Item 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 \( p_{we} - p' \), 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).

(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 "$\phi$" 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).

(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
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

\[ U = 1.25 \ (D + L + W) \] .......................... (15-2)

OR

\[ U = 0.9D + 1.1W \] .......................... (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 “pw − py” in any section of a flexural member exceeds 0.18f′c′/fy, or whenever the specified yield strength, “fy”, 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 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, “fy”, 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.

Sec. 2616. (a) Notations. The notations used in these regulations shall be defined as follows:

\[ A_s = \text{area of tension reinforcement.} \]

\[ A_s' = \text{area of compression reinforcement.} \]
$A_{sf}$ = 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).

$p_f$ = $A_{sf}/b'd$.

$p_w$ = $A_s/b'd$.

$q$ = $A_{sf}/bd f_c'$.

$t$ = flange thickness in I- and T-sections.

$\phi$ = 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:

$$M_u = \phi \left[ bd^2 f_c' q \left( 1 - 0.59q \right) \right] = \phi \left[ A_{sf} y \left( d - \frac{a}{2} \right) \right] \tag{16-1}$$

WHERE:

$q = pf_\mu/f_c'$.

$a = A_{sf}/0.85f_c'b$.

The reinforcement ratio, "p", shall not exceed 0.75 of the ratio, "$p_b$", which produces balanced conditions at ultimate strength given by:

$$p_b = \frac{0.85 k_1 f_c'}{f_y} \frac{87,000}{87,000 + f_y} \tag{16-2}$$

(c) Rectangular Beams with Compression Reinforcement. The ultimate design resisting moment in rectangular beams with compression reinforcement shall be calculated by:

$$M_u = \phi \left[ \left( A_s - A_{s}' \right) f_y \left( d - \frac{a}{2} \right) + A_{s}' f_y \left( d - d' \right) \right] \tag{16-3}$$
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:
\[
p - p' \geq 0.85 k_1 \frac{f_c'd'}{f_{ud}d} \frac{87,000}{87,000 - f_y} \quad \text{......(16-4)}
\]

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:
\[
M_u = \phi \left( (A_s - A_{sf}) f_y \left( d - \frac{a}{2} \right) + A_{sf} f_{y} \left( d - 0.5t \right) \right)
\]
\[ \quad \text{..............................................(16-5)} \]
in which "A_{sf}"; the steel area necessary to develop the compressive strength of overhanging flanges is:
\[ A_{sf} = 0.85 (b - b') t f_c' / f_y \quad \text{......(16-6)} \]

AND
\[ a = (A_s - A_{sf}) f_y / 0.85 f_c' b' \]

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).

**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.
- \( \alpha \) = 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.
- \( p_{wv} \) = \( A_s / b'd \).
- \( s \) = spacing of stirrups or bent bars in a direction parallel to the longitudinal reinforcement.
- \( t \) = total depth of section.
- \( \nu_c \) = shear stress carried by concrete.
- \( \nu_u \) = 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.
- \( \phi \) = capacity reduction factor [see Section 2615 (e)].
(b) **Ultimate Shear Strength.** The nominal ultimate shear stress, as a measure of diagonal tension, in reinforced concrete members shall be computed by:

\[ \sigma_u = \frac{V_u}{bd} \]  

For design, the maximum shear shall be considered as that at the section a distance, "d", from the face of the support. 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, "\( \sigma_c \)"., 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. For members with axial tension, "\( \sigma_c \)" shall not exceed the value given in Section 2617 (b).

The shear stress permitted on an unreinforced web shall not exceed that given by:

\[ \sigma_c = \phi \left( 1.9 \sqrt{f_c} + 2500 \frac{p_u V_d}{M} \right) \]  

except that "\( \sigma_c \)" 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. "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

\[ M' = M - N \left( \frac{4t - d}{8} \right) \]  

and "\( \sigma_c \)" shall not exceed \( 3.5\phi \sqrt{f_c} (1 + 0.002 N / A_d) \)

(c) **Web Reinforcement.** Wherever the value of the ultimate shear stress, "\( \sigma_u \)"., computed by Formula (17-1) plus effects of torsion, exceeds the shear stress, "\( \sigma_c \)"., permitted for the concrete of an unreinforced web by Section 2617 (b),

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1Special provisions for lightweight aggregate concretes are given in Section 2617 (i).

2This provision does not apply to brackets and other short cantilevers.
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 (r).

(d) **Stirrups.** The area of steel required in stirrups placed perpendicular to the longitudinal reinforcement shall be computed by:

\[
A_v = \frac{V_u's}{\phi f_y d} \quad \text{(17-4)}
\]

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:

\[
A_v = \frac{V_u'}{\phi f_y \sin \alpha} \quad \text{(17-5)}
\]

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:

\[
A_v = \frac{V_u's}{\phi f_y d (\sin \alpha + \cos \alpha)} \quad \text{(17-6)}
\]

Bent bars used alone as web reinforcement shall be so spaced that the effective inclined portion defined in the first

\(^1\)This provision does not apply to brackets and other short cantilevers.
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 \( 100 \sqrt{f_c} \) 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 \( 60 \sqrt{f_c} \), 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 0.15 per cent of the area, \( b_s \), 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.** 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.

The nominal ultimate shear stress shall be computed by:

\[
V_u = V_u / h o d
\]

in which \( V_u \) and \( b_o \) are taken at the critical section specified in the preceding paragraph. The ultimate shear stress,

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1 For transfer of moments and effect of openings see Section 2609 (s).
"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 10 inches.

(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:
   \[
   0.3\phi F_{sp} \sqrt{f_c'} \text{ ........................ (17-8)}
   \]

2. Formula (17-2) shall be replaced by:
   \[
   v_c = \phi \left( 0.28 F_{sp} \sqrt{f_c'} + 2500 \frac{p_{uc} V_d}{M} \right) \text{ ........................ (17-9)}
   \]

3. The limiting value for shearing stress in slabs and footings, "v_u", in Section 2617 (h) shall be:
   \[
   0.6\phi F_{sp} \sqrt{f_c'} \text{ ........................ (17-10)}
   \]

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
   \[
   v_c = \left( 3.7 - \frac{H}{D} \right) 2\phi \sqrt{f_c'} \text{ ........................ (17-11)}
   \]

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
Shear and Diagonal Tension—Ultimate Strength Design (Continued)

\[ A_v = \frac{V'_{us} s}{\phi f_y d \left( \frac{H}{D} - 1 \right)} \] (17-12)

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

\[ v_u = \left( 0.8 + 4.6 \frac{H}{D} \right) \phi \sqrt{f'_c} \] (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.

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).
- \( \Sigma o \) = 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.
- \( i \) = 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:

\[ u_u = \frac{V_u}{\phi \Sigma o i d} \] (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 \( M/\phi \), divided by the product of \( \Sigma_0 \) times the embedment length.

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, except for those designated as Special Large Size Deformed Reinforcing Bars:

\[
\text{Top bars}^1 \quad \frac{6.7\sqrt{f_c}}{D} \quad \text{nor 560 p.s.i.} \\
\text{Bars other than top bars} \quad \frac{9.5\sqrt{f_c}}{D} \quad \text{nor 800 p.s.i.}
\]

2. For tension bars designated as Special Large Size Deformed Reinforcing Bars in U.B.C. Standard No. 26-7:

\[
\text{Top bars}^1 \quad 4.2\sqrt{f_c} \\
\text{Bars other than top bars} \quad 6\sqrt{f_c}
\]

3. For all deformed compression bars:

\[ 13\sqrt{f_c} \text{ nor 800 p.s.i.} \]

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, 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.

**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.
- \( A_t = \) area of tension reinforcement.
- \( A_c = \) area of compression reinforcement.

\(^1\)Top bars, in reference to bond, are horizontal bars so placed that more than 12 inches of concrete is cast in the member below the bar.
\( A_{st} \) = 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

\[ = d \left( \frac{87,000}{87,000 + f_y} \right) . \]

\( d \) = distance from extreme compression fiber to centroid of tension reinforcement.

\( d' \) = 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).

\( m \) = \( f_y / 0.85f_{c'} \).

\( m' = m - 1. \)

\( M_b \) = moment capacity at simultaneous crushing of concrete and yielding of tension steel (balanced conditions) = "\( P_{be} \)".

\( M_u \) = moment capacity under combined axial load and bending.

\( p = A_{st} / bd. \)

\( p' = A_{st}' / bd. \)

\( p_t = A_{st} / A_y. \)

\( P_b \) = 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.
\[ t = \text{over-all depth of a rectangular section or diameter of a circular section.} \]

\[ \phi = \text{capacity reduction factor [see Section 2615 (e)].} \]

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.

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 0.05\( t \) for spirally reinforced columns or 0.10\( t \) 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.

\[ P_u = \phi [0.85 f_c' ba + A_s' f_y - A_s f_y] \quad (19-1) \]

\[ P_{u e'} = \phi \left[ 0.85 f_c' ba \left( d - \frac{a}{2} \right) + A_s' f_y (d - d') \right] \quad (19-2) \]

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

\[
M_b = P_b c_b = \phi \left[ 0.85 f_c' b a_b \left( d - d'' - \frac{a_b}{2} \right) + A_s' f_y (d - d' - d'') + A_s f_y d' \right] \tag{19-3}
\]

The ultimate capacity of a member is controlled by tension in the following paragraph, when "P_u" is less than "P_b" (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:

\[
P_u = \phi \left[ 0.85 f_c' b d \left\{ p'm' - pm + (1 - e'/d) \right\} + \sqrt{(1 - e'/d)^2 + 2[(e'/d)(pm - p'm') + p'm'(1 - d'/d)]} \right] \tag{19-4}
\]

For symmetrical reinforcement in two faces, this reduces to:

\[
P_u = \phi \left[ 0.85 f_c' bd \left\{ -p + 1 - e'/d \right\} + \sqrt{(1 - e'/d)^2 + 2p \left[m'(1 - d'/d) + e'/d\right]} \right] \tag{19-5}
\]

With no compression reinforcement, Formula (19-4) reduces to:

\[
P_u = \phi \left[ 0.85 f_c' bd \left\{ -pm + 1 - e'/d \right\} + \sqrt{(1 - e'/d)^2 + 2 \frac{e' pm}{d}} \right] \tag{19-6}
\]

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:

\[ P_o = \phi [0.85f'_c (A_g - A_{st}) + A_{stf_y}] \quad \text{(19-7)} \]

For this assumption the ultimate strength is given by either Formula (19-8) or (19-9):

\[
P_u = \frac{P_o}{1 + \left( \frac{P_o}{P_b} - 1 \right) \frac{e}{e_b}} \quad \text{(19-8)}
\]

\[
P_u = P_o - \left( P_o - P_b \right) \frac{M_u}{M_b} \quad \text{(19-9)}
\]

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:

\[
P_u = \phi \left[ \frac{A_{stf_y}}{e} + \frac{b t f'_c}{d - d'} + 0.5 \left( \frac{3}{d^2} \right) + 1.18 \right] \quad \text{(19-10)}
\]

(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:

\[
P_u = \phi \left\{ 0.85f'_c D^2 \left[ \sqrt{\left( \frac{0.85e}{D} - 0.38 \right)^2 + \frac{p_m D_s}{2.5D}} \right] - \left( \frac{0.85e}{D} - 0.38 \right) \right\} \quad \text{(19-11)}
\]

When compression controls:

\[
P_u = \phi \left[ \frac{A_{stf_y}}{3e} + \frac{A_{ofc'}}{D_s + 1} \left( \frac{9.6D_e}{(0.8D + 0.67D_s)^2} + 1.18 \right) \right] \quad \text{(19-12)}
\]

(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:
When compression controls:

$$P_u = \phi \left\{ 0.85 \frac{bt f_c'}{t} \sqrt{\left( \frac{e}{t} - 0.5 \right)^2 + 0.67 \frac{D_s}{t}} - \left( \frac{e}{t} - 0.5 \right) \right\} \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots (19-13)$$

When 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).

$$P_u = \phi \left\{ \frac{\Delta_s f_y}{3e} + \frac{\Delta_s f_c'}{D_s + 1} + \frac{12te}{(t + 0.67D_s)^2} + 1.18 \right\} \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots (19-14)$$

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 (\(\frac{1}{2}''\)) 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 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 (\(3\frac{1}{2}''\)) 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).

\(^1\)The requirements of this Section are satisfied by any of the methods of design shown in U.B.C. Standard No. 26-17.
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.
- **bo** = 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.
- **fc'** = 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 “Ic” required by Formula (21-1).
- **L** = span length of a flat slab panel center to center of supports.
- **Mo** = numerical sum of assumed positive and average negative moments at the critical design sections of a flat slab panel [see Section 2621 (e) 6].
- **Rn** = factor for increasing negative moment. [Section 2621 (e), Formula (21-2)].
- **Rp** = factor for increasing positive moment. [Section 2621 (e), Formula (21-3)].
- **t** = thickness in inches of slab at center of panel.
- **t1** = thickness in inches of slab without drop panels, or through drop panel, if any.
- **t2** = 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.
- **Wp** = total dead load on panel.
- **Wl** = 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 4 inches 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:

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
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.

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 4 inches in thickness.

Slabs without drop panels as described above shall be not less than L/36 nor 5 inches 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 6 inches 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:

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 1.5t 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.

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.

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 125 feet high with maximum story height not exceeding 12 feet 6 inches.

2. **Columns.** The minimum dimension of any column shall be as determined by the following paragraphs, but in no case less than 10 inches.

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\(^4\) \((1000''^4)\).

\[
I_c = \frac{t^3H}{0.5 + \frac{W_D}{W_L}} \quad (21-1)
\]

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

\[ R_n = 1 + \frac{(1 - K)^2}{2.2 (1 + 1.4W_D/W_L)} \]  \hspace{1cm} (21-2)

For positive moments

\[ R_p = 1 + \frac{(1 - K)^2}{1.2 (1 + 0.10W_D/W_L)} \]  \hspace{1cm} (21-3)

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 1½ inches 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 “t1” or “t2” 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:

\[ L/36 \] 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 5 inches nor “t1” as given in Formula (21-4).

\[ L/40 \] for slabs with drop panels conforming to paragraph 5 at all supports, but not less than 4 inches nor “t2” as given in Formula (21-5).

The total thickness, “t1”, in inches, of slabs without drop panels, or through the drop panel if any, shall be at least

\[
t_1 = 0.028L \left(1 - \frac{2c}{3L}\right) \sqrt{\frac{w}{f_c'/2000}} + 1\frac{1}{2} \ldots (21-4)
\]

The total thickness, “t2”, in inches, of slabs with drop panels, at points beyond the drop panel shall be at least

\[
t_2 = 0.024L \left(1 - \frac{2c}{3L}\right) \sqrt{\frac{w}{f_c'/2000}} + 1 \ldots (21-5)
\]

Where the exterior supports provide only negligible restraint to the slab, the values of “t1” and “t2” 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 1.5t2.

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 (t1 + t2)/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

\[^1\] In these formulas “t1” and “t2” are in inches, “L” and “c” are in feet, and “w” is in pounds per square foot.
\[ M_o = 0.09 \, WLF \left( 1 - \frac{2c}{3L} \right)^2 \]  

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.

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.

Sec. 2622. (a) Notations. The notations used in these regulations are defined as follows:

\( f_c = \) allowable compressive stress on concrete.
Reinforced Concrete Walls (Continued)

\[ f_c' = \text{compressive strength of concrete (see Section 2603).} \]
\[ h = \text{clear distance between supporting or enclosing members (vertical or horizontal stiffening elements).} \]
\[ t = \text{thickness of wall.} \]

(b) **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.

(c) **Height and Thickness.** Reinforced concrete bearing walls shall have a minimum thickness of not less than 6 inches nor a thickness less than 1/25 of the shorter unsupported 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 4 inches 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 2 inches 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.

(d) **Design and Reinforcement.** The maximum allowable compressive stress for working stress design using Sections 2610 through 2614 shall not exceed

\[ f_c = 0.225f_c' \left[ 1 - \left( \frac{h}{40t} \right)^3 \right] \] ............(22-1)

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 or the area 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 18 inches 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 24 inches beyond the corner of the openings.

Walls more than 10 inches 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 2 inches, specified in Section 2608 (h), nor more than one-third the thickness of the wall from the exterior surface.

The other layer, comprising the balance of the required reinforcement, shall be placed not less than 3/4 inch and not more than one-third the thickness of the wall from the interior surface.

Reinforced concrete walls shall be anchored as specified in Section 2313.

(e) 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-resistant time-period rating set forth in Table No. 43-B.

EXCEPTION: Where panels are designed to span horizontally to columns or isolated footings, the effects of deep beam action and buckling shall be provided for in the design and the ratio of height to thickness shall not exceed 36 for bearing or shear walls and shall not exceed 48 for other walls.

2. Reinforcement. The provisions of Subsection (d) shall govern the minimum requirements for reinforcing steel.

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 stresses on horizontal joints between precast and poured elements shall not exceed that specified in Section 2625 (f) 2. On vertical joints or where shear is transferred through a mortar bed, the shear stress 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. 26-1 may be used.

Sec. 2623. (a) Scope. The requirements prescribed in Section 2623 (b) through (i) apply only to isolated 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.
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.

\[
\text{Reinforcement in band-width (B)} = \frac{2}{S + 1}, \quad (23-1)
\]

Total reinforcement in short direction

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.

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 (1/8").

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.
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 0.25fc. 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 $1.6\sqrt{fc}$ for design by Sections 2610 to 2614 or $3.2\sqrt{fc}$ 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).

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.
(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 (\( \frac{5}{8} \)).

(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.

Sec. 2625. (a) Notations. The notations used in these regulations are defined as follows:

\[ b' = \text{width of area of contact between precast and cast-in-place concretes.} \]
\[ d_p = \text{effective depth of the tension reinforcement in precast component.} \]
\[ I = \text{moment of inertia of the transformed composite section neglecting area of concrete in tension.} \]
\[ M_D = \text{moment due to dead load, produced prior to the time at which the cast-in-place concrete attains 75 per cent of its specified 28-day strength.} \]
\[ M_L = \text{moment due to live load and superimposed dead load.} \]
\[ Q = \text{statical moment of the transformed area outside of the contact surface about the neutral axis of the composite section.} \]
\[ V = \text{total shear.} \]
\[ v_h = \text{horizontal shear stress along contact surface.} \]
(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.

(e) **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) **Flexural 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.

2. **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:

\[(1.15 + 0.24 \frac{M_{L}}{M_{D}})d_{p}\]

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.

3. **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:

\[v_{h} = \frac{VQ}{lb'} \]  

(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.

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 3 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 24 inches. 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:

\[ a = \frac{\Delta_{fsu}}{0.85 f'_{c}} b \]

\[ A_b = \text{bearing area of anchor plate of post-tensioning steel.} \]

\[ A_{b'} = \text{maximum area of the portion of the anchorage surface that is geometrically similar to and concentric with the area of the anchor plate of the posttensioning steel.} \]

\[ A_s = \text{area of prestressed tendons.} \]

\[ A_{st} = \text{area of reinforcement to develop compressive strength of overhanging flanges in flanged members.} \]

\[ A_{sr} = \text{area of tendon required to develop the web.} \]

\[ A'_r = \text{area of unprestressed reinforcement.} \]

\[ A_v = \text{area of web reinforcement placed perpendicular to the axis of the member.} \]

\[ b = \text{width of compression face of flexural member.} \]

\[ b' = \text{minimum width of web of a flanged member.} \]

\[ d = \text{distance from extreme compression fiber to centroid of the prestressing force.} \]

\[ f'_c = \text{compressive strength of concrete (see Section 2603).} \]

\[ f_{ci} = \text{compressive strength of concrete at time of initial prestress.} \]
$f_{cp}$ = 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.

$f_{pc}$ = 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.

$f_{sc}$ = 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.

$K$ = 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.

$M_{cr}$ = 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.

$T_0$ = 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.

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1The 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.
\[ V_c = \text{shear carried by concrete.} \]
\[ V_{ei} = \text{shear at diagonal cracking due to all loads, when such cracking is the result of combined shear and moment.} \]
\[ V_{ew} = \text{shear force at diagonal cracking due to all loads, when such cracking is the result of excessive principal tension stresses in the web.} \]
\[ V_d = \text{shear due to dead load.} \]
\[ V_p = \text{vertical component of the effective prestress force at the section considered.} \]
\[ V_u = \text{shear due to specified ultimate load.} \]
\[ y = \text{distance from the centroidal axis of the section resisting the applied loads to the extreme fiber in tension.} \]
\[ \alpha = \text{total angular change of prestressing steel profile in radians from jacking end to any point \textquotedblright} x\text{\textquotedblright}.} \]
\[ e = \text{base of Naperian logarithms.} \]
\[ \mu = \text{curvature friction coefficient.} \]
\[ \phi = \text{capacity reduction factor [see Section 2615 (e)].} \]

(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.

FRICITION, CURVATURE FRICITION, is friction resulting from bends or curves in the specified cable profile.

FRICITION, WOBBLE FRICITION, 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).

POSTTENSIONING 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.
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 (e), 2609 (j), 2609 (l), 2613, 2614, 2615 (i), 2618, 2620 (a) first paragraph, 2621, and 2625 (c) 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 posttensioned 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:

<table>
<thead>
<tr>
<th>Stress Type</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>$0.60 \sigma_{ci}'$</td>
</tr>
<tr>
<td>Tension in members without auxiliary reinforcement (unprestressed or prestressed) in the tension zone</td>
<td>$3\sqrt{f_{ci}'}$</td>
</tr>
</tbody>
</table>
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.

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 anchorages in posttensioned concrete with adequate reinforcement in the end regions shall not exceed:

$$f_{cp} = 0.6f_{c'} \sqrt{A_b/A_b}$$

but not greater than $f_{c'}$.

(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.

2. Effective prestress.................................................... $0.70 f_s'$
   or $0.80 f_{su}$ 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.
5. Relaxation of steel stress.
6. Frictional loss due to intended or unintended curvature in the tendons.

Friction losses in posttensioned 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.
When \((KL + \mu \alpha)\) is not greater than 0.3, Formula (26-3) may be used.

\[
T_o = T_x (1 + KL + \mu \alpha) \text{(26-3)}
\]

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:

\[
M_u = \phi \left[ \frac{A_s f_{su} d (1 - 0.59 \alpha)}{A_d} \right] = \phi \left[ A_s f_{su} \left( d - \frac{a}{2} \right) \right]
\]

\[
(26-4)
\]

Flanged sections in which the neutral axis falls outside the flange:

\[
M_u = \phi \left[ A_s f_{su} d \left( 1 - \frac{0.59 A_{sr} f_{su}}{b'd f_c} \right) \right] + 0.85 f' (b' - b') t (d - 0.5t)
\]

\[
(26-5)
\]

**WHERE:**

\[
A_{sr} = A_s - A_{sf}
\]

AND

\[
A_{sf} = 0.85 f' (b - b') t / f_{su}
\]

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

\[
f_{su} = f' (1 - 0.5 p f_{ss}/f_c') \text{ (26-6)}
\]

Unbonded members

\[
f_{su} = f_{se} + 15,000 \text{ p.s.i. (26-7)}
\]

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

\[
\frac{p f_{su}}{f_c} + \frac{p' f_y}{f_c'} \text{ does not exceed 0.3}
\]

**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.

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

\[ M_u = \phi[0.25 f'c'bd^2] \] (26-8)

Flanged sections in which the neutral axis falls outside the flange

\[ M_u = \phi[0.25 f'c'bd^2 + 0.85f'c' (b - b')t (d - 0.5t)] \] (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:

\[ A_v = \frac{(V_u - \phi V_c)s}{\phi df_y} \] (26-10)

nor less than

\[ A_v = \frac{A_s f_s' s}{80f_y} \cdot \frac{\sqrt{d}}{b'} \] (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
$V_{ei} = 0.6 \, b'd \, \sqrt{f_c'} + \frac{M_{cr}}{M - \frac{d}{V}} + V_d \quad \ldots \ldots (26-12)$

but not less than $1.7 \, b'd \, \sqrt{f_c'}$.

**WHERE:**

$$M_{cr} = \frac{l}{y} \left( 6 \, \sqrt{f_c'} + f_{pc} - f_d \right)$$

$$V_{cw} = b'd \left( 3.5 \, \sqrt{f_c'} + 0.3f_{pc} \right) + V_p \ldots (26-13)$$

For lightweight aggregate concrete

$$V_{ei} = 0.1 \, F_{sp} \, b'd \, \sqrt{f_c'} + \frac{M_{cr}}{M - \frac{d}{V}} + V_d \quad \ldots \ldots (26-12A)$$

but not less than $0.25 \, F_{sp} \, b'd \, \sqrt{f_c'}$.

**WHERE:**

$$M_{cr} = \frac{l}{y} \left( 0.9F_{sp} \, \sqrt{f_c'} + f_{pc} - f_d \right)$$

$$V_{cw} = b'd \left[ 0.5 \, F_{sp} \, \sqrt{f_c'} + f_{pc} \left( 0.2 + \frac{F_{sp}}{677} \right) \right] + V_p \quad \ldots \ldots \ldots (26-13A)$$

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 $0.6F_{sp}\sqrt{f_c'}$ 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.

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 24 inches, 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:

$\left( \frac{f_{su}}{2} - \frac{f_{se}}{3} \right) D$

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.
(o) **End Regions.** End blocks shall be provided if necessary for end bearing or for distribution of concentrated pre-stressing 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.

<table>
<thead>
<tr>
<th>COVER (in Inches)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete surfaces in contact with ground</td>
<td>2</td>
</tr>
<tr>
<td>Beams and girders</td>
<td></td>
</tr>
<tr>
<td>Prestressing steel and main reinforcing bars</td>
<td>1 1/2</td>
</tr>
<tr>
<td>Stirrups and ties</td>
<td>1</td>
</tr>
<tr>
<td>Slabs and joists exposed to weather</td>
<td>1</td>
</tr>
<tr>
<td>Slabs and joists not exposed to weather</td>
<td>3/4</td>
</tr>
</tbody>
</table>

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 posttensioning 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 1/4 inch larger than the diameter of the posttensioning bar or large enough to
produce an internal area at least twice the gross area of wires, strands, or cables.

(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 \( \frac{3}{8} \)-inch strands and smaller, and 3500 pounds per square inch for \( \frac{5}{8} \)-inch and \( \frac{3}{4} \)-inch 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 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-
don elongation and also (2) either by checking jack pressure
on a recently calibrated gauge or by the use of a recently cali-
brated dynamometer. The cause of any discrepancy which
exceeds five per cent shall be ascertained and corrected. Elon-
gation requirements shall be taken from average load-elon-
gation 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 ten-
dons 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) Posttensioning Anchorages and Couplers. Anchor-
ages, couplers, and splices for posttensioned 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 hous-
ings 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 dam-
age during release of the prestressing force.

Forms for posttensioned members shall be constructed to
minimize resistance to the shortening of the member. Deflec-
tion 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 concentra-
tions, 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.

**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.

**Sec. 2628.** Bolts shall be solidly embedded in plain or reinforced concrete, and the connection shall be designed so that the shear or tension on every bolt is not more than the value set forth in Table No. 26-I.

**Sec. 2629.** The minimum thickness of concrete floor slabs supported directly on the ground shall be not less than 3½ inches.

**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.
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:

\[ U = 1.40 (D + L + E) \]  
\[ U = .90 D + 1.25 E \]  

(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.
- \( P_d \) = maximum design axial load on column.
- \( p \) = tension reinforcement ratio.
- \( p' \) = compression reinforcement ratio.
- \( D \) = nominal diameter of bar, inches.
- \( \Sigma \xi \) = 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 A615 billet-steel bars conforming to U.B.C. Standard No. 26-7. For flexural members only A615 Grade 40 billet-steel bars shall be used. Sizes 14 and 18 reinforcing bars when
bent more than 10 degrees shall meet the 90-degree bend test requirements for A615 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.

(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 \( \frac{200}{f_y} \) throughout their length. At least two bars shall be provided both top and bottom. The tension reinforcement ratio, \( p_\text{t} \), shall not exceed 0.025 nor \( 0.46 \frac{f_c}{f_y} \), 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:

\[
L = \frac{A_{sfy}}{1.5f_y \Sigma \sigma} \tag{30-3}
\]

including hook and vertical extension, but not less than 24 inches.

When framing into only one side of a column, which resists 25 per cent or more of the story-bent shear, main
flexural reinforcement shall be capable of being anchored, without horizontal offsets, within the confined column core. For other cases, at least 50 per cent of such reinforcement shall be anchored within such column cores and the remainder shall be anchored in regions outside the column core confined as specified herein for columns.

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:

\[
M_{uA} + M_{uB} + 1.4 V_{D+L} \leq \frac{M_{u}}{l}
\]

where “\(M_{uA}\)” and “\(M_{uB}\)” 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 12 inches, 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 2 inches 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 12 inches.

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 16 inches. 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 24 inches.

4. Special transverse reinforcement. The cores of columns shall be confined by special transverse reinforcement as specified herein or as required to meet shear requirements.
A. The volumetric ratio of spiral reinforcement shall be not less than that required in Section 2609 (1) or \( p'' = \frac{f'_c}{f''_{y}} \)

whichever is greater.

B. The total cross-sectional area \( (A''_{sh}) \) of rectangular hoop reinforcement shall be not less than

\[
A''_{sh} = 0.45 ah'' \frac{f'_c}{f''_{y}h} \left( \frac{A_g}{A_c} - 1 \right) \text{ nor } A''_{sh} = 0.12 ah'' \frac{f'_c}{f''_{y}h}
\]

whichever is greater.

WHERE:

- \( a \) = center to center spacing of hoops in inches with a maximum of 4 inches.
- \( A_c \) = area of column core.
- \( A_g \) = gross area of column.
- \( A''_{sh} \) = total cross-sectional area in square inches of hoop reinforcement having a spacing of \( (a) \) inches and crossing a section having a core dimension of \( h'' \).
- \( h'' \) = core dimension of tied column in inches.
- \( f''_{y}h \) = yield strength of hoop reinforcement.

Single or overlapping hoops may be provided to meet this requirement. Supplementary ties using standard hooks engaging both hoops and vertical bars may be used up to 25 per cent of the required area. The minimum size of reinforcing steel for hoops and supplementary ties shall be No. 3 bars.

C. Special transverse reinforcement shall be provided in that portion of the column over a length equal to the maximum column dimension or one-sixth of the clear height of the column, but not less than 18 inches from either face of the joint.

D. At any section where the ultimate capacity of the column \( (P_u) \) is less than the sum of the shears \( (\Sigma V_u) \) computed by Formula (30-4) for all the beams framing into the column from all directions above the level under consideration, special transverse reinforcement shall be provided. For beams framing into opposite sides of the column, the moment components of Formula (30-4) may be assumed to be of opposite sign. For the purpose of this determination the factor 1.4 in Formula (30-4) may be changed to 1.1. For determination of \( P_u \), the moments resulting from Formula (30-4) may be assumed to result from deformation of the frame in any one principal axis.

E. Columns which support discontinuous shear walls, braced frames, or other rigid elements shall have special transverse reinforcement for the full height of the supporting columns.

F. Special transverse reinforcement shall be provided through the beam column joint.
SECTION 2630

Ductile Moment-Resisting Space Frames—Seismic Zones No. 2 and No. 3 (Continued)

EXCEPTION: Special transverse reinforcement of one-half of the amount otherwise required by Subsection (f) 4 and 5 shall be required within the joint, determined 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 of a tied column, unconfined by flexural members, exceeds 4 inches, the full special transverse reinforcement shall be provided through the joint.

G. Where confinement of the concrete through the joint is effected, as provided herein, the provisions of Section 2609 (p) 3 shall be assumed to apply.

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”.

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_u” 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 “\( \frac{1}{2} \)” shall be omitted if only one column frames into the top connection.
\[ V_c = v_c \cdot h d \] where "\( v_c \)" shall be in accordance with Section 2617 (b) except that "\( v_c \)" shall be considered zero when \( P_{u0}/A_v \leq 0.12 \cdot f_c \).

\[ s = \text{spacing, } \leq \frac{1}{2} \text{ minimum column dimension.} \]

\[ A_v = \text{total cross-sectional area of special transverse reinforcement in tension within a distance "} s", \text{ except that two-thirds of such area shall be used in the case of circular spirals.} \]

7. **Design limitations.** At any beam-column connection where \( P_{u0}/A_v \geq 0.12 \cdot f_c \), 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 \( P_{u0}/A_v \leq 0.12 \cdot f_c \), 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).

(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.

**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 2 inches from the column face. The next six stirrups shall be spaced 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 4 inches 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 2 inches 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.

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. See Table No. 26-D — Working Stress Design Shear Values.

3. Formulas (15-2) and (15-3) of Section 2615 (g) for earthquake loading shall be modified to:

\[
U = 1.4 (D + L + E) \quad \text{(32-1)}
\]

\[
U = 0.9 D + 1.25 E \quad \text{(32-2)}
\]

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 A36, A440, A441, A572 (except Grades 60 and 65) or A588 Grades A, B or C, 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.

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.

**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.
(b) **Wall Thickness.** The thickness of plain concrete walls may be 2 inches less than required by Section 2417 (b) for plain masonry walls but in no case less than 7 inches, 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:

<table>
<thead>
<tr>
<th>Type</th>
<th>Allowable Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>(0.25 f'_c)</td>
</tr>
<tr>
<td>Tension</td>
<td>(1.6\sqrt{f'_c})</td>
</tr>
<tr>
<td>Shear</td>
<td>(0.02 f'_c)</td>
</tr>
</tbody>
</table>
**TABLE NO. 26-A—MAXIMUM PERMISSIBLE WATER-CEMENT RATIOS FOR CONCRETE (METHOD NO. 1)**

<table>
<thead>
<tr>
<th>SPECIFIED COMpressive STRENGTH AT 28 DAYS, P.S.I. $f_{c'}$</th>
<th>MAXIMUM PERMISSIBLE WATER-CEMENT RATIO</th>
<th>NONAIR-ENTRAINED CONCRETE</th>
<th>AIR-ENTRAINED CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. GAL. PER 94-LB. BAG OF CEMENT</td>
<td>ABSOLUTE RATIO BY WEIGHT</td>
<td>U.S. GAL. PER 94-LB. BAG OF CEMENT</td>
<td>ABSOLUTE RATIO BY WEIGHT</td>
</tr>
<tr>
<td>2000</td>
<td>$7^{1/2}$</td>
<td>0.663</td>
<td>7</td>
</tr>
<tr>
<td>2500</td>
<td>$7^{1/4}$</td>
<td>0.642</td>
<td>$6^{3/4}$</td>
</tr>
<tr>
<td>3000</td>
<td>$6^{1/2}$</td>
<td>0.576</td>
<td>$5^{3/4}$</td>
</tr>
<tr>
<td>3500</td>
<td>$5^{3/4}$</td>
<td>0.510</td>
<td>$4^{3/2}$</td>
</tr>
<tr>
<td>4000</td>
<td>5</td>
<td>0.443</td>
<td>4</td>
</tr>
</tbody>
</table>

1The 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).

2Including free surface moisture on aggregates.

**TABLE NO. 26-B—MINIMUM RADII OF BEND**

<table>
<thead>
<tr>
<th>MINIMUM RADII</th>
<th>BAR SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 3, No. 4, or No. 5</td>
<td>$2^{1/2}$ bar diameters</td>
</tr>
<tr>
<td>No. 6, No. 7, or No. 8</td>
<td>3 bar diameters</td>
</tr>
<tr>
<td>No. 9, No. 10, or No. 11</td>
<td>4 bar diameters</td>
</tr>
<tr>
<td>No. 14S or No. 18S</td>
<td>5 bar diameters</td>
</tr>
</tbody>
</table>

1Special 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.

**TABLE NO. 26-C—MINIMUM THICKNESS OR DEPTH OF FLEXURAL MEMBERS UNLESS DEFLECTIONS ARE COMPUTED**

<table>
<thead>
<tr>
<th>MEMBER</th>
<th>SIMPLY SUPPORTED</th>
<th>ONE END CONTINUOUS</th>
<th>BOTH ENDS CONTINUOUS</th>
<th>CANTILEVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-way slabs</td>
<td>$l/25$</td>
<td>$l/30$</td>
<td>$l/35$</td>
<td>$l/12$</td>
</tr>
<tr>
<td>Beams</td>
<td>$l/20$</td>
<td>$l/23$</td>
<td>$l/26$</td>
<td>$l/10$</td>
</tr>
</tbody>
</table>
### TABLE NO. 26-D—ALLOWABLE STRESSES IN CONCRETE

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FOR ANY STRENGTH OF CONCRETE IN ACCORDANCE WITH SECTION 2605 (c)</th>
<th>ALLOWABLE STRESSES IN P.S.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$f'_c = 2000$</td>
</tr>
<tr>
<td>Modulus of elasticity ratio: $n$</td>
<td>$29,000,000 \over w^{1.533} \sqrt{f'_c}$</td>
<td>11</td>
</tr>
<tr>
<td>For concrete weighing 145 lb. per cu. ft. [See Section 2611 (c)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexure: $f_c$</td>
<td></td>
<td>900</td>
</tr>
<tr>
<td>Extreme fiber stress in compression</td>
<td>$f_c$</td>
<td>0.45$f'_c$</td>
</tr>
<tr>
<td>Extreme fiber stress in tension in plain concrete footings and walls</td>
<td>$f_c$</td>
<td>$1.6 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>Shear: $v$ (as a measure of diagonal tension at a distance “$d$” from the face of the support)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beams with no web reinforcement</td>
<td>$v_c$</td>
<td>$1.1 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>Joists with no web reinforcement</td>
<td>$v_c$</td>
<td>$1.2 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>Members with vertical or inclined web reinforcement or properly combined bent bars and vertical stirrups</td>
<td>$v$</td>
<td>$5 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>Slabs and footings [peripheral shear, Section 2612 (h)]</td>
<td>$v_c$</td>
<td>$2 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Shear in Walls Resisting other than Seismic Forces:</td>
<td>$v_c$</td>
<td>$3 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>Shear carried by concrete$^3$</td>
<td>$v_c$</td>
<td>$1.1 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>H/D ≤ 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H/D ≥ 2.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear carried by concrete and reinforcement$^4$</td>
<td>$v$</td>
<td>$3 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>H/D ≤ 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H/D ≥ 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing: $f_c$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On full area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On one-third area or less$^5$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.375$f'_c$</td>
<td></td>
<td>750</td>
</tr>
<tr>
<td>Shear in walls resisting seismic forces in buildings with a 100% moment resisting space frame:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear carried by concrete$^3$</td>
<td>$v_c$</td>
<td>$2.5 \sqrt{f'_c}$</td>
</tr>
<tr>
<td>H/D ≤ 1</td>
<td></td>
<td></td>
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<tr>
<td>H/D ≥ 2.7</td>
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<tr>
<td>Shear carried by concrete and reinforcement$^4$</td>
<td>$v$</td>
<td>$2.5 \sqrt{f'_c}$</td>
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<tr>
<td>H/D ≤ 1</td>
<td></td>
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<td>H/D ≥ 2</td>
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<td>(Continued)</td>
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</tbody>
</table>
TABLE NO. 26-D (Continued)

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FOR ANY STRENGTH OF CONCRETE IN ACCORDANCE WITH SECTION 2605 (c)</th>
<th>ALLOWABLE STRESSES IN P.S.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f'_c = 2000$</td>
<td>$f'_c = 2500$</td>
</tr>
<tr>
<td>Shear in walls resisting seismic forces in buildings without a 100% moment resisting space frame.</td>
<td>$v_c = 1.25 \sqrt{f'_c}$</td>
<td>56</td>
</tr>
<tr>
<td>Shear carried by concrete</td>
<td>$v_c = 0.45 \sqrt{f'_c}$</td>
<td>20</td>
</tr>
<tr>
<td>H/D $\leq 2.7$</td>
<td>$v = 1.25 \sqrt{f'_c}$</td>
<td>56</td>
</tr>
<tr>
<td>H/D $\leq 2$</td>
<td>$v = 2.30 \sqrt{f'_c}$</td>
<td>103</td>
</tr>
</tbody>
</table>

1For shear values for lightweight aggregate concrete see Section 2612 (i).
2The stresses indicated may be increased one-third when caused by wind forces.
3For values between "H/D" of 1.0 and 2.7, the allowable shear varies linearly. For lightweight concrete multiply tabulated values by .15 $F_{sp}$.
4For values between "H/D" of 1.0 and 2.0, the allowable shear varies linearly.
5This 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.
6The stresses indicated may be increased one-third when caused by seismic forces.

TABLE NO. 26-E—MINIMUM SLAB THICKNESS

<table>
<thead>
<tr>
<th>$f'_u$</th>
<th>WITH DROP PANELS</th>
<th>WITHOUT DROP PANELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>40,000</td>
<td>L/40 or 4 inches</td>
<td>L/36 or 5 inches</td>
</tr>
<tr>
<td>50,000</td>
<td>L/36 or 4 inches</td>
<td>L/33 or 5 inches</td>
</tr>
<tr>
<td>60,000</td>
<td>L/33 or 4 inches</td>
<td>L/30 or 5 inches</td>
</tr>
</tbody>
</table>

1To 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.”

<table>
<thead>
<tr>
<th>STRIP</th>
<th>COLUMN HEAD</th>
<th>SIDE SUPPORT TYPE</th>
<th>END SUPPORT TYPE</th>
<th>EXTERIOR PANEL</th>
<th>INTERIOR PANEL</th>
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<td>EXTERIOR</td>
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<td>POSITIVE</td>
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<td>MOMENT</td>
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<td>POSITIVE</td>
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<td>MOMENT</td>
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<td>MOMENT</td>
<td>MOMENT</td>
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<td>POSITIVE</td>
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<td>MOMENT</td>
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<td>POSITIVE</td>
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<td>MOMENT</td>
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<td>POSITIVE</td>
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<td>MOMENT</td>
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<td>POSITIVE</td>
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<td>MOMENT</td>
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<td>POSITIVE</td>
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</tbody>
</table>
|                        |                   |                   |                  |Moments in Flat Slab Panels in Percentages of “M.” (Continued)
<table>
<thead>
<tr>
<th>STRIP</th>
<th>COLUMN HEAD</th>
<th>SIDE SUPPORT TYPE</th>
<th>END SUPPORT TYPE</th>
<th>EXTERIOR PANEL</th>
<th>INTERIOR PANEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EXTERIOR MOMENT</td>
<td>POSITIVE MOMENT</td>
</tr>
<tr>
<td>Half column strip adjacent to marginal beam or wall</td>
<td>With drop</td>
<td>3</td>
<td>A</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Without drop</td>
<td>1</td>
<td>A</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Half column strip adjacent to marginal beam or wall</td>
<td>Without drop</td>
<td>3</td>
<td>A</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>
### TABLE NO. 26-F (Continued)

<table>
<thead>
<tr>
<th>PERCENTAGE OF PANEL LOAD TO BE CARRIED BY MARGINAL BEAM OR WALL IN ADDITION TO LOADS DIRECTLY SUPERIMPOSED THEREON</th>
<th>SIDE SUPPORT PARALLEL TO STRIP</th>
<th>TYPE OF SUPPORT LISTED IN TABLE NO. 26-F</th>
<th>SIDE OR END EDGE CONDITION OF SLABS OF DEPTH &quot;t&quot;</th>
<th>END SUPPORT AT RIGHT ANGLES TO STRIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Columns with no beams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>Columns with beams of total depth $1{1/4}t$</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>Columns with beams of total depth $3t$ or more</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforced concrete bearing walls integral with slab</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Masonry or other walls providing negligible restraint</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

*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 26-2.*
<table>
<thead>
<tr>
<th>PANEL</th>
<th>INTERIOR</th>
<th>EXTERIOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SUPPORT</td>
<td>CENTER</td>
</tr>
<tr>
<td></td>
<td>OF SPAN</td>
<td>SUPPORT</td>
</tr>
<tr>
<td>END SUPPORT</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>MARGINAL</td>
<td>-12</td>
<td>+6</td>
</tr>
<tr>
<td>COLUMN STRIP</td>
<td>-19</td>
<td>+11</td>
</tr>
<tr>
<td>MIDDLE STRIP</td>
<td>-23</td>
<td>+11</td>
</tr>
<tr>
<td>COLUMN STRIP</td>
<td>-16*</td>
<td>+16</td>
</tr>
</tbody>
</table>

Fig. No. 26-1—Moments in flat slab panels in percentages of $M_0$. 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.
### Fig. No. 26-2—Moments in flat slab panels in percentages of $M_e$.—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.*
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.

<table>
<thead>
<tr>
<th>MARK</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.33L</td>
<td>0.30L</td>
<td>0.27L</td>
<td>0.25L</td>
<td>0.20L</td>
<td>0.15L</td>
<td></td>
</tr>
</tbody>
</table>

At interior supports, L is longer of adjacent spans.
### TABLE NO. 26-G—DISTRIBUTION BETWEEN COLUMN STRIPS AND MIDDLE STRIPS IN PER CENT OF TOTAL MOMENTS AT CRITICAL SECTIONS OF A PANEL

<table>
<thead>
<tr>
<th>STRIP</th>
<th>MOMENT SECTION</th>
<th>NEGATIVE MOMENT AT EXTERIOR SUPPORT</th>
<th>POSITIVE MOMENT</th>
<th>SLAB SUPPORTED ON COLUMNS AND ON BEAMS OF TOTAL DEPTH EQUAL TO THE SLAB THICKNESS¹</th>
<th>SLAB SUPPORTED ON REINFORCED CONCRETE BEARING WALL OR COLUMNS WITH BEAMS OF TOTAL DEPTH EQUAL OR GREATER THAN 3 TIMES THE SLAB THICKNESS¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column strip</td>
<td>76</td>
<td>60</td>
<td>80</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Middle strip</td>
<td>24</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Half column strip adjacent and parallel to marginal beam or wall</td>
<td>38</td>
<td>30</td>
<td>40</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Total depth of beam equal to slab thickness¹</td>
<td>19</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Total depth of beam or wall equal to or greater than 3 times slab thickness¹</td>
<td>38</td>
<td>30</td>
<td>40</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

¹Interpolate 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.
TABLE NO. 26-H-1—MINIMUM LENGTH OF NEGATIVE REINFORCEMENT

<table>
<thead>
<tr>
<th>STRIP</th>
<th>MINIMUM DISTANCE BEYOND CENTER LINE OF SUPPORT TO END OF STRAIGHT BAR OR TO BEND POINT OF BENT BAR&lt;sup&gt;1&lt;/sup&gt;</th>
<th>FLAT SLABS WITHOUT DROP PANELS</th>
<th>FLAT SLABS WITH DROP PANELS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PERCENTAGE OF REQUIRED REINFORCING STEEL AREA TO BE EXTENDED AT LEAST AS INDICATED</td>
<td>STRAIGHT</td>
<td>STRAIGHT</td>
</tr>
<tr>
<td>Column strip reinforcement</td>
<td>Not less than 33 per cent</td>
<td>0.30L&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.33L&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Not less than an additional 34 per cent</td>
<td>0.27L&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.30L&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Remainder&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.25L or 0.20L</td>
<td>0.25L or To edge of drop but at least 0.20L</td>
</tr>
<tr>
<td>Middle strip reinforcement</td>
<td>Not less than 50 per cent</td>
<td>0.25L</td>
<td>0.25L</td>
</tr>
<tr>
<td></td>
<td>Remainder&lt;sup&gt;4&lt;/sup&gt;</td>
<td>0.25L or 0.15L</td>
<td>0.25L or 0.15L</td>
</tr>
</tbody>
</table>

<sup>1</sup>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.

<sup>2</sup>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.

<sup>3</sup>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.

<sup>4</sup>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 350-351).
## TABLE NO. 26-H-2—MINIMUM LENGTH OF POSITIVE REINFORCEMENT

<table>
<thead>
<tr>
<th>STRIP</th>
<th>MAXIMUM DISTANCE FROM CENTER LINE OF SUPPORT TO END OF STRAIGHT BAR OR BEND POINT OF BENT BAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FLAT SLABS WITHOUT DROP PANELS</td>
</tr>
<tr>
<td></td>
<td>STRAIGHT</td>
</tr>
<tr>
<td>Column strip reinforcement</td>
<td>Not less than 33 per cent</td>
</tr>
<tr>
<td></td>
<td>Not less than 50 per cent</td>
</tr>
<tr>
<td></td>
<td>Remainder</td>
</tr>
<tr>
<td>Middle strip reinforcement</td>
<td>50 per cent</td>
</tr>
<tr>
<td></td>
<td>50 per cent</td>
</tr>
</tbody>
</table>

1Bars 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.
TABLE NO. 26-1 — ALLOWABLE SHEAR AND TENSION ON BOLTS
(In Pounds)¹

<table>
<thead>
<tr>
<th>DIAMETER (In Inches)</th>
<th>MINIMUM EMBEDMENT (In Inches)</th>
<th>SHEAR MINIMUM CONCRETE STRENGTH (In p.s.i.)</th>
<th>TENSION 2000 to 5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>⅛</td>
<td>2½</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>⅜</td>
<td>3</td>
<td>550</td>
<td>500</td>
</tr>
<tr>
<td>½</td>
<td>4</td>
<td>1000</td>
<td>950</td>
</tr>
<tr>
<td>¾</td>
<td>5</td>
<td>1375</td>
<td>1500</td>
</tr>
<tr>
<td>⅜</td>
<td>6</td>
<td>1470</td>
<td>1780</td>
</tr>
<tr>
<td>⅞</td>
<td>7</td>
<td>1790</td>
<td>2075</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>1790</td>
<td>2250</td>
</tr>
<tr>
<td>1⅝</td>
<td>9</td>
<td>1790</td>
<td>2650</td>
</tr>
</tbody>
</table>

¹NOTES: Values shown are for work without special inspection. Where special inspection is provided values may be increased 100 per cent.

Values are for natural stone aggregate concrete and bolts of at least A307 quality. Bolts shall have a standard bolt head or an equal deformity in the embedded portion.

Values are based upon a bolt spacing of 12 diameters with a minimum edge distance of 6 diameters. Such spacing and edge distance may be reduced 50 per cent with an equal reduction in value. Use linear interpolation for intermediate spacings and edge margins.
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:

<table>
<thead>
<tr>
<th>MATERIAL AND DESIGN</th>
<th>U.B.C. DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRUCTURAL STEEL</strong></td>
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</tr>
<tr>
<td>Material Specifications</td>
<td>27- 1</td>
</tr>
<tr>
<td>Erection, Fabrication, Identification and Painting</td>
<td>27- 2</td>
</tr>
<tr>
<td>Stress Variation or Stress Reversal Design</td>
<td>27- 3</td>
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<tr>
<td>Open Web Steel Joist Design</td>
<td>27- 4</td>
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<td>Rivet Steel</td>
<td>27- 5</td>
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<td>Welding</td>
<td>27- 6</td>
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<tr>
<td>High Tensile Bolts</td>
<td>27- 7</td>
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<tr>
<td><strong>COMPOSITE DESIGN</strong></td>
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<td><strong>LIGHT STEEL FOR STRUCTURAL MEMBERS</strong></td>
<td></td>
</tr>
<tr>
<td>Specifications and Design, Carbon and Low</td>
<td></td>
</tr>
<tr>
<td>Alloy Steels</td>
<td>27- 9</td>
</tr>
<tr>
<td><strong>SPECIFICATION AND DESIGN FOR STAINLESS STEEL</strong></td>
<td>27-10</td>
</tr>
</tbody>
</table>

(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. 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 thereon in accordance with the requirements of U.B.C. Standard No. 27-2.

Light gauge carbon and low alloy steel shall be identified by the fabricator in accordance with U.B.C. Standard No. 27-9. 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.

Cold-formed stainless steel structural elements designed in accordance with U.B.C. Standard No. 27-10 shall be identified as to grade through mill test reports, and certification shall be furnished that the yield point of the material supplied equals or exceeds that considered in the design. Identification
shall be by painting, decal, tagging or other suitable means on each lift or bundle of fabricated elements.

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 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 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:

\[ Ab = \text{Nominal body area of a bolt.} \]
\[ Ac = \text{Actual area of effective concrete flange in composite design as defined in Section 2708 (a).} \]
\[ Abc = \text{Planar area of web at beam to column connection.} \]
\[ A_t = \text{Area of compression flange.} \]
\[ As = \text{Area of steel beam in composite design.} \]
\[ Asr = \text{Area of reinforcing steel providing composite action at point of negative reinforcement within the boundaries specified in Section 2708 (a).} \]
\[ Ast = \text{Cross-sectional area of stiffener or pair of stiffeners.} \]
\[ Aw = \text{Area of girder web.} \]
\[ C = \text{Ratio of bolt tensile strength to tensile strength of connected part.} \]
\[ C_b = \text{Bending coefficient dependent upon moment gradient; equal to} \]
\[ 1.75 + 1.05 \left( \frac{M_1}{M_2} \right) + 0.3 \left( \frac{M_1}{M_2} \right)^2 \]
C_e = 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. See Section 2703.

C_p = Stiffness factor for primary member in a flat roof.

C_s = Stiffness factor in secondary member in a flat roof.

C_1 = Ratio of beam yield stress to column yield stress.

C_2 = Ratio of column yield stress to stiffener yield stress.

C_v = Ratio of "critical" web stress, according to the linear buckling theory, to the shear yield stress of web material; equal to

\[ \frac{\pi^2 E k \sqrt{3}}{12 (1 - v^2) (h/t)^2 F_y} \]

or
\[ \frac{190}{h/t} \sqrt{\frac{k}{F_y}} \]

[See Section 2707 (e)].

D = Factor depending upon type of transverse stiffeners.

E = Modulus of elasticity of steel (29,000 kips 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 for hybrid girders or because of large web depth-to-thickness ratio.

F'_e = Euler stress divided by factor of safety; equal to

\[ \frac{12\pi^2 E}{23(Kl_b/r_b)^2} \]

F_p = Allowable bearing stress.

F_t = Allowable tensile stress.
Material Standards and Symbols

(Continued)

$F_v$ = Allowable shear stress.

$F_y$ = Specified minimum yield stress of the type of steel being used (kips per square inch).

$F_{yr}$ = Yield stress of reinforcing steel providing composite action at point of negative moment.

$I_d$ = Moment of inertia of steel deck on a flat roof.

$I_p$ = Moment of inertia of primary member in flat roof framing.

$I_s$ = Moment of inertia of secondary member in flat roof framing.

$I_{tr}$ = Moment of inertia of transformed composite section.

$K$ = Effective length factor.

$L$ = Span length, in feet.

$L_p$ = Length of primary member in a flat roof (feet).

$L_s$ = Length of secondary member in a flat roof (feet).

$M$ = Moment.

$M_1$ = Smaller moment at end of unbraced length of beam-column.

$M_2$ = Larger moment at end of unbraced length of beam-column.

$M_D$ = Moment produced by dead load.

$M_L$ = Moment produced by live load.

$M_{m}$ = Critical moment that can be resisted by a plastically designed member in absence of axial load.

$M_p$ = Plastic moment.

$N$ = Length of bearing of applied load.

$N_1$ = Number of shear connectors equal to $V_{h}/q$.

$N_2$ = Number of shear connectors required where closer spacing is needed adjacent to point of zero moment.

$P$ = Applied load.

$P_{cr}$ = $1.70\, AF_a$.

$P_e$ = $1.92\, AF_e$.

$P_y$ = Plastic axial load; equal to profile area times specified minimum yield point.

$Q_s$ = Axial stress reduction factor where width-thickness ratio of unstiffened elements exceeds limiting value given in Subsection 2706 (a).

$Q_a$ = Ratio of effective profile area of an axially loaded member to its total profile area.

$R$ = Reaction or concentrated transverse load applied to beam or girder, in kips.
<table>
<thead>
<tr>
<th>Symbol</th>
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<tr>
<td>$S$</td>
<td>Spacing of secondary members in a flat roof (feet).</td>
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<tr>
<td>$S_{eff}$</td>
<td>Effective section modulus corresponding to partial composite action.</td>
</tr>
<tr>
<td>$S_s$</td>
<td>Section modulus of steel beam used in composite design, referred to the bottom flange.</td>
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<tr>
<td>$S_{tr}$</td>
<td>Section modulus of transformed composite cross section, referred to the bottom flange.</td>
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<td>$T_b$</td>
<td>Proof load of a high strength bolt.</td>
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<td>$V$</td>
<td>Statically shear on beam.</td>
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<tr>
<td>$V_h$</td>
<td>Total horizontal shear to be resisted by connectors under full composite action.</td>
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<tr>
<td>$V'_h$</td>
<td>Total horizontal shear to be resisted by connectors in providing partial composite action (kips). See Section 2708 (d).</td>
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<td>$V_u$</td>
<td>Statically shear produced by &quot;ultimate&quot; load in plastic design.</td>
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<td>$Y$</td>
<td>Ratio of yield point of web steel to yield point of stiffener steel.</td>
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<td>$a$</td>
<td>Clear distance between transverse stiffeners.</td>
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<tr>
<td>$a'$</td>
<td>Distance required at ends of welded partial length cover plate to develop stress.</td>
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<td>$b$</td>
<td>Effective width of concrete slab; actual width of stiffened compression element.</td>
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<tr>
<td>$b_{tr}$</td>
<td>Effective width of stiffened compression element.</td>
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<tr>
<td>$b_f$</td>
<td>Flange width of rolled beam or plate girder.</td>
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<td>$c$</td>
<td>Distance from neutral axis to extreme fiber of beam.</td>
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<tr>
<td>$d$</td>
<td>Depth of beam or girder in inches. Also diameter of roller or rocker bearing.</td>
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<tr>
<td>$d_c$</td>
<td>Column web depth clear of fillets.</td>
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<td>$e$</td>
<td>Horizontal displacement, in the direction of the span, between top and bottom of simply supported beam at its ends.</td>
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<td>$f$</td>
<td>Axial compression load on member divided by effective area.</td>
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<td>$f_a$</td>
<td>Computed axial stress.</td>
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<tr>
<td>$f_b$</td>
<td>Computed bending stress.</td>
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<td>$f_{c}$</td>
<td>Specified compression strength of concrete.</td>
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<tr>
<td>$f_t$</td>
<td>Computed tensile stress.</td>
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<td>$f_v$</td>
<td>Computed shear stress.</td>
</tr>
<tr>
<td>$f_{vs}$</td>
<td>Shear between girder web and transverse stiffeners, in kips per linear inch of single stiffener or pair of stiffeners.</td>
</tr>
<tr>
<td>$g$</td>
<td>Transverse spacing between fastener gauge lines.</td>
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Material Standards and Symbols (Continued)

1970 EDITION

SECTIONS 2701-2702

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 stress in kips per square inch shall not exceed the values specified in this Section.

(b) Structural Steel. 1. Tension. On the net section, except at pinholes

\[ F_t = 0.60F_y \]

but not more than 0.5 times the minimum tensile strength of the steel.

On the net section at pinholes in eyebars, pin-connected plates or built-up members

\[ F_t = 0.45F_y \]
See Table No. 27-A for tension on threaded portions.

2. **Shear.** On the gross section (for shear calculation, the gross section of rolled and fabricated shapes 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 \( C_c \).

   \[
   F_a = \frac{1 - \frac{(KL/r)^2}{2C_c^2}}{F_y}
   \]

   \[ \text{AND} \]

   \[
   F_a = \frac{5}{3} + \frac{3(KL/r)}{8C_c} - \frac{(KL/r)^3}{8C_c^3}
   \]

   \[
   C_c = \sqrt{\frac{2\pi^2E}{F_y}}
   \]

   On the gross section of axially loaded compression members when \( KL/r \) exceeds \( C_c \):

   \[
   F_a = \frac{12\pi^2E}{23(KL/r)^2}
   \]

   On the gross section of axially loaded bracing and secondary members, when \( l/r \) exceeds 120 (for this case \( K \) is taken as unity)

   \[
   F_{as} = \frac{F_a \text{ [by Formula (1) or (2)]}}{1.6 \cdot \frac{l}{200r}}
   \]

   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. Except for hybrid girders and members of A514 steel, tension and compression on extreme fibers of compact hot-rolled or built-up members symmetrical about, and loaded in, the plane of their minor axis and meeting the requirements of this Section shall not exceed:

\[ F_b = 0.66F_y \]

PROVIDED:

The flange is continuously connected to the web or webs.

The width-thickness ratio of unstiffened projecting elements of the compression flange, as defined in Section 2706 does not exceed:

\[ \frac{52.2}{\sqrt{F_y}} \]

The width-thickness ratio of stiffened elements of the compression flange, as defined in Section 2706 does not exceed:

\[ \frac{190}{\sqrt{F_y}} \]

The depth-thickness ratio of the web or webs does not exceed:

\[ \frac{412 (1 - 2.33 \frac{f_o}{F_y})}{\sqrt{F_y}} \]

but need not be less than:

\[ \frac{257}{\sqrt{F_y}} \]

The compression flange is supported laterally at intervals not exceeding:

\[ \frac{76b_f}{\sqrt{F_y}} \]

nor:

\[ \frac{20,000 A_f}{dF_y} \]

Except as specified in this paragraph, beams and girders, including members designed for composite action, qualifying for \( F_b = 0.66 F_y \) and which 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, or when including the one-third allowable stress increase for wind or earthquake forces. 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 \( F_a \).

Members qualifying for \( F_b = 0.66 F_y \), except that \( \frac{b_f}{2t_f} \) exceeds \( \frac{52.2}{\sqrt{F_y}} \) but is less than \( \frac{95.0}{\sqrt{F_y}} \), may have an allowable bending stress of:

\[
F_b = F_y \left[ 0.733 - 0.0014 \left( \frac{b_f}{2t_f} \right) \left( \frac{1}{\sqrt{F_y}} \right) \right]
\]

Tension and compression on extreme fibers of doubly-symmetrical \( I \) and \( H \) shape members with flanges continuously connected to web or webs, unstiffened projecting elements of the compression flange not exceeding \( \frac{52.2}{\sqrt{F_y}} \) and bent about their minor axis; solid round and square bars; and solid rectangular bars bent about their weaker axis shall not exceed

\[
F_b = 0.75 F_y
\]

This does not include \( I \) and \( H \) shapes of A514 steel.

Tension and compression on extreme fibers of box-type flexural members where the compression flange and web width-thickness ratio do not qualify with the conditions for \( F_b = 0.66 F_y \) but do conform with Section 2706, and where the compression flange is braced laterally at intervals not exceeding \( \frac{2500}{F_y} \) times the transverse distance out-to-out of the webs shall not exceed

\[
F_b = 0.60 F_y
\]

Tension on extreme fibers of flexural members not previously covered in this Subsection on bending shall not exceed

\[
F_b = 0.60 F_y \quad \text{Formula (4)}
\]
Compression on extreme fibers of flexural members included under the preceding paragraph, having an axis of symmetry in and loaded in the plane of their web, and compression on extreme fibers of channels bent about their major axis shall not exceed the larger of Formulas (5) and (6), when applicable, but not more than 0.60 $F_y$.

WHEN:

$$F_b = \left[ \frac{2}{3} - \frac{F_y (L/rt)^2}{1530 (10^3) C_b} \right] F_y$$

......Formula (5a)

WHEN:

$$L/rt \subseteq \frac{\sqrt{510 (10^3) C_b}}{F_y}$$

$$F_b = \frac{170 (10^3) C_b}{(L/rt)^2}$$

......Formula (5b)

Or when the compression flange is solid and approximately rectangular in cross section and the area is not less than the tension flange:

$$F_b = \frac{12 (10^3) C_b}{ld/A_f}$$

......Formula (6)

WHERE:

$l = $ distance between cross sections braced against twist or lateral displacement of the compression flange. Canti-levered beams, if unstayed at the free end, must be stayed at the support against translation and rotation.

$r_t = $ radius of gyrations of a section comprising the compression flange plus one-third of the compression web area, taken about an axis in the plane of the web.

$$C_b^1 = 1.75 + 1.05 \left( \frac{M_1}{M_2} \right) + 0.3 \left( \frac{M_1}{M_2} \right)^2$$

but more than 2.3 where $M_1$ is the smaller and $M_2$ the larger bending moment at the ends of the unbraced length, taken about the strong axis of the member, and where $M_1/M_2$, the ratio of end moments, is positive when there is reverse curvature bending and negative when there is single curvature bending. When the bending moment at any point within an unbraced

$^1C_b$ can be conservatively taken as unity.
length is larger than that at both ends of this length, 
\( C_b \) shall be unity. It shall also be unity when comput­
ing the value of \( F_{bx} \) and \( F_{by} \) in Formula (6a).

For hybrid plate girders, \( F_y \) in Formulas (5a) and (5b) is 
the yield stress of the compression flange. Formula (6a) shall 
not apply to hybrid girders.

Compression on extreme fibers of flexural members qualify­
ing for Formula (4), which do not qualify for Formulas (5a), 
(5b) and (6), and provided that sections bent about their 
major axis are braced laterally in the region of compression 
stress at intervals not exceeding \( 76.0 \frac{b_f}{\sqrt{F_y}} \) shall not exceed

\[ F_b = 0.60 F_y \]

See Section 2707 for further limitations in plate girder 
flange stress.

5. **Bearing (on contact area).** Milled surfaces including 
bearing stiffeners and pins in reamed, drilled or bored holes

\[ F_p = 0.90 F_y \]

Expansion rollers and rockers, kips per linear inch

\[ F_p = \left( \frac{F_y - 13}{20} \right) 0.66d \]

where \( d \) is the diameter of roller or rocker in inches.

(c) **Rivets, Bolts and Threaded Parts.** 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. High strength bolts required to support applied loads 
by direct tension shall have an average tensile stress, inde­
pendent of any initial tightening force, not exceeding the 
appropriate stress in Table No. 27-A. The applied load shall 
be the sum of the external load and any tension resulting from 
pyeing action by deformation of the connected parts.

3. Allowable bearing stress on projected area of bolts in 
bearing-type connections and on rivets

\[ F_p = 1.35 F_y \]

WHERE:

\[ F_p = \text{Allowable bearing stress. Also see footnote 1,} \]

\[ \text{Table No. 27-A.} \]

(d) **Welds.** Except as modified by Section 2704, weld 
stresses shall comply with Table No. 27-B.

(e) **Effective Areas of Weld Metal.** The effective area of 
groove and fillet welds shall be considered as the effective 
length of the weld times the effective throat thickness.

---

1 When parts in contact have different yield points, \( F_y \) shall be the 
smaller value.
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 specified above for fillet welds, using for effective length, the length of center line 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 groove 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. However, for fillet welds made by the submerged arc process, the effective throat thickness shall be the leg size for 5/8 inch and smaller fillet welds and equal to the theoretical throat plus 0.11 inch for fillet welds over 5/8 inch.

The effective throat thickness of a complete penetration groove weld [i.e., a groove weld conforming to the requirements of Section 2720 (f)] shall be the thickness of the thinner part joined.

The effective throat thickness of single and double partial penetration groove welds shall be the depth of the groove. However, the effective throat thickness of a bevel joint made by manual shielded metal-arc welding shall be \( \frac{1}{6} \) inch less than the depth of the groove, and the effective throat thickness not less than \( \sqrt{t} \), where \( t \) is the thickness of the thinner part connected by the weld.

(f) Cast Steel and Steel Forgings. The allowable stress for cast steel and steel forgings shall not exceed the values specified in Section 2702 (b).

Sec. 2703. (a) Axial Compression and Bending. Members subject to both axial compression and bending stresses shall be proportioned to satisfy the following requirements:

\[
\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{br}} + \frac{C_{my} f_{by}}{\left(1 - \frac{f_a}{F'_{ey}}\right) F_{by}} \leq 1.0
\]

.................................................. Formula (6a)

\[
\frac{f_a}{0.60F_y} + \frac{f_{ux}}{F_{bx}} + \frac{F_{by}}{F_{by}} \leq 1.0
\]

........... Formula (6b)
Combined Stresses (Continued)

WHEN:

\( \frac{f_a}{F_a} \leq 0.15 \), Formula (7) may be used in lieu of Formulas (6a) and (6b)

\[
\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0
\]

Formula (7)

\( C_m \) = 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, \( C_m = 0.6 - 0.4 \frac{M_1}{M_2} \), but not less than 0.4, where \( \frac{M_1}{M_2} \) 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. \( \frac{M_1}{M_2} \) is positive when the member is bent in reverse curvature and negative when bent in single 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 at all points along their length to satisfy the requirements of Formula (6b) where \( f_b \) is the computed bending tensile stress. However, the computed compressive stress, taken alone, shall not exceed the applicable value permitted by Section 2702 (b) 4.

(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 A502, Grade 1 rivets ...... \( F_t = 28.0 - 1.6f_v \cong 20.0 \)
For A502, Grade 2 rivets ...... \( F_t = 38.0 - 1.6f_v \cong 27.0 \)
For A307 bolts .................. \( F_t = 28.0 - 1.6f_v \cong 20.0 \)
For A325 and A449 bolts in bearing-type joints .......... \( F_t = 50.0 - 1.6f_v \cong 40.0 \)
For A490 bolts in bearing-type joints \[ F_t = 70.0 - 1.6f_v \leq 54.0 \]
where the shear stress \( f_v \) produced by the same forces 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 and A449 bolts \[ F_v \leq 15.0 \left(1 - \frac{f_tA_b}{T_b}\right) \]
- For A490 bolts \[ F_v \leq 20.0 \left(1 - \frac{f_tA_b}{T_b}\right) \]
where \( f_t \) is the average tensile stress due to a direct load applied to all of the bolts in a connection, and \( T_b \) is the specified pretension load of the bolt.

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.

Sec. 2705. (a) General. General stability shall be provided for the structure as a whole and for each compression element. 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.

(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. In frames where lateral stability is dependent on the bending stiffness of rigidly connected beams and columns, the effective length \( Kl \) of compression members shall be determined by a rational method and shall not be less than the actual unbraced length.

(d) Maximum Ratios. The slenderness ratio, \( l/r \), of compression members shall not exceed 200.

The slenderness ratio, \( l/r \), of tension members, other than rods, shall not exceed:
- For main members ....................................................... 240
- For bracing and other secondary members .......................... 300

Sec. 2706. (a) Unstiffened Elements Under Compression. Unstiffened (projecting) compression elements are those having one free edge parallel to the direction of compression stress. The width of unstiffened plates shall be taken from the free edge to the first row of fasteners or welds; the width of angle legs, channel and zee flanges and stems of tees shall be taken as the full nominal dimension; the flanges of I-shaped members 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.

Unstiffened elements subject to axial compression or compression due to bending shall be considered as fully effective when the ratio of width to thickness is not greater than the following:

Single-angle struts; double-angle struts with separators

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

Stems of tees

(b) Stiffened Elements Under Compression. Stiffened compression elements are those having lateral support along both edges which are parallel to the direction of the compression stress. The width of such elements shall be the distance between nearest lines of fasteners or welds, or between the roots of flanges of rolled sections.

Stiffened elements subject to axial compression, or to uniform compression due to bending, such as the flange of a flexural member, shall be considered fully effective when the ratio of width to thickness does not exceed the following:

Flanges of square and rectangular sections of uniform thickness

Unsupported width of cover plates perforated with a succession of access holes

All other uniformly compressed stiffened elements

Except in the case of perforated cover plates, when the actual width-to-thickness ratio exceeds these values the design shall be governed by other approved methods.

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 (b), exceeds 15 per cent of the gross flange area, the excess shall be deducted.

Hybrid girders may be proportioned by the moment of inertia of their gross section, subject to the other provisions

1Webs of flexural members are regulated by Sections 2707 (b) and 2707 (f).
2Assumes net area of plate at widest hole in computing compression stress.
3Web stresses produced by the bending moment are unlimited except as regulated in Section 2704 and U.B.C. Standard No. 27-3.
of this Section, provided they do not resist an axial force exceeding $0.15F_y$ times the gross section where $F_y$ is the yield stress of the flange material. Hybrid girders must have flanges of equal areas at any section and have the same grade of steel.

(b) Web. The clear distance between flanges in inches shall not exceed

$$\frac{14,000 \ (t)}{\sqrt{F_y (F_y + 16.5)}}$$

WHERE:

$$F_y = \text{Yield stress of the compression flanges. A minimum value of } 2000/\sqrt{F_y} \text{ may be used provided there are transverse stiffeners spaced not more than 1.5 times the girder depth.}$$

(c) Flanges. The thickness of outstanding parts of flanges shall conform to the requirements of Section 2706 (a).

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 Section 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 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 flange angle fillet or the flange-to-web welds shall be considered effective in bearing.

Except as provided in this Section, the average web shear, $f_v$ in kips per square inch, shall not exceed:

$$F_v = \frac{F_y (C_v)}{2.89} \leq 0.4F_y \quad \text{......Formula (8)}$$

WHERE:

$$C_v = \begin{cases} \frac{45,000k}{F_y(h/t)^2} & \text{when } C_v \text{ is less than 0.8.} \\ \frac{190}{h/t} \sqrt{\frac{k}{F_y}} & \text{when } C_v \text{ is more than 0.8.} \end{cases}$$

$$k = \begin{cases} 4.00 + \frac{5.34}{(a/h)^2} & \text{when } a/h \text{ is less than 1.0.} \\ 5.34 + \frac{4.00}{(a/h)^2} & \text{when } a/h \text{ is more than 1.0.} \end{cases}$$

1 See Section 2707 (i) for welded plate girders.
Where intermediate stiffeners are provided at spacings complying with this Section and if \( C_v \leq 1.00 \), girders other than hybrid types may have an allowable shear of:

\[
F_v = \frac{F_y}{2.89} \left[ C_v + \frac{1 - C_v}{1.15 \sqrt{1 + (a/h)^2}} \right] \leq 0.4F_y
\]

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 (8).

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 Formula (8) or (9), as applicable and the ratio \( a/h \) shall not exceed:

\[
\left( \frac{260}{h/t} \right)^2 \text{nor 3.0.}
\]

For girders designed for tension field action, 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:

\[
\frac{348t}{\sqrt{f_v}}
\]

The moment of inertia of a pair of intermediate stiffeners, or a single intermediate stiffener about an axis in the web plane shall be not less than \((h/50)^4\).

The gross area, in square inches, of intermediate stiffeners spaced in accordance with Formula (9) shall be not less than that computed by Formula (10).

\[
A_{st} = \frac{1 - C_v}{2} \left[ \frac{a}{h} - \frac{(a/h)^2}{\sqrt{1 + (a/h)^2}} \right] YDht \quad \text{Formula (10)}^2
\]

WHERE:

- \( C_v \) is as defined in Section 2707 (e).
- \( Y = \) yield stress of web steel/yield stress of stiffener steel.
- \( D = 1.0 \) for stiffeners furnished in pairs.
- \( D = 1.8 \) for single angle stiffeners.
- \( D = 2.4 \) for single plate stiffeners.

\(^1\)Recognizes the contribution of tension field action.
\(^2\)Total area when stiffeners are furnished in pairs.
When the greatest shear stress \( f_v \) in a panel is less than that permitted by Formula (9) this gross area requirement may be reduced in like proportion.

Intermediate stiffeners required by the provisions of Formula (9) shall be connected for a shear transfer in kips per linear inch of single or pairs of stiffeners not less than

\[
f_{vs} = h \sqrt\left(\frac{F_y}{340}\right)^3
\]

WHERE:

\( F_y \) = yield stress 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 (9). 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.

Intermediate stiffeners may be stopped short of the tension flange a maximum distance of 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 attached to a stiffener or pair of stiffeners, lateral bracing 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.

Rivets connecting stiffeners to the girder web shall be spaced not more than 12 inches on center. If intermittent fillet welds are used, the clear distance between welds shall be not more than 16 times the web thickness nor more than 10 inches.

(f) Reduction in Flange Stress. When the web depth to thickness ratio exceeds \( 760/\sqrt{F_b} \), the maximum stress in the compression flange shall not exceed:

\[
F'_{b} \equiv F_b \left[ 1.0 - 0.0005 \frac{A_w}{A_f} \left( \frac{h}{t} - \frac{760}{\sqrt{F_b}} \right) \right] \text{Formula (11a)}
\]

The maximum stress in either flange of a hybrid girder shall not exceed \( F'_{b} \) in Formula (11a) nor

\[
F'_{b} \equiv F_b \left[ \frac{12 + \left( \frac{A_w}{A_f} \right) (3\alpha - \alpha^3)}{12 + 2 \left( A_w/A_f \right) } \right] \text{Formula (11b)}
\]
WHERE:

\( \alpha = \text{ratio of web yield stress to flange yield stress.} \)

(g) **Combined Shear and Tension Stress.** Plate girder webs shall be so proportioned that the bending tensile stress, due to moment in the plane of the girder web, shall not exceed:

\[
0.6F_y \quad \text{nor} \quad \left( 0.825 - 0.375 \frac{f_v}{F_v} \right) F_y \quad \text{Formula (12)}
\]

The allowable shear stress in webs of girders having A514 flanges and webs shall not exceed that determined by Formula (8) if the flexural stress in the flange exceeds \( 0.75F_b \).

(h) **Splices.** Groove 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.

(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 \( 0.75F_y \).

The compressive stress at the web top of the fillets shall be computed using the following formulas:

For interior loads:

\[
\frac{R}{t(N + 2k)} \leq 0.75F_y \quad \text{Formula (13)}
\]

For end-reactions:

\[
\frac{R}{t(N + k)} \leq 0.75F_y \quad \text{Formula (14)}
\]

WHERE:

\( N = \text{length of bearing in inches (not less than } k \text{ for end reactions).} \)

Bearing stiffeners shall be provided where the compressive stress exceeds that determined by Formulas (13) and (14).
Plate Girders and Rolled Beams (Continued)

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 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,

\[
\left[ 5.5 + \frac{4}{(a/h)^2} \right] \frac{10,000}{(h/t)^2} \quad \text{Formula (15)}
\]

When the flange is not restrained against rotation,

\[
\left[ 2 + \frac{4}{(a/h)^2} \right] \frac{10,000}{(h/t)^2} \quad \text{Formula (16)}
\]

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 kips per linear inch of length, shall be divided by the web thickness.

(k) Rotational Restraint at Points of Support. Beams, girders and trusses shall be restrained against rotation, about their longitudinal axis, at points of support.

(1) Lateral Restraint. Steel beams used as joists shall be braced at 10-foot intervals along the joist length, with bracing capable of transmitting a load of 500 pounds applied perpendicular to the bottom of the member.

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 2 inches or more on their sides and soffit in concrete cast 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 1\(\frac{1}{2}\) inches below the top and 2 inches 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 computed bending stress of 0.66\(F_y\), where \(F_y\) is the yield stress of the steel beam. The bending stress produced by loads after the concrete has hardened shall be computed on the basis of the section properties of the composite section. Concrete tension stresses shall be neglected. Alternatively, the steel beam may be proportioned to resist unassisted the positive moment produced by all loads, live and dead, using a bending stress equal to 0.76\(F_y\), 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. This includes composite sections where the structural steel is not shored during construction.

Reinforcement parallel to the beam within the effective width of the slab, when anchored in conformance with Chapter 26, may be included in the properties of composite sections subject to negative bending moments provided shear connectors comply with Section 2708 (d). The section properties of the composite section shall be computed in accordance with the elastic theory. Concrete tension stresses shall be neglected. The compression area of the concrete on the compression side of the neutral axis shall be treated as an equivalent area of steel by dividing it by the modular ratio \(n\).

Where shear connectors in conformance with Section 2708 (d) are not provided, the effective section modulus used in stress calculations shall not exceed:

\[
S_{eff} = S_s + \frac{V'}{V} (S_{tr} - S_s) \quad \text{Formula (17a)}
\]

For construction without temporary shoring the value of the section modulus of the transformed composite section used in stress calculations shall not exceed:

\[
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\]
WHERE:

\[ ML = \text{moment caused by loads applied after concrete has attained 75 per cent of its required strength.} \]

\[ MD = \text{moment caused by loads applied prior to this time.} \]

The steel beam alone, supporting the loads before the concrete has hardened, shall not be stressed to more than the applicable bending stress given in Section 2702 (b).

Provisions shall be made to prevent cracking of the slab spanning perpendicular to the beam.

The actual section modulus of the transformed composite section shall be used in calculating the concrete flexural compression stress and, for construction without temporary shores, this stress shall be based upon loading applied after the concrete has reached 75 per cent of its required strength. The stress in the concrete shall not exceed 0.45f'c.

(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). For full composite action with concrete subject to flexural compression, the total horizontal shear between the point of maximum positive moment and points of zero moment shall be the smaller of the following:

\[ V_h = \frac{0.85f'c A_e}{2} \quad \text{Formula (18a)} \]

\[ V_h = \frac{A_s F_y}{2} \quad \text{Formula (18b)} \]

In continuous composite beams where longitudinal reinforcing steel is considered to act compositely with the steel beam in the negative moment regions, the total horizontal shear resisted by shear connectors between an interior support and each adjacent point of contraflexure shall be:

\[ V_h = \frac{A_{se} F_{ye}}{2} \quad \text{Formula (19)} \]

For full composite action the number of connectors resisting the horizontal shear obtained from Formula (18a) or (18b)
shall be not less than that determined by the following formula:

\[
\frac{V_h}{q} \]

Working values for concrete with aggregates not conforming with U.B.C. Standard No. 26-4 and for connectors other than shown in Table No. 27-C must be established by an approved test program.

For incomplete composite action with concrete subject to flexural compression, \( V_h \) in Formula (17a) shall be \( q \) multiplied by the number of connectors furnished between the point of maximum moment and the nearest point of zero moment.

The connectors required on each side of the point of maximum moment in an area of positive bending may be uniformly distributed between that point and adjacent points of zero moment except that \( N_2 \), the number of shear connectors required between any concentrated load in that area and the nearest point of zero moment, shall be determined by the following formula:

\[
N_2 = N_1 \left[ \frac{M \beta}{M (\text{max})} - 1 \right] \left( \frac{\beta}{\beta - 1} \right)
\]

WHERE:

\( M \) = the moment (less than the maximum moment) at a concentrated load point.

\( N_1 \) = number of connectors required between point of maximum moment and point of zero moment, determined by the relationship \( V_h/q \) or \( V'h/q \), as applicable.

\( \beta = \frac{S_{\text{fr}}}{S_s} \) or \( \frac{S_{\text{eff}}}{S_s} \), as applicable.

Connectors required in the region of negative bending on a continuous beam may be uniformly distributed between the point of maximum moment and each point of zero moment.

Shear connectors shall have at least 1 inch of concrete cover on all directions. Unless located directly over the web the diameter of studs shall be not greater than 2.5 times the thickness of the flange to which they are welded.

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
Sec. 2710. (a) General. Horizontal framing members shall be designed for the deflection criteria and ponding requirements specified in Section 2307 and Subsection 230.5 (f).

Beams and girders supporting large open floor areas free of partitions or other sources of damping, where transient vibration due to pedestrian traffic might not be acceptable, shall be designed with due regard for vibration.

(b) Ponding. Unless a roof surface is provided with sufficient slope towards points of free drainage or adequate individual drains to prevent the accumulation of water, the roof system shall be investigated by a rational analysis to assure stability under ponding conditions. The roof system shall be considered stable and no further investigation needed provided the following formulas are satisfied:

\[ C_p + 0.9C_s \leq 0.25 \]

AND

\[ I_d \geq \frac{25S^4}{10^6} \]

WHERE:

\[ C_p = \frac{32L_s L_p^4}{10^7I_p} \]

\[ C_s = \frac{32Ss^4}{10^7I_s} \]

For trusses and joists, \( I_s \) shall be decreased by 15 per cent when used in the above formulas. A steel deck shall be considered a secondary member when it is directly supported by the primary members.

Total bending stress due to dead loads, live loads and ponding shall not exceed \( 0.8F_y \) for primary and secondary members. Stresses due to wind or seismic forces need not be included in the ponding analysis.

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

$$s^2 - 4g$$

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.

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 \(\frac{1}{8}\) inch 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 \(\frac{1}{2}\) inch. 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 \(\frac{3}{8}\) inch greater than the diameter of the pin. For steels having a yield stress greater than 70 k.s.i., the diameter of the pinhole shall not exceed five times the plate thickness.

The minimum net section across the pinhole, transverse to the axis of the member, in pin-connected 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 pinhole shall be not less than 1.25 times the smaller of the distances from the edge of the pinhole to the edge of the member or separated element at the pinhole. The diameter of the pinhole shall be not more than \( \frac{3}{4} \) inch greater than the diameter of the pin. In the case of pin-connected plates of uniform thickness, for steels having a yield stress greater than 70 k.s.i., the diameter of the pinhole shall not exceed five times the plate thickness.

Thickness limitations on both eyebars and pin-connected plates may be waived whenever external nuts are provided to tighten pin plates and filler plates into snug contact. When the plates are thus contained, the allowable stress in bearing shall be no greater than \( F_p = 0.90F_y \).

Sec. 2712. (a) Minimum Connections. Connections shall be designed for all tributary forces and shall be capable of supporting not less than six kips.

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, groups of 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, 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.

\[ \frac{f_b L}{3600} \] 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 kips per square inch.

(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.

When fully restrained beams are framed to the flange of an \( I \) or \( H \) shaped column, stiffeners shall be provided on the column web as follows:

Opposite the compression flanges when

\[ t < \frac{C_1 A_f}{t_b + 5k} \]

or when

\[ t \leq \frac{d_c}{5\sqrt{F_y}}. \]

Opposite the tension flange when

\[ t_t < 0.4 \sqrt{C_1 A_f} \]

WHERE:

\( t \) = thickness of web to be stiffened.

\( k \) = distance from outer face of flange to web toe of fillet of member to be stiffened. For welded sections, \( k \) shall be the flange thickness plus the distance to the farthest toe of the connecting weld.

\( t_b \) = thickness of flange delivering concentrated load.

\( t_t \) = thickness of flange of member to be stiffened.

\( A_f \) = area of flange delivering concentrated load.
The area of stiffeners shall be:

\[ A_{st} \geq [C_1 A_f - t (t_b + 5k)] C_2 \]

Their ends shall be welded to the inside face of the flange opposite the concentrated tensile load to transfer the load from the beam flange to the column web. 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 member depth, but the welding connecting it to the web shall be sufficient to develop \( F_y A_{st} \).

(f) Fillers. When rivets or bolts carrying computed stress pass through fillers thicker than \( \frac{3}{8} \) inch, 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 \( \frac{3}{8} \) inch 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 \( \frac{3}{8} \) inch 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 force due to the design load, but not less than 50 per cent of the effective strength of the member.

(h) Compression Members with Bearing Joints. Where columns bear on bearing plates, or are finished to bear at splices, 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.

(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 200 feet or more in height.
- Column splices in tier structures 100 feet to 200 feet in height, if the least horizontal dimension is less than 40 per cent of the height.
- Column splices in tier structures less than 100 feet 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 125 feet 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.

Sec. 2713. (a) High Strength Bolts. Use of high strength bolts shall conform to the provisions of U.B.C. Standard No. 385
27.7. A449 bolts no greater than 1¼ inches in diameter may be used in lieu of A325 bolts provided a hardened washer is installed under the bolt head. However, nuts used with A449 bolts shall comply with A325 requirements.

(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 1/8 inch 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-D.

(f) **Minimum Edge Distance of Line of Stress.** In connections of tension members, where there are not more than two rivets in a line parallel to the direction of stress, the distance from the center of the end rivet to that end of the connected part toward which the stress is directed shall be not less than the area of the rivet divided by the thickness of the connected part for rivets in single shear, or twice this distance for rivets in double shear.

In bearing-type connections of tension members, where there are not more than two bolts in a line parallel to the direction of stress, the distance from the center of the end bolt to that end of the connected part toward which the stress is directed shall be not less than \( A_b C / t \) for single shear or \( 2A_b C / t \) for double shear, where \( A_b \) is the nominal cross-sectional area of the bolt, \( t \) is the thickness of the connected part and \( C \) is the ratio of specified minimum tensile strength of the bolt to the specified minimum tensile strength of the connected part.

However, the end distance prescribed in this Subsection may be decreased in such proportion as the fastener stress is less than that permitted in Section 2702 (c) but it shall not be less than the distance specified in Section 2713 (e) and need not exceed one and one-half times the transverse spacing of fasteners.

When more than two fasteners are provided in the line of stress Section 2713 (e) shall govern.
(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 6 inches.

Sec. 2714. (a) General. Welder qualification requirements, welding procedure and welding electrodes shall conform to U.B.C. Standard No. 27-6.

(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 \( \frac{1}{4} \) inch thick, the maximum size may be equal to the thickness of the material.

2. Along edges of material \( \frac{1}{4} \) inch or more in thickness, the maximum size shall be \( \frac{1}{8} \) inch 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 8 inches, 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 \( 1\frac{1}{2} \) inches.

(e) Lap Joints. The minimum amount of laps on lap joints shall be five times the thickness of the thinner part joined and not less than 1 inch. 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 2702(e). 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 \( \frac{3}{16} \) inch, rounded to the next greater odd \( \frac{1}{16} \) inch, 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 \( \frac{3}{16} \) inch, rounded to the next greater odd \( \frac{1}{16} \) inch, 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 \( \frac{5}{8} \) inch or less in thickness shall be equal to the thickness of the material. In material over \( \frac{5}{8} \) inch in thickness, it shall be at least one-half the thickness of the material but not less than \( \frac{5}{8} \) inch.

Built-up Members

Sec. 2715. (a) **Open Web Steel Joists, J, H, LJ, and LH Series.** Open web steel joists shall be designed as set forth in U.B.C. Standard No. 27-4.
(b) **Open Box-Type Beams and Grillages.** Where two or more rolled beams or channels are used side by side to form a flexural member, they shall be connected together at intervals of not more than 5 feet. Through-bolts and separators may be used, provided that in beams having a depth of 12 inches 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 2706.

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

\[
\frac{127t}{\sqrt{F_y}}
\]

but not more than 12 inches.

When rivets or bolts are staggered

\[
\frac{190t}{\sqrt{F_y}}
\]

but not more than 18 inches on each gauge line.

WHERE:

\[ t = \text{thickness of thinner outside plate in inches.} \]

The maximum longitudinal spacing of rivets, bolts or intermittent welds connecting two rolled shapes in contact with one another shall not exceed 24 inches.
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 slenderness 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 15 inches, 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 1⅛ inches.

(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 12 inches. The longitudinal spacing of rivets, bolts and intermittent welds connecting two or more shapes in a tension member shall not exceed 24 inches. 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 6 inches. 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.

**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 80 feet or greater span shall be cambered for the dead load deflection. Crane girders of 75 feet or greater span shall be cambered for the dead plus half the live load deflection.

**Sec. 2717.** Adequate provision shall be made for expansion and contraction appropriate to the service conditions of the structure.

**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, 2 inches or less in thickness, may be used without planing, provided a satisfactory contact bearing is obtained; rolled steel bearing plates over 2 inches but not over 4 inches in thickness may be straightened by pressing; or, if presses are not available, by planing for all
Column Bases (Continued)  

bearing surfaces (except as noted under requirement 3 of this Section), to obtain a satisfactory contact bearing; rolled steel bearing plates over 4 inches in thickness shall be planed for all bearing surfaces (except as noted under requirement 3 of this Section).

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.

Plastic Design

Sec. 2721. (a) Scope. Subject to the requirements specified in this Section, simple or continuous beams, one- and two-story rigid frames, braced multistory 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 a factored load of 1.7 times the live load and dead load or 1.3 times these loads acting in conjunction with 1.3 times wind or 1.4 times earthquake forces.

EXCEPTION: Braced multistory frames are not permitted in Seismic Zones No. 1, No. 2 and No. 3.

Rigid frames shall be assumed to have beam-to-column connections of sufficient rigidity to hold virtually unchanged the original angles between intersecting members in the plane of the frame. Members between rigid frames may be connected at ends for shear only and be free to rotate under loads.

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.

(c) **Vertical Bracing System.** The vertical bracing system for a plastically designed braced multistory shall be adequate, as determined by a rational analysis, to prevent buckling of the structure under factored gravity loads; and maintain the lateral stability of the structure, including the overturning effects of drift, under factored gravity plus factored horizontal loads.

The vertical bracing system may be considered to function together with in-plane shear-resisting exterior and interior walls, floor slabs, and roof decks, if they are secured to the structural frames. The columns, girders, beams, and diagonal members, when used as the vertical bracing system, may be considered to comprise a vertical-cantilever, simply-connected truss in the analyses for frame buckling and lateral stability. Axial deformation of all members in the vertical bracing system shall be included in the lateral stability analysis. The axial force in these members caused by factored gravity plus factored horizontal loads, shall not exceed $0.85 \frac{P_y}{F_y}$, where $P_y$ is the product of yield stress times area of the member.

Girders and beams included in the vertical bracing system of a braced multistory frame shall be proportioned for axial force and moment caused by the concurrent factored horizontal and gravity loads, in accordance with Formula (21), with $P_{cr}$ taken as the maximum axial strength of the beam, based on the actual slenderness ratio between braced points in the plane of bending.

(d) **Columns.** In the plane of bending of columns, which would develop a plastic hinge at ultimate loading, the slenderness ratio $l/r$ shall not exceed $C_c$, as defined in Section 2701 (c).

The maximum strength of an axially loaded compression member shall be:

$$P_{cr} = 1.7AF_a \quad \text{........Formula (20)}$$

WHERE:

$A$ = gross area of the member.

$F_a$ = See Formula (1) in Section 2702 (b).

Members subject to combined axial load and bending moment shall satisfy the following conditions:

$$\frac{P}{P_{cr}} + \frac{C_m M}{\left(1 - \frac{P}{P_{cr}}\right) M_n} \leq 1.0 \quad \text{........Formula (21)}$$
Plastic Design (Continued)

\[
\frac{P}{P_y} + \frac{M}{1.18M_p} \leq 1.0; \quad M \leq M_p \quad \text{Formula (22)}
\]

For columns braced in the weak direction:

\[M_m = M_p\]

For columns unbraced in the weak direction:

\[M_m = \left[ 1.07 - \frac{(l/r_y) \sqrt{F_y}}{3160} \right] M_p \leq M_p \quad \text{Formula (23)}\]

(e) **Shear.** Unreinforced webs of columns, beams, and girders, including areas within the boundaries of the connections, shall be so proportioned that

\[V_u \leq 0.55F_ytd \quad \text{Formula (24)}\]

(f) **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 as required by Section 2712 (e).

(g) **Minimum Thickness (Width-thickness Ratios).** The width-thickness ratio for flanges of rolled "I", wide flange, and similar built-up single-web shapes that would be subjected to compressions involving hinge rotation under ultimate loading shall not exceed the following values:

<table>
<thead>
<tr>
<th>(F_y)</th>
<th>(b_i/2t_f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>8.5</td>
</tr>
<tr>
<td>42</td>
<td>8.0</td>
</tr>
<tr>
<td>45</td>
<td>7.4</td>
</tr>
<tr>
<td>50</td>
<td>7.0</td>
</tr>
<tr>
<td>55</td>
<td>6.6</td>
</tr>
<tr>
<td>60</td>
<td>6.3</td>
</tr>
<tr>
<td>65</td>
<td>6.0</td>
</tr>
</tbody>
</table>

The thickness of sloping flanges may be taken as their average thickness.

The width-thickness ratio of similarly compressed flange plates in box sections and cover-plates shall not exceed \(190/\sqrt{F_y}\). For this purpose the width of a cover-plate shall be the distance between longitudinal lines of connecting rivets, high strength bolts or welds.

The depth-thickness ratio of webs of members subjected to plastic bending shall not exceed the following:
WHERE:

\[ \frac{p}{p_y} \leq 0.27 \]

\[ \frac{d}{t} = \frac{412}{\sqrt{F_y}} \left( 1 - 1.4 \frac{p}{p_y} \right) \]

WHERE:

\[ \frac{p}{p_y} > 0.27 \]

\[ \frac{d}{t} = \frac{257}{\sqrt{F_y}} \]

(h) Connections. All connections shall be capable of resisting the moments, shears and axial loads to which they would be subjected by the full factored loading, or any partial distribution thereof.

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.

Rivets, welds and bolts shall be proportioned to resist the forces produced at factored load using allowable stresses equal to 1.7 times those permitted in other sections of this Chapter.

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 factored loading of the plastic hinges assumed in the design.

(i) Lateral Bracing. Members shall be adequately braced to resist lateral and tortional displacements at the plastic hinge locations. The laterally unsupported distance, \( l_{cr} \), shall not exceed:

WHERE:

\[ + 1.0 > \frac{M}{M_p} > -0.5 \]

\[ l_{cr} = \frac{1375}{F_y} + 25 \]

\[ r_y = \frac{F_y}{F_y} \]

395
WHERE:

\[ M - 0.5 \geq \frac{M}{M_p} > -1.0 \]

where:

\[ l_{cr} = \frac{1375}{\frac{r_y}{F_y}} \] Formula (26b)

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 reverse curvature and negative when bent in single 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 (5a), (5b), (6), (6a), and (6b) in this Chapter. For this case the value of \( f_a \) and \( f_b \) shall be computed from the moment and axial force at factored 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.

(i) Fabrication. The provisions of U.B.C. Standard No. 27-2 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 factored loading. If used they shall be finished smooth by grinding, chipping or planing.
- In locations subject to plastic hinge rotation at factored loading, holes for rivets or bolts in the tension area shall be subpunched and reamed or drilled full size.

Sec. 2722. (a) General. Design and construction of steel framing in ductile moment-resisting space frames in Seismic Zones No. 2 and No. 3 shall conform to the requirements of the Code and to all the requirements of this Section. Welding shall comply with U.B.C. Standard No. 27-6.
(b) Definitions. 1. Joints. The joint is the entire assemblage at the intersections of the members.

2. Connections. The connection consists of only those elements that connect the member to the joint.

(c) Materials. Structural steel shall conform to A36, A440, A441, A572 (Grades 42, 45, 50 and 55), or A588 Grades A, B, or C.

   EXCEPTION: Structural steel A283 Grade D may be used for base plates and anchor bolts.

(d) Connections. Each beam or girder moment connection to a column shall be capable of developing in the beam the full plastic capacity of the beam or girder.

   EXCEPTION: The connection need not develop the full plastic capacity of the beam or girder if it can be shown that adequately ductile joint displacement capacity is provided with a lesser connection.

For steel whose specified ultimate strength is less than 1.5 of the specified yield strength, plastic hinges in beams formed during inelastic deformations of the frame shall not occur at locations in which the beam flange area has been reduced such as by holes for bolts.

(e) Local Buckling. Members in which hinges will form during inelastic displacement of the frames shall comply with the requirement for “plastic design sections.”

(f) Slenderness Ratios. The effective length “Kl” used in determining the slenderness ratio of an axially loaded compression member in the ductile moment-resisting space frame shall be based on the assumption that the frame depends on its own bending stiffness for the lateral stability of the building, even if bracing or shear walls are provided.

(g) Nondestructive Weld Testing. Tension butt welded connections between primary members of the ductile moment-resisting space frame shall be tested by nondestructive methods for compliance with U.B.C. Standard No. 27-6 and job specifications. A program for this testing shall be established by the person responsible for structural design.

Sec. 2723. (a) General. Compliance with this Section 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.

(b) Design and Construction. The design and construction for steel ductile moment-resisting space frames for buildings located in Seismic Zone No. 1 shall conform to all applicable requirements of this Code except Section 2722.
# TABLE NO. 27-A

## UNIFORM BUILDING CODE

### TABLE NO. 27-A — ALLOWABLE STRESSES FOR RIVETS AND BOLTS†

*(kips/in.²)*

<table>
<thead>
<tr>
<th>DESCRIPTION OF FASTENER</th>
<th>TENSION ((F_t))</th>
<th>SHEAR ((F_s))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TENSION Type</td>
<td>Friction-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Type Connections</td>
</tr>
<tr>
<td>A502, Grade 1 hot-driven rivets</td>
<td>20.0</td>
<td>15.0</td>
</tr>
<tr>
<td>A502, Grade 2 hot-driven rivets</td>
<td>27.0</td>
<td>20.0</td>
</tr>
<tr>
<td>A307 bolts Threaded parts of steel complying with Section 2701</td>
<td>20.0²</td>
<td>10.0</td>
</tr>
<tr>
<td>A325 and A449 bolts when threading is not excluded from shear planes</td>
<td>0.60(F_y)²</td>
<td>0.30(F_y)</td>
</tr>
<tr>
<td>A325 and A449 bolts when threading is excluded from shear planes</td>
<td>40.0³</td>
<td>15.0</td>
</tr>
<tr>
<td>A490 bolts when threading is not excluded from shear planes</td>
<td>40.0³</td>
<td>15.0</td>
</tr>
<tr>
<td>A490 bolts when threading is excluded from shear planes</td>
<td>54.0³.⁵</td>
<td>22.0</td>
</tr>
</tbody>
</table>

†There are no bearing stresses in friction-type connections of A325, A449 or A490 bolts.

²Applied to tensile stress area \(0.7854 \left( D - \frac{0.9743}{n} \right)^{2} \) where \(D\) = major thread diameter and \(n\) = number of threads per inch.

³Applied to nominal bolt area.

⁴For upset rods, the smaller of the nominal or stress area shall be used.

⁵Dead loads, ordinary live loads and crane loads not causing fatigue.
<table>
<thead>
<tr>
<th>KIND OF STRESS</th>
<th>PERMISSIBLE STRESS</th>
<th>&quot;MATCHING&quot; BASE METAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension and Compression parallel to axis of any complete penetration groove weld</td>
<td>Same as for base metal¹</td>
<td></td>
</tr>
<tr>
<td>Tension normal to effective throat of complete penetration groove weld</td>
<td>Same as allowable tensile stress for base metal¹</td>
<td></td>
</tr>
<tr>
<td>Compression normal to effective throat of complete or partial-penetration groove welds</td>
<td>Same as allowable compressive stress for base metal¹</td>
<td></td>
</tr>
<tr>
<td>Shear on effective throat of complete-penetration groove weld</td>
<td>Same as allowable shear stress for base metal¹</td>
<td></td>
</tr>
<tr>
<td>Shear stress on effective throat of fillet weld² and partial-penetration groove weld regardless of direction of application of load, tension normal² to the axis on the effective throat of a partial-penetration groove weld, and shear stress on the effective area of a plug or slot weld. The given stresses shall also apply to welds made with the specified electrode on steel having a yield stress greater than that of the &quot;matching&quot; base metal. The permissible unit stress, regardless of electrode classification used, shall not exceed that given in the table for the weaker &quot;matching&quot; base metal joined.</td>
<td>18.0 k.s.i. – using AWS A5.1, E80XX electrodes; AWS A5.17, F6X-EXXX flux-electrode combination; or AWS A5.20, E601-X electrodes; with AWS A5.18, E70U-1 electrodes; or AWS A5.20, E70T-X electrodes; with A500 Grade A and A570 Grade D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.0 k.s.i. – using AWS A5.1 or A5.5, E70XX electrodes, AWS A5.17, F7X-EXXX flux-electrode combination; AWS A5.18; E70S-X or E70U-1 electrodes; or AWS A5.20, E70T-X electrodes; with A36, A53 Grade B, A242, A375, A441, A500 Grade B, A501, A529, A572 Grade E, A570 Grades 42, 60 and A588</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24.0 k.s.i. – using AWS A5.5; E80XX electrodes; Grade 80 Submerged Arc, Gas Metal-Arc or Flux Cored Arc Weld Metal, with A572 Grade 65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.0 k.s.i. – using AWS A5.5, E90XX electrodes; Grade 90 Submerged Arc, Gas Metal-Arc or Flux Cored Arc Weld Metal, with A514 over 2½&quot; thick</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.0 k.s.i. – using AWS A5.5, E100XX electrodes; Grade 100 Submerged Arc, Gas Metal-Arc or Flux Cored Arc Weld Metal, with A514 over 2½&quot; thick</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33.0 k.s.i. – using AWS A5.5, E110XX electrodes; Grade 110 Submerged Arc, Gas Metal-Arc or Flux Cored Arc Weld Metal, with A514 2½&quot; and less in thickness</td>
<td></td>
</tr>
</tbody>
</table>

¹The electrode or flux set forth in Table No. 27-6, U.B.C. Standards, shall be used.
²For definition of effective throat of fillet welds and partial penetration groove welds see Section 2702 (d).
³Fillet welds and partial penetration groove welds joining the component elements of built-up members, such as flange-to-web connections, may be designed without regard to the tension or compression stress in these elements parallel to the axis of the welds.
⁴Only low-hydrogen electrodes shall be used on A242, A441, A514, A572 and A588 steel.
### TABLE NO. 27-C

<table>
<thead>
<tr>
<th>CONNECTOR</th>
<th>ALLOWABLE HORIZONTAL SHEAR LOAD (q) (kips) (Applicable only to concrete made with ASTM C33 aggregates)</th>
<th>f'c (kips per square inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; diam. x 2&quot; hooked or headed stud</td>
<td>5.1</td>
<td>5.5</td>
</tr>
<tr>
<td>5/8&quot; diam. x 21/2&quot; hooked or headed stud</td>
<td>8.0</td>
<td>8.6</td>
</tr>
<tr>
<td>3/4&quot; diam. x 3&quot; hooked or headed stud</td>
<td>11.5</td>
<td>12.5</td>
</tr>
<tr>
<td>7/8&quot; diam. x 31/2&quot; hooked or headed stud</td>
<td>15.6</td>
<td>16.8</td>
</tr>
<tr>
<td>3&quot; channel, 4.1 lb.</td>
<td>4.3w</td>
<td>4.7w</td>
</tr>
<tr>
<td>4&quot; channel, 5.4 lb.</td>
<td>4.6w</td>
<td>5.0w</td>
</tr>
<tr>
<td>5&quot; channel, 6.7 lb.</td>
<td>4.9w</td>
<td>5.3w</td>
</tr>
</tbody>
</table>

w = length of channel in inches.

### TABLE NO. 27-D

<table>
<thead>
<tr>
<th>RIVET OR BOLT DIAMETER (Inches)</th>
<th>MINIMUM EDGE DISTANCE FOR PUNCHED,REAMED OR DRILLED HOLES (Inches)</th>
<th>At Sheared Edges</th>
<th>At Rolled Edges of Plates, Shapes or Bars or Gas Cut Edges1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>7/6</td>
<td>3/4</td>
<td>7/8</td>
</tr>
<tr>
<td>5/8</td>
<td>11/8</td>
<td>7/8</td>
<td>7/8</td>
</tr>
<tr>
<td>3/4</td>
<td>11/4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7/8</td>
<td>11/2</td>
<td>11/2</td>
<td>11/2</td>
</tr>
<tr>
<td>1</td>
<td>11/2</td>
<td>11/2</td>
<td>11/2</td>
</tr>
<tr>
<td>1 1/8</td>
<td>2</td>
<td>11/2</td>
<td>11/2</td>
</tr>
<tr>
<td>1 1/4</td>
<td>2 1/4</td>
<td>11/2</td>
<td>11/2</td>
</tr>
<tr>
<td>Over 1 1/4</td>
<td>1 3/4 × Diameter</td>
<td>1 1/4 × Diameter</td>
<td></td>
</tr>
</tbody>
</table>

1All edge distances in this column may be reduced 1/8 inch when the hole is at a point where stress does not exceed 25 per cent of the maximum allowed stress in the element.

2These may be 1 1/4 inches at the ends of beam connection angles.
CHAPTER 28 — ALUMINUM

NOTE: Tables in Chapter 28 appear at the end of the Chapter.

Sec. 2801. (a) General. The quality, design, fabrication and erection of aluminum used structurally in buildings and structures shall conform to the requirements of this Chapter, to other applicable requirements of this Code and to U.B.C. Standard No. 28-1.

(b) Alloys. The use of aluminum alloys and tempers other than those covered by this Chapter shall be permitted for structural members and assemblies, provided standards of performance not less than those required by this Chapter are substantiated to the satisfaction of the Building Official. When required by the Building Official, certification that the alloys and tempers called for on the plans have been furnished shall be provided.

(c) Symbols and Notations. The symbols and notations used in these regulations are defined as follows:

\[ A = \text{area, inches}^2. \]
\[ A_w = \text{area of cross section lying within 1.0 inch of a weld, inches}^2. \]
\[ a_1 = \text{shorter dimension of rectangular panel, inches.} \]
\[ a_2 = \text{longer dimension of rectangular panel, inches.} \]
\[ a_e = \text{equivalent width of rectangular panel, inches.} \]

\[ B, D, C, = \text{buckling formula constants, with following subscript:} \]
\[ c = \text{compression in columns} \]
\[ p = \text{compression in flat plates} \]
\[ t = \text{compression in round tubes} \]
\[ t_b = \text{bending in round tubes} \]
\[ b = \text{bending in rectangular bars} \]
\[ s = \text{shear in flat plates} \]
\[ b = \text{width of sections, inches.} \]
\[ b/t = \text{width to thickness ratio of rectangular element of a cross section} \]
\[ c = \text{distance from neutral axis to extreme fiber, inches.} \]
\[ D = \text{diameter, inches.} \]
\[ d = \text{depth of section or beam, inches.} \]
\[ E = \text{compressive modulus of elasticity, k.s.i.} \]
\[ f = \text{calculated stress, k.s.i.} \]
\[ f_a = \text{average compressive stress on cross section of member produced by axial compressive load, k.s.i.} \]
\[ f_b = \text{maximum bending stress (compression) caused by transverse loads or end moments, k.s.i.} \]
\[ f_s = \text{shear stress caused by torsion or transverse shear, k.s.i.} \]
SECTION 2801  
Material Standards and Symbols  
(Continued)

\( F = \) allowable stress, k.s.i.  
\( F_a = \) allowable compressive stress for member considered as an axially loaded column, k.s.i.  
\( F_b = \) allowable compressive stress for member considered as a beam, k.s.i.  
\( F_{bu} = \) bearing ultimate strength, k.s.i.  
\( F_{buw} = \) bearing ultimate strength within 1.0 inch of a weld, k.s.i.  
\( F_{by} = \) bearing yield strength, k.s.i.  
\( F_{byw} = \) bearing yield strength within 1.0 inch of a weld, k.s.i.  
\( F_c = \) allowable compressive stress, k.s.i.  
\( F_{cy} = \) compressive yield strength, k.s.i.  
\( F_{cyw} = \) compressive yield strength across a butt weld (0.2 per cent offset in 10 inches gauge length), k.s.i.  
\( F_{ec} = \pi^2E/[\nu_n(L/r)^2] \), where “\( L/r \)” is slenderness ratio for member considered as a column tending to fail in the plane of the applied bending moments, k.s.i.  
\( F_n = \) allowable stress for cross section 1.0 inch or more from weld, k.s.i.  
\( F_{nc} = \) allowable stress on cross section, part of whose area lies within 1.0 inch of a weld, k.s.i.  
\( F_{s} = \) allowable shear stress for members subjected only to torsion or shear, k.s.i.  
\( F_{su} = \) shear ultimate strength, k.s.i.  
\( F_{suw} = \) shear ultimate strength within 1.0 inch of a weld, k.s.i.  
\( F_{sy} = \) shear yield strength, k.s.i.  
\( F_{syw} = \) shear yield strength within 1.0 inch of a weld, k.s.i.  
\( F_{tu} = \) tensile ultimate strength, k.s.i.  
\( F_{tuw} = \) tensile ultimate strength across a butt weld, k.s.i.  
\( F_{ty} = \) tensile yield strength, k.s.i.  
\( F_{tyw} = \) tensile yield strength across a butt weld (0.2 per cent offset in 10 inches gauge length), k.s.i.  
\( F_y = \) either “\( F_{ty} \)” or “\( F_{cy} \)”, whichever is smaller, k.s.i.  
\( g = \) spacing of rivet or bolt holes perpendicular to direction of load, inches.  
\( G = \) modulus of elasticity in shear, k.s.i.  
\( h = \) clear height of shear web, inches.  
\( I = \) moment of inertia, inches\(^4\).  
\( I_h = \) moment of inertia of horizontal stiffener, inches\(^4\).  
\( I_s = \) moment of inertia of transverse stiffener to resist shear buckling, inches\(^4\).  
\( I_z = \) moment of inertia of a beam about axis perpendicular to web, inches\(^4\).  
\( I_y = \) moment of inertia of a beam about axis parallel to web, inches\(^4\).  
\( J = \) torsion constant, inches\(^4\).
$k_1 =$ coefficient for determining slenderness limit “$S_2$” for sections for which the allowable compressive stress is based on crippling strength.

$k_2 =$ coefficient for determining allowable compressive stress in sections with slenderness ratio above “$S_2$” for which the allowable compressive stress is based on crippling strength.

$k_c =$ coefficient for compression members.

$k_t =$ coefficient for tension members.

$L =$ length of compression member between points of lateral support, or twice the length of a cantilever column (except where analysis shows that a shorter length can be used), inches.

$L/r =$ slenderness ratio for columns.

$L_b =$ length of beam between points at which the compression flange is supported against lateral movement, or length of cantilever beam from free end to point at which the compression flange is supported against lateral movement, inches.

$L_h =$ total length of portion of column lying within 1.0 inch of a weld (excluding welds at ends of columns that are supported at both ends), inches.

$L_w =$ increased length to be substituted in column formula to determine allowable stress for welded column, inches.

$M =$ bending moment, inch-kips.

$M_c =$ bending moment at center of span resulting from applied bending loads, inch-kips.

$M_m =$ maximum bending moment in span resulting from applied bending loads, inch-kips.

$M_1, M_2 =$ bending moments at two ends of a beam, inch-kips.

$n_a =$ factor of safety on appearance of buckling.

$n_u =$ factor of safety on ultimate strength.

$n_y =$ factor of safety on yield strength.

$P =$ local load concentration on bearing stiffener, kips.

$r =$ least radius of gyration of a column, inches.

$r_L =$ radius of gyration of lip or bulb about face of flange from which lip projects, inches.

$r_y =$ radius of gyration of a beam (about axis parallel to web), inches. (For beams that are unsymmetrical about the horizontal axis, “$r_y$” should be calculated as though both flanges were the same as the compression flange.)

$R =$ outside radius of round tube or maximum outside radius for an oval tube, inches.
$R_b = \text{radius of curvature of tubular members, inches.}$

$s = \text{spacing of transverse stiffeners (clear distance between stiffeners for stiffeners consisting of a pair of members, one on each side of the web, center-to-center distance between stiffeners consisting of a member on one side of the web only), inches; spacing of rivet or bolt holes parallel to direction of load, inches.}$

$S_c = \text{section modulus of a beam, compression side, inches}^3.$

$S_t = \text{section modulus of a beam, tension side, inches}^3.$

$S_1, S_2 = \text{slenderness limits.}$

$t = \text{thickness of flange, plate, web or tube, inches. (For tapered flanges, } \bar{t} \text{ is the average thickness.)}$

$V = \text{shear force on web at stiffener location, kips.}$

$\alpha = \text{a factor equal to unity for a stiffener consisting of equal members on both sides of the web and equal to 3.5 for a stiffener consisting of a member on one side only.}$

(d) Identification. Aluminum for structural elements shall at all times be segregated or otherwise handled in the fabricator's plant so that the separate alloys and tempers are positively identified, and after completion of fabrication shall be marked to identify the alloy and temper. Such markings shall be affixed to complete members and assemblies or to boxed or bundled shipments of multiple units prior to shipment from the fabricator's plant.

Sec. 2802. (a) Allowable Unit Stresses. Except as modified by U.B.C. Standard No. 28-1, allowable unit stresses in aluminum alloy structural members shall be determined in accordance with the formulas of Table No. 28-C, utilizing the safety factors listed in Table No. 28-D and the constants and coefficients listed in Tables Nos. 28-E, 28-F and 28-G. Where two formulas are given, the smaller of the resulting stresses shall be used.

(b) Welded Structural Members. Allowable unit stresses for structural members whose entire cross-sectional area lies within 1 inch of the center line of a butt weld or the heel of a fillet weld shall be determined by means of the formulas of Table No. 28-C utilizing the applicable minimum expected mechanical properties for welded aluminum alloys listed in U.B.C. Standard No. 28-1. The tensile ultimate strength, $F_{tuw}$, shall be 90 per cent of the ASME weld qualification test value of ultimate strength. Except as modified by U.B.C. Standard No. 28-1, buckling constants determined in accordance with the formulas of Tables Nos. 28-E and 28-G shall be calculated using the nonwelded mechanical properties of the respective aluminum alloys.

If less than 15 per cent of the area of a given cross section lies within 1 inch of the center line of a butt weld or the heel
of a fillet weld, the effect of the weld may be neglected and allowable stresses for nonwelded structural members may be used.

If the area of a cross section that lies within 1 inch of a weld is between 15 per cent and 100 per cent of the total area of the cross section, the allowable stress shall be calculated by the following formula:

\[ F_{pw} = F_n - \frac{A_w}{A} (F_n - F_w) \]

**WHERE:**

- \( F_{pw} \) = allowable stress on cross section part of whose area lies within 1.0 inch of a weld.
- \( F_n \) = allowable stress for cross section 1.0 inch or more from weld.
- \( F_w \) = allowable stress on cross section if entire area were to lie within 1.0 inch of a weld.
- \( A_w \) = area of cross section lying within 1.0 inch of a weld.
- \( A \) = net area of cross section of a tension member or tension flange of a beam, or gross area of cross section of a compression member or compression flange of a beam, inches\(^2\) (a beam flange is considered to consist of that portion of the member further than \(2c/3\) from the neutral axis, where \(c\) is the distance from the neutral axis to the extreme fiber.)

For columns and beams with welds at locations other than at their supported ends (not farther from the supports than 0.05 \(L\) from the ends), and for cantilever columns and single web beams with transverse welds at or near the supported end, the effect of welding on allowable stresses shall be determined in accordance with the provisions of U.B.C. Standard No. 28-1.

(c) **Rivets and Bolts.** Allowable stresses in aluminum rivets and bolts shall be as set forth in Table No. 28-A.

(d) **Fillet Welds.** Allowable sheer stresses in fillet welds shall be as set forth in Table No. 28-B.

**Sec. 2803.** (a) **Combined Stresses.** Members subjected to combinations of compression and bending or shear, compression and bending shall be proportioned in accordance with the provisions of U.B.C. Standard No. 28-1.

(b) **Light Gauge Members.** Where the design of light gauge structural members is involved, the special provisions of U.B.C. Standard No. 28-1 shall be applied.
(c) **Connections.** The design of mechanical and welded connections shall be in accordance with this Chapter and the provisions of U.B.C. Standard No. 28-1.

Sec. 2804. (a) **Cutting.** Oxygen cutting of aluminum alloys shall not be permitted.

(b) **Fasteners.** Bolts and other fasteners shall be aluminum, stainless steel or aluminized, hot-dip galvanized or electro-galvanized steel. Double cadmium plated AN steel bolts may also be used. Steel rivets shall not be used except where aluminum is to be joined to steel, or where corrosion resistance of the structure is not a requirement, or where the structure is to be protected against corrosion.

(c) **Dissimilar Materials.** Where aluminum alloy parts are in contact with dissimilar metals, other than stainless, aluminized or galvanized steel, or absorbent building materials likely to be continuously or intermittently wet, the faying surfaces shall be painted or otherwise separated in accordance with U.B.C. Standard No. 28-1.

(d) **Painting.** Except as prescribed in Section 2804 (c), painting or coating of aluminum alloy parts shall be required only when called for on the plans.

(e) **Welding.** Aluminum parts shall be welded with an inert gas shielded arc or resistance welding process. No welding process that requires a welding flux shall be used. Filler alloys complying with the requirements of U.B.C. Standard No. 28-1 shall be used.

(f) **Welder Qualification.** All welds of structural members shall be performed by welders qualified in accordance with the procedures of U.B.C. Standard No. 28-1.

(g) **Erection.** During erection, structural aluminum shall be adequately braced and fastened to resist dead, wind and erection loads.
### TABLE NO. 28-A
ALLOWABLE STRESSES FOR RIVETS

<table>
<thead>
<tr>
<th>DESIGNATION BEFORE DRIVING</th>
<th>DRIVING PROCEDURE</th>
<th>DESIGNATION AFTER DRIVING</th>
<th>MINIMUM EXPECTED SHEAR STRENGTH k.s.i.</th>
<th>ALLOWABLE SHEAR STRESS ON EFFECTIVE AREA k.s.i.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1100-H14</td>
<td>Cold, as received</td>
<td>1100-F</td>
<td>9.5</td>
<td>4</td>
</tr>
<tr>
<td>2017-T4</td>
<td>Cold, as received</td>
<td>2017-T3</td>
<td>34</td>
<td>14.5</td>
</tr>
<tr>
<td>2117-T4</td>
<td>Cold, as received</td>
<td>2117-T3</td>
<td>29</td>
<td>12</td>
</tr>
<tr>
<td>5056-H3</td>
<td>Cold, as received</td>
<td>5056-H321</td>
<td>26</td>
<td>11</td>
</tr>
<tr>
<td>6053-T61</td>
<td>Cold, as received</td>
<td>6053-T61</td>
<td>20</td>
<td>8.5</td>
</tr>
<tr>
<td>6061-T4</td>
<td>Hot, 990°F to 1050°F.</td>
<td>6061-T43</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>6061-T6</td>
<td>Cold, as received</td>
<td>6061-T6</td>
<td>26</td>
<td>11</td>
</tr>
</tbody>
</table>

### ALLOWABLE STRESSES FOR BOLTS

<table>
<thead>
<tr>
<th>ALLOY AND TEMPER</th>
<th>MINIMUM EXPECTED SHEAR STRENGTH k.s.i.</th>
<th>ALLOWABLE SHEAR STRESS ON EFFECTIVE AREA k.s.i.</th>
<th>ALLOWABLE TENSILE STRESS ON ROOT AREA k.s.i.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024-T4</td>
<td>37</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>6061-T6</td>
<td>27</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>7075-T73</td>
<td>40</td>
<td>17</td>
<td>28</td>
</tr>
</tbody>
</table>

*Also applies to 6061-T6 Pins.

*Values apply to either turned bolts or unfinished bolts in holes not more than 1/16 inch oversized.

### TABLE NO. 28-B
ALLOWABLE SHEAR STRESSES IN FILLET WELDS-k.s.i.
(Shear Stress is Considered to be Equal to the Load Divided by the Throat Area)

<table>
<thead>
<tr>
<th>FILLER ALLOY</th>
<th>1100</th>
<th>4043</th>
<th>5356</th>
<th>5554</th>
<th>5556</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Alloy</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>1100</td>
<td>3.2</td>
<td>4.8</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3003</td>
<td>3.2</td>
<td>5</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Alclad 3004</td>
<td>*</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>*</td>
</tr>
<tr>
<td>5052</td>
<td>*</td>
<td>5</td>
<td>7</td>
<td>8.5</td>
<td>*</td>
</tr>
<tr>
<td>5083</td>
<td>*</td>
<td>*</td>
<td>7</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>5086</td>
<td>*</td>
<td>*</td>
<td>7</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>5454</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>5456</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>6061</td>
<td>*</td>
<td>5</td>
<td>7</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>6063</td>
<td>*</td>
<td>5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

*Not permitted.
<table>
<thead>
<tr>
<th>TYPE OF STRESS</th>
<th>TYPE OF MEMBER OR COMPONENT</th>
<th>SPEC. NO.</th>
<th>ALLOWABLE STRESS, KSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TENSION, axial, net section</td>
<td>Any tension member:</td>
<td>1</td>
<td>( F_{ay} / n_s ) or ( F_{ay} / (k_s n_w) )</td>
</tr>
<tr>
<td>TENSION IN BEAMS, extreme fiber, net section</td>
<td>Rectangular tubes, structural shapes bent about strong axis</td>
<td>2</td>
<td>( F_{ay} / n_s ) or ( F_{ay} / (k_s n_w) )</td>
</tr>
<tr>
<td></td>
<td>Round or oval tubes</td>
<td>3</td>
<td>( 1.17 F_{ay} / n_s ) or ( 1.24 F_{ay} / (k_s n_w) )</td>
</tr>
<tr>
<td></td>
<td>Rectangular bars, plates, shapes bent about weak axis</td>
<td>4</td>
<td>( 1.30 F_{ay} / n_s ) or ( 1.42 F_{ay} / (k_s n_w) )</td>
</tr>
<tr>
<td>BEARING</td>
<td>On rivets and bolts</td>
<td>5</td>
<td>( F_{ay} / n_s ) or ( F_{ay} / (1.2 n_s) )</td>
</tr>
<tr>
<td></td>
<td>On flat surfaces and pins</td>
<td>6</td>
<td>( F_{ay} / (1.5 n_s) ) or ( F_{ay} / (1.8 n_s) )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ALLOWABLE STRESS, KSI, SLENDERNESS &lt; ( S ), SLENDERNESS LIMIT, ( S )</th>
<th>ALLOWABLE STRESS, KSI SLENDERNESS BETWEEN ( S ) AND ( S ), SLENDERNESS LIMIT, ( S )</th>
<th>ALLOWABLE STRESS, KSI SLENDERNESS ≥ ( S ), SLENDERNESS LIMIT, ( S )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{ck} / k_t n_s )</td>
<td>( t = \frac{B_p - n_s F_{ck}}{k_t n_s} )</td>
<td>( \frac{1}{n_s} (B_p - D_c) )</td>
</tr>
<tr>
<td>Outstanding flanges and legs</td>
<td>( b = \frac{B_p - n_s F_{ck}}{5.1 D_p} )</td>
<td>( \frac{1}{n_s} (B_p - 5.1 D_p) )</td>
</tr>
<tr>
<td>Flat plates with both edges supported</td>
<td>( b = \frac{B_p - n_s F_{ck}}{1.6 D_p} )</td>
<td>( \frac{1}{n_s} (B_p - 1.6 D_p) )</td>
</tr>
<tr>
<td>Curved plates supported on both edges, walls of round or oval tubes</td>
<td>( R = \frac{(B_l - n_s F_{ck})^2}{D_l} )</td>
<td>( \frac{1}{n_s} (B_l - D_l \sqrt{R}) )</td>
</tr>
<tr>
<td>Compression in Beams, extreme fiber, gross section</td>
<td>Single web beams bent about strong axis</td>
<td>11</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Round or oval tubes</td>
<td>12</td>
<td>$\frac{1.17F_{cr}}{n_g}$</td>
</tr>
<tr>
<td>Solid rectangular beams</td>
<td>13</td>
<td>$\frac{1.3F_{cr}}{n_g}$</td>
</tr>
<tr>
<td>Rectangular tubes and box sections</td>
<td>14</td>
<td>$\frac{F_{cr}}{n_g}$</td>
</tr>
<tr>
<td>Compression in Components of Beams, (component under uniform compression), gross section</td>
<td>Outstanding flanges</td>
<td>15</td>
</tr>
<tr>
<td>Flat plates with both edges supported</td>
<td>16</td>
<td>$\frac{F_{cr}}{n_g}$</td>
</tr>
<tr>
<td>Compression in Components of Beams, (component under bending in own plane), gross section</td>
<td>Flat plates with compression edge free, tension edge supported</td>
<td>17</td>
</tr>
<tr>
<td>Flat plates with both edges supported</td>
<td>18</td>
<td>$\frac{1.3F_{cr}}{n_g}$</td>
</tr>
<tr>
<td>Flat plates with horizontal stiffener, both edges supported</td>
<td>19</td>
<td>$\frac{1.3F_{cr}}{n_g}$</td>
</tr>
<tr>
<td>Shear in Webs, gross section</td>
<td>Unstiffened flat webs</td>
<td>20</td>
</tr>
<tr>
<td>Stiffened flat webs</td>
<td>21</td>
<td>$\frac{F_{cr}}{n_g}$</td>
</tr>
</tbody>
</table>
### Table No. 28-D — Factors of Safety for Use with Aluminum Allowable Stress Specifications

<table>
<thead>
<tr>
<th>Type of Member and Stress</th>
<th>Intercept, ksi</th>
<th>Slope, ksi</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression in Columns and Beam Flanges</td>
<td>( B_c = F_{cy} \left[ 1 + \left( \frac{F_{cy}}{1000} \right)^{1/5} \right] )</td>
<td>( D_c = \frac{B_c}{20} \left( \frac{6B_c}{F} \right)^{1/2} )</td>
<td>( C_c = \frac{2B_c}{3D_c} )</td>
</tr>
<tr>
<td>Compression in Flat Plates</td>
<td>( B_p = F_{py} \left[ 1 + \left( \frac{F_{py}}{7,6} \right)^{1/3} \right] )</td>
<td>( D_p = \frac{B_p}{20} \left( \frac{6B_p}{E} \right)^{1/2} )</td>
<td>( C_p = \frac{2B_p}{3D_p} )</td>
</tr>
<tr>
<td>Compression in Round Tubes Under Axial End Load</td>
<td>( B_t = F_{ty} \left[ 1 + \left( \frac{F_{ty}}{5,8} \right)^{1/3} \right] )</td>
<td>( D_t = \frac{B_t}{37} \left( \frac{6B_t}{E} \right)^{1/2} )</td>
<td>( C_t = \left( \frac{2B_t}{3D_t} \right) )</td>
</tr>
<tr>
<td>Compressive Bending Stress in Solid Rectangular Bars</td>
<td>( B_s = 1.3F_{sy} \left[ 1 + \left( \frac{F_{sy}}{7} \right)^{1/3} \right] )</td>
<td>( D_s = \frac{B_s}{20} \left( \frac{6B_s}{E} \right)^{1/2} )</td>
<td>( C_s = \frac{2B_s}{3D_s} )</td>
</tr>
<tr>
<td>Compressive Bending Stress in Round Tubes</td>
<td>( B_n = 1.5F_{nz} \left[ 1 + \left( \frac{F_{nz}}{5,8} \right)^{1/3} \right] )</td>
<td>( D_n = \frac{B_n}{27} \left( \frac{6B_n}{E} \right)^{1/2} )</td>
<td>( C_n = \left( \frac{B_n - B_n}{D_n - D_n} \right)^2 )</td>
</tr>
<tr>
<td>Shear Stress in Flat Plates</td>
<td>( \sigma_s = \frac{F_{sz}}{6.2} )</td>
<td>( \sigma_b = \frac{20}{20} \left( \frac{6B_s}{E} \right)^{1/2} )</td>
<td>( C_s = \frac{2B_s}{3D_s} )</td>
</tr>
</tbody>
</table>

**C** can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.

---

### Table No. 28-E — Formulas for Buckling Constants

For all products whose temper designation begins with -O, -H, -T1, -T2, -T3, or -T4

<table>
<thead>
<tr>
<th>Type of Member and Stress</th>
<th>Intercept, ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression in Columns and Beam Flanges</td>
<td>( B_c = F_{cy} \left[ 1 + \left( \frac{F_{cy}}{1000} \right)^{1/5} \right] )</td>
</tr>
<tr>
<td>Compression in Flat Plates</td>
<td>( B_p = F_{py} \left[ 1 + \left( \frac{F_{py}}{7,6} \right)^{1/3} \right] )</td>
</tr>
<tr>
<td>Compression in Round Tubes Under Axial End Load</td>
<td>( B_t = F_{ty} \left[ 1 + \left( \frac{F_{ty}}{5,8} \right)^{1/3} \right] )</td>
</tr>
<tr>
<td>Compressive Bending Stress in Solid Rectangular Bars</td>
<td>( B_s = 1.3F_{sy} \left[ 1 + \left( \frac{F_{sy}}{7} \right)^{1/3} \right] )</td>
</tr>
<tr>
<td>Compressive Bending Stress in Round Tubes</td>
<td>( B_n = 1.5F_{nz} \left[ 1 + \left( \frac{F_{nz}}{5,8} \right)^{1/3} \right] )</td>
</tr>
<tr>
<td>Shear Stress in Flat Plates</td>
<td>( \sigma_s = \frac{F_{sz}}{6.2} )</td>
</tr>
</tbody>
</table>

**k**, can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.
### TABLE NO. 28-F

**VALUES OF COEFFICIENTS \( k_t \) and \( k_c \)**

<table>
<thead>
<tr>
<th>ALLOY AND TEMPER</th>
<th>NONWELDED OR REGIONS FARTHER THAN 1.0 INCH FROM A WELD</th>
<th>REGIONS WITHIN 1.0 INCH OF A WELD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( k_t )</td>
<td>( k_c )</td>
</tr>
<tr>
<td>2014-T6, -T651</td>
<td>1.25</td>
<td>1.12</td>
</tr>
<tr>
<td>Alclad 2014-T6, -T651</td>
<td>1.25</td>
<td>1.12</td>
</tr>
<tr>
<td>6061-T6, -T651</td>
<td>1.0</td>
<td>1.12</td>
</tr>
<tr>
<td>6063-T5, -T6, -T83</td>
<td>1.0</td>
<td>1.12</td>
</tr>
<tr>
<td>All Others Listed in U.B.C. Standard No. 28-1</td>
<td>1.0</td>
<td>1.10</td>
</tr>
</tbody>
</table>

*If the weld yield strength exceeds 0.9 of the parent metal yield strength, the allowable compressive stress within 1.0 inch of a weld should be taken equal to the allowable stress for nonwelded material.*

### TABLE NO. 28-G — FORMULAS FOR BUCKLING CONSTANTS

For Products Whose Temper Designation Begins With -T5, -T6, -T7, -T8, or -T9

<table>
<thead>
<tr>
<th>Type of Member and Stress</th>
<th>Intercept, ksi</th>
<th>Slope, ksi</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression in Columns and Beam Flanges</td>
<td>( B_c = F_{cy} \left[ 1 + \left( \frac{F_{2y}}{2250} \right)^{1/3} \right] )</td>
<td>( D_c = \frac{B_c (B_c)^{1/2}}{10 (E)} )</td>
<td>( C_c = 0.41 \frac{B_c}{D_c} )</td>
</tr>
<tr>
<td>Compression in Flat Plates</td>
<td>( B_p = F_{cy} \left[ 1 + \left( \frac{F_{2y}}{11.4} \right)^{1/3} \right] )</td>
<td>( D_p = \frac{B_p (B_p)^{1/2}}{10 (E)} )</td>
<td>( C_p = 0.41 \frac{B_p}{D_p} )</td>
</tr>
<tr>
<td>Compression in Round Tubes Under Axial End Load</td>
<td>( B_l = F_{cy} \left[ 1 + \left( \frac{F_{2y}}{8.7} \right)^{1/3} \right] )</td>
<td>( D_l = \frac{B_l (B_l)^{1/2}}{4.5 (E)} )</td>
<td>( C_l )</td>
</tr>
<tr>
<td>Compressive Bending Stress in Solid Rectangular Bars</td>
<td>( B_b = 1.3 F_{cy} \left[ 1 + \left( \frac{F_{2y}}{2250} \right)^{1/3} \right] )</td>
<td>( D_b = \frac{B_b (B_b)^{1/2}}{20 (E)} )</td>
<td>( C_b = \frac{2 B_b}{3 D_b} )</td>
</tr>
<tr>
<td>Compressive Bending Stress in Round Tubes</td>
<td>( B_{ob} = 1.5 F_{cy} \left[ 1 + \left( \frac{F_{2y}}{8.7} \right)^{1/3} \right] )</td>
<td>( D_{ob} = \frac{B_{ob} (B_{ob})^{1/2}}{2.7 (E)} )</td>
<td>( C_{ob} = \left( \frac{B_{ob} - B_b}{D_{ob} - D_b} \right)^{2} )</td>
</tr>
<tr>
<td>Shear Stress in Flat Plates</td>
<td>( B_s = F_{sy} \left[ 1 + \left( \frac{F_{2y}}{9.3} \right)^{1/3} \right] )</td>
<td>( D_s = \frac{B_s (B_s)^{1/2}}{10 (E)} )</td>
<td>( C_s = 0.41 \frac{B_s}{D_s} )</td>
</tr>
</tbody>
</table>

\( C, \) can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.
PART VII
DETAILED REGULATIONS
CHAPTER 29 — EXCAVATIONS, FOUNDATIONS, AND RETAINING WALLS

NOTE: Tables in Chapter 29 appear at the end of the Chapter.

Sec. 2901. 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.

Sec. 2902. (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 2 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.
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.

Sec. 2903. (a) General. The classification of the soil at each building site shall be determined when required by the Building Official. The Building Official may require that this determination be made by an engineer or architect licensed by the state to practice as such.

(b) Investigation. The classification shall be based on observation and any necessary tests of the materials disclosed by borings or excavations made in appropriate locations. Additional studies may be necessary to evaluate bearing capacity, compressibility, or other pertinent characteristics of the foundation materials.

The investigation shall include a consideration of the effect of moisture variation on soil bearing capacity, compressibility and volume change (expansiveness). Soils that swell more than three per cent from air dry to saturation under a surcharge load of 60 pounds per square foot shall be classed as expansive.

(c) Reports. The soil classification and design bearing capacity shall be shown on the plans, unless the foundation conforms to Table No. 29-A. The Building Official may require submission of a written report of the investigation which shall include, but need not be limited to the following information:

1. A plot showing the location of all test borings and/or excavations.
2. Descriptions and classifications of the materials encountered.
3. Elevation of the water table if encountered.
4. Recommendations for foundation type and design criteria including bearing capacity, provisions to minimize the effects of expansive soils, and the effects of adjacent loads.
5. Expected total and differential settlement.

(d) Expansive Soils. When expansive soils are present, the Building Official may require that special provisions be
Foundation Investigation (Continued)

made in the foundation design and construction to safeguard against damage due to this expansiveness. He may require a special investigation and report to provide this design and construction criteria.

(e) Adjacent Loads. Where footings are placed at varying elevations the effect of adjacent loads shall be included in the foundation design.

(f) Exemptions. The foregoing provisions may be waived by the Building Official for the following structures:

1. Minor buildings or structures.
2. Type V buildings except where expansive soils or materials of highly different bearing capacities are present.
3. Type IV buildings under 2,000 square feet in area.

Allowable Soil Pressures

Sec. 2904. The allowable unit soil pressure upon every footing shall not exceed the values set forth in Table No. 29-C, unless data to substantiate the use of higher values is submitted to and approved by the Building Official.

Footings

Sec. 2905. (a) General. Footings and foundations, unless otherwise specifically provided, shall be constructed of solid masonry or concrete and in all cases extend below the frost line. Foundations supporting wood shall extend at least 6 inches above the adjacent finish grade.

(b) Bearing Walls. Bearing walls shall be supported on solid masonry or concrete footings or piles of sufficient size to support all loads. Where a design is not provided, the minimum foundation requirements for stud bearing walls shall be as set forth in Table No. 29-A.

EXCEPTIONS: 1. A one-story wood or metal frame building not used for human occupancy and not over 400 square feet in floor area may be constructed with walls supported on a wood foundation plate.

2. The support of buildings by posts embedded in earth shall be designed as specified in Section 2906 (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 2908 (f).

(c) Stepped Foundations. Foundations for all buildings where the surface of the ground slopes more than 1 foot in 10 feet 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 2907 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.

(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 (\( \frac{1}{2} \)) 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).

(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.

\[
d = \frac{A}{\sqrt{1 + \frac{4.36h}{A}}}\]

WHERE:

\[
P = \text{Applied lateral force in pounds.}
\]

\[
A = \frac{2.34P}{b}
\]

\[
S_1 = \text{Allowable lateral soil-bearing pressure as set forth in Table No. 29-B based on a depth of one-third the depth of embedment.}
\]

\[
S_3 = \text{Allowable lateral soil-bearing pressure as set forth in Table No. 29-B based on a depth equal to the depth of embedment.}
\]

\[
b = \text{Diameter of round post or footing or diagonal dimension of square post or footing (feet).}
\]

\[
h = \text{Distance in feet from ground surface to point of application of "P."}
\]

\[
d = \text{Depth of embedment in earth in feet but not over twelve feet (12') for purpose of computing lateral pressure.}
\]

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.

\[
d^2 = 4.25 \frac{Ph}{S_3b}
\]

**Vertical load.** The resistance to vertical loads is determined by the allowable soil-bearing pressure set forth in Table No. 29-C.
Footings (Continued)

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.

Sec. 2906. 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.

Sec. 2907. (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.
(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 2908.

**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. 29-C 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 2903. 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 2909, 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.

**Sec. 2908.** (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.

(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 2903.

Allowable Axial Load = \( R/4 \) for all piles.

WHERE:

\[
R \text{ (for steel piles)} = \frac{W + 0.25P}{12 Wh} \frac{RL 24,000}{S + \frac{AE}{R}}
\]

\[
R \text{ (for other piles)} = \frac{W + 0.1P}{12 Wh} \frac{RL 24,000}{S + \frac{AE}{R}}
\]

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.
Sec. 2909. (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. 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.

2. Allowable stresses. The allowable unit stresses for round wood piles shall not exceed those set forth in Table No. 25-E.

(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 \( 0.33f'_c \). The allowable stress in the reinforcing steel shall not exceed that specified for tied columns in Section 2610 (d).

(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 8 inches. 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. Allowable stresses shall not exceed the values specified in Section 2909 (b) 2, except that the allowable concrete stress may be increased to a maximum value of \( 0.40f'_c \) for that portion of the pile meeting the following conditions:
1. The thickness of the metal casing is not less than No. 14 gauge.

2. The casing is seamless or is provided with seams of equal strength and is of a configuration which will provide confinement to the cast-in-place concrete.

3. The design \( f'c \) shall not exceed 5000 pounds per square inch and the ratio of metal yield strength to concrete ultimate strength shall be not less than 6.

4. The pile diameter is not greater than 16 inches.

(d) Precast Concrete Piles. 1. Material. Precast concrete piles shall be cast in one piece and prior to driving and at 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 (\( \frac{1}{4} \)) 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 2909 (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. 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 (1/4") 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.

The compressive stress in the concrete due to externally applied load shall not exceed

\[ f_c = 0.33f'_c - 0.27f_{pe} \]

WHERE:

"f_{pe}" is the effective prestress stress on the gross section.

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.

No section shall have a nominal thickness of metal less than 3/8 inch.

2. Allowable Stresses. The allowable stresses shall not exceed .35 of the minimum specified yield strength, "F_y", provided such yield strength shall not be assumed greater than 36,000 pounds per square inch for computation purposes.

(g) Concrete-filled Steel Pipe Piles. 1. Material. Steel pipe piles shall conform to U.B.C. Standard No. 27-1. 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 .35 of the minimum specified yield strength "F_y" on the steel plus 0.33 of the ultimate compressive strength (f'_c) of the concrete, provided "F_y" shall not be assumed greater than 36,000 pounds per square inch for computation purposes.
TABLE NO. 29-A — FOUNDATIONS FOR STUD BEARING WALLS
MINIMUM REQUIREMENTS

<table>
<thead>
<tr>
<th>NUMBER OF STORIES</th>
<th>THICKNESS OF FOUNDATION WALL (Inches)</th>
<th>WIDTH OF FOOTING (Inches)</th>
<th>THICKNESS OF FOOTING (Inches)</th>
<th>DEPTH OF FOUNDATION BELOW NATURAL SURFACE OF GROUND AND FINISH GRADE (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONCRETE</td>
<td>UNIT MASONRY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>8</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>10</td>
<td>18</td>
<td>8</td>
</tr>
</tbody>
</table>

NOTES:
Where unusual conditions or frost conditions are found, footings and foundations shall be as required in Section 2905 (a).
The ground under the floor may be excavated to the elevation of the top of the footing.

TABLE NO. 29-B — ALLOWABLE LATERAL SOIL PRESSURE

<table>
<thead>
<tr>
<th>CLASS OF MATERIAL</th>
<th>ALLOWABLE VALUES PER FOOT OF DEPTH BELOW NATURAL GRADE (Pounds per Square Foot)</th>
<th>MAXIMUM ALLOWABLE VALUES (Pounds per Square Foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good — compact well-graded sand and gravel Hard Clay</td>
<td>400</td>
<td>8000</td>
</tr>
<tr>
<td>Well-graded fine and coarse sand (All drained so water will not stand)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average—compact fine sand Medium Clay Compact sandy loam Loose coarse sand and gravel (All drained so water will not stand)</td>
<td>200</td>
<td>2500</td>
</tr>
<tr>
<td>Poor—Soft Clay Clay Loam Poorly compacted sand Clays containing large amounts of silt (Water stands during wet season)</td>
<td>100</td>
<td>1500</td>
</tr>
</tbody>
</table>

1Isolated poles, such as flagpoles, or signs, may be designed using lateral bearing values equal to two times tabulated values.
<table>
<thead>
<tr>
<th>CLASS OF MATERIAL</th>
<th>MINIMUM DEPTH OF FOOTING BELOW ADJACENT VIRGIN GROUND</th>
<th>VALUE PERMISSIBLE IF FOOTING IS AT MINIMUM DEPTH, POUNDS PER SQUARE FOOT</th>
<th>INCREASE IN VALUE FOR EACH FOOT OF DEPTH THAT FOOTING IS BELOW MINIMUM DEPTH, POUNDS PER SQUARE FOOT</th>
<th>MAXIMUM VALUE POUNDS PER SQUARE FOOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock</td>
<td>0'</td>
<td>20% of ultimate crushing strength</td>
<td>0</td>
<td>20% of ultimate crushing strength</td>
</tr>
<tr>
<td>Compact coarse sand</td>
<td>1'</td>
<td>1500'</td>
<td>300'</td>
<td>8000</td>
</tr>
<tr>
<td>Compact fine sand</td>
<td>1'</td>
<td>1000'</td>
<td>200'</td>
<td>8000</td>
</tr>
<tr>
<td>Loose sand</td>
<td>2'</td>
<td>500'</td>
<td>100'</td>
<td>3000</td>
</tr>
<tr>
<td>Hard clay or sandy clay</td>
<td>1'</td>
<td>4000</td>
<td>800</td>
<td>8000</td>
</tr>
<tr>
<td>Medium-stiff clay or sandy clay</td>
<td>1'</td>
<td>2000</td>
<td>200</td>
<td>6000</td>
</tr>
<tr>
<td>Soft sandy clay or clay</td>
<td>2'</td>
<td>1000</td>
<td>50</td>
<td>2000</td>
</tr>
<tr>
<td>Expansive soils</td>
<td>1 6/3&quot;</td>
<td>1000&quot;</td>
<td>50&quot;</td>
<td>4000</td>
</tr>
<tr>
<td>Compact inorganic sand and silt mixtures</td>
<td>1'</td>
<td>1000</td>
<td>200</td>
<td>4000</td>
</tr>
<tr>
<td>Loose inorganic sand silt mixtures</td>
<td>2'</td>
<td>500</td>
<td>100</td>
<td>1000</td>
</tr>
<tr>
<td>Loose organic sand and silt mixtures and muck or bay mud</td>
<td>0'</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1These values are for footings 1 foot in width and may be increased in direct proportion to the width of the footing to a maximum of three times the designated value.
2For depths greater than 8 feet use values given for clay of comparable consistency.
3Also, see Section 2903 (d).
CHAPTER 30 — VENEER

Scope

Sec. 3001. (a) General. All veneer and its application shall conform to the requirements of this Code. Wainscots not exceeding 4 feet 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 20 feet in height above the adjacent ground elevation except when approved by the Building Official considering special construction design to provide for differential movement.

Definitions

Sec. 3002. 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. 3003. 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 noncombustible and corrosion-resistant.

Design

Sec. 3004. (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.
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.

Sec. 3005. (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 2517 (g).

(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 3001 (b).

(c) Unit Size Limitations. Veneer units shall not exceed 36 inches in the greatest dimension, nor more than 720 square inches 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 3004 (a) adhered veneer may be applied by one of the methods specified in U.B.C. Standard No. 30-1.

(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.

Sec. 3006. (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 noncombustible supports.

Where anchored veneer is applied more than 20 feet above the adjacent ground elevation, it shall be supported by noncombustible, corrosion-resistant, structural framing having hor-
izontal supports spaced not over 12 feet vertically above the 20-foot height.

Noncombustible noncorrosive lintels and noncombustible 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 3001 (b).

(d) Application. In lieu of the design required by Section 3004 anchored veneer may be applied by one of the methods specified in U.B.C. Standard No. 30-1.
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.

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 on the roof.

Sec. 3202. 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-Q.

Sec. 3203. (a) General. Roof coverings shall be as specified in this Section.

(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 or inorganic fiber shingles, smooth coating, or mineral aggregate.

BUILT-UP ROOF is two or more layers of roofing consisting of base sheets, and cap sheet, mineral aggregate, smooth coating, or similar surfacing material.

CAP SHEET is roofing made of organic or inorganic fibers, saturated and coated on both sides with a bituminous compound, surfaced with mineral granules, mica, talc, ilminite, asbestos or other inorganic fibers, or similar materials.

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.
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 matted organic or 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.
PREPARED ROOFING is any composition roofing other than built-up roofing assemblies.
ROOFING SQUARE is 100 square feet of roofing surface.
SPOT-CEMENTING is discontinuous application of hot asphalt, cold liquid asphalt compound, hot coal tar pitch or other approved cementing material.
STRIP-MOPPING is a continuous application of bitumen in parallel strips for attachment of built-up roofing to a deck.
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 100 square feet of roof coverage.
WOOD SHAKES are tapered or nontapered pieces of Western red cedar or redwood of random widths ranging from 4 inches to 14 inches, and of the following four types:
1. Hand-split and resawn; tapered and having one sawed and one split face, 18 inches, 24 inches or 32 inches in length.
2. Taper-split; tapered and having both split faces, 24 inches in length.
3. Straight-split; nontapered and with both split faces, either 18 inches, or 24 inches in length.
4. Taper sawn redwood shakes — sawn both sides — edges sawn or split with edge variation not to exceed ½ inch per side. Minimum butt thickness shall be not less than ½ inch, with a tolerance of ¼ inch permitted in the specified thickness. Lengths 24 inches and longer.
WOOD SHINGLES are tapered pieces of Western Red Cedar or Redwood, sawed both sides, of random widths ranging from 3 inches to 14 inches and 16 inches, 18 inches or 24 inches in length.
(c) Roofing Materials. 1. Materials. Materials shall conform to the following Standards:
## Roof Coverings (Continued)

### Asphalt, Roofing
- 32-1

### Coal Tar, Roofing
- 32-1

### Cap Sheet
- 32-1
  - Mineral Surfaced - 32-3
  - Smooth Surfaced - 32-1

### Felt, Roofing
- 32-1

### Metal Roofing
- 32-4

### Mineral Roofing Aggregate
- 32-5

### Nails, Corrosion-resistant
- 32-6

### ROOFING, COMPOSITION

- **Class A** - 32-7
- **Class B** - 32-7
- **Class C** - 32-7

### Shakes, hand-split
- 32-8

### SHINGLES

- Asbestos - 32-7
- Asbestos-cement - 32-9
- Asphalt - 32-3
- Slate - 32-10
- Wood - 32-11

### TILE

- Concrete - 32-12
- Clay - 32-12

### WIRE
- 32-13

### SPECIAL PURPOSE ROOFS
- 32-14

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.
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 U.B.C. Standard No. 27-9.

5. Nails. Nails for composition roofs shall be not smaller than No. 12 gauge, with heads not less than three-eighths inch (\(\frac{3}{8}\)"") in diameter for shingle application and seven-sixteenths inch (\(\frac{7}{16}\)"") in diameter for built-up roofs, and shall be long enough to penetrate into the sheathing three-fourths inch (\(\frac{3}{4}\)"), 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. 14 1/2 gauge corrosion-resistant and shall be long enough to penetrate into the sheathing three-fourths inch (\(\frac{3}{4}\)"), 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 (\(\frac{3}{4}\)" 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. 11 gauge corrosion-resistant, and shall be long enough to penetrate into the sheathing \(\frac{3}{4}\) inch, or through the thickness of the sheathing, whichever is less.

EXCEPTION: Approved tiles of clay or concrete designed to be held in place by lugs engaging battens, may be installed in accordance with their approvals.

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.
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.

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. Ribboned or otherwise faulty slate shingles shall not be used.


(d) **Application.** 1. **Built-up roofs.** Built-up roofing shall be applied only to solid surface roofs.

Base sheets shall be cemented, spot- or strip-mopped to a nonnailable deck as required by the type of deck material, using not less than 20 pounds of hot asphalt for solid mopping (10 pounds for spot- or strip-mopping), 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.

Over nailable decks, base sheets shall be nailed, using not less than one nail per each 1\(\frac{1}{2}\) square foot with nails of the type required by the manufacturer for the type of deck.

Successive layers shall be cemented to the base sheets using no less cementing material than that specified for solidly cemented base sheets.

Mineral aggregate 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 not less than 375°F., nor more than 450°F., for high melt types. Low melt types shall not be applied at a temperature of less than 350°F., nor more than 400°F.

Coal tar pitch shall not be heated to a temperature above 475°F., for a high melt type nor 400°F., for low melt types. Coal tar pitch shall not be heated to a temperature above 400°F. At no time shall the asphalt be heated to a temperature which will exceed its flash point at the kettle.

\(^1\)See U.B.C. Standard No. 32-5 for mineral roofing aggregate weighing less than 60 pounds per cubic foot.
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 36 inches wide and two nails per each individual shingle less than 20 inches wide.

Composition shingles shall not be installed on a roof having a slope of less than 4 inches to 12 inches 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 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 shakes, 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 conforming to the provisions of Section 3203 (c), paragraphs 5 and 9, or other approved means.

Tile shall not be installed on a roof having a slope of less than 3 inches to 12 inches unless approved by the Building Official.

Tile with projecting anchor lugs at the bottom of the tiles shall be held in position by means of 1-inch by 2-inch wood stripping nailed to the roof sheathing over the underlay.

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 four inches (1" x 4") 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 (¾"). 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 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 (1 1/2") between joints in adjacent courses. Edges shall be parallel within one inch (1"). Spacing between shakes shall be not more than one-half inch (1/2").

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

<table>
<thead>
<tr>
<th>PITCH OF ROOF</th>
<th>SHINGLE LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISE</td>
<td>16-INCH</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
</tr>
<tr>
<td>3&quot; to less than 4&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>4&quot; or more</td>
<td>12&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TAPERED WOOD SHAKES</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE TO WEATHER</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>7½&quot;</td>
</tr>
<tr>
<td>10&quot;</td>
</tr>
<tr>
<td>13&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRAIGHT-SPLIT WOOD SHAKES</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE TO WEATHER</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>5½&quot;</td>
</tr>
<tr>
<td>7½&quot;</td>
</tr>
</tbody>
</table>

Section 3203 (d) 1 consisting of not less than the following:

**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**
- 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, or

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1 See U.B.C. Standard No. 32-5 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.
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).
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.

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.

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.
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 3000 square feet by partitions extending from the ceiling to the roof.

Such partitions shall be not less than one-half-inch (1/2") thick gypsum wallboard, or one-inch (1") nominal thickness tight-fitting wood, 9/16-inch thick plywood, or approved non-combustible 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 9000 square feet.

(c) Ventilation. Where determined necessary by the Building Official due to atmospheric or climatic conditions, 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.

Sec. 3206. (a) When Required. Smoke and heat vents shall be installed in accordance with the provisions of this Section as follows:

1. In Groups G and F Occupancies over 50,000 square feet in single floor area.

2. In Group E Occupancies over 15,000 square feet in single floor area.
(b) **Mixed Occupancies.** Venting facilities shall be installed in buildings of mixed occupancy on the basis of the individual occupancy involved.

(c) **Types of Vents.** Vents shall be fixed in the open position or shall open automatically in the event of fire, and may consist of skylights, exterior wall windows or other openings leading directly to the exterior of the building. Vents shall be at or near the highest elevation of the ceiling and in no case lower than the upper one-third of the smoke curtain. Where plain glass is used, provision shall be made to protect the occupants from glass breakage. In no case shall vents be located closer than 20 feet to an adjoining property line.

(d) **Releasing Devices.** Releasing devices for automatically opening vents shall be activated by temperature. The temperature releasing device shall be operated normally at a maximum temperature of 165°F.; special circumstances warranting higher releasing temperatures may be approved by the Building Official. Noncorrodible materials shall be used for hinges, latches and related details to prevent sticking and consequent failure to open.

(e) **Size and Spacing of Vents.**

1. **Effective vent area.** The effective venting area is the minimum cross-sectional area through which the hot gases must pass enroute to atmosphere. The effective venting area shall be not less than 16 square feet with no dimension less than 2 feet.

2. **Spacing.** The maximum center-to-center spacing between vents within the building shall be:
   
   A. In Groups G and F Occupancies: 120 feet.
   
   B. In Group E Occupancies: 100 feet.

3. **Venting ratios.** The following ratios of effective area of vent openings to floor areas shall be:
   
   A. In Groups G and F Occupancies: 1:100.
   
   B. In Group E Occupancies: 1:50.

(f) **Curtain Boards.**

1. **General.** Curtain boards shall be provided to subdivide a vented building in accordance with the provisions of this Subsection.

2. **Construction.** Curtain boards shall be sheet metal, asbestos board, lath and plaster, gypsum wallboard or other substantial materials.

3. **Location and depth.** Curtain boards shall extend down from the ceiling for a minimum depth of 6 feet but need not extend closer than 8 feet to the floor. In Group E Occupancies, the minimum depth shall be 12 feet except that it need not be closer than 8 feet to the floor providing the curtain is not less than 6 feet in depth.
4. **Spacing.** The distance between curtain boards shall not exceed 250 feet and the curtained area shall be limited to 50,000 square feet. In Group E Occupancies, the distance between curtain boards shall not exceed 100 feet and the curtained area shall be limited to 15,000 square feet.

**Sec. 3207. (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 2 inches 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 2 inches above the low point of the adjacent roof and having a minimum opening height of 4 inches.

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.

(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.

**Sec. 3208.** 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).
SECTION 3301

CHAPTER 33—STAIRS, EXITS AND OCCUPANT LOADS

General

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.

(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, smoke-proof 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 way of passage from one building into another building on approximately the same level, or is a way of passage through or around a wall constructed as required for a two-hour occupancy separation and which completely divides a floor into two or more separate areas so as to establish an area of refuge affording safety from fire or smoke coming from the area from which escape is made.

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 10 feet 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-
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 18 inches 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 24 inches 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.

(k) Changes in Elevation. Except in Group I Occupancies, changes in elevation of less than 12 inches along any exit serving a tributary occupant load of 10 or more, shall be by means of ramps.

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 2000 square feet or if more than 60 feet in any dimension shall have not less than two stairways to an adjacent floor.

For special requirements for Groups A, B, C, D, and E Occupancies, see Sections 3315, 3316, 3317, 3318, and 3319. 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,
<table>
<thead>
<tr>
<th>Use</th>
<th>Minimum of Two Exits Required Where Number of Occupants Is Over</th>
<th>Square Feet Per Occupant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft Hangars (No repair)</td>
<td>10</td>
<td>500</td>
</tr>
<tr>
<td>Auction Rooms</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Assembly Areas, Concentrated Use (without fixed seats)</td>
<td>50</td>
<td>7</td>
</tr>
<tr>
<td>Auditoriums</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bowling Alleys (Assembly areas)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Churches and Chapels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dance Floors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lodge Rooms</td>
<td></td>
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<tr>
<td>Reviewing Stands</td>
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<td>Stadiums</td>
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</tr>
<tr>
<td>Assembly Areas, Less-concentrated Use</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>Conference Rooms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dining Rooms</td>
<td></td>
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</tr>
<tr>
<td>Drinking Establishments</td>
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<tr>
<td>Exhibit Rooms</td>
<td></td>
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<tr>
<td>Gymnasiums</td>
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<tr>
<td>Lounges</td>
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<td>Skating Rinks</td>
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<tr>
<td>Stages</td>
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<tr>
<td>Children's Homes and Homes for the Aged</td>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>Classrooms</td>
<td>50</td>
<td>20</td>
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<td>Dormitories</td>
<td>10</td>
<td>50</td>
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<tr>
<td>Dwellings</td>
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<td>Garage, Parking</td>
<td>10</td>
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<td>Hospitals and Sanitariums—Nursing Homes</td>
<td>30</td>
<td>80</td>
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<tr>
<td>Hotels and Apartments</td>
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<tr>
<td>Kitchen—Commercial</td>
<td>30</td>
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<tr>
<td>Library Reading Room</td>
<td>50</td>
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</tr>
<tr>
<td>Locker Rooms</td>
<td>30</td>
<td>50</td>
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<tr>
<td>Mechanical Equipment Room</td>
<td>30</td>
<td>300</td>
</tr>
<tr>
<td>Nurseries for Children (Day-care)</td>
<td>5</td>
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</tr>
<tr>
<td>Offices</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>School Shops and Vocational Rooms</td>
<td>50</td>
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<tr>
<td>Stores—Retail Sales Rooms</td>
<td></td>
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<tr>
<td>Basement</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Ground Floor</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Upper Floors</td>
<td>10</td>
<td>50</td>
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<tr>
<td>Warehouses</td>
<td>30</td>
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</tr>
<tr>
<td>All Others</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

1Refer to Sections 3318 and 3319 for other specific requirements.
2See Section 3302 for basement exit requirements.
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').

(e) Exits Through Adjoining or Accessory Areas. Exits from a room may open into an adjoining or intervening room or area provided such adjoining room is accessory to the area served and provides a direct means of egress to an exit corridor, exit stairway, exterior exit, horizontal exit, exterior exit balcony or exit passageway.

EXCEPTION: Exits are not to pass through kitchens, storerooms, rest rooms, closets or spaces used for similar purposes.

Foyers, lobbies and reception rooms constructed as required for corridors shall not be construed as intervening rooms.

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.

Manually operated edge or surface mounted flush bolts and surface bolts are prohibited. When exit doors are used in pairs and approved automatic flush bolts are used, the door leaf having the automatic flush bolts shall have no door knob or surface mounted hardware. The unlatching of any leaf shall not require more than one operation.

(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 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 a 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 provided 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.

Sec. 3304. (a) General. This Section shall apply to every corridor serving as a required exit for an occupant load of 10 or more persons. For the purposes of this Section the term “corridor” shall include “exterior exit balcony” and any covered or enclosed exit passageway including walkways, tunnels and malls.

Foyers, lobbies and reception rooms meeting the construction requirements of corridors as specified in this Section may be classed as corridors.

Partitions, rails, counters and similar space dividers not over 5 feet in height above the floor shall not be construed to form corridors.

(b) Width. Every corridor shall be not less in width than 44 inches. For special requirements for Groups C and D Occupancies, see Sections 3317 and 3318.

(c) Height. Corridors and exterior exit balconies shall have a clear height of not less than 7 feet measured to the lowest projection from the ceiling.

(d) Projections. The required width of corridors shall be unobstructed.

EXCEPTION: Trim handrails, and doors when fully opened, shall not reduce the required width by more than 7 inches. Doors in any position shall not reduce the required width by more than one-half.

(e) 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 to a separate exit, except for dead ends permitted by this Section.

(f) Dead Ends. Corridors with dead ends are permitted when the dead end does not exceed 20 feet in length.

(g) Construction. Walls and ceilings of corridors serving an occupant load of 30 or more shall be of not less than one-hour fire-resistive construction.

EXCEPTIONS: 1. One-story buildings housing Group G Occupancies.
2. Corridors more than 30 feet in width where occupancies served by such corridor have at least one exit independent from the corridor.
3. Exterior sides of exterior exit balconies.
Ceilings of noncombustible construction without a fire-resistive rating may be suspended below the fire-resistive ceiling.

(h) **Openings.** Where corridor walls are required to be of one-hour fire-resistive construction by Subsection (g) above, every door opening shall be protected with a tight-fitting smoke or draft stop fire assembly having a fire-protection rating of not less than 20 minutes when tested in accordance with U.B.C. Standard No. 43-2 without the hose stream test. Clos­ing devices will not be required. Glazed openings of the size and construction permitted for three-fourths-hour fire door assemblies in Section 4306 (f) may be installed in such doors. Other interior openings shall be protected by approved ¼-inch thick wired glass set in steel frames except that interior openings to an exterior exit balcony need not be protected. The total area of all openings, other than doors, in any portion of an interior corridor shall not exceed 25 per cent of the area of the corridor wall of the room which it is separating from the corridor.

**EXCEPTION:** Protection of openings in interior walls of exterior exit balconies is not required.

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 44 inches. Stairways serving an occupant load of 50 or less may be 36 inches wide. Private stairways serving an occupant load of less than 10 may be 30 inches wide.

Trim shall not reduce the required width by more than 3½ inches. Handrails may project from each side of a stairway a distance of 3½ inches into the required width.

(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 (3⁄8”).

**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
Stairways (Continued)

Section 3305 of the Uniform Building Code states:

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 (\( \frac{3}{16} \)) 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 (3\( \frac{1}{2} \)) 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 12 feet vertically between landings.

(i) Handrails. Stairways shall have handrails on each side, and every stairway required to be more than 88 inches in width shall be provided with not less than one intermediate handrail for each 88 inches of required width. Intermediate handrails shall be spaced approximately equal within the entire width of the stairway.

Handrails shall be placed not less than 30 inches nor more than 34 inches above the nosing of treads, and ends of handrails shall be returned or shall terminate in newel posts or safety terminals.

EXCEPTIONS: 1. Stairways 44 inches 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.

Handrails projecting from a wall shall have a space of not less than 1\( \frac{1}{2} \) inches between the wall and the handrail.

(j) Guardrails. See Section 1714.

(k) Exterior Stairway Protection. All openings in the exterior wall below or within 10 feet, 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.
All required interior stairways which extend to the top floor in any building four or more stories in height shall have provided at the highest point of the stair shaft an approved hatch openable to the exterior not less than 16 square feet in area with a minimum dimension of 2 feet.

EXCEPTION: The hatch shall not be required on smokeproof enclosures or on stairways that extend to the roof with an opening onto that roof.

(m) Stairway Construction—Exterior. Exterior stairways shall be of noncombustible 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 2 inches 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 four or more stories in height, one stairway shall extend to the roof surface, unless the roof has a slope greater than four in 12.

(o) Headroom. Every required stairway shall have a headroom clearance of not less than 6 feet 6 inches. 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.

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 1 foot in 8 feet.

(d) Handrails. A ramp with slope exceeding 1 foot in 10 feet 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.

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 wall which provides a horizontal exit shall be protected by a fire assembly having a fire-resistance rating of not less than one and one-half hours. Such fire assembly shall be maintained self-closing or shall be automatic closing as provided in Section 4306 (b).

(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 3 square feet of net clear floor area per ambulatory occupant and 20 square feet 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.

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 17.

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 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 by a fire assembly having a fire-protection rating of not less than one hour where one-hour shaft construction is permitted and one and one-half hours where two-hour shaft construction is required. Doors shall be maintained self-closing or shall be automatic closing by means of products of combustion detectors other than heat as provided for in Section 4306 (b). The maximum transmitted temperature end point shall not exceed 450°F. above ambient at the end of 30 minutes of the fire exposure specified in U.B.C. Standard No. 43-2.

(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.

Sec. 3309. (a) General. A smokeproof enclosure shall consist of a vestibule and continuous stairway enclosed from the highest point to the lowest point by walls of two-hour fire-resistant construction. The supporting frame shall be protected as set forth in Table No. 17-A.

(b) Where Required. Where a floor of any story is located more than 75 feet above the highest grade, 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 Section 3305 (n).

(c) Construction. Stairs in smokeproof enclosures shall be of noncombustible construction.

(d) Outlet. A smokeproof enclosure shall exit into a public way or into an exit passageway leading to a public way. The exit passageway shall be without other openings and shall have walls, floors, and ceiling of two-hour fire resistance.

(e) Barrier. A stairway in a smokeproof enclosure shall not continue below the grade level unless an approved barrier is provided at the ground level to prevent persons from accidentally continuing into the basement.

(f) Access. Access to the stairway shall be by way of a vestibule or by way of an open exterior balcony of noncombustible materials.

(g) Smokeproof Enclosures by Natural Ventilation. 1. Doors. Doors to both the vestibule and to the stairway shall have a one-hour fire-resistive rating and have closing devices as specified in Section 3309 (h) 6.

2. Open air vestibule. The vestibule shall have a minimum of 16 square feet of opening, in a wall facing an exterior court, yard or public way at least 20 feet in width.

(h) Smokeproof Enclosures by Mechanical Ventilation. 1. Doors. The door from the building into the vestibule shall have a one and one-half-hour fire-resistive rating and have closing devices as specified in Section 4306 (b).

The door from the vestibule to the stairway shall be a tight-fitting door equal to not less than an exterior type solid wood door without voids, assembled with exterior type glue, 1½-inch minimum thickness set in a steel frame. Wired glass, if provided, shall not exceed 100 square inches in area and shall be set in a steel frame. The door shall be provided with a drop sill or other provision to minimize air leakage.
2. **Vestibule size.** The vestibule shall have a minimum dimension of 44 inches in width and 72 inches in direction of exit travel.

3. **Vestibule ventilation.** The vestibule shall be provided with not less than one air change per minute and the exhaust shall be 150 per cent of the supply. Supply air shall enter and exhaust air shall discharge from the vestibule through separate, tightly constructed ducts used only for that purpose. Supply air shall enter the vestibule within 6 inches of the floor level. The top of the exhaust register shall be located at the top of the smoke trap but no more than 6 inches down from the top of the trap and shall be entirely within the smoke trap area. Doors, when in the open position, shall not obstruct duct openings. Duct openings may be provided with controlling dampers, if needed, to meet the design requirements but are not otherwise required.

    **NOTE:** For buildings where such air changes would result in excessively large duct and blower requirements, a specially engineered system may be used. Such an engineered system shall provide 2500 cfm exhaust from a vestibule when in emergency operation and shall be sized to handle three vestibules simultaneously and the smoke detector located outside each vestibule shall release to open the supply and exhaust duct dampers in that effected vestibule.

4. **Smoke trap.** The vestibule ceiling shall be at least 20 inches higher than the door opening into the vestibule to serve as a smoke and heat trap and to provide an upward moving air column.

5. **Stairshaft air movement system.** The stairshaft shall be provided with mechanical supply and exhaust air. There shall be a minimum of 2500 cfm discharge at the top of the shaft. The supply shall be sufficient to provide a minimum of .05 inch of water column with respect to atmospheric pressure with all doors closed and a minimum of .10-inch water column difference between the stairshaft and the vestibule.

6. **Exit doors.** The exit doors into the vestibule and into the stairshaft shall close automatically when released by activation of a detector meeting the requirements of Section 4306 (b) 2. The door holding devices shall be of an approved type which will release the doors so that they will close in the event of a power failure.

7. **Operation of ventilating equipment.** Vestibule and stairshaft mechanical ventilation may be inactive or may operate at reduced levels for normal operations as approved by the Building Official; but when the detectors referred to in paragraph 6 either fail or are activated, the mechanical equipment shall operate at the levels specified in paragraphs 3 and 5.

8. **Stand-by power.** Mechanical ventilation equipment shall be provided by an approved self-contained generator set to
operate whenever there is a loss of power in the normal house current. The generator shall be in a separate room having a minimum one-hour fire-resistive occupancy separation and shall have a minimum fuel supply adequate to operate the equipment for two hours.

9. **Acceptance and testing.** Before the mechanical equipment is accepted by the Building Official, it shall be tested in his presence to confirm that the mechanical equipment is operating in compliance with these requirements.

10. **Emergency lighting.** The stairshaft and the vestibule shall be provided with emergency lighting. The standby generator which is installed for the smokeproof enclosure mechanical ventilation equipment may be used for standby emergency lighting power supply.

11. **Air-conditioned buildings.** In buildings with air conditioning systems or pressure air supply, a products of combustion detector conforming to the requirements of Section 4306 (b) shall be placed in the return air prior to exhausting from the building or being diluted by outside air and so located as to operate and shut off building system in case of smoke in the air stream, or such devices may be installed in each room or space served by a return air duct.

**Sec. 3310.** (a) **General.** Every exit court shall discharge into a public way or exit passageway.

(b) **Width.** Exit court minimum widths shall be determined in accordance with provisions of Section 3302 based on the tributary occupancy load and such required width shall be unobstructed except for projections permitted in corridors in Section 3304.

Where the width is reduced from any cause, the reduction shall be effected gradually by a guardrail at least 3 feet in height and making an angle of not more than 30° with the axis of the exit court.

(c) **Number of Exits.** Every exit court shall be provided with exits as determined by Section 3302.

(d) **Openings.** All openings into an exit court less than 10 feet wide shall be protected by fire assemblies having not less than a three-fourths hour fire-protection rating.

**EXCEPTION:** Openings more than 10 feet above the floor of the exit court may be unprotected.

**Sec. 3311.** (a) **Discharge.** The walls of exit passageways shall be without openings other than required exits and shall have walls, floors, and ceilings of the same period of fire resistance as required for the walls, floors and ceilings of the building served with a minimum of one-hour fire-resistive construction. Exit openings throughout the enclosing walls of
Exit Passageways (Continued)

exit passageways shall be protected by fire assemblies having a three-fourths-hour fire-protection rating.

(b) **Detailed Requirements.** Exit passageways shall have width, height, and other construction requirements as required for corridors in Section 3304.

**Section 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 footcandle 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.

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 50 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.
**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.

(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').

**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.
Seats (Continued)

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) Bleacher Seats. Seats used in grandstands, bleachers and reviewing stands shall conform to Section 3321.

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.

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 door-
way 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 back-
ground. 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 Occu-
pancies having an occupant load of more than 100, exit doors
shall not be provided with a latch or lock unless it is panic
hardware. Panic hardware may be waived on gates surround-
ing stadiums, when the gates are under constant immediate
supervision while the public is present and provided safe dis-
persal 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 3321 for exits from dis-
persal areas.

(c) **Skating Rinks.** Skating rinks shall be located at or near
the adjacent ground level and exits shall be by means of
ramps.

Sec. 3317. (a) **Special Provisions.** Every room in a Group
C, Division 1 Occupancy used by students shall have direct
exit to the exterior of the building or to an exterior exit bal-
cony. In lieu of the above, corridors, stairways, storage rooms,
laboratories and administrative areas shall be protected with
an automatic fire-extinguishing system. Such fire-extinguish-
ing system shall be connected to the school fire alarm system.

Classrooms having openable windows usable for emergency
escape purposes, and with a sill height of the openable section
not more than 36 inches above the floor and not more than
6 feet above the adjacent grade level need not have direct
exits to the exterior nor need they be equipped with an auto-
matic fire-extinguishing system unless such system is required
by other provisions of this Code.

(b) **Corridors and Exterior Exit Balconies.** The width of a
corridor in a Group C, Division 1 Occupancy shall be the
width required by Section 3302, plus 2 feet, but no corridor
shall be less than 6 feet wide.

**EXCEPTION:** When the number of occupants served is
less than 100, the corridor may be 44 inches wide.

Corridor walls shall be of not less than one-hour fire-resis-
tive construction with openings protected as required in Sec-
tion 3304 (g).
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 in elevation of less than 2 feet in a corridor or exterior balcony unless ramps are used.

(c) Exit Serving Auditoriums in Group C, Division 1 Occupancy. 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.

(d) Stairs. Each floor above or below the ground floor level shall have not less than two exits 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 5 feet in clear width.

EXCEPTION: The Subsection does not apply to rooms used for maintenance, storage, and similar purposes.

(e) Doors. The width of exit doors shall be sufficient to accommodate the occupant load served.

(f) Basement or Cellar Rooms. Exit stairways from the cellar or basement shall open directly to the exterior of the building without entering the first floor corridor.

(g) 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.

(h) Fences and Gates. School grounds may be fenced in and gates equipped with locks provided safe dispersal areas located not less than 50 feet from the buildings are available for persons between buildings and fence. Dispersal areas shall be based upon an area of not less than 3 square feet per occupant. Gates shall not be permitted across corridors or passageways leading to such dispersal areas unless they comply with exit requirements. See Section 3321 for exits from dispersal areas.

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.

In Group D-1 Occupancies such as jails, prisons, reformatories and similar buildings with open barred cells forming corridor walls, the corridors and cell doors need not be fire-resistive.

(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 doorknobs or similar devices which can be opened readily from the corridor side without the use of keys or any special knowledge or effort.

Sec. 3319. Every portion of a Group E Occupancy having a floor area of 200 square feet 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 75 feet from an exit.

Doors leading to a corridor of fire-resistive construction shall have a minimum three-fourths hour fire protection rating; shall have not more than 100 square inches of wired glass set in steel frames; shall be maintained self-closing or shall be automatic closing as required by Section 4306 (b); and shall open in the direction of exit travel.
Sec. 3320. (a) Boiler, Furnace and Incinerator Rooms. Except in Group I Occupancies, any room containing a boiler, furnace, incinerator, or other fuel-fired equipment must be provided with two means of egress when both of the following conditions exist:

1. The area of the room exceeds 500 square feet, and
2. The largest single piece of fuel-fired equipment exceeds 1,000,000 B.t.u. per hour input capacity.

If two means of egress must be provided, one may be a fixed ladder. The means of egress must be separated by a horizontal distance not less than half the greatest horizontal dimension of the room. All openings shall be protected with a self-closing fire assembly having a minimum one-hour fire-protection rating. Where oil-fired boilers are used, a 6-inch noncombustible sill (dike) shall be provided. There shall be no interior openings between a Group E Occupancy and a boiler, furnace or incinerator room.

(b) Cellulose Nitrate Handling. Where cellulose nitrate is handled in film laboratories, projection rooms and film processing rooms, two exits shall be provided. Doors shall be self-closing and have a fire-protection rating of one-hour.

Sec. 3321. (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 50 feet from the stand or building. Dispersal areas shall be based upon an area of not less than 3 square feet per person.

(c) Height of Stands. Stands employing combustible framing shall be limited to 11 rows or 9 feet 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.

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-sixteenth inch (\(\frac{3}{16}\)) and the maximum variation in the height of two adjacent risers shall not exceed three-sixteenth 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 handrails.

Seats at the extreme end or rear of bleachers or grandstands and open sides of stairways and ramps shall be provided with guardrails in accordance with the requirements of Section 1714.

(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.

(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.
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 4 inches above the roof. The curbs on which the skylight rests shall be constructed of noncombustible materials except for Type III or Type V buildings.

Spacing between supports in one direction for flat wired glass in skylights shall not exceed 25 inches. Corrugated wired glass may have supports 5 feet apart in the direction of the corrugation. All glass in skylights shall be wire glass or tempered glass, minimum thickness \( \frac{7}{8} \) inch, 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 4 feet 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 1 inch. The screen shall be substantially supported below the glass.

Ordinary glass may be used in the roofs and skylights for greenhouses, provided the height of the greenhouse at the ridge does not exceed 20 feet 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 20 feet 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 \( \frac{1}{2} \) inch in thickness. Any such glass over 16 square inches in area shall have wire mesh embedded in the same or shall be provided with a wire screen underneath as specified for skylights in 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 3 feet 6 inches 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—NO REQUIREMENTS
CHAPTER 36—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 28 feet 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 12 feet in height above the roof.

(b) Area. The aggregate area of all penthouses and other roof structures shall not exceed 33 1/3 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.

EXCEPTIONS: 1. On Types I and II buildings the exterior walls and roofs of penthouses which are 5 feet or more from an adjacent property line may be of one-hour fire-resistive noncombustible construction.

2. On Type III buildings, walls not less than 5 feet from a property line may be of one-hour fire-resistive noncombustible construction.

3. Enclosures housing only mechanical equipment and located at least 20 feet from adjacent property lines may be of unprotected noncombustible construction.

4. On one-story buildings, unroofed mechanical equipment screens, fences or similar enclosures may be of combustible construction when located at least 20 feet from adjacent property lines and when not exceeding 4 feet in height above the roof surface.

The restrictions of this Subsection shall not prohibit the placing of wood flagpoles or similar structures on the roof of any building.

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 75 feet 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 1600 square feet 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 100 square feet 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 noncombustible materials when more than 25 feet in height and shall be directly supported on a noncombustible 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.
SECTION 3701

CHAPTER 37—CHIMNEYS, FIREPLACES AND BARBECUES

Scope

Sec. 3701. (a) General. Chimneys, flues, and fireplaces and their connections, carrying products of combustion shall conform to the requirements of this Chapter.

(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 metal 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 fireclay or other approved material that meets the requirements of U.B.C. Standard No. 37-1.

EQUIVALENT SOLID THICKNESS is defined in U.B.C. Standard No. 24-4.

FIREBRICK is a refractory brick which meets the requirements of U.B.C. Standard No. 37-1.

*See Chimney Selection Chart, Table No. 9-A, Uniform Building Code, Volume II, Mechanical.
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.

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) Factory-built Chimneys. Factory-built chimneys are listed chimneys and shall be installed in strict accordance with the terms of their listings and manufacturer's instructions.

(d) Metal Chimneys. Metal chimneys shall be constructed and installed in accordance with Section 914 of the Uniform Building Code, Volume II – Mechanical.

(e) Masonry Chimneys. Every masonry chimney shall have walls of masonry units, bricks, stones, listed masonry units, reinforced concrete or equivalent solid thickness of hollow masonry. Fireplaces and chimneys of unburned clay units shall be lined with firebrick not less than 4 inches. Chimneys of other masonry units shall be lined with suitable liners in accordance with the following requirements:

1. Masonry chimneys for residential type appliances. Lined masonry chimneys shall be constructed of masonry units or reinforced concrete with walls not less than 4 inches thick except that walls of unburned clay units shall be not less than 8 inches thick and walls of rubble stone masonry shall be not less than 12 inches thick. The chimney liner shall be in accordance with Section 3702 (f). Unlined chimneys shall be constructed with masonry or concrete walls not less than 8 inches thick.

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 (f).

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 fire-
brick laid in a solid bed of fireclay 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 (25') above the chimney connector entrance. Chimneys extending twenty-five feet (25') or less above the chimney connector shall be lined to the top.

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 multi-story buildings (apartment-type incinerators).** Chimneys for incinerators installed in multi-story 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 (f) 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.

(f) **Lining.** Fireclay chimney lining shall be not less than % inch thick. The lining shall extend from 8 inches below the lowest inlet or, in the case of fireplaces, from the throat of the fireplace to a point above enclosing masonry walls. Fireclay chimney linings shall be installed ahead of the construction of the chimney as it is carried up, carefully bedded one on the other in mortar, with close-fitting joints left smooth on the inside. Firebrick not less than 2 inches thick may be used.
in place of fireclay chimney lining as set forth in Table No. 37-A.

(g) **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.

(h) **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.

### TABLE NO. 37-A—MINIMUM PASSAGEWAY AREAS FOR MASONRY CHIMNEYS

<table>
<thead>
<tr>
<th>TYPE OF MASONRY CHIMNEY</th>
<th>MINIMUM CROSS-SECTIONAL AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Round</td>
</tr>
<tr>
<td>Residential</td>
<td>50 Sq. in.</td>
</tr>
<tr>
<td>Fireplace²</td>
<td>1/12 of opening Minimum 50 Sq. in.</td>
</tr>
<tr>
<td>Low Heat</td>
<td>50 Sq. in.</td>
</tr>
<tr>
<td>Incinerator Apartment Type</td>
<td>1 opening</td>
</tr>
<tr>
<td></td>
<td>2 to 6 openings</td>
</tr>
<tr>
<td></td>
<td>7 to 14 openings</td>
</tr>
<tr>
<td></td>
<td>15 or more openings</td>
</tr>
</tbody>
</table>

¹Areas for medium- and high-heat chimneys shall be determined using accepted engineering methods and as approved by the Building Official.

²Where fireplaces open on more than one side, the fireplace opening shall be measured along the greatest dimension.

Note: For altitudes over 2000 feet above sea level, the Building Official shall be consulted in determining the area of the passageway.
(i) Chimney Offset. Chimneys may be offset at a slope of not more than 4 inches in 24 inches but not more than one-third the dimension of the chimney in the direction of the offset. Where lined, the lining shall be appropriately cut to fit.

(j) 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.

(k) 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.

(l) Inlets. Every inlet to any masonry chimney shall enter the side thereof and shall be of not less than one-eighth-inch (\(\frac{1}{8}\)") thick metal or five-eighths-inch (\(\frac{5}{8}\)"") thick refractory material.

(m) 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.

(n) Termination. All incinerator chimneys shall terminate in a substantially constructed spark arrester having a mesh not exceeding three-fourths inch (\(\frac{3}{4}\)").

(o) Cleanouts. Cleanout openings shall be provided at the base of every masonry chimney.

Sec. 3703. (a) General. Chimneys shall be designed and constructed as required in this Chapter and Chapters 23 and 29. Chimneys for residential fireplaces may be constructed in accordance with Section 3704 (n). Chimneys shall not support any load other than their own weight unless designed accordingly.

(b) Earthquake Anchorage. In Seismic Zones No. 2 and No. 3, masonry or concrete chimneys in wood-framed buildings shall be anchored at each floor and roof line more than 6 feet above grade for a minimum horizontal force of 900 pounds in any direction unless otherwise designed in accordance with the provisions of this Code. Two steel straps each \(\frac{1}{8}\) square inch in area, secured to the chimney vertical reinforcement, and fastened to the structural framework of the building with six 16d common nails, may be considered as adequate anchorage provided the unsupported height of the chimney above the topmost anchor does not exceed 8 feet.

(c) Masonry Chimneys. Masonry chimneys shall be constructed to meet the requirements of Section 3702.
Sec. 3704. (a) General. Fireplaces, barbecues, smoke chambers and fireplace chimneys shall meet the requirements of Section 3702 (e) and conform to the minimum requirements specified in this Section and Chapter 9 of the Uniform Building Code, Volume II — Mechanical. 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 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 (1/4").

(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. Chimneys for residential fireplaces shall be constructed as specified in Section 3702 (e) for residential type appliances.

(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 (3/2") 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 (1/8") 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.

(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. Dampers, when used, 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.

(i) **Lintel.** Masonry over the fireplace opening shall be supported by a noncombustible lintel. The vertical distance from the top of the fireplace opening to the top of the firebox sides shall be not less than 6 inches.

(j) **Hearth.** Every fireplace shall be provided with a brick, concrete, stone or other approved noncombustible hearth slab at least 12 inches wider on each side than the fireplace opening and projecting at least 18 inches therefrom. This slab shall be not less than 4 inches thick and shall be supported by noncombustible materials or reinforced to carry its own weight and all imposed loads. Combustible forms and centering shall be removed.

When the fireplace opens into the interior of a building, the hearth slab shall be readily distinguishable from the surrounding or adjacent flooring.

(k) **Firestopping.** Firestopping between chimneys and wooden construction shall meet the requirements specified in Section 2517 (f).

(l) **Nonconforming Fireplaces.** Imitation and other fireplaces not conforming to the other requirements of this Section shall not exceed 6 inches 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 29. Where no design is provided, foundations for masonry and concrete fireplaces shall be not less than 12 inches thick, extend not less than 6 inches outside the fireplace wall, and extend below the natural ground surface in accordance with the depth of foundations required for the building by Table No. 29-A.

(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 1/2-inch 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 24-inch intervals with not less than \( \frac{3}{4} \)-inch diameter steel ties. Where the width of the chimney exceeds 40 inches, two additional \( \frac{3}{2} \)-inch diameter vertical bars shall be provided for each additional flue incorporated in the chimney or for each additional 40 inches in width or fraction thereof.
CHAPTER 38—FIRE-EXTINGUISHING SYSTEMS

Scope

Sec. 3801. (a) General. All fire-extinguishing systems required in this Code shall be installed in accordance with the requirements of this Chapter.

All hose threads used in connection with fire-extinguishing systems shall comply with the standards of the Fire Department.

(b) Approvals. All fire-extinguishing systems including automatic sprinklers, combination standpipes, dry and wet standpipes, special automatic extinguishing systems, and basement inlet pipes shall be approved and shall be subject to such periodic tests as may be required. The location of all Fire Department connections shall be approved by the Fire Department.

(c) Definitions. For the purpose of this Chapter, certain terms are defined as follows:

COMBINATION STANDPIPE is a fire line system with a constant water supply and installed for the use of the Fire Department and the occupants of the building.

DRY STANDPIPE is a fire line system without a constant water supply and equipped with Fire Department inlet and outlet connections and installed exclusively for the use of the Fire Department.

FIRE DEPARTMENT HOSE CONNECTION is a hose connection at grade or street level for use by the Fire Department only.

WET STANDPIPE is an auxiliary fire line system with a constant water supply installed primarily for emergency fire use by the occupants of the building.

(d) Standards. Fire-extinguishing systems shall comply with U.B.C. Standards No. 38-1 and No. 38-2.

Sec. 3802. (a) General. Automatic fire-extinguishing systems shall comply with the provisions of this Section.

(b) Where Required. Standard automatic fire-extinguishing systems shall be installed and maintained in operable condition as specified in this Chapter in the following locations:

1. In every story, basement or cellar of all buildings except Group I Occupancies when floor area exceeds 1500 square feet and there is not provided at least 20 square feet of opening entirely above the adjoining ground level in each 50 lineal feet or fraction thereof of exterior wall in the story, basement or cellar on at least one side of the building. Openings shall have a minimum dimension of not less than 30 inches. Such
openings shall be maintained readily accessible to the Fire Department and shall not be obstructed in a manner that fire fighting or rescue cannot be accomplished from the exterior.

When openings in a story are provided on only one side and the opposite wall of such story is more than 75 feet from such openings, the story 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.

If any portion of a basement or cellar is located more than 75 feet from openings required in this Section, the basement or cellar shall be provided with an approved automatic fire-extinguishing system.

2. Under the roof and gridiron, in the tie and fly galleries and in all places behind the proscenium wall of stages, over enclosed platforms in excess of 500 square feet in area; and in dressing rooms, workshops and storerooms accessory to such stages or enclosed platforms.

EXCEPTIONS: 1. Stages or enclosed platforms open to the auditorium room on three or more sides.

2. Altars, pulpits, or similar platforms and their accessory rooms.

3. Stage gridirons when side wall sprinklers with 135°F. rated heads with heat-baffle plates are installed around the entire perimeter of the stage at points not more than 30 inches below the gridiron, nor more than 6 inches below the baffle plate.

4. Understage or under enclosed platform areas less than 4 feet in clear height used exclusively for chair or table storage and lined on the inside with materials approved for one-hour fire-resistive construction.

3. In any enclosed usable space below or over a stairway in Groups B, C, and D Occupancies. See Section 3308 (f).

4. In basements or cellars larger than 1500 square feet in floor area of Groups A, B, and C Occupancies.

5. In all Group D Occupancies except jails, prisons and reformatories; however, the respective increases for area and height specified in Sections 506 (c) and 507 shall be permitted.

6. In Group E, Divisions 1 and 2 Occupancies having an area of more than 1500 square feet; in Group E, Division 3
Occupancies having an area of more than 3000 square feet; and in Group E, Division 4 Occupancies more than one story in height.

7. At the top of rubbish and linen chutes and in their terminal room in other than Group I Occupancies. Chutes extending through three or more floors shall have additional sprinkler heads installed within such chutes at alternate floors. Sprinkler heads shall be accessible for servicing.

8. In Group F, Division 2 Occupancies used for retail sales when the occupancy is over 12,000 square feet in a single floor area or more than two stories in height; however, the respective increases for area and height specified in Sections 506 and 507 shall be permitted.

9. In Groups A and B Occupancies when the occupancy has over 12,000 square feet of floor area which can be used for exhibition or display purposes; however, the respective increases for area specified in Sections 506 and 507 shall be permitted.

(c) Detailed Requirements. Automatic fire-extinguishing systems shall be installed in accordance with Section 3801 (d).

EXCEPTIONS:
1. Automatic fire-extinguishing systems shall have at least one automatic water supply of adequate pressure, capacity and reliability.

2. Automatic fire-sprinkling systems may be connected to the domestic water supply main when approved by the Building Official provided the domestic water supply is of adequate pressure, capacity and sizing for the combined domestic and fire sprinkler requirements. In such case, the fire-sprinkler system connection shall be made between the public water main or meter and the building shutoff valve and there shall not be intervening valves or connections. The fire department connection may be omitted when approved by the Fire Department.

3. The sprinkler alarm valve for an automatic fire-sprinkling system may be omitted when the sprinkler system serves less than six heads or where the system is connected to an approved fire alarm system.

Sec. 3803. (a) General. Dry standpipes shall comply with the requirements of this Section.

(b) Where Required. All buildings, four or more stories in height, shall be equipped with one or more dry standpipes.

(c) Location. There shall be one dry standpipe outlet connection located at every floor level landing above the first floor of every required enclosed stairway or smokeproof enclosure. Outlets at enclosed stairways shall be located within the enclosure. No point within a building requiring dry standpipes
shall be more than 130 feet travel distance from a dry standpipe outlet connection.

Portions of dry standpipe systems not located within an enclosed stairway or smokeproof enclosure shall be protected by a degree of fire resistance equal to that required for vertical enclosures in the building in which they are located.

(d) Detailed Requirements. 1. Construction. Fittings and connections shall be of sufficient strength to withstand 300 pounds per square inch of water pressure when ready for service. All dry standpipes shall be tested hydrostatically to withstand not less than 300 pounds per square inch of pressure for two hours, but in no case shall the pressure be less than 50 pounds per square inch above the maximum working pressure.

2. Piping. All horizontal runs of dry standpipe systems shall be pitched at the rate of 1⁄4 inch to 10 feet for purposes of draining.

Where pipe traps occur in such standpipe systems including fire department connections, they shall be provided with drains.

3. Size. The size of the standpipe shall be not less than 4 inches in buildings in which the highest outlet is 75 feet or less above the fire department connection and shall be not less than 6 inches where the highest outlet is higher than 75 feet above the fire department connection.

4. Fire department connections. All 4-inch dry standpipes shall be equipped with a two-way fire department connection. All 6-inch dry standpipes shall be equipped with a four-way fire department connection. All fire department connections shall be located on a street front, not less than 18 inches nor more than 4 feet above grade and shall be equipped with an approved straightway check valve and substantial plugs or caps. All fire department connections shall be protected against mechanical injury and shall be visible and accessible. More than one fire department connection may be required.

5. Outlets. Each standpipe shall be equipped with an approved 2½-inch outlet not less than 2 feet nor more than 4 feet above the floor level of each story. All dry standpipes shall be equipped with a two-way, 2½-inch outlet above the roof line of the building when the roof has a pitch of less than 4 inches in 12 inches. All outlets shall be installed so that a 12 inch long wrench may be used in connecting the hose with clearance for the wrench on all sides of the outlet. Standpipes located in smokeproof enclosures shall have outlets located in the vestibule or on the balcony. Standpipe outlets in stairway enclosures or smoke towers shall be so located that the exit doors do not interfere with the use of the outlet. All outlets shall be equipped with an approved valve, cap and chains.
6. **Signs.** An approved, durable sign with raised letters of at least 1 inch in height shall be permanently attached adjacent to all fire department street connections. Such sign shall read, “DRY STANDPIPE.”

**Sec. 3804.** (a) **General.** Wet standpipes shall comply with the requirements of this Section.

(b) **Where Required.** Wet standpipes extending from the cellar or basement into the topmost story shall be provided in Groups A and B, Divisions 1 and 2, Occupancies with an occupant load exceeding 1000; in Groups C, D, E, F, G, and H Occupancies four or more stories in height; and in Groups E and F Occupancies having a floor area exceeding 20,000 square feet per floor.

**EXCEPTIONS:**
1. Wet standpipes are not required in buildings equipped throughout with an automatic fire-extinguishing system.
2. Wet standpipes are not required in basements or cellars equipped with a complete automatic fire-extinguishing system.
3. Wet standpipes shall not be required in assembly areas used solely for worship.

(c) **Location.** Wet standpipes shall be located so that all portions of the building are within 20 feet of a nozzle attached to 75 feet of hose.

In Group A, Group B, Division 1 and Group B, Division 2, Occupancies, when the occupant load is more than 1000, outlets shall be located on each side of any stage, on each side of the rear of the auditorium and on each side of the balcony.

(d) **Detailed Requirements.** 1. **Construction.** Wet standpipes shall be installed and tested as required for the water distribution system within the building.

2. **Size.** The size of the standpipe shall be not less than 2½ inches in diameter when the height of the riser is 50 feet or more above the source and shall be not less than 2 inches in diameter when the height of the riser is less than 50 feet above the source.

3. **Outlets.** All interior wet standpipes shall be equipped with a 1½-inch valve in each story, including the basement or cellar of the building and located not less than 3 feet nor more than 6 feet above the floor.

4. **Water supply.** The wet standpipe system shall deliver not less than 35 gallons of water per minute at not less than 25 pounds per square inch residual pressure from each of any two outlets flowing simultaneously for 30 minutes. When more than one interior wet standpipe is required in the building, such standpipes may be connected at their bases or highest points by pipes of equal size. Where combination standpipes are installed, the 1½-inch outlet system may be
supplied from the combination system with a 2-inch connecting line.

5. **Pressure and gravity tanks.** Pressure or gravity tanks shall have a capacity sufficient to furnish at least 70 gallons of water per minute for 30 minutes. Other such tanks shall be located so as to provide not less than 25 pounds per square inch residual pressure from each of two outlets flowing simultaneously for 30 minutes. Discharge pipes from pressure tanks shall extend 2 inches from and into the bottom of such tanks. All tanks shall be equipped with a manhole, ladder and platform, drainpipe, water and pressure gauges, and a pressure relief valve. Each 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, but not less than 150 pounds per square inch. Where such tanks are used also for domestic purposes, the supply take-off for such purposes shall be located above the required capacity of such tanks. Supply tanks shall be supported on noncombustible construction with not less than 3-foot clearances over the top and under the bottom to adjacent construction. Approved pressure gauges shall be provided at pressure tanks and at the air pump.

6. **Fire pumps.** Fire pumps shall be approved and shall deliver not less than the required fire flow and pressure. Such pumps shall be supplied with adequate power source and shall be automatic in operation. Where the wet standpipe system is supplied with water from the domestic supply of the building, approved fire pumps shall not be required provided the domestic pump used delivers the required fire flow.

7. **Hose and hose reels.** Each wet standpipe outlet shall be supplied with a hose not less than $1\frac{1}{2}$ inches in diameter. Such hose shall be equipped with an approved variable fog nozzle. An approved hose reel rack or cabinet shall be provided and shall be located so as to make the hose accessible. The hose reel rack or cabinet shall be recessed in the wall or protected by suitable cabinets.

8. **Connection to fire-extinguishing systems.** Wet standpipe systems may be supplied from a fire-extinguishing system complying with U.B.C. Standard No. 38-1 and shall be connected as required in Section 3801.

9. **Pressure reduction.** Where the static pressure at any standpipe outlet exceeds 100 pounds per square inch, an approved pressure reduction device shall be permanently installed at the outlet to reduce the water flow so that the nozzle pressure does not exceed 80 pounds per square inch in accordance with Table No. 38-A.
TABLE NO. 38-A

<table>
<thead>
<tr>
<th>STANDPIPE PRESSURE AT HOSE OUTLET (Pounds per square inch)</th>
<th>SIZE OF ORIFICE (In inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>( \frac{1}{10} )</td>
</tr>
<tr>
<td>120</td>
<td>( \frac{2}{10} )</td>
</tr>
<tr>
<td>130</td>
<td>( \frac{3}{10} )</td>
</tr>
<tr>
<td>140</td>
<td>( \frac{4}{10} )</td>
</tr>
<tr>
<td>150</td>
<td>( \frac{5}{10} )</td>
</tr>
<tr>
<td>160</td>
<td>( \frac{6}{10} )</td>
</tr>
<tr>
<td>170</td>
<td>( \frac{7}{10} )</td>
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<tr>
<td>180</td>
<td>( \frac{8}{10} )</td>
</tr>
<tr>
<td>200</td>
<td>( \frac{10}{10} )</td>
</tr>
<tr>
<td>225</td>
<td>( \frac{11}{10} )</td>
</tr>
<tr>
<td>250</td>
<td>( \frac{12}{10} )</td>
</tr>
<tr>
<td>280</td>
<td>( \frac{15}{10} )</td>
</tr>
</tbody>
</table>

Orifice size to reduce volume at \( \frac{1}{2} \)-inch nozzle to 80 pounds, based on 75-foot \( \frac{1}{2} \)-inch approved hose.

Sec. 3805. (a) General. All combination standpipes shall comply with the requirements of this Section. Design and installation shall be in accordance with U.B.C. Standard No. 38-3. Where a combination standpipe system is installed in accordance with this Section, a separate dry standpipe system need not be installed.

(b) Where Required. One combination standpipe shall be required for every stairway or smokeproof enclosure that extends from the ground floor to the roof in buildings exceeding 150 feet in height.

(c) Location. Combination standpipe systems shall have connections for dry standpipes located as required in Section 3803 (c) and shall have wet standpipe outlets as required in Section 3804 (c).

Portions of combination standpipe systems, including extensions for wet standpipe outlets, not within an enclosed stairway or smokeproof enclosure shall be protected by a degree of fire resistance equal to that required for vertical enclosures in the building in which they are located.

In buildings where more than one combination standpipe system is provided, they shall be cross connected at the bottom.

(d) Detailed Requirements. 1. Construction. Combination standpipe systems shall be installed and tested as required for dry standpipe systems in accordance with Section 3803 (d) 1.
2. Size. Combination standpipe systems shall be not less than 6 inches in diameter.

3. Riser shutoff valve and drain. Each individual riser must be equipped with an OS and Y valve at its base and an approved valve for draining.

4. Fire department connections. All combination standpipe systems shall be equipped with a four-way fire department connection. Combination standpipe systems with three or more standpipes shall be provided with not less than two four-way fire department inlet connections.

All fire department connections shall be located on a street front not less than 18 inches nor more than 4 feet above grade and shall be equipped with an approved straightway check valve and substantial plugs or caps. All fire department connections shall be protected against mechanical injury and shall be visible and accessible. The number of fire department connections shall be determined by the Fire Department.

5. Outlets. Every standpipe shall be equipped with a 2½-inch outlet not less than 2 feet nor more than 4 feet above the floor level at each story. All standpipes shall be equipped with a three-way 2½-inch outlet above the roof line when the roof has a pitch of less than 4 inches in 12 inches. Roof outlets are not required for roofs with a pitch greater than 4 inches in 12 inches. All outlets shall be installed so that a 12-inch long wrench may be used in connecting the hose with wrench clearance on all sides of the outlet. Standpipes located in smoke-proof enclosures shall have outlets at the vestibule or balcony. Outlets above the fourth floor above grade shall be provided with 100 feet of 2½-inch approved unlined fabric hose with 1-inch orifice, straight-tipped brass nozzle without a shutoff at the nozzle unless waived by the Fire Department. Such outlets shall be identified with a sign having 3-inch high letters reading: “FIRE DEPARTMENT USE ONLY.” The hose and nozzle shall be installed in an approved hose cabinet. An approved drip cock or drain connection shall be located between the standpipe outlet and the hose. Roof outlets need not be provided with hoses. In areas subject to freezing, wet standpipe systems shall be protected from freezing.

6. Signs. An approved durable sign with raised letters at least 1 inch high shall be permanently attached to all fire department street connections and test connections, and such sign shall read: “COMBINATION STANDPIPE AND TEST CONNECTIONS.”

Sec. 3806. (a) General. During the construction of a building and until the permanent fire-extinguishing system has been installed and is in service, fire protection shall be provided in accordance with this Section.

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(b) Where Required. Every building, six stories or more in height, shall be provided with not less than one standpipe for fire department use during construction. Such standpipes shall be installed when the progress of construction is not more than 50 feet in height above grade. Such standpipe shall be provided with fire department inlet connections at accessible locations adjacent to usable stairs. Such standpipe systems shall be extended as construction progresses to within one floor of the highest point of construction having secured decking or flooring.

In each floor there shall be provided a 2½-inch valve outlet for fire department use. Where construction height requires installation of a combination standpipe, fire pumps and water main connections shall be provided to serve the standpipe.

(c) Temporary Standpipes. Temporary standpipes may be provided in place of permanent systems if they are designed to furnish 75 gallons of water per minute at 50 pounds per square inch pressure with a standpipe size of not less than 4 inches. All outlets shall be not less than 2½ inches. Pumping equipment sufficient to provide this pressure and volume shall be available at all times when a combination system is required.

(d) Detailed Requirements. Standpipe systems for buildings under construction shall be installed as required for permanent standpipe systems.

Sec. 3807. For basement pipe inlet requirements, see Appendix, Section 3807.
CHAPTER 39—STAGES AND PLATFORMS

Sec. 3901. (a) General. There shall be one or more ventilators constructed of metal or other noncombustible 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.
Sec. 3901. (Continued)

(i) **Curb Construction.** Curbs shall be constructed as required for the roof.

Sec. 3902. Gridirons, fly galleries, and pinrails shall be constructed of noncombustible 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.

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.

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 noncombustible 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.

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.

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 storerooms 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.

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.

Sec. 3908. A protecting hood shall be provided over the full length of the stage switchboard.

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 where ribbon-type cellulose acetate or other safety film is used in conjunction with electric arc, Xenon or other light source projection equipment which develops hazardous gases, dust or radiation. Where cellulose nitrate film is used, projection rooms shall comply with Part III of U.B.C. Standard No. 48-2.

(b) Projection Room Required. Every motion picture machine projecting film as mentioned within the scope of this Chapter shall be enclosed in a projection room. Appurtenant electrical equipment, such as rheostats, transformers and generators, may be within the projection room or in an adjacent room of equivalent construction.

There shall be posted on the outside of each projection room door and within the projection room itself a conspicuous sign with 1-inch block letters stating: “SAFETY FILM ONLY PERMITTED IN THIS ROOM”.

Construction

Sec. 4002. Every projection room shall be of permanent construction consistent with the construction requirements for the type of building in which the projection room is located. Openings need not be protected.

The room shall have a floor area of not less than 80 square feet for a single machine, and at least 40 square feet for each additional machine. Each motion picture projector, floodlight, spotlight or similar piece of equipment shall have a clear working space not less than 30 inches by 30 inches on each side and at the rear thereof, but only one such space shall be required between two adjacent projectors.

The projection room and the rooms appurtenant thereto shall have a ceiling height of not less than 7 feet, 6 inches.

Sec. 4003. Exits shall be provided as required in Chapter 33.

Sec. 4004. The aggregate of openings for projection equipment shall not exceed 25 per cent of the area of the wall between the projection room and the auditorium.

All openings shall be provided with glass or other approved material, so as to completely close the opening.

Ventilation

Sec. 4005. (a) General. Ventilation shall be provided in accordance with the provisions of this Section.

(b) Projection Booth. 1. Supply air. Each projection room shall be provided with two or more separate fresh air inlet ducts with screened openings terminating within 12 inches of
the floor, and located at opposite ends of the room. Such air inlets shall be of sufficient size to permit an air change every three minutes. Fresh air may be supplied from the general building air conditioning system; but when this is done, it shall be so arranged that the projection booth will continue to receive one change of air every three minutes, regardless of the status of the general air conditioning system.

2. Exhaust air. Each projection room shall be provided with one or more exhaust air outlets which may be manifolded into a single duct outside the booth. Such outlets shall be so located as to insure circulation throughout the room. Projection room exhaust air systems shall be independent of any other air systems in the buildings. Exhaust air ducts shall terminate at the exterior of the building in such a location that the exhaust air cannot be readily recirculated into the supply air system. The exhaust system shall be mechanically operated and of such a capacity as to provide a minimum of one change of air every three minutes. The blower motor shall be outside the duct system. The projection room ventilation system may also serve appurtenant rooms, such as the generator room and the rewind room.

(c) Projection Equipment Ventilation. Each projection machine shall be provided with an exhaust duct which will draw air from each lamp and exhaust it directly to the outside of the building in such a fashion that it will not be picked up by supply inlets. Such a duct shall be of rigid materials, except for a continuous flexible connector approved for the purpose. The lamp exhaust system shall not be interconnected with any other system.

1. Electric arc projection equipment. The exhaust capacity shall be 200 cubic feet per minute for each lamp connected to the lamp exhaust system, or as recommended by the equipment manufacturer. Auxiliary air may be introduced into the system through a screened opening to stabilize the arc.

2. Xenon projection equipment. The lamp exhaust system shall exhaust not less than 300 cubic feet per minute per lamp, nor less than that exhaust volume required or recommended by the equipment manufacturer, whichever is the greater. The external temperature of the lamp housing shall not exceed 130°F. when operating.

Sec. 4006. Each projection room shall be provided with rewind and film storage facilities.

A maximum of four containers for flammable liquids not greater than 16-ounce capacity and of a nonbreakable type, may be permitted in each projection booth.

Sec. 4007. Every projection room shall be provided with a lavatory. Every projection room serving an assembly occupancy shall be provided with a water closet.
CHAPTER 41 — NO REQUIREMENTS

PART VIII
FIRE-RESISTIVE STANDARDS FOR FIRE PROTECTION
CHAPTER 42—INTERIOR WALL AND CEILING FINISH

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 a noncombustible backing.

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:


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 in the way intended for use. The products of combustion shall be no more toxic than the burning of untreated wood under similar conditions.

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 noncombustible construction, the finish material of any class shall be applied directly against such fire-resistive construction or to furring strips not exceeding 1¾ inches 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 8 feet in any direction.

2. Where walls and ceilings are required to be of fire­resistive or noncombustible 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 a noncombustible 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 noncombustible 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 2517 (f) 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

<table>
<thead>
<tr>
<th>Class</th>
<th>Tunnel Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0-25</td>
</tr>
<tr>
<td>II</td>
<td>26-75</td>
</tr>
<tr>
<td>III</td>
<td>76-225</td>
</tr>
</tbody>
</table>

4. All interior wall or ceiling finish other than Class I material which is less than one-fourth inch (\(\frac{3}{4}\)"") thick shall be applied directly against a noncombustible backing unless the qualifying tests were made with the material suspended from the noncombustible backing.

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.
### TABLE NO. 42-B—MINIMUM INTERIOR-FINISH CLASSIFICATIONS

<table>
<thead>
<tr>
<th>OCCUPANCY GROUP</th>
<th>ENCLOSED VERTICAL EXITWAYS</th>
<th>OTHER EXITWAYS</th>
<th>ROOMS OR AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>B</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>C</td>
<td>I</td>
<td>II</td>
<td>III</td>
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<tr>
<td>D</td>
<td>I</td>
<td>II</td>
<td>II'</td>
</tr>
<tr>
<td>E</td>
<td>I</td>
<td>II</td>
<td>III²</td>
</tr>
<tr>
<td>F</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>G</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>H</td>
<td>I</td>
<td>II</td>
<td>III'</td>
</tr>
<tr>
<td>I</td>
<td>NO RESTRICTIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>NO RESTRICTIONS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

**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 48 inches 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

NOTE: Tables in Chapter 43 appear at the end of the Chapter.

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.

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.

(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 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.

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.
(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 (\( \frac{3}{8}'' \)) into the protection.

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 \( \frac{3}{4} \) inch for slabs and 1 inch for beams is required for any aggregate concrete.

   C. For the purpose of establishing a fire-resistive rating, tendons having a clear covering less than that set forth in Table No. 43-A shall not contribute more than 50 per cent of the required ultimate moment capacity for members less than 350 square inches in cross-sectional area and 65 per cent for larger members. 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 6 feet, shelf angles, or plates that are not a part of the structural frame.

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**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.

**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 Section 1706.
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-resistant 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.

(d) Unusable Space Above or Below. In one-hour fire-resistant construction the ceiling may be omitted over unusable space and flooring may be omitted where unusable space occurs above.

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.

(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 dampers used in air distribution systems and for ventilation purposes shall be fabricated and installed in accordance with U.B.C. Standard No. 43-7.

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 other than heat.

Unless otherwise specified, the closing device shall be one rated at a maximum temperature of 165°F. If products of combustion other than heat are being detected to actuate the closing device, the closing device shall operate by the activation of an approved detector set to operate when smoke reduces the intensity of a 1-foot long beam of white light by 4 per cent or any other detection device conforming to the requirements specified in U.B.C. Standard No. 43-6.

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.

(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 and No. 43-4.

(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 fire-exit doors shall have closing devices as specified in Chapter 33.
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 providing three-hour fire protection 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 3 feet above the opening.

Fire assemblies protecting openings required to have one and one-half, one or three-fourths-hour fire-protection rating, and which are not exit doors, may be activated in a similar manner or by a single fusible link in the opening incorporated in the closing device.

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.
(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 (\(\frac{3}{16}\)") 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 (for doors) or No. 43-4 (for windows). Glass shall be held in place by steel glazing angles except that in casement windows wire clips may be used.

(i) **Tin-clad Doors.** If constructed as specified in U.B.C. Standard No. 43-3, 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.

(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
```
<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Columns and All Members of Primary Trusses</td>
<td>1</td>
<td>Grade A concrete, members 6&quot; x 6&quot; or greater (not including sandstone, granite and siliceous gravel)(^1)</td>
<td>2(\frac{1}{2}) 2 1(\frac{1}{2}) 1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Grade A concrete, members 8&quot; x 8&quot; or greater (not including sandstone, granite and siliceous gravel)(^1)</td>
<td>2 1(\frac{1}{2}) 1 1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Grade A concrete, members 12&quot; x 12&quot; or greater (not including sandstone, granite and siliceous gravel)(^1)</td>
<td>1(\frac{1}{2}) 1 1 1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Grade B concrete and Grade A concrete excluded above, members 6&quot; x 6&quot; or greater(^1)</td>
<td>3 2 1(\frac{1}{2}) 1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Grade B concrete and Grade A concrete excluded above, members 8&quot; x 8&quot; or greater(^1)</td>
<td>2(\frac{1}{2}) 2 1 1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Grade B concrete and Grade A concrete excluded above, members 12&quot; x 12&quot; or greater(^1)</td>
<td>2 1 1 1</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Clay or shale brick with brick and mortar fill(^1)</td>
<td>3(\frac{3}{4}) 2(\frac{1}{4})</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>4&quot; Hollow clay tile in two 2&quot; layers; 3(\frac{1}{2})&quot; mortar between tile and column; 5(\frac{5}{8})&quot; metal mesh (wire diameter = .046&quot;) in horizontal joints; tile fill(^1)</td>
<td>4</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Columns and All Members of Primary Trusses (Cont'd.)</td>
<td>9</td>
<td>2&quot; Hollow clay tile; ¾&quot; mortar between tile and column; ¾&quot; metal mesh (.046&quot; wire diameter) in horizontal joints; Grade A concrete fill; plastered with ¾&quot; gypsum plaster</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2&quot; Hollow clay tile with outside wire ties (.08&quot; diameter) at each course of tile or ¾&quot; metal mesh (.046&quot; diameter wire) in horizontal joints; Grade A concrete fill extending 1&quot; outside column on all sides</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>2&quot; Hollow clay tile with outside wire ties (.08&quot; diameter) at each course of tile with or without Grade A concrete fill; ¾&quot; mortar between tile and column</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Solid gypsum blocks with woven wire mesh in horizontal joints, laid with 1&quot; mortar on flanges and plastered with ½&quot; gypsum plaster</td>
<td>2 ½ 2 ½</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Hollow gypsum blocks with ¾&quot; wide No. 12 gauge metal cramps and woven wire mesh in horizontal joints. PL denotes ½&quot; gypsum plaster</td>
<td>3 ½ 3 ½ PL 3 3 3 3</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Wood-fibered gypsum plaster poured solid, (reentrant space filled) and reinforced with 4&quot; x 4&quot; x No. 14 gauge wire mesh</td>
<td>2 1 ½ 1 1</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Portland cement plaster over metal lath wire tied to ¾&quot; cold-rolled vertical channels with No. 18 gauge wire ties spaced 3&quot; to 6&quot; on center. Plaster mixed 1:2½ by volume, cement to sand</td>
<td>2 ½ 3 ½ 7 8</td>
</tr>
<tr>
<td>Steel Columns and All Members of Primary Trusses (Cont'd.)</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
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<td>----</td>
</tr>
<tr>
<td>Vermiculite concrete, 1:4 mix by volume over paperbacked wire fabric lath wrapped directly around column with additional 2&quot; x 2&quot; No. 16/16 gauge wire fabric placed ¾&quot; from outer concrete surface. Wire fabric tied with No. 18 gauge wire spaced 6&quot; on center for inner layer and 2&quot; on center for outer layer</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perlite or vermiculite gypsum plaster over metal lath wrapped around column and furred 1 ¼&quot; from column flanges. Sheets lapped at ends and tied at 6&quot; intervals with No. 18 gauge tie wire. Plaster pushed through to flanges</td>
<td>1 ½</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Perlite or vermiculite gypsum plaster over self-furring metal lath wrapped directly around column, lapped 1&quot; and tied at 6&quot; intervals with No. 18 gauge wire</td>
<td>1¾</td>
<td>1¾</td>
<td>1</td>
</tr>
<tr>
<td>Perlite or vermiculite gypsum plaster on metal lath applied to ¾&quot; cold-rolled channels spaced 24 inches apart vertically and wrapped flatwise around column</td>
<td>1½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perlite or vermiculite gypsum plaster over 2 layers of ½&quot; plain full-length gypsum lath applied tight to column flanges. Lath wrapped with 1&quot; hexagonal mesh of No. 20 gauge wire and tied with doubled No. 18 gauge wire ties spaced 23&quot; 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</td>
<td>2½</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Perlite or vermiculite gypsum plaster over one layer of ½&quot; plain full-length gypsum lath applied tight to column flanges. Lath tied with doubled No. 18 gauge wire ties spaced 23&quot; on center and scratch coat wrapped with 1&quot; 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</td>
<td></td>
<td></td>
<td></td>
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(Continued)
<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>4 Hr.</th>
<th>3 Hr.</th>
<th>2 Hr.</th>
<th>1 Hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Columns and All Members of Primary Trusses (Cont'd.)</td>
<td>22</td>
<td>Perlite or vermiculite gypsum plaster over $\frac{3}{8}$&quot; perforated gypsum lath applied tight to column flanges and tied with doubled No. 18 gauge wire ties spaced 15&quot; on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to $2\frac{1}{2}$ cubic feet of aggregate for the two-hour system</td>
<td>1%</td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Gypsum plaster over $\frac{3}{8}$&quot; perforated gypsum lath applied tight to column flanges and tied with doubled No. 18 gauge wire ties spaced 15&quot; on center</td>
<td>2%</td>
<td>1%</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Multiple layers of $\frac{1}{4}$&quot; gypsum wallboard adhesively 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&quot; on center. Exposed corners taped and treated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Three layers of $\frac{5}{8}$&quot; Type &quot;X&quot; gypsum wallboard. First and second layer held in place by $\frac{1}{8}$&quot; diameter by $1\frac{1}{8}$&quot; long ring shank nails with $\frac{1}{16}$&quot; diameter heads spaced 24&quot; on center at corners. Middle layer also secured with metal straps at mid-height and 18&quot; from each end, and by metal corner bead at each corner held by the metal straps. Third layer attached to corner bead with 1&quot; long gypsum wallboard screws spaced 12&quot; on center</td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Three layers of $\frac{5}{8}$&quot; Type &quot;X&quot; gypsum wallboard, each layer screw attached to 1% steel studs (No. 25 gauge) at each corner of column. Middle layer also secured with No. 18 gauge double strand tie wire, 24&quot; on center. Screws are No. 6 by 1&quot; spaced 24&quot; on center for inner layer, No. 6 by 1%&quot; spaced 12&quot; on center for middle layer and No. 8 by 2%&quot; spaced 12&quot; on center for outer layer</td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Steel Columns and All Members of Primary Trusses (Cont'd.)</td>
<td>Wood-fibered gypsum plaster mixed 1:1 by weight gypsum to sand aggregate applied over metal lath. Lath lapped 1&quot; and tied 6&quot; on center at all ends, edges and spacers with No. 18 gauge tie wire. Lath applied over ½&quot; spacers made of ¼&quot; furring channel with 2&quot; legs bent around each corner. Spacers located 1&quot; from top and bottom of member and a maximum of 40&quot; on center and wire tied with a single strand of No. 18 gauge wire. Corner bead tied to the lath at 6&quot; on center along each corner to provide plaster thickness</td>
<td>27</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Webs or Flanges of Steel Beams and Girders</td>
<td>Grade A concrete (not including sandstone, granite and siliceous gravel) with 3&quot; or finer metal mesh placed 1&quot; 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</td>
<td>28</td>
<td>2</td>
<td>1½</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grade B concrete and Grade A concrete excluded above with 3&quot; or finer metal mesh placed 1&quot; 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</td>
<td>29</td>
<td>2½</td>
<td>2</td>
<td>1½</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Portland cement plaster on metal lath attached to ¾&quot; cold-rolled channels with No. 18 gauge wire ties spaced 3&quot; to 6&quot; on center. Plaster mixed 1:2½ by volume, cement to sand</td>
<td>30</td>
<td>2½</td>
<td>7½</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vermiculite Gypsum plaster on a metal lath cage, wire tied to No. 8 steel wire hangers wrapped around beam and spaced 16&quot; on center. Metal lath ties spaced approximately 5&quot; on center at cage sides and bottom</td>
<td>31</td>
<td>7½</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
**TABLE NO. 43-A—MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS—(Continued)**

<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two layers of 5/8&quot; Type &quot;X&quot; gypsum wallboard are attached to U-shaped brackets spaced 24&quot; on center. No. 25 gauge 15/8&quot; deep by 1&quot; galvanized steel runner channels are first installed parallel to and on each side of the top beam flange to provide a 1/2&quot; clearance to the flange. The channel runners are attached to steel deck or concrete floor construction with approved fasteners spaced 12&quot; on center. U-shaped brackets are formed from members identical to the channel runners. At the bent portion of the U-shaped bracket, the webs of the channel are cut out so that 15/8&quot; deep corner channels can be inserted without attachment parallel to each side of the lower flange. As an alternate No. 24 gauge 1&quot; by 2&quot; runner and corner angles may be used in lieu of channels and the web cutouts in the U-shaped brackets may be omitted. Each angle is attached to the bracket with 1/2&quot; long No. 8 self-drilling screws. The vertical legs of the U-shaped bracket are attached to the runners with one 1/2&quot; long No. 8 self-drilling screw. The completed steel framing provides a 21/2&quot; and 11/2&quot; space between the inner layer of wallboard and the sides and bottom of the steel beam respectively. The inner layer of wallboard is attached to the top runners and bottom corner channels or corner angles with 11/2&quot; long No. 6 self-drilling screws spaced 16&quot; on center. The outer layer of wallboard is applied with 13/4&quot; long No. 6 self-drilling screws spaced 8&quot; on center. The bottom corners are reinforced with metal corner beads.</td>
<td>32</td>
<td>1 1/4</td>
<td></td>
</tr>
</tbody>
</table>
Three layers of 5/8" Type X gypsum wallboard attached to a steel suspension system as described immediately above utilizing the No. 25 gauge 1" by 2" lower corner angles. The framing is located so that a 2 1/4" and 2" space is provided between the inner layer of wallboard and the sides and bottom of the beam respectively. The first two layers of wallboard are attached as described immediately above. A layer of No. 20 gauge 1" hexagonal galvanized wire mesh is applied under the soffit of the middle layer and up the sides approximately 2". The mesh is held in position with the No. 6 1/4" long screws installed in the vertical leg of the bottom corner angles. The outer layer of wallboard is attached with No. 6 2 1/4" long screws spaced 8" on center. One screw is also installed at the mid-depth of the bracket in each layer. Bottom corners are finished as described above.

<table>
<thead>
<tr>
<th>Webs or Flanges of Steel Beams and Girders (Cont'd.)</th>
<th>33</th>
<th>1/8</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bonded Tendons in Prestressed Concrete</th>
<th>34</th>
<th>Grade A concrete</th>
<th>Beams or girders 4²</th>
<th>3²</th>
<th>2 1/2²</th>
<th>1 1/2²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid slabs 5²</td>
<td>2</td>
<td>1 1/2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reinforcing Steel in Reinforced Concrete Columns, Beams, Girders and Trusses</th>
<th>35</th>
<th>Grade A concrete, members 12&quot; or larger, square or round (Size limit does not apply to beams and girders monolithic with floors)</th>
<th>1 1/2</th>
<th>1 1/2</th>
<th>1 1/2</th>
<th>1 1/2</th>
</tr>
</thead>
</table>

| | 36 | Grade B concrete, members 12" or larger, square or round (Size limit does not apply to beams and girders monolithic with floors) | 2 | 1 1/2 | 1 1/2 | 1 1/2 |

(Continued)
### TABLE NO. 43-A—MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS—(Continued)

<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR FOLLOWING FIRE-RESISTIVE PERIODS (in Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforcing Steel in Reinforced Concrete Joists⁹</td>
<td>37</td>
<td>Grade A concrete</td>
<td>1 ¹⁄₄  1 ¹⁄₄  1  ¹⁄₄</td>
</tr>
<tr>
<td>Reinforcing Steel in Reinforced Concrete Joists⁹</td>
<td>38</td>
<td>Grade B concrete</td>
<td>1 ³⁄₄  1 ³⁄₄  1  ¹⁄₄</td>
</tr>
<tr>
<td>Reinforcing and Tie Rods in Floor and Roof Slabs⁹</td>
<td>39</td>
<td>Grade A concrete</td>
<td>1 1  ³⁄₄  ³⁄₄</td>
</tr>
<tr>
<td>Reinforcing and Tie Rods in Floor and Roof Slabs⁹</td>
<td>40</td>
<td>Grade B concrete</td>
<td>1 ¹⁄₄  1  ¹⁄₄</td>
</tr>
</tbody>
</table>

¹Reentrant parts of protected members to be filled solidly.
²Woven wire mesh consists of three-eighths-inch (¹⁄₈") mesh of No. 17 gauge wire.
³Two layers of equal thickness with a three-fourths-inch (¹⁄₄") air space between.
⁴An approved adhesive qualified under U.B.C. Standard No. 43-1.
⁵Cover 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.
⁶For Grade B concrete increase tendon cover 20 per cent.
⁷Adequate 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").
⁸Prestressed slabs shall have a thickness not less than that required in Table No. 43-C for the respective fire-resistive time period.
⁹For use with concrete slabs having a comparable fire endurance where members are framed into the structure in such a manner as to provide equivalent performance to that of monolithic concrete construction.
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 Hr.</td>
</tr>
<tr>
<td>Brick of Clay or Shale</td>
<td>1</td>
<td>Solid units (at least 75 per cent solid)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Solid units plastered each side with 1/2&quot; gypsum or portland cement plaster. Portland cement plaster mixed 1:2½ by weight, cement to sand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Hollow brick units at least 71 per cent solid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Hollow brick units at least 71 per cent solid, plastered each side with 1/2&quot; gypsum plaster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Hollow (rowlock)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Hollow (rowlock) plastered each side with 1/2&quot; gypsum or portland cement plaster. Portland cement plaster mixed 1:2½ by weight, cement to sand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Hollow cavity wall consisting of two 4&quot; nominal clay brick units with air space between</td>
<td></td>
</tr>
<tr>
<td>Hollow Clay Tile, Non-load-bearing (End or Side Construction)</td>
<td>8</td>
<td>One cell in wall thickness, units at least 50 per cent solid, plastered each side with 1/2&quot; gypsum plaster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Two cells in wall thickness, units at least 45 per cent solid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Two cells in wall thickness, units at least 45 per cent solid. Plastered each side with 1/2&quot; gypsum plaster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Two cells in wall thickness, units at least 60 per cent solid. Plastered each side with 1/2&quot; gypsum plaster</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Two cells in wall thickness, units at least 40 per cent solid</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollow Clay Tile, Load-bearing (End or Side Construction)</td>
<td>13</td>
<td>Two cells in wall thickness, units at least 40 per cent solid. Plastered one side with 6&quot; gypsum plaster</td>
<td>8 1/2</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Two cells in wall thickness, units at least 49 per cent solid</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Three cells in wall thickness, units at least 40 per cent solid</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Two units and three cells in wall thickness, units at least 40 per cent solid</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Two units and four cells in wall thickness, units at least 45 per cent solid</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Two units and three cells in wall thickness, units at least 40 per cent solid. Plastered one side with 6&quot; gypsum plaster</td>
<td>12 1/2</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Three cells in wall thickness, units at least 43 per cent solid. Plastered one side with 6&quot; gypsum plaster</td>
<td>8 1/2</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Two cells in wall thickness, units at least 40 per cent solid. Plastered each side with 6&quot; gypsum plaster</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Three cells in wall thickness, units at least 43 per cent solid. Plastered each side with 6&quot; gypsum plaster</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Three cells in wall thickness, units at least 40 per cent solid. Plastered each side with 6&quot; gypsum plaster</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Hollow cavity wall consisting of two 4&quot; nominal clay tile units (at least 40 per cent solid) with air space between. Plastered one side (exterior) with 6&quot; portland cement plaster and other side with 6&quot; gypsum plaster. Portland cement plaster mixed 1:3 by volume, cement to sand</td>
<td>10</td>
</tr>
<tr>
<td>Combination of Clay Brick and Load-bearing Hollow Clay Tile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>24 4&quot; brick and 8&quot; tile</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 4&quot; brick and 4&quot; tile</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 4&quot; brick and 4&quot; tile plastered on the tile side with 5/8&quot; gypsum plaster</td>
<td>8(\frac{1}{2})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concrete Masonry Units?</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>27 Expanded slag or pumice</td>
<td>4.7</td>
<td>4.0</td>
<td>3.2</td>
<td>2.1</td>
</tr>
<tr>
<td>28 Expanded clay or shale</td>
<td>5.7</td>
<td>4.8</td>
<td>3.8</td>
<td>2.6</td>
</tr>
<tr>
<td>29 Limestone, cinders or air cooled slag</td>
<td>5.9</td>
<td>5.0</td>
<td>4.0</td>
<td>2.7</td>
</tr>
<tr>
<td>30 Calcareous or siliceous gravel</td>
<td>6.2</td>
<td>5.3</td>
<td>4.2</td>
<td>2.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solid Concrete</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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)</td>
<td>Grade A Concrete</td>
<td>6(\frac{1}{2})</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Grade B Concrete</td>
<td>7(\frac{1}{2})</td>
<td>6(\frac{1}{2})</td>
<td>5(\frac{1}{2})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hollow Gypsum Tile</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>32 3&quot; tile not less than 70 per cent solid</td>
<td></td>
<td>3(\frac{4}{4})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 3&quot; tile plastered one side with 5/8&quot; gypsum plaster</td>
<td></td>
<td>3(\frac{3}{4})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 4&quot; tile plastered one side with 1/2&quot; gypsum plaster</td>
<td>4(\frac{1}{4})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 3&quot; tile plastered both sides with 1/2&quot; gypsum plaster</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36 4&quot; tile plastered both sides with 1/2&quot; gypsum plaster</td>
<td>5(\frac{4}{4})</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glazed or Unglazed Facing Tile, Nonload-bearing</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>37 One 2&quot; unit cored 15 per cent maximum and one 4&quot; unit cored 25 per cent maximum with 3/4&quot; mortar filled collar joint. Unit positions reversed in alternate courses</td>
<td></td>
<td></td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE³ (In inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>One 2” unit cored 15 per cent maximum and one 4” unit cored 40 per cent maximum with ¾” 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</td>
<td>6 ¾</td>
</tr>
<tr>
<td>Glazed or Unglazed Facing Tile, Nonload-bearing (Cont’d.)</td>
<td>39</td>
<td>One unit with three cells in wall thickness, cored 29 per cent maximum</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>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</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>One 4” unit cored 25 per cent maximum with ¾” gypsum plaster on one side</td>
<td>4 ¾</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>One 4” unit with two cells in wall thickness, cored 22 per cent maximum</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>One 4” unit cored 30 per cent maximum with ¾” vermiculite gypsum plaster on one side</td>
<td>4 ½</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>One 4” unit cored 39 per cent maximum with ¾” gypsum plaster on one side</td>
<td>4 ½</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>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</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Studless with ( \frac{1}{2}'' ) 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</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>( \frac{3}{4}'' ) by No. 16 gauge cold-rolled channels 16&quot; on center with metal lath applied to one face and tied with No. 18 gauge wire at 6&quot; 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</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Studless with ( \frac{1}{2}'' ) full-length plain gypsum lath and perlite or vermiculite gypsum plaster each side</td>
<td></td>
<td>2(^{1/4})</td>
</tr>
<tr>
<td>49</td>
<td>Studless partition with ( \frac{3}{8}'' ) rib metal lath installed vertically, adjacent edges tied 6&quot; on center with No. 18 gauge wire ties, gypsum plaster each side mixed 1:2 by weight, gypsum to sand aggregate</td>
<td></td>
<td>2(^{1/4})</td>
</tr>
<tr>
<td>50</td>
<td>( \frac{3}{4}'' ) by No. 16 gauge vertical cold-rolled channels, 16&quot; on center, with ( \frac{3}{8}'' ) gypsum lath applied to one face and attached with sheet metal clips. Gypsum plaster each side mixed 1:2 by weight, gypsum to sand aggregate.</td>
<td></td>
<td>2(^{1/4})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Perlite mixed in the ratio of 3 cubic feet to 100 pounds of portland cement and machine applied to stud side of 1½&quot; mesh by No. 17 gauge paperbacked woven wire fabric lath nailed to 4&quot; deep steel trussed wire(^2) studs 16&quot; on center with 1&quot; long by No. 11 gauge by ( \frac{1}{8}'' ) head annular ring shank nails</td>
<td></td>
<td>3(^{3/4})</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Neat Wood Fibered Gypsum Plaster</td>
<td>52</td>
<td>⅝&quot; by No. 16 gauge cold-rolled channels, 12&quot; on center with 2.5-pound flat metal lath applied to one face and tied with No. 18 gauge wire at 6&quot; spacing. Neat gypsum plaster applied each side</td>
<td>24</td>
</tr>
<tr>
<td>Solid Gypsum Wallboard Partition</td>
<td>53</td>
<td>One full-length layer ⅛&quot; Type &quot;X&quot; gypsum wallboard laminated to each side of 1&quot; full length V-edge gypsum coreboard with approved laminating compound. Vertical joints of face layer and coreboard staggered at least 3&quot;</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>One full-length layer of ⅛&quot; gypsum wallboard laminated to each side of 1&quot; full length interlocking factory laminated gypsum coreboard with approved laminating compound. Vertical joints of face layer and coreboard staggered</td>
<td>24</td>
</tr>
<tr>
<td>Hollow (Studless) Gypsum Wallboard Partition</td>
<td>55</td>
<td>One full-length layer of ⅝&quot; Type &quot;X&quot; gypsum wallboard attached to both sides of wood or metal top and bottom runners laminated to each side of 1&quot; x 6&quot; full-length gypsum coreboard ribs spaced 24&quot; on center with approved laminating compound. Ribs centered at vertical joints of face plies and joints staggered 24&quot; in opposing faces. Ribs may be recessed 6&quot; from the top and bottom</td>
<td>2 ⅛/4</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>1&quot; regular gypsum &quot;V&quot; edge full-length backing board attached to both sides of wood or metal top and bottom runners with nails or 1 ⅜&quot; drywall screws at 24&quot; on center. Minimum width of runners 1 ⅜&quot;. Face layer of ½&quot; regular full-length gypsum wallboard laminated to outer faces of backing board with approved laminating compound</td>
<td>4 ⅜/4</td>
</tr>
<tr>
<td></td>
<td>Noncombustible Studs - Interior Partition with Plaster Each Side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>3½&quot; by No. 18 gauge steel studs spaced 24&quot; on center. ½&quot; gypsum plaster on metal lath each side mixed 1:2 by weight, gypsum to sand aggregate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>3½&quot; No. 16 gauge approved nailable studs spaced 24&quot; on center. ¾&quot; neat gypsum wood fibered plaster each side over ¾&quot; rib metal lath nailed to studs with 6d common nails, 8&quot; on center. Nails driven 1½&quot; and bent over</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>2½&quot; steel studs 16&quot; on center formed with No. 16 gauge angle flanges and No. 7 gauge wire diagonals. ¾&quot; perforated gypsum lath attached to the studs each side with No. 12 gauge wire clips at horizontal and vertical joints. ½&quot; gypsum plaster applied each side mixed 1:2 by weight, gypsum to sand aggregate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>2½&quot; steel studs 16&quot; on center formed with No. 16 gauge angle flanges and No. 7 gauge wire diagonals. ¾&quot; 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&quot; perlite or vermiculite gypsum plaster applied each side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>4&quot; No. 18 gauge channel-shaped steel studs at 16&quot; on center. On each side approved resilient clips pressed onto stud flange at 16&quot; vertical spacing, ¼&quot; pencil rods snapped into or wire-tied onto outer loop of clips, metal lath wire-tied to pencil rods at 6&quot; intervals, 1&quot; perlite gypsum plaster, each side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>2½&quot; No. 18 gauge steel studs spaced 16&quot; on center. Wood fibered gypsum plaster mixed 1:1 by weight gypsum to sand aggregate applied on 3.4 pound metal lath wire tied to studs, each side. ¾&quot; plaster applied over each face, including finish coat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior Stud with Plaster Each Side</td>
<td>63</td>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with ( \frac{7}{8} )&quot; gypsum plaster on metal lath. Lath attached by 4d common nails bent over or No. 14 gauge by 1 1/4&quot; x ( \frac{3}{4} )&quot; crown width staples spaced 6&quot; on center. Plaster mixed 1:1 1/2 for scratch coat and 1:3 for brown coat, by weight, gypsum to sand aggregate</td>
<td>5 1/4</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with metal lath and ( \frac{7}{8} )&quot; neat wood fibered gypsum plaster each side. Lath attached by 6d common nails, 7&quot; on center. Nails driven 1 1/4&quot; and bent over</td>
<td>5 5/8</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with ( \frac{7}{8} )&quot; perforated or plain gypsum lath and ( \frac{1}{2} )&quot; gypsum plaster each side. Lath nailed with 1 1/8&quot; by No. 13 gauge by ( \frac{3}{4} )&quot; head plasterboard blued nails, 4&quot; on center. Plaster mixed 1:2 by weight, gypsum to sand aggregate</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>66</td>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with ( \frac{7}{8} )&quot; Type &quot;X&quot; gypsum lath and ( \frac{1}{2} )&quot; gypsum plaster each side. Lath nailed with 1 1/8&quot; by No. 13 gauge by ( \frac{3}{4} )&quot; head plasterboard blued nails, 5&quot; on center. Plaster mixed 1:2 by weight, gypsum to sand aggregate</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with ( \frac{7}{8} )&quot; plain gypsum lath and ( \frac{1}{2} )&quot; neat wood-fibered gypsum plaster each side. Lath nailed with 4d common wire nails, 5&quot; on center</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>68</td>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with ( \frac{7}{8} )&quot; perforated gypsum lath and ( \frac{1}{2} )&quot; perlite or vermiculite gypsum plaster each side. Lath nailed with 1 1/4&quot; by No. 13 gauge by ( \frac{3}{4} )&quot; head plasterboard blued nails, 5&quot; on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 21/2 cubic feet of aggregate</td>
<td>5</td>
</tr>
</tbody>
</table>

TABLE NO. 43-B—RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALLS AND PARTITIONS—Continued
<table>
<thead>
<tr>
<th>Wood Studs Interior Partition with Plaster Each Side (Cont'd.)</th>
<th>69</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; x 4&quot; wood studs 16&quot; on center with 3/8&quot; perforated gypsum lath with 1&quot; hexagonal mesh of No. 20 gauge wire furred out 1/8&quot; and 1&quot; perlite or vermiculite gypsum plaster each side. Lath nailed with 1 1/4&quot; by No. 13 gauge by 1/8&quot; head plaster-board blue nails spaced 5&quot; on center. Mesh attached by 1 1/4&quot; by No. 12 gauge by 3/8&quot; head nails with 3/8&quot; furrings, spaced 8&quot; on center. For three-coat work the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2 1/2 cubic feet of aggregate</td>
<td>6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Noncombustible Studs — Interior Partition with Gypsum Wallboard Each Side</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 25 gauge channel-shaped studs 24&quot; on center with one full-length layer of 3/8&quot; Type &quot;X&quot; gypsum wallboard applied vertically attached with 1&quot; long No. 6 drywall screws to each side. Screws are 8&quot; on center around the perimeter and 12&quot; on center on the intermediate stud. The wallboard may be applied horizontally when attached to 3/8&quot; studs and the horizontal joints are staggered with those on the opposite side</td>
<td>2 3/4</td>
</tr>
</tbody>
</table>

| 71 |
| No. 25 gauge channel-shaped studs 24" on center with two full-length layers of 3/8" 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. | 6 3/4 |

<p>| 72 |
| No. 25 gauge channel-shaped studs 24&quot; on center with two full-length layers of 1/2&quot; Type &quot;X&quot; gypsum wallboard applied vertically each side. First layer attached with 1&quot; long, No. 6 drywall screws, 8&quot; on center around the perimeter and 12&quot; on center on the intermediate stud. Second layer applied with vertical joints offset one stud space from first layer using 1 1/4&quot; long, No. 6 drywall screws spaced 9&quot; on center along vertical joints, 12&quot; on center at intermediate studs and 24&quot; on center along top and bottom runners | 3 3/4 |</p>
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE³ (in Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noncombustible Studs—Interior Partition with Gypsum Wallboard Each Side (Cont'd.)</td>
<td>73</td>
<td>No. 16 gauge approved nailable metal studs⁹ 24” on center with full-length ¾” 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</td>
<td>4 %</td>
</tr>
<tr>
<td>Wood Studs—Interior Partition with Gypsum Wallboard Each Side</td>
<td>74</td>
<td>2” x 4” wood studs 16” on center with two layers ½” 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</td>
<td>5 %</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>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</td>
<td>5 %</td>
</tr>
<tr>
<td></td>
<td>76</td>
<td>2” x 4” wood studs 16” on center with ¾” Type “X” gypsum wallboard applied vertically or horizontally nailed with 6d cooler nails 7” on center with end joints on nailing members</td>
<td>4 %</td>
</tr>
<tr>
<td></td>
<td>77</td>
<td>2” x 4” fire-retardant treated wood studs spaced 24” on center with one layer of ¾” 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</td>
<td>4 %</td>
</tr>
<tr>
<td>Wood Studs – Interior Partition With Gypsum Wallboard Each Side (Cont’d.)</td>
<td>2” x 4” wood studs 16” on center with two layers ½” 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</td>
<td>6¾</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2” x 3” fire-retardant treated wood studs spaced 24” on center with one layer of ¾” thick Type “X” gypsum wallboard applied with face paper grain (long dimension) at right angles to studs. Wallboard attached with 6d cement coated box nails spaced 7” on center</td>
<td>3¾³⁄₄</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2” x 4” wood studs 16” on center with metal lath and ¾” exterior cement plaster¹⁰ on each side. Lath attached with 6d common nails 7” on center driven to 1” minimum penetration and bent over. Plaster mix 1:4 for scratch coat and 1:5 for brown coat, by volume, cement to sand</td>
<td>5½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2” x 4” wood studs 16” on center with ¾” 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 1:4 for scratch coat and 1:5 for brown coat, by volume, cement to sand</td>
<td>Varies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>83</td>
<td>3 3/8&quot; No. 16 gauge noncombustible studs 16&quot; on center with 7/8&quot; exterior cement plaster (measured from the face of the studs) on the exterior surface with interior surface treatment as required for interior, nonbearing, noncombustible stud partitions in this Table. Plaster mix 1:4 for scratch coat and 1:5 for brown coat, by volume, cement to sand</td>
<td>Varies^{4}</td>
</tr>
<tr>
<td></td>
<td>84</td>
<td>2 1/4&quot; x 3 3/4&quot; clay face brick with cored holes over 1/2&quot; gypsum sheathing on exterior surface of 2&quot; x 4&quot; wood studs at 16&quot; on center and two layers 5/8&quot; Type &quot;X&quot; gypsum wallboard on interior surface. Sheathing placed horizontally or vertically with vertical joints over studs nailed 6&quot; on center with 1 3/4&quot; by No. 11 gauge by 7/8&quot; head galvanized nails. Inner layer of wallboard placed horizontally or vertically and nailed 8&quot; on center with 6d coater nails. Outer layer of wallboard placed horizontally or vertically and nailed 8&quot; on center with 8d coater 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 3/8&quot; x 6/8&quot; attached to each stud with two 8d coater nails, every sixth course of bricks</td>
<td>10 3/4</td>
</tr>
</tbody>
</table>

^{4} See note on page 22 for explanation.
<table>
<thead>
<tr>
<th></th>
<th>85</th>
<th>86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior or Interior Walls (Cont'd.)</td>
<td>2&quot; x 6&quot; fire-retardant treated wood studs 16&quot; on center. Interior face has two layers of 5/8&quot; Type &quot;X&quot; gypsum wallboard with the base layer placed vertically and attached with 6d box nails 12&quot; on center. The face layer is placed horizontally and attached with 8d box nails 8&quot; on center at joints and 12&quot; on center elsewhere. The exterior face has a base layer of 5/8&quot; Type &quot;X&quot; gypsum wallboard placed vertically with 6d box nails 8&quot; on center at joints and 12&quot; on center elsewhere. An approved building paper is next applied, followed by self-furred exterior lath attached with 8d by 2 1/2&quot; long galvanized roofing nails spaced 6&quot; on center along each stud. Exterior cement plaster consisting of a 1/2&quot; scratch coat, a bonding agent and a 1/2&quot; brown coat is then applied. The scratch coat is mixed in the proportion of 1:3 by weight, cement to sand with 10 pounds of hydrated lime and 3 pounds of asbestos fiber per sack of cement. The brown coat is mixed in the proportion of 1:4 by weight, cement to sand with the same amounts of hydrated lime and asbestos fiber used in the scratch coat.</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>4&quot; No. 18 gauge, nonload bearing metal studs, 16&quot; on center, with 1&quot; portland cement lime plaster (measured from the back side of the 3.4# expanded metal lath) on the exterior surface. Interior surface to be covered with 1&quot; of gypsum plaster on 3.4# expanded metal lath proportioned by weight - 1:2 for scratch coat, 1:3 for brown, gypsum to sand. Lath on one side of the partition fastened to 1/4&quot; diameter pencil rods supported by No. 20 gauge metal clips, located 16&quot; on center vertically, on each stud. 3&quot; thick mineral fiber insulating batts friction fitted between the studs.</td>
<td>6½ 4</td>
</tr>
</tbody>
</table>

FOR FOOTNOTES SEE PAGE 520.
FOOTNOTES TO TABLE NO. 43-B

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. Thickness includes plaster, lath and gypsum wallboard where mentioned and grout when all cells are solidly grouted.
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 portland cement plaster or 1.5 times the thickness of gypsum 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 Three pounds of asbestos fiber added for each bag of portland cement.

TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS

<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (In Inches)</th>
<th>MINIMUM THICKNESS OF CEILING (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete - Excluding Ex-</td>
<td>1</td>
<td>Slab (no ceiling required)</td>
<td>6½</td>
<td>5½</td>
</tr>
<tr>
<td>panded Clay Shale or</td>
<td></td>
<td></td>
<td>4 Hr.</td>
<td>3 Hr.</td>
</tr>
<tr>
<td>Slate (by Rotary Kiln</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process) or Expanded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slag</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete - Expanded Clay</td>
<td>2</td>
<td>Slab (no ceiling required)</td>
<td>5</td>
<td>4½</td>
</tr>
<tr>
<td>Shale or Slate (by Rotary</td>
<td></td>
<td></td>
<td>4 Hr.</td>
<td>3 Hr.</td>
</tr>
<tr>
<td>Kiln Process) or Expanded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slag</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>reinforced Concrete</td>
<td>3</td>
<td>Slab with suspended</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Joists</td>
<td></td>
<td>ceiling of vermiculite gypsum plaster over metal lath attached to ¼&quot; cold-rolled channels spaced 12&quot; on center. Ceiling located 6&quot; minimum below joists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete Joists (Cont'd.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-----------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4

21/2% Type "X" gypsum wallboard attached to No. 25-gauge hat-shaped galvanized steel channels with 1" long No. 6 screws. The channels are spaced 24" on center, span 35", and are supported along their length at 35" intervals by No. 21-gauge galvanized steel flat strap hangers having formed edges which engage the lips of the channel. The strap hangers are attached to the side of the concrete joists with 5/8" by 2 1/4" powder-driven fasteners. The wallboard is installed parallel to the main channels, 12" each side, at end joint occurrences. The finish ceiling is located approximately 12" below the soffit of the floor slab (Continued)
<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (IN INCHES)</th>
<th>MINIMUM THICKNESS OF CEILING (IN INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gypsum plaster on metal lath attached to the bottom chord with single No. 16 gauge or doubled No. 18 gauge wire ties spaced 6&quot; 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</td>
<td>2½ 2¾</td>
<td>¾ ½</td>
</tr>
<tr>
<td>Steel Joist Construction</td>
<td>5</td>
<td>Vermiculite gypsum plaster on metal lath attached to the bottom chord with single No. 16 gauge or doubled No. 18 gauge wire ties spaced 6&quot; on center</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>with a Reinforced Concrete Slab on Top Poured on a Metal Lath Form³</td>
<td>6</td>
<td>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&quot; 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</td>
<td>2¼ 2</td>
<td>¾ ¼ ¾ ½</td>
</tr>
</tbody>
</table>
Perlite or vermiculite gypsum plaster on %-" perforated gypsum lath attached to %-" 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.

<table>
<thead>
<tr>
<th>8</th>
<th>Gypsum plaster on %-&quot; perforated gypsum lath attached to %-&quot; 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</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>%-&quot; Type &quot;X&quot; gypsum wallboard attached to approved nailing channels 16&quot; on center with 1¼&quot; by No. 11 gauge by %-&quot; head nails with annular ring shanks spaced 7&quot; 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</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (In Inches)</th>
<th>MINIMUM THICKNESS OF CEILING (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hr.</td>
<td>3 hr.</td>
</tr>
<tr>
<td>Steel Joist Construction with a Reinforced Concrete Slab on Top Poured on a Metal Lath Form³ (Cont'd.)</td>
<td>11</td>
<td>Ceiling of ⅜” Type “X” wallboard attached to ⅜” deep by 2½” 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</td>
<td>2½</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Wood-fibered gypsum plaster mixed 1:1 by weight gypsum to sand aggregate applied over metal lath. Lath tied 6” on center to ⅝” channels spaced 13½” on center. Channels secured to joists at each intersection with two strands of No. 18 gauge galvanized wire</td>
<td>2½</td>
<td></td>
</tr>
<tr>
<td>Reinforced Gypsum Concrete Slab Poured on ½” Gypsum Formboard Supported on Unprotected Steel Bulb Tees, 32½” on Center, Supported on Individually Protected Steel Beams⁸</td>
<td>13</td>
<td>None</td>
<td>2½</td>
<td></td>
</tr>
<tr>
<td>Reinforced Concrete Slab and Joists with Hollow Clay Tile Fillers Laid End to End in Rows 2 1/2&quot; or More Apart; Reinforcement Placed Between Rows and Concrete Cast Around and Over Tile</td>
<td>14</td>
<td>5/8&quot; gypsum plaster on bottom of floor or roof construction</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>------------------------</td>
<td>----</td>
<td>-------------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>15</td>
<td>None</td>
<td></td>
<td>5 1/2</td>
<td>11</td>
</tr>
<tr>
<td>Steel Joist Construction with a Reinforced Concrete Slab on Top poured on a 1/2&quot; deep Steel Deck</td>
<td>16</td>
<td>Vermiculite gypsum plaster on metal lath attached to 3/4&quot; cold-rolled channels with No. 18 gauge wire ties spaced 6&quot; on center</td>
<td>2 1/2</td>
<td>12</td>
</tr>
<tr>
<td>3&quot; Deep Cellular Steel Deck with Concrete Slab on Top. Slab Thickness Measured to Top of Cells</td>
<td>17</td>
<td>Perlite or vermiculite gypsum plaster on 3/4&quot; perforated gypsum lath attached to 3/4&quot; cold-rolled channels with approved clips. Channels suspended by No. 8 gauge hanger wire through units between cells</td>
<td>2 1/2</td>
<td>7</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Deck Type</th>
<th>Thickness</th>
<th>Protection</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; Deep Cellular Steel</td>
<td>1 1/8&quot;</td>
<td>2 1/2</td>
<td>1 1/8 13</td>
</tr>
<tr>
<td></td>
<td>Deck with Concrete Slab</td>
<td>on Top. Slab Thickness Measured to Top of Cells (Cont'd.)</td>
<td></td>
</tr>
<tr>
<td>1 1/8&quot; Deep Steel Roof Deck</td>
<td>1 7/8 8</td>
<td>3/8 8</td>
<td>3/8 8</td>
</tr>
<tr>
<td>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</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ceiling of gypsum plaster on metal lath. Lath attached to 3/4" furring channels with No. 18 gauge wire ties spaced 6" on center. 3/4" 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.
<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (In Inches)</th>
<th>MINIMUM THICKNESS OF CEILING (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Wood Floor Over Wood Joists Spaced 16&quot; On Center</td>
<td>22</td>
<td>Gypsum plaster over ¾&quot; perforated gypsum lath attached to joists with 1¾&quot; by No. 13 gauge by ⅛&quot; head plasterboard blued nails at a spacing of 4&quot; on center. All joints reinforced with 3&quot; wide strips of metal lath nailed through gypsum lath to joists with 1¾&quot; by No. 11 gauge by ⅛&quot; head nails spaced 5&quot; on center along joists and with two nails per joist in the opposite direction. Plaster mixed 1:2 by weight, gypsum to sand aggregate.</td>
<td>4 Hr.</td>
<td>3 Hr.</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Perlite or vermiculite plaster over ¾&quot; perforated gypsum lath nailed with 1¾&quot; by No. 13 gauge by ¾&quot; head plasterboard blued nails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Gypsum plaster over ( \frac{3}{8} )&quot; Type &quot;X&quot; gypsum lath. Lath initially applied with not less than four 1 1/2&quot; by No. 13 gauge by ( \frac{1}{4} )&quot; head plasterboard blued nails per bearing. Continuous stripping over lath along all joist lines. Stripping consists of 3&quot; wide strips of metal lath attached by 1 1/2&quot; by No. 11 gauge by ( \frac{1}{2} )&quot; head roofing nails spaced 6&quot; on center. Alternate stripping consists of 3&quot; wide .049&quot; diameter wire stripping weighing one pound per sq. yd. and attached by No. 16 gauge by 1 1/2&quot; by ( \frac{3}{8} )&quot; crown width staples, spaced 4&quot; on center. Where alternate stripping is used the 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</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 25 | Portland cement or gypsum plaster on metal lath. Lath fastened with 1 1/2" by No. 11 gauge by \( \frac{1}{4} \)" 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 |

(Continued)
<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (In Inches)</th>
<th>MINIMUM THICKNESS OF CEILING (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Wood Floor Over Wood Joists Spaced 16' On Center</td>
<td>26</td>
<td>Perlite or vermiculite gypsum plaster on metal lath secured to joists with 1½&quot; by No. 11 gauge by ( \frac{1}{16} )&quot; head barbed shank roofing nails spaced 5&quot; on center</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>( \frac{5}{8} )&quot; Type &quot;X&quot; gypsum wallboard nailed to joists with 6d cooler nails spaced 6&quot; on center. End joints of wallboard centered on joists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood Stressed Skin Panels Consisting of ( \frac{5}{8} )&quot; Thick Interior C-D (Exterior Glue) Top Stressed Skin on 2&quot; x 6&quot; Nominal (Minimum) Stringers. Adjacent Panel Edges Joined with 8d Common Wire Nails Spaced 6&quot; on Center. Stringers Spaced 12&quot; on Maximum on Center</td>
<td>28</td>
<td>( \frac{1}{2} )&quot; thick wood fiberboard weighing 15 to 18 lbs. per cu. ft. installed with long dimension parallel to stringers using 5d cooler nails spaced 12&quot; on center. Second layer of ( \frac{5}{8} )&quot; Type &quot;X&quot; gypsum wallboard applied with long dimension perpendicular to joists and attached with 8d cooler nails spaced 6&quot; on center at end joints and 8&quot; on center elsewhere. Wallboard joints staggered with respect to fiberboard joints</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>None</td>
<td>31/2</td>
<td>312</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>----</td>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Vermiculite Concrete Slab Proportioned</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:4 (Portland Cement to Vermiculite</td>
<td></td>
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<tr>
<td>Aggregate) on a 1 1/2&quot; Deep Steel Deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Supported on Individually Protected</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel Framing. Slab Reinforced with 4&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x 8&quot; No. 12/14 Welded Wire Mesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>30</th>
<th>None</th>
<th>3 1/2</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perlite Concrete Slab Proportioned 1:6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Portland Cement to Perlite Aggregate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on a 1 3/4&quot; Deep Steel Deck Supported</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on Individually Protected Steel Framing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slab Reinforced with 4&quot; x 8&quot; No. 12/14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded Wire Mesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                                          | 31 | Perlite gypsum plaster on     | 215  | 215 | %   | %   |
|                                          |    | metal lath wire tied to       |       |     |     |     |
|                                          |    | 3/4" furring channels        |       |     |     |     |
|                                          |    | attached with No. 16 gauge    |       |     |     |     |
|                                          |    | wire ties to lower chord of   |       |     |     |     |
|                                          |    | joists                       |       |     |     |     |

(Continued)
### TABLE NO. 43-C—MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS—Continued

<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (In Inches)</th>
<th>MINIMUM THICKNESS OF CEILING (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perlite Concrete Slab Proportional 1:6 (Portland Cement to Perlite Aggregate) on 1¼&quot; Deep Steel Deck Supported on Individually Protected Steel Framing. Slab Reinforced with No. 19 Gauge Hexagonal Wire mesh. Fire-retardant roof covering on top</td>
<td>32</td>
<td>None</td>
<td></td>
<td>2½ 15</td>
</tr>
<tr>
<td>Floor and Beam Construction Consisting of 3&quot; 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</td>
<td>33</td>
<td>Suspended envelope ceiling of perlite gypsum plaster on metal lath attached to ¾&quot; cold-rolled channels, secured to 1½&quot; cold-rolled channels spaced 42&quot; on center supported by No. 6 wire 36&quot; on center. Beams in envelope with 3&quot; minimum air space between beam soffit and lath have a 4-hour rating</td>
<td></td>
<td>2½ 15</td>
</tr>
</tbody>
</table>
FOOTNOTES TO TABLE NO. 43-C

1Staples with equivalent holding power and penetration may be used as alternate fasteners to nails for attachment to wood framing.

2The thickness may be reduced to three inches (3") where limestone aggregate is used.

3Slab thickness over steel joists measured at the joists.

4Portland cement plaster with 40 pounds of asbestos fiber per bag of cement.

5Portland cement plaster with 15 pounds of hydrated lime and three pounds of asbestos fiber per bag of cement.

6One inch (1") by No. 20 gauge hexagonal wire mesh installed below lath and tied to each furring channel at joints between lath.

7No. 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.

8Furring channels spaced twelve inches (12") on center.

9Allowable 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.

10Six-inch (6") hollow clay tile with two-inch (2") concrete slab above.

11Four-inch (4") hollow clay tile with one and one-half-inch (1½") concrete slab above.

12Thickness measured to bottom of steel form units.

13Five-eighths inch (5/8") of vermiculite gypsum plaster plus one-half inch (1/2") of approved vermiculite acoustical plastic.

14Double 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 (1/2") 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 (5/8") interior type tongue and groove plywood finish flooring.

15Thickness measured to top of steel deck unit.
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.
The walkway shall be capable of supporting a uniform live load of 150 pounds per square foot. A durable wearing surface shall be provided.

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 mid-rail.

(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>
<thead>
<tr>
<th>TABLE NO. 44-A—TYPE OF PROTECTION REQUIRED FOR PEDESTRIANS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HEIGHT OF CONSTRUCTION</strong></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Eight feet or less</td>
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<tr>
<td>More than eight feet</td>
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</tbody>
</table>
2. Plywood one-fourth inch (1/4") or five-sixteenths inch (1/16") in thickness shall have studs spaced not more than two feet (2') on center.

3. Plywood three-eighths inch (3/8") or one-half inch (1/2") 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 (5/8") 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.
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.

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.

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').
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 by the building and constructed of noncombustible material or when supported by a building of Type V construction may be of 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 (\( \frac{3}{16} \)) 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.

Sec. 4506. (a) **Definitions.** For the purpose of this Section, certain terms are defined as follows:

**AWNING** is a temporary shelter supported entirely from the exterior wall of a building.

(b) **Construction.** Awnings shall have noncombustible frames but may have combustible coverings. Every awning shall be collapsible, retractable, or capable of being folded
Awnings (Continued) against the face of the supporting building. When collapsed, retracted, or folded, the design shall be such that the awning does not block any required exit.

EXCEPTION: A fixed awning not more than 10 feet in length may be erected over a doorway to the building.

(c) Projection. Awnings may extend over public property not more than 7 feet from the face of a supporting building but no portion shall extend nearer than 2 feet to the face of the nearest curb line measured horizontally. In no case shall the awning extend over public property greater than two-thirds of the distance from the property line to the nearest curb in front of the building site.

(d) Clearances. All portions of an awning shall be at least 8 feet above any public walkway.

EXCEPTION: Any valance attached to an awning shall not project above the roof of the awning at the point of attachment and shall not extend more than 12 inches below the roof of the awning at the point of attachment, but in no case shall any portion of a valance be less than 7 feet in height above a public way.

(e) Design. Unless cloth covered, awnings shall be designed for a vertical live load of not less than five pounds per square foot, except snow loads shall be used if greater than this amount.

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.

CHAPTER 46 — NO REQUIREMENTS

540
PART X
PLASTER AND WALLBOARD
CHAPTER 47—LATHING, PLASTERING AND INSTALLATION
OF WALLBOARD

NOTE: Tables in Chapter 47 appear at the end of the Chapter.

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.

(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.

STEEL STUDS, LOAD-BEARING AND NONLOAD-BEARING, are prefabricated channel shapes, welded wire, or combination wire and steel angle types, galvanized or coated with rust-resistive material.

STRIPPING is flat reinforcing units of expanded metal or wire fabric or other materials not less than three inches (3") wide to be installed as required over joints of gypsum lath.

TIE WIRE is wire for securing together metal framing or supports, for tying metal and wire fabric 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.

Sec. 4702. Lathing, plastering and wallboard materials shall conform to the following Standards:

<table>
<thead>
<tr>
<th>MATERIALS AND DESIGN</th>
<th>U.B.C. DESIGNATION</th>
</tr>
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<tbody>
<tr>
<td>ADHESIVES</td>
<td></td>
</tr>
<tr>
<td>Plaster Liquid Bonding Agents</td>
<td>47- 1</td>
</tr>
<tr>
<td>Wallboard</td>
<td>47- 2</td>
</tr>
<tr>
<td>AGGREGATE</td>
<td></td>
</tr>
<tr>
<td>Sand, Perlite and Vermiculite</td>
<td>47- 3</td>
</tr>
<tr>
<td>METAL LATH, WIRE LATH, WIRE FABRIC AND METAL ACCESSORIES</td>
<td>47- 4</td>
</tr>
<tr>
<td>COMPOUND, WALLBOARD TAPE AND JOINT</td>
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<td>GYPSUM MATERIALS</td>
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<tr>
<td>Air-entrained</td>
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</tbody>
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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. For wood framing, see Chapter 25. For metal framing, see Chapter 27.

EXCEPTION: Wood framed assemblies meeting the requirements of Section 2518 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.

(c) Studless Partitions. The minimum thickness of vertically erected studless solid plaster partitions of three-eighths-inch (3/8") and three-fourths-inch (3/4") rib metal lath or one-half-inch (1/2") thick long-length gypsum lath and gypsum wallboard partitions shall be two inches (2").

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 Section 2518 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 (3/8") 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. Cross­furring 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.

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.

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 (\(\frac{3}{8}\)"") 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 fabric 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 fabric 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 (\(\frac{1}{2}\)"") at sides and one inch (1"") at ends. Wire fabric 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 (\(\frac{1}{8}\)"), shall be lapped at sides by nesting outside ribs. When edge ribs are one-eighth inch (\(\frac{1}{8}\)"") or less, rib metal lath may be lapped one-half inch (\(\frac{1}{2}\)"") 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.

Sec. 4705 (c) Interior 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 or a lath shall provide sufficient rigidity to permit plaster application.

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 fabric lath and portland cement plaster.

Backing is not required under metal lath or paperbacked wire fabric lath.

(d) Weather Resistant Barriers. Weather resistive barriers shall be installed as required in Section 1707 (a).

(e) Application of Metal Plaster Bases. The application of metal lath or wire fabric 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 (\(\frac{1}{4}\)"") 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"") except where weep screeds are provided.
A weep screed shall be provided at the foundation plate line on all exterior stud walls constructed on concrete slabs at grade. The screed shall be of a type which will allow trapped water to drain to the exterior of the building.

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 fabric 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) Base Coat 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) Base Coat Application. Base coats 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 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 (\(\frac{1}{16}\)).
Portland cement and lime finish coats may be applied over interior Portland cement base coats which have been in place not less than 48 hours.

Approved acoustical finish plaster may be applied over any base coat 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 base coat 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 fabric lath shall be installed on such surfaces before plastering.

Sec. 4708. (a) **General.** Plastering with Portland cement plaster shall be not less than three coats when applied over metal lath or wire fabric 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 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 Portland cement plaster in an amount not to exceed that set forth in Table No. 47-F.

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) **Base Coat Proportions.** The proportion of aggregate to cementitious materials shall be as set forth in Table No. 47-F.

(c) **Base Coat Application.** The first coat shall be applied with sufficient material and pressure to fill solidly all openings
Exterior Plaster  (Continued) 

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 (\( \frac{1}{4}'' \)) 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 base coats which have been in place for the time periods set forth in Table No. 47-F. The third or finish coat shall be applied with sufficient material and pressure to bond to and to cover the brown coat and shall be of sufficient thickness to conceal the brown coat.

(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 base coat plaster may be omitted. See Table No. 47-D for thickness.

Exposed Aggregate Plaster

Sec. 4709. (a) General. Exposed natural or integrally colored aggregate may be partially embedded in a natural or colored bedding coat of portland cement or gypsum plaster subject to the provisions of this Section.

(b) Aggregate. The aggregate may be applied manually or mechanically and shall consist of marble chips, pebbles, or similar durable, nonreactive materials, moderately hard (three or more on the MOH scale).

(c) Bedding Coat Proportions. The exterior bedding coat shall be composed of one part portland cement, one part Type S lime and a maximum three parts of graded white or natural sand by volume. The interior bedding coat shall be composed of 100 pounds neat gypsum plaster and a maximum 200 pounds of graded white sand, or exterior or interior may be
a factory prepared bedding coat. The exterior bedding coat shall have a minimum compressive strength of 1000 pounds per square inch.

(d) Application. The bedding coat may be applied directly over the first (scratch) coat of plaster provided the ultimate over-all thickness is a minimum of 7/8 inch including lath. Over concrete or masonry surfaces the over-all thickness shall be a minimum of 1/2 inch.

(e) Bases. Exposed aggregate plaster may be applied over concrete, masonry, portland cement plaster base coats or gypsum plaster base coats.

(f) Preparation of Masonry and Concrete. Masonry and concrete surfaces shall be prepared in accordance with the provisions of Section 4708 (e).

(g) Curing. Portland cement base coats shall be cured in accordance with Table No. 47-F. Portland cement bedding coat shall retain sufficient moisture for hydration (hardening) for 24 hours minimum or, where necessary, shall be kept damp for 24 hours by light water spraying.

Sec. 4710. 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.

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 (“”). 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.

Sec. 4711. (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 (%") 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-sixteenth inch (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.
Sec. 4712. (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. 47-1.

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 2518 (f) 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 1 1/2 to 1.

(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 (3/8") 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.
TABLE NO. 47-A—SUSPENDED AND FURRED CEILINGS
(For Support of Ceilings Weighing Not More than 10 Pounds per Square Foot)

<table>
<thead>
<tr>
<th>Minimum Sizes for Wire and Rigid Hangers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIZE AND TYPE</strong></td>
</tr>
<tr>
<td><strong>Hangers for Suspended Ceilings</strong></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td><strong>Hangers for Attaching Runners and Furring Directly to Beams and Joists</strong></td>
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<td></td>
</tr>
</tbody>
</table>
### Minimum Sizes and Maximum Spans for Main Runners

<table>
<thead>
<tr>
<th>SIZE AND TYPE</th>
<th>MAXIMUM SPACING OF HANGERS OR SUPPORTS (ALONG RUNNERS)</th>
<th>MAXIMUM SPACING OF RUNNERS (TRANSVERSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; - .3 pound per foot, cold- or hot-rolled channel</td>
<td>2'0&quot;</td>
<td>3'0&quot;</td>
</tr>
<tr>
<td>1 1/2&quot; - .475 pound per foot, cold-rolled channel</td>
<td>3'0&quot;</td>
<td>4'0&quot;</td>
</tr>
<tr>
<td>1 1/2&quot; - .475 pound per foot, cold-rolled channel</td>
<td>3'6&quot;</td>
<td>3'0&quot;</td>
</tr>
<tr>
<td>1 1/2&quot; - .475 pound per foot, cold-rolled channel</td>
<td>4'0&quot;</td>
<td>3'0&quot;</td>
</tr>
<tr>
<td>1 1/2&quot; - 1.12 pounds per foot, hot-rolled channel</td>
<td>4'0&quot;</td>
<td>5'0&quot;</td>
</tr>
<tr>
<td>2&quot; - 1.26 pounds per foot, hot-rolled channel</td>
<td>5'0&quot;</td>
<td>5'0&quot;</td>
</tr>
<tr>
<td>2&quot; - .59 pound per foot, cold-rolled channel</td>
<td>5'0&quot;</td>
<td>3'6&quot;</td>
</tr>
<tr>
<td>1 1/2&quot; x 1 1/2&quot; x 1/8&quot; angle</td>
<td>5'0&quot;</td>
<td>3'6&quot;</td>
</tr>
</tbody>
</table>

### Minimum Sizes and Maximum Spans for Cross Furring

<table>
<thead>
<tr>
<th>SIZE AND TYPE OF CROSS FURRING</th>
<th>MAXIMUM SPACING OF RUNNERS OR SUPPORTS</th>
<th>MAXIMUM SPACING OF CROSS FURRING MEMBERS (TRANSVERSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4&quot; diameter pencil rods</td>
<td>2'0&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>3/8&quot; diameter pencil rods</td>
<td>2'0&quot;</td>
<td>19&quot;</td>
</tr>
<tr>
<td>3/8&quot; diameter pencil rods</td>
<td>2'6&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>3/4&quot; - .3 pound per foot, cold- or hot-rolled channel</td>
<td>3'0&quot;</td>
<td>24&quot;</td>
</tr>
<tr>
<td>3/4&quot; - .3 pound per foot, cold- or hot-rolled channel</td>
<td>3'6&quot;</td>
<td>16&quot;</td>
</tr>
<tr>
<td>3/4&quot; - .3 pound per foot, cold- or hot-rolled channel</td>
<td>4'0&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>1&quot; - .410 pound per foot, hot-rolled channel</td>
<td>4'0&quot;</td>
<td>24&quot;</td>
</tr>
<tr>
<td>1&quot; - .410 pound per foot, hot-rolled channel</td>
<td>4'6&quot;</td>
<td>19&quot;</td>
</tr>
<tr>
<td>1&quot; - .410 pound per foot, hot-rolled channel</td>
<td>5'0&quot;</td>
<td>12&quot;</td>
</tr>
</tbody>
</table>

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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’—TYPES OF LATH—MAXIMUM SPACING OF SUPPORTS

<table>
<thead>
<tr>
<th>TYPE OF LATH²</th>
<th>MINIMUM WEIGHT (Per Square Yard)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GAUGE AND MESH SIZE</td>
</tr>
<tr>
<td></td>
<td>VERTICAL (In Inches)</td>
</tr>
<tr>
<td></td>
<td>Metal</td>
</tr>
<tr>
<td></td>
<td>HORIZONTAL (In Inches)</td>
</tr>
<tr>
<td></td>
<td>Wood</td>
</tr>
<tr>
<td></td>
<td>Solid</td>
</tr>
<tr>
<td></td>
<td>Plaster Partitions</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>Wood or Concrete</td>
</tr>
<tr>
<td></td>
<td>Metal</td>
</tr>
</tbody>
</table>

1. Expanded Metal Lath (Diamond Mesh) 2.5 16 16 12 12
2. Expanded Metal Lath (Diamond Mesh) 3.4 16 16 16 16
3. Flat Rib Expanded Metal Lath 2.75 16 16 16 16
4. Flat Rib Expanded Metal Lath 3.4 19 24 19 19
5. Stucco Mesh Expanded Metal Lath 1.8 and 16² — — —
6. Stucco Mesh Expanded Metal Lath 3.6 — — — —
7. 3/8” Rib Expanded Metal Lath 3.4 24 24 24 24
8. 3/8” Rib Expanded Metal Lath 4.0 24 24 24 24
9. Sheet Lath 4.5 24 — 24 24
<table>
<thead>
<tr>
<th>3/8&quot; Rib Expanded Metal Lath</th>
<th>5.4</th>
<th>—</th>
<th>—4</th>
<th>—</th>
<th>365</th>
<th>365</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire Fabric Lath</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded</td>
<td>1.95 pounds, No. 11 gauge, 2&quot; x 2&quot;</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>1.4 pounds, No. 16 gauge, 2&quot; x 2&quot;</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>1.4 pounds, No. 18 gauge, 1&quot; x 1&quot;6</td>
<td>163</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Woven3</td>
<td>1.4 pounds, No. 17 gauge, 1 1/2&quot; Hexagonal6</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>3/8&quot; Gypsum Lath (perforated)</td>
<td>16</td>
<td>—</td>
<td>167</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>3/8&quot; Gypsum Lath (plain)</td>
<td>16</td>
<td>—</td>
<td>167</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Lath (perforated)</td>
<td>16</td>
<td>—</td>
<td>167</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>1/2&quot; Gypsum Lath (plain)</td>
<td>24</td>
<td>—</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

1For Fire-resistive Construction, see Tables No. 43-A, No. 43-B and No 43-C. For Shear-resisting Elements, see Table No. 47-1.
2Metal lath and wire fabric lath used as reinforcement for portland cement plaster shall be furred out away from vertical supports at least one-fourth inch (1/4"). Self-furring lath meets furring requirement. Exception: Furring is not required on steel supports having a flange width of one inch (1") or less.
3Wire backing required on open vertical frame construction except under expanded metal lath and paper backed wire fabric lath.
4May be used for studless solid partitions.
5Contact or furred ceilings only. May not be used in suspended ceilings.
6Woven wire or welded wire fabric lath, not to be used as base for gypsum plaster, without absorbent paper backing or slot-perforated separator.
7Span may be increased to twenty-four inches (24") on vertical screw or approved nailable assemblies.
<table>
<thead>
<tr>
<th>Type of Lath</th>
<th>Nails</th>
<th>Maximum Spacing</th>
<th>Staples</th>
<th>MAXIMUM SPACING OF ATTACHMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Vertical</td>
<td>Horizontal</td>
<td>Leg</td>
</tr>
<tr>
<td>Diamond Mesh Expanded Metal Lath and Flat Rib Metal Lath</td>
<td>4d blued box (clinched)</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1&quot; No. 11 gauge, ( \frac{5}{8} )&quot; head, barbed</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1( \frac{1}{2} )&quot; No. 11 gauge, ( \frac{5}{8} )&quot; head, barbed</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( \frac{3}{8} )&quot; Rib Metal Lath and Sheet Lath</td>
<td>1( \frac{1}{2} )&quot; No. 11 gauge, ( \frac{5}{8} )&quot; head, barbed</td>
<td>6</td>
<td>6</td>
<td>1( \frac{1}{4} )</td>
</tr>
<tr>
<td>( \frac{3}{4} )&quot; Rib Metal Lath</td>
<td>4d Common</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2&quot;, No. 11 Gauge, ( \frac{5}{8} )&quot; head, barbed</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wire Fabric Lath</td>
<td>4d blued box (clinched)</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1&quot; No. 11 gauge, ( \frac{5}{8} )&quot; head, barbed</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1( \frac{1}{2} )&quot; No. 11 gauge, ( \frac{5}{8} )&quot; head, barbed</td>
<td>6</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1( \frac{1}{2} )&quot; No. 12 gauge, ( \frac{5}{8} )&quot; head, furring</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( \frac{3}{8} )&quot; Gypsum Lath</td>
<td>1( \frac{1}{2} )&quot; No. 13 gauge, ( \frac{5}{8} )&quot; head, blued</td>
<td>5</td>
<td>5</td>
<td>7( \frac{1}{4} )</td>
</tr>
<tr>
<td>( \frac{1}{2} )&quot; Gypsum Lath</td>
<td>1( \frac{1}{4} )&quot; No. 13 gauge, ( \frac{5}{8} )&quot; head, blued</td>
<td>5( \frac{1}{4} )</td>
<td>47</td>
<td>1( \frac{1}{4} )</td>
</tr>
</tbody>
</table>

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 (\( \frac{1}{8} \" \)).
4. For interiors only.
5. Attach self-furring wire fabric lath to supports at furring device.
6. Perforated lath.
7. Plain lath.
<table>
<thead>
<tr>
<th>PLASTER BASE</th>
<th>Gypsum Plaster</th>
<th>Portland Cement Plaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expanded Metal Lath</td>
<td>5/8&quot; minimum 2</td>
<td>5/8&quot; minimum 2</td>
</tr>
<tr>
<td>Wire Fabric Lath</td>
<td>5/8&quot; minimum 2</td>
<td>3/4&quot; minimum (interior) 3</td>
</tr>
<tr>
<td>Gypsum Lath</td>
<td>1/2&quot; minimum</td>
<td>7/8&quot; minimum (exterior) 3</td>
</tr>
<tr>
<td>Masonry Walls 4</td>
<td>1/2&quot; minimum</td>
<td>1/2&quot; minimum</td>
</tr>
<tr>
<td>Monolithic Concrete Walls 4</td>
<td>1/2&quot; maximum</td>
<td>7/8&quot; maximum</td>
</tr>
<tr>
<td>Monolithic Concrete Ceilings 5</td>
<td>3/8&quot; maximum 6, 7</td>
<td>7/8&quot; maximum 7</td>
</tr>
</tbody>
</table>

1For Fire-resistive Construction, see Tables No. 43-A, No. 43-B, and No. 43-C.
2When 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.
3When measured from face of support or backing.
4Because masonry and concrete surfaces may vary in plane, thickness of plaster need not be uniform.
5When applied over a liquid bonding agent, finish coat may be applied directly to concrete surface.
6Approved acoustical plaster may be applied directly to concrete, or over base coat plaster, beyond the maximum plaster thickness shown.
7On concrete ceilings, where the base coat plaster thickness exceeds the maximum thickness shown, metal lath or wire fabric lath shall be attached to the concrete.
### TABLE NO. 47-E—GYPSUM PLASTER PROPORTIONS

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>COAT</th>
<th>PLASTER BASE OR LATH</th>
<th>MAXIMUM VOLUME AGGREGATE PER 100 POUNDS NEAT PLASTER (Cubic Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Damp Loose Sand$^4$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Perlite or Vermiculite$^4$</td>
</tr>
<tr>
<td>Two-coat Work</td>
<td>Base Coat</td>
<td>Gypsum Lath</td>
<td>2½</td>
</tr>
<tr>
<td></td>
<td>Base Coat</td>
<td>Masonry</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>First Coat</td>
<td>Lath</td>
<td>2$^5$</td>
</tr>
<tr>
<td></td>
<td>Second Coat</td>
<td>Lath</td>
<td>3$^5$</td>
</tr>
<tr>
<td></td>
<td>First and</td>
<td>Masonry</td>
<td>3</td>
</tr>
<tr>
<td>Three-coat Work</td>
<td>Second Coats</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

$^1$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>
<thead>
<tr>
<th>COAT</th>
<th>VOLUME CEMENT</th>
<th>MAXIMUM WEIGHT (OR VOLUME) LIME PER VOLUME CEMENT</th>
<th>MAXIMUM VOLUME SAND PER VOLUME CEMENT</th>
<th>APPROXIMATE MINIMUM THICKNESS</th>
<th>MINIMUM PERIOD MOIST CURING</th>
<th>MINIMUM INTERVAL BETWEEN COATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1</td>
<td>20 lbs./cu. ft.</td>
<td>4</td>
<td>3/8&quot;</td>
<td>48 Hours</td>
<td>487 Hours</td>
</tr>
<tr>
<td>Second</td>
<td>1</td>
<td>20 lbs./cu. ft.</td>
<td>5</td>
<td>1st and 2nd Coats total 3/4&quot;</td>
<td>48 Hours</td>
<td>7 Days</td>
</tr>
<tr>
<td>Finish</td>
<td>1</td>
<td>1/4</td>
<td>3</td>
<td>1st, 2nd and Finish Coats 3/8&quot;</td>
<td>-</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COAT</th>
<th>VOLUME CEMENT</th>
<th>MAXIMUM VOLUME LIME PER VOLUME CEMENT</th>
<th>MAXIMUM VOLUME SAND PER VOLUME CEMENT OF SAND AND LIME</th>
<th>APPROXIMATE MINIMUM THICKNESS</th>
<th>MINIMUM PERIOD MOIST CURING</th>
<th>MINIMUM INTERVAL BETWEEN COATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3/8&quot;</td>
<td>48 Hours</td>
<td>487 Hours</td>
</tr>
<tr>
<td>Second</td>
<td>1</td>
<td>1</td>
<td>4 1/2</td>
<td>1st and 2nd Coats total 3/4&quot;</td>
<td>48 Hours</td>
<td>7 Days</td>
</tr>
<tr>
<td>Finish</td>
<td>1</td>
<td>1/4</td>
<td>3</td>
<td>1st, 2nd and Finish Coats 3/8&quot;</td>
<td>-</td>
<td>8</td>
</tr>
</tbody>
</table>

1. Exposed aggregate plaster shall be applied in accordance with Section 4709. Minimum over-all thickness shall be 7/8 inch.
2. Up to 20 pounds of dry hydrated lime (or an equivalent amount of lime putty) may be used as a plasticizing agent in proportion to each sack (cubic foot) of Type I and Type II Standard portland cement in first and second coats of plaster. See Section 4708 (a) for use of plastic cement.
3. When determining the amount of sand in set plaster, a tolerance of 10 per cent may be allowed.
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. Twenty-four hours minimum period for moist curing of interior portland cement plaster.
9. Twenty-four hours minimum interval between coats of interior portland cement plaster.
10. Finish coat plaster may be applied to interior portland cement base coats after a 48-hour period.
11. For finish coat plaster, up to an equal part of dry hydrated lime by weight (or an equivalent amount of lime putty) may be added to Types I, II, and III Standard portland cement.
12. No additions of plasticizing agents shall be made.
13. Type I, II or III Standard portland cement. See Section 4708 (a) for use of plastic cement.
### TABLE NO. 47-G—APPLICATION OF SINGLE-PLY GYPSUM WALLBOARD

<table>
<thead>
<tr>
<th>Thickness of Gypsum Wallboard (Inch)</th>
<th>Plane of Framing Surface</th>
<th>Long Dimension of Gypsum Wallboard Sheets in Relation to Direction of Framing Members</th>
<th>Maximum Spacing of Framing Members (Center to Center) (In Inches)</th>
<th>Maximum Spacing of Fasteners (Center to Center) (In Inches)</th>
<th>Nails*</th>
<th>Screws*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>Horizontal</td>
<td>Either Direction</td>
<td>16</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>Perpendicular</td>
<td>24</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>5/8</td>
<td>Horizontal</td>
<td>Either Direction</td>
<td>16</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Horizontal</td>
<td>Perpendicular</td>
<td>24</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

*Fastening Required with Adhesive Application

| 1/2 or 5/8                           | Horizontal               | Either Direction                                                                 | 16                                                               | 16                                                       | 16     |         |
|                                       | Perpendicular            | 24                                                                               | 12                                                               | 16                                                       |        |         |
|                                       | Vertical                 | Either Direction                                                                 | 24                                                               | 24                                                       | 24     |         |

---

1. For Fire-resistant Construction, see Tables No. 43-B and No. 43-C. Support spacing of twenty-four inches (24") may be allowed for ceilings only where fire-resistant construction is not required. 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 (5/8") 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. 13 1/2" gauge, one and five-eighths inches (1 5/8") long, fifteen-sixty-fourths-inch (15/64") head for one-half-inch (1/2") gypsum wallboard; 6d, No. 13 gauge, one and seven-eighths inches (1 7/8") long, fifteen-sixty-fourths-inch (15/64") head for five-eighths-inch (5/8") gypsum wallboard.

3. Two nails spaced not less than two inches (2") apart, nor more than two and one-half inches (2 1/2") apart and pairs of nails spaced not more than twelve inches (12") center to center may be used.

4. Screws shall be of an approved type long enough to penetrate into wood framing not less than five-eighths inch (5/8") and through metal framing not less than one-fourth inch (1/4").
### TABLE NO. 47-H—APPLICATION OF TWO-PLY GYPSUM WALLBOARD

#### Fasteners Only

<table>
<thead>
<tr>
<th>Thickness of Gypsum Wallboard (Each Ply) (Inch)</th>
<th>Plane of Framing Surface</th>
<th>Long Dimension of Gypsum Wallboard Sheets</th>
<th>Maximum Spacing of Framing Members (Center to Center) (In Inches)</th>
<th>Maximum Spacing of Fasteners (Center to Center) (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nails</td>
<td>Screws</td>
</tr>
<tr>
<td>3/8</td>
<td>Horizontal</td>
<td>Perpendicular only</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>1/2</td>
<td>Horizontal</td>
<td>Perpendicular only</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>5/8</td>
<td>Horizontal</td>
<td>Perpendicular only</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

#### Fasteners and Adhesives

<table>
<thead>
<tr>
<th>Base Ply</th>
<th>Plane of Framing Surface</th>
<th>Long Dimension of Gypsum Wallboard Sheets</th>
<th>Maximum Spacing of Fasteners (Center to Center) (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 Base Ply</td>
<td>Horizontal</td>
<td>Perpendicular only</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
</tr>
<tr>
<td>1/2 Base Ply</td>
<td>Horizontal</td>
<td>Perpendicular only</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
</tr>
<tr>
<td>5/8 Base Ply</td>
<td>Horizontal</td>
<td>Perpendicular only</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Either Direction</td>
<td>24</td>
</tr>
</tbody>
</table>

1. For Fire-resistant 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. 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 No. 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>
<thead>
<tr>
<th>TYPE OF MATERIAL</th>
<th>THICKNESS OF MATERIAL</th>
<th>WALL CONSTRUCTION</th>
<th>MINIMUM NAIL SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum Lath, Plain or Perforated</td>
<td>3/8&quot; Lath and 1/2&quot; Plaster</td>
<td>Unblocked</td>
<td>5, 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unblocked</td>
<td>4, 75</td>
</tr>
<tr>
<td>Gypsum Sheathing Board</td>
<td>1/2&quot; x 2' x 8'</td>
<td>Unblocked</td>
<td>4, 175</td>
</tr>
<tr>
<td></td>
<td>1/2&quot; x 4'</td>
<td>Blocked</td>
<td>4, 175</td>
</tr>
<tr>
<td>Gypsum Wallboard</td>
<td>1/2&quot;</td>
<td>Unblocked</td>
<td>4, 125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blocked</td>
<td>7, 125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5d cooler nails</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6d cooler nails</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/8&quot;</td>
<td>Blocked</td>
<td>4, 175</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Base Ply 9, Face Ply 7</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Base Ply—6d cooler nails</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Face Ply—8d cooler nails</td>
<td></td>
</tr>
</tbody>
</table>

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.
PART XI

SPECIAL SUBJECTS

CHAPTER 48—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 49—NO REQUIREMENTS

(See page 595—Appendix.)

CHAPTER 50—PREFABRICATED CONSTRUCTION

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.

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.

Sec. 5003. The Building Official may require special tests to be made on assemblies to determine their durability and weather resistance.

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.

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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.

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.

(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

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.

Sec. 5202. Approved plastic materials shall be those which have a flame-spread rating of 225 or less when tested in accordance with U.B.C. Standard No. 42-1, in the way intended for use; and a smoke density rating no greater than 450 when tested in accordance with U.B.C. Standard No. 42-1, in the way intended for use; or a smoke density rating no greater than 75 when tested in the thickness intended for use by the chamber method of test under U.B.C. Standard No. 52-2.

The products of combustion shall be no more toxic than those of untreated wood when burned under similar conditions.

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.
Sec. 5204. (a) Definition. PLASTIC GLAZING MATERIALS — light transmitting material glazed or set in frame or sash and not held by mechanical fasteners which pass through the glazing material.

(b) General. In Type V-N construction, doors, sash and framed openings, not required to be fire protected, may be glazed or equipped with approved plastic materials.

In all types of construction having occupancies other than Groups A, B-1, D-2, D-3, E-1, E-2 and F-1, and in all types of buildings equipped with an approved automatic fire-extinguishing system, such openings not required to be fire protected may be glazed or equipped with approved plastic materials subject to the following requirements:

1. The area of such glazing shall not exceed 30 per cent of the wall face of the story in which it is installed.

2. In stories above the first story the area of a unit or pane of glazing shall not exceed 12 square feet and the vertical dimension of a unit or pane shall not exceed 3 feet.

3. Assemblies of plastic glazing shall be separated vertically by noncombustible wall surfacing material to a height of at least 4 feet, or a height equal to at least 50 per cent of the height of the highest panel of the next lower assembly or run, whichever is greater.

4. Such installations shall be of materials easily broken or removed by firemen to permit venting of a fire or entry by firemen, or clearly marked access panels shall be provided.

EXCEPTIONS: 1. Installations of approved plastic materials which will automatically vent a fire in the occupancy prior to ignition of the plastic materials may occupy a maximum of 50 per cent of the area of the wall face and the story when installed in the first three stories. The area of such plastic glazing above the third story shall not exceed 30 per cent of the area of the wall face and story of which it is installed. These materials will be subject to the installation requirements specified in Items 2, 3 and 4 above.

2. Plastic materials qualifying under Exception 1 above, may be installed in areas up to 50 per cent of the wall area of each story in structures less than 150 feet in height which are provided, on each floor above the first floor, with continuous architectural projections meeting the requirements of Section 1710 and extending at least 3 feet from the surface of the wall in which the glazing is installed. The size and dimensions of individual units or panes shall not be limited in such installations except as required to meet loading requirements.

Sec. 5205. (a) General. Approved plastics may be used in skylights installed on roofs in accordance with the following provisions:
1. The plastic shall be mounted at least 4 inches above the plane of the roof on a curb constructed of, or clad with, a metal or noncombustible material. The curb may be omitted where skylights are provided with a screen immediately below the skylight. The screen shall be substantially mounted and of wire not smaller than No. 12 U. S. gauge having openings not larger than 1 inch.

2. Flat or corrugated plastic lights shall slope at least 4:12.

3. Dome-shaped skylights shall rise above the mounting flange a minimum distance equal to 10 per cent of the maximum span of the dome, but not less than 5 inches.

4. The edges of the plastic lights or dome shall be protected by metal or noncombustible material.

5. Each skylight unit may have a maximum area within the curb of 100 square feet.

6. The aggregate area of skylights shall not exceed 25 per cent of the floor area of the room or space sheltered by the roof in which they are installed.

7. Skylight units shall be installed on the roof with a minimum distance of 4 feet between units and, except for Groups H and I Occupancies, not less than 4 feet from any exterior wall. In no case shall they extend into yards beyond a vertical plane where fire protection of wall openings is required.

(b) Exceptions. 1. Provision 5 of Section 5205 (a) need not be applied if the building on which the skylights are located is not more than one story in height, the building has an exterior separation from other buildings of at least 30 feet and the room or space sheltered by the roof is not classified in a Group D-1 or D-2 Occupancy, or as a required means of egress, or the plastic material meets the fire-retardant requirements of the roof.

2. Except for Groups A, B-1, D and E Occupancies, approved plastic materials may be used beyond the limitations specified in provisions 5 and 7 of Section 5205 (a) if serving as an approved fire venting system, or if used in a building equipped with an approved automatic fire-extinguishing system.

(c) Plastics over Stair Shafts. Approved plastic materials which will not automatically vent but which are able to be vented may be used over stairways and shafts, provided the installation conforms to the requirements of Section 5205 (a) above.

(d) Combinations of Roof Panels and Skylights. Combinations of approved plastics used in roofs and skylights shall not exceed 25 per cent of the floor area of the room or occupancy sheltered.
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 200 square feet. The total aggregate area of plastics used in skylights, monitors and sawtooth glazing shall not exceed 30 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 noncombustible material or by a section of the roofing material of the structure not less than 4 feet in length.

Sec. 5207. (a) Luminous Ceilings. For the purpose of this Section, a luminous ceiling shall be defined as any light diffusing or light transmitting ceiling consisting of transparent, translucent, louvered, eggcrated, mesh, or similar materials suspended from a ceiling or structural framework by means of hangers and which may include a supporting grid on which the material rests.

Where ceilings are required to be fire-resistive or of noncombustible construction and are dropped greater than the distance specified in paragraph 1 of Section 4203, plastics conforming to the requirements of a Class I finish material shall be used except where they are protected on both sides by an automatic fire-extinguishing system.

EXCEPTION: Ceiling light diffusers of approved plastics shall not be required to conform to the above requirement, provided the installation meets the following requirements:

1. The ceiling light diffusers, as installed, will fall from their mountings at an ambient temperature of at least 200°F. below the ignition temperature of the plastic material, as measured by U.B.C. Standard No. 52-3.

2. The plastic light diffusers are mounted in the ceiling in such a manner that they will remain in place at an ambient room temperature of 175°F. for a period of not less than 15 minutes.

3. The maximum length of any single plastic light transmitting panel shall not exceed 10 feet.

Luminous ceilings installed below sprinkler heads shall be installed so that they will not interfere with the effective operation of the sprinkler system in the area to be protected and shall provide a ready means of access to all valves and sprinkler heads of the system.
(b) Use of Approved Plastics with Electrical Lighting Fixtures. Light transmitting and light diffusing panels made from plastic materials installed in approved electric lighting fixtures shall be exempt from the requirements of Chapter 42 and Section 5207 (a) above and shall meet the following requirements:

1. The light diffusers shall meet the requirements of Section 5207 (a), Exceptions 1 and 2.

2. Unless the occupancy is protected by an approved automatic sprinkler system, the area of approved plastic materials when used in exitways, exit passages, or corridors or in Groups A, B-1 and D Occupancies shall not exceed 30 per cent of the aggregate area of the ceiling in which they are installed.

3. The maximum area of any single plastic light diffuser shall not exceed 30 square feet.

Sec. 5208. Where partitions are not required to be of fire-resistive or noncombustible construction, approved plastics conforming to the requirements specified in Chapter 42 and Section 1705 (a) 4 may be used.

Sec. 5209. (a) General. Exterior veneer shall be of approved plastic materials and shall conform to the provisions of this Section.

(b) Limitations. Exterior plastic veneer which meets the requirements for noncombustibility as defined in Section 415 shall be unlimited as to height and length of veneered area except as limited by Sections 3001 (b) and 3005 (c).

All other approved plastic materials shall conform to the following provisions:

1. Height. The approved veneer shall not be attached to any exterior wall above 35 feet.

   EXCEPTION: Plastic veneer may be attached to exterior walls above the first story of buildings outside of Fire Zones No. 1 and No. 2, provided the height of veneer is not in excess of 50 feet above the adjacent grade elevation.

2. Area. Sections of plastic veneer shall not exceed 200 square feet in area.

   EXCEPTION: In Fire Zone No. 3, the area may be increased by 50 per cent.

3. Separation. Sections of plastic veneer shall be separated by a minimum of 4 feet vertically.

Sec. 5210. Approved plastics may be used in awnings. All such awnings shall be constructed in accordance with provisions governing projections and appendages as specified in Section 4506.

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 U.B.C. Standard No. 27-9.

(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 noncombustible 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 water-wash spray booth.

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Sec. 5305. All electrical equipment shall be installed in accordance with U.B.C. Standard No. 53-1. Other sources of ignition shall also meet the requirements of this Standard.

### TABLE NO. 53-A—MINIMUM THICKNESS OF EXHAUST DUCTS

<table>
<thead>
<tr>
<th>DIAMETER OF DUCT (IN INCHES)</th>
<th>MINIMUM THICKNESS (IN U. S. STANDARD GAUGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8&quot; or less</td>
<td>24</td>
</tr>
<tr>
<td>Over 8&quot; to 18&quot; Inclusive</td>
<td>22</td>
</tr>
<tr>
<td>Over 18&quot; to 30&quot; Inclusive</td>
<td>20</td>
</tr>
<tr>
<td>Over 30&quot;</td>
<td>18</td>
</tr>
</tbody>
</table>
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.

Standards for glazing subject to human impact shall be as specified in U.B.C. Standard No. 54-2.

(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 be not more than set forth in Table No. 54-A or as adjusted by Table No. 54-B.

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

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.

Wired-glass with wire exposed on longitudinal edges shall not be used in jalousies or louvered windows.
Sec. 5406. Glazing in locations which may be subject to human impact such as frameless glass doors, glass entrance and exit doors, fixed glass panels, sliding glass doors, shower doors, tub enclosures, and storm doors shall meet the requirements set forth in Table No. 54-D or No. 54-E.

EXCEPTIONS: 1. Glass lights located not less than 18 inches above the adjacent finished floor walking surface.

2. Glass lights when the least dimension is no greater than 18 inches.

3. Glass lights when by comparative tests are proven to produce equivalent performance as those set forth in Tables No. 54-D and No. 54-E.
**TABLE NO. 54-A — MAXIMUM ALLOWABLE AREA OF GLASS**
(In Square Feet)

<table>
<thead>
<tr>
<th>WIND LOAD (In Pounds per Square Foot)</th>
<th>PLATE OR FLOAT GLASS THICKNESS (In Inches)</th>
<th>SHEET GLASS THICKNESS (In Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\frac{1}{4}$</td>
<td>$\frac{3}{16}$</td>
</tr>
<tr>
<td>10</td>
<td>41</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
<td>27</td>
<td>48</td>
</tr>
<tr>
<td>20</td>
<td>21</td>
<td>36</td>
</tr>
<tr>
<td>25</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td>30</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>35</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>45</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>50</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>60</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>70</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>80</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>90</td>
<td>4.5</td>
<td>8</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

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-I-C, Uniform Building Code Standards, No. 54-1.
### TABLE NO. 54-B—ADJUSTMENT FACTORS—RELATIVE RESISTANCE TO WIND LOAD

<table>
<thead>
<tr>
<th>GLASS TYPE</th>
<th>APPROXIMATE RELATIONSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminated</td>
<td>0.6</td>
</tr>
<tr>
<td>Wired</td>
<td>0.5</td>
</tr>
<tr>
<td>Heat-strengthened</td>
<td>2.0</td>
</tr>
<tr>
<td>Fully tempered</td>
<td>4.0</td>
</tr>
<tr>
<td>Factory-fabricated Double Glazing</td>
<td>1.5</td>
</tr>
<tr>
<td>Rough Rolled Plate</td>
<td>1.0</td>
</tr>
<tr>
<td>Sandblasted</td>
<td>Varies</td>
</tr>
<tr>
<td>Regular Plate or Sheet</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1To 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 (1/4") 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 (1/4") 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.).

2Use thickness of the thinner of the two lights, not thickness of the unit.

3To 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

<table>
<thead>
<tr>
<th>Fixed Windows and Openable Windows Other Than Horizontal Sliding</th>
<th>6 TO 14 SQ. FT.</th>
<th>14 TO 32 SQ. FT.</th>
<th>32 TO 50 SQ. FT.</th>
<th>OVER 50 SQ. FT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Frame Lap....</td>
<td>1/4&quot;</td>
<td>1/4&quot;</td>
<td>7/16&quot;</td>
<td>9/16&quot;</td>
</tr>
<tr>
<td>Minimum Glass Edge Clearance</td>
<td>1/8&quot;1,2</td>
<td>1/8&quot;1,2</td>
<td>7/32&quot;1</td>
<td>1/4&quot;1</td>
</tr>
<tr>
<td>Continuous Glazing Rabbet and Glass Retainer3...</td>
<td>Required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resilient Setting Material4...</td>
<td>Not Required</td>
<td>Required</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sliding Doors and Horizontal Sliding Windows</th>
<th>14 TO 32 SQ. FT.</th>
<th>32 TO 50 SQ. FT.</th>
<th>OVER 50 SQ. FT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Glass Frame Lap...</td>
<td>1/4&quot;</td>
<td>3/8&quot;</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>Minimum Glass Edge Clearance</td>
<td>1/8&quot;2</td>
<td>3/16&quot;</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>Continuous Glazing Rabbet and Glass Retainer3...</td>
<td>Required</td>
<td>Required</td>
<td></td>
</tr>
<tr>
<td>Resilient Setting Material4...</td>
<td>Not Required</td>
<td>Required</td>
<td></td>
</tr>
</tbody>
</table>

*Footnotes on page 576.
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.

### TABLE NO. 54-D — IMPACT LOADS — GLAZING

<table>
<thead>
<tr>
<th>SPECIFIC HAZARDOUS LOCATIONS</th>
<th>SIZE OF INDIVIDUAL GLAZED AREA</th>
<th>REQUIREMENTS$^{1,2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazing in exit and entrance doors and adjacent fixed glazed panels</td>
<td>Over 6 square feet</td>
<td>Each glazed area shall pass the test requirements of U.B.C. Standard No. 54-2 if not protected by a protective grill or push-bar$^3$ firmly attached to stiles on each exposed side</td>
</tr>
<tr>
<td>Glazing in storm doors</td>
<td>Over 2 square feet</td>
<td>Each glazed area shall pass the test requirements of U.B.C. Standard No. 54-2 if not protected by a protective grille firmly attached to stiles on each exposed side</td>
</tr>
<tr>
<td>Glazing in sliding doors (both fixed and sliding panels)</td>
<td>Over 6 square feet</td>
<td>Each glazed area shall pass the test requirements of U.B.C. Standard No. 54-2</td>
</tr>
<tr>
<td>Glass in all unframed doors (swinging)</td>
<td>All sizes</td>
<td>Shall be fully-tempered glass and pass the test requirements of U.B.C. Standard No. 54-2</td>
</tr>
<tr>
<td>Glazing in shower doors and tub enclosures</td>
<td>All sizes</td>
<td>Shall conform to the requirements of Section 1711 (d) and shall pass the test requirements of U.B.C. Standard No. 54-2.</td>
</tr>
</tbody>
</table>

$^1$Annealed glass less than single strength (SS) in thickness shall not be used.

$^2$If short dimension is larger than 24 inches, annealed glass must be double strength (DS) or thicker.

$^3$Shall be constructed and attached in such a manner so as to limit or prevent human impact from being delivered to glass surface.
### TABLE NO. 54-E — APPLICATION OF SPECIAL GLAZING MATERIALS

<table>
<thead>
<tr>
<th>GLAZING MATERIALS</th>
<th>SIZE OF INDIVIDUAL GLAZED AREA</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annealed glass (regular plate, float, sheet, rolled or obscure)</td>
<td>Over 6 square feet</td>
<td>Not less than ( \frac{3}{16} ) &quot; nominal thickness. Each glazed area must be protected by protective grill or push-bar(^1) firmly attached to stiles on each exposed side</td>
</tr>
<tr>
<td>Annealed glass (regular plate, float, sheet, rolled or obscure) face sand-blasted, etched or otherwise depreciated</td>
<td>Over 6 square feet</td>
<td>Not less than ( \frac{3}{16} ) &quot; nominal thickness. Each glazed area must be protected by protective grill or push-bar(^1) firmly attached to stiles on each exposed side</td>
</tr>
<tr>
<td>Fully-tempered glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminated glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wired glass Obscure, patterned or transparent</td>
<td>All sizes</td>
<td>Shall pass the test requirements of U.B.C. Standard No. 54-2</td>
</tr>
<tr>
<td>Transparent rigid plastic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Shall be constructed and attached in such a manner so as to limit or prevent human impact from being delivered to glass surface.

### CHAPTERS 55-59 — NO REQUIREMENTS

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PART XII—LEGISLATIVE

CHAPTER 60—LEGISLATIVE

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.

Sec. 6002. The U.B.C. Standards which are referred to in various parts of this Ordinance shall be the Uniform Building Code Standards, 1970 Edition, and are hereby declared to be a part of this Ordinance.

<table>
<thead>
<tr>
<th>U.B.C. STD. AND SEC. NO.</th>
<th>TITLE AND SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAPTER 4</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CHAPTER 6</td>
<td></td>
</tr>
<tr>
<td>6- 1 Proscenium Curtains. Recommended Standards of the International Conference of Building Officials.</td>
<td></td>
</tr>
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<td></td>
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<td>CHAPTER 9</td>
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<td>CHAPTER 10</td>
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<tr>
<td>24- 1 Building Brick and Facing Brick. (Made from Clay or Shale.) Standard Specifications C62-58 and C216-66 of the ASTM.</td>
<td></td>
</tr>
<tr>
<td>24- 3 Concrete Building Brick. Standard Specification C55-55 of the ASTM.</td>
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*ASTM refers to American Society for Testing and Materials.
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<thead>
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<td>24-4 2403</td>
<td>Hollow Load-Bearing Concrete Masonry Units. Standard Specification C90-59 of the ASTM.</td>
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<tr>
<td>24-5 2403</td>
<td>Solid Load-Bearing Concrete Masonry Units. Standard Specification C145-59 of the ASTM.</td>
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<td>Hollow Nonload-Bearing Concrete Masonry Units. Standard Specification C129-59 of the ASTM.</td>
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<td>Method of Test for Concrete Masonry Units. Standard Specification C140-63T of the ASTM.</td>
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<td>Structural Clay Floor Tile. Standard Specification C57-57 of the ASTM.</td>
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<td>Gypsum Partition Tile or Block. Standard Specification C52-54 of the ASTM.</td>
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<td>24-14 2403</td>
<td>Cast Stone. Specification ACI 704-44 of the American Concrete Institute.</td>
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<td>Cold-Drawn Steel Wire for Concrete Reinforcement. Standard Specification A82 of the ASTM.</td>
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<td>24-17 2403</td>
<td>Cement, Masonry. Standard Specification C91-67 of the ASTM.</td>
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<td>Quicklime for Structural Purposes. Standard Specification C5-59 of the ASTM.</td>
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<td>Processed Pulverized Quicklime. Standard Specification C51-47 of the ASTM.</td>
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<td>24-21 2403</td>
<td>Mortar for Unit Masonry and Reinforced Masonry Other than Gypsum. Specifications C161-44T and C270-59T of the ASTM.</td>
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<td>Sampling and Testing Brick. Standard Specification C67-60 of the ASTM.</td>
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Commerce and Technical Bulletin 1069, Forest Products Laboratory, U. S. Department of Agriculture.

Structural Glued-Laminated Wood - Douglas Fir; Southern Pine, Hardwood, West Coast Hemlock, and Larch. Standard Specifications of West Coast Lumber Inspection Bureau (1963), Southern Pine Association (1960), Western Wood Products Association (1960); Southern Hardwood Producers; Appalachian Hardwood Manufacturers; Northern Hardwood and Pine Manufacturers (1963) and U. S. Forest Products Laboratory.


Wood Poles. Specifications and Dimensions for Wood Poles, ANS 05.1-1963 (March 5, 1963) of the American National Standards Institute, Inc.*


Test for Glue Joints in Laminated Wood Products. Standard Method of Testing D1101-59 of the ASTM.

*Formerly United States of America Standards Institute, Inc.
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| 26-2 2604 | Portland Blast Furnace Slag Cement. Specification C205-62T of the ASTM. |
| 26-3 2604 | Portland-Pozzolan Cement. Specification C340-62T of the ASTM. |
| 26-4 2604 | Concrete Aggregates. Specification C33-61T of the ASTM. |
| 26-5 2604 | Lightweight Aggregates for Structural Concrete. Standard Specification C330-60T of the ASTM. |
| 26-6 2604 | Concrete Proportions. ACI 613-54 and 613A-59 of the American Concrete Institute. |
| 26-7 2604 | Concrete Reinforcement. Specifications A615-68, A616-68, and A617-68 of the ASTM. |
| 26-8 2604 | Prestressed Steel Strand for Concrete. Standard Specification A416-59T of the ASTM. |
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| 26-10 2604 | Steel Bar Mats. Standard Specifications A184-65, A615-68, A616-68 and A617-68 of the ASTM. |
| 26-11 2604 | Welded Steel Wire Fabric. Specification A185-61T of the ASTM. |
| 26-12 2604 | Admixtures for Concrete. Standard Specification C494-62T of the ASTM. |
### CHAPTER 27

#### 27-1 Material Specifications for Structural Steel. Standard


#### 27-3 Stress Variation or Stress Reversal Design. Specifications of American Institute of Steel Construction, Inc.


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<td>2802</td>
<td>Aluminum Association (November, 1967).</td>
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<td></td>
<td>Underwriters’ Laboratories, Inc.</td>
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<td>Roofing Asphalt. Standard Specification D312-44 of</td>
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<td>32- 3</td>
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<tr>
<td>3203</td>
<td>(April, 1962), Underwriters’ Laboratories, Inc.</td>
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<td>32- 4</td>
<td>Sheet Metals. Standard Specifications A245-62aT,</td>
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<tr>
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<tr>
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<td>32- 7</td>
<td>Composition Roofing Testing. Standard Specification</td>
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<tr>
<td>3203</td>
<td>790 (September, 1958), Underwriters’ Laboratories,</td>
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<td></td>
<td>Inc.</td>
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<td>32- 8</td>
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<tr>
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</tr>
<tr>
<td></td>
<td>and Hand-Split Shake Bureau.</td>
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<td>3203</td>
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</tr>
<tr>
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<tr>
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<td>Fireclay Refractories. Standard Specification C27-60</td>
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<td>of the ASTM.</td>
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<tr>
<td><strong>CHAPTER 38</strong></td>
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<tr>
<td>38- 1</td>
<td>Installation of Automatic Fire-Extinguishing Systems</td>
</tr>
<tr>
<td>3802</td>
<td>Pamphlet 13 (May 1968), National Fire Protection</td>
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<td></td>
<td>Association.</td>
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<table>
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<tr>
<th>U.B.C. STD. AND SEC. NO.</th>
<th>TITLE AND SOURCE</th>
</tr>
</thead>
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**CHAPTER 42**


**CHAPTER 43**

**43- 1** Fire Tests of Building Construction and Materials. Standard Method E119-58 of the ASTM.

**43- 2** Fire Tests of Door Assemblies. Standard Method E152-58 of the ASTM.

**43- 3** Tin-Clad Fire Doors and Shutters. Standard Subject 10 (a) (January 1965), Underwriters' Laboratories, Inc.

**43- 4** Fire Tests of Window Assemblies. Standard Specification E163-60T of the ASTM.


**43- 7** Fire Dampers. Based on Pamphlet No. 90A (1968), 1706 National Fire Protection Association and UL 555-1968, Underwriters' Laboratories, Inc.

**CHAPTER 47**


**47- 2** Adhesives for Fastening Gypsum Wallboard to Wood Framing. Specification C557-67 of the ASTM.


**47- 5** Gypsum Wallboard Tape and Joint Compound. Standard Specifications C475-64 and C474-67 of the ASTM.

**47- 6** Gypsum Backing Board. Standard Specification C442-67 of the ASTM.

**47- 7** Gypsum Lath. Standard Specification C37-67 of the ASTM.

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<table>
<thead>
<tr>
<th>U.B.C. STD. AND SEC. NO.</th>
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<tr>
<td>47-9 4702</td>
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<td>Keene's Cement. Standard Specification C61-64 of the ASTM.</td>
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</tbody>
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**CHAPTER 48**


**CHAPTER 52**

52-2 5202            | Chamber Method of Test for Measuring the Density of Smoke from the Burning or Decomposition of Plastic Materials. Based on D2843-70 of the ASTM. |
52-3 5207            | Ignition Properties of Plastic. Based on D1929-69 of the ASTM. |

**CHAPTER 53**


**CHAPTER 54**


**CHAPTER 70**

70-1 7012            | Moisture-Density Relations of Soils. Tentative Methods of Test D1557-58T of the ASTM. |
70-2 7012            | In-Place Density of Soils. Tentative Methods of Test D1556-58T of the ASTM. |

Sec. 6003. Ordinance No........................................and all ordinances amendatory thereto, and all ordinances or parts of ordinances in conflict with this Ordinance are hereby repealed.

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.

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APPENDIX

CHAPTER 13—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-resistant 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-resistant 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 (1 3/4") 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-resistant 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 noncombustible or of wood of not less than two-inch (2") nominal thickness with solid treads and risers.
(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 noncombustible, 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.
## WEIGHS OF BUILDING MATERIALS

<table>
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<th>MATERIAL</th>
<th>LBS. PER CU. FT.</th>
<th>Weights of Building Materials</th>
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<tbody>
<tr>
<td>Common</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>Common, laid ¾&quot; joints</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Pressed</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Soft, laid ¾&quot; joints</td>
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<td></td>
</tr>
<tr>
<td>CAST IRON</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>CINDERS, DRY, BITUMINOUS, IN BULK</td>
<td>45</td>
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<tr>
<td>CONCRETE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cinder, structural</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>Stone or gravel</td>
<td>144</td>
<td></td>
</tr>
<tr>
<td>Concrete building tile, 60 per cent solid</td>
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<td></td>
</tr>
<tr>
<td>Concrete building tile, 55 per cent solid</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>EARTH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common loam, dry and loose</td>
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<td></td>
</tr>
<tr>
<td>Clay and gravel, dry and loose</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Common earth, dry and packed</td>
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<td></td>
</tr>
<tr>
<td>Wet mud</td>
<td>120</td>
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</tr>
<tr>
<td>GLASS</td>
<td>157</td>
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<tr>
<td>GRANITE</td>
<td>170</td>
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<tr>
<td>GRANITE MASONRY, DRESSED</td>
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<td>GRANITE MASONRY, RUBBLE</td>
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<td></td>
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<td>SLAG (BLAST FURNACE)</td>
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<td>TERRA COTTA, FILLED WITH BRICKWORK</td>
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<td>TERRA COTTA, DENNISON INTERLOCK TILE, LAID</td>
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<td>TIMBER</td>
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<td>Fir, dry</td>
<td>32</td>
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</tr>
<tr>
<td>Fir, wet</td>
<td>44</td>
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<tr>
<td>Oak</td>
<td>46</td>
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<tr>
<td>WATER, FRESH AT 60°F.</td>
<td>62.5</td>
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<td>CEILINGS</td>
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<tr>
<td>Wood, lath and plaster</td>
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</tr>
<tr>
<td>Metal lath and plaster suspended</td>
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<thead>
<tr>
<th>Material Description</th>
<th>LBS. PER SQ. FT.</th>
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<tbody>
<tr>
<td><strong>PLASTER ON HOLLOW CLAY TILE (ONE SIDE)</strong></td>
<td></td>
</tr>
<tr>
<td>2&quot; hollow clay tile</td>
<td>13</td>
</tr>
<tr>
<td>3&quot; hollow clay tile</td>
<td>16</td>
</tr>
<tr>
<td>4&quot; hollow clay tile</td>
<td>18</td>
</tr>
<tr>
<td>5&quot; hollow clay tile</td>
<td>20</td>
</tr>
<tr>
<td>6&quot; hollow clay tile</td>
<td>25</td>
</tr>
<tr>
<td>8&quot; hollow clay tile</td>
<td>30</td>
</tr>
<tr>
<td>12&quot; hollow clay tile</td>
<td>45</td>
</tr>
</tbody>
</table>

| **PLASTER ON PLASTER-BLOCK PARTITIONS (ONE SIDE)**                                   |                  |
| 2" plaster blocks                                                                    | 5                |
| 2½" plaster blocks                                                                   | 7                |
| 3" plaster blocks                                                                    | 8.5              |
| 3½" plaster blocks                                                                   | 9.5              |
| 4" plaster blocks                                                                    | 10.5             |
| 5" plaster blocks                                                                    | 12               |
| 6" plaster blocks                                                                    | 15               |
| 8" plaster blocks                                                                    | 18               |

| **ROOFINGS**                                                                         |                  |
| Wood shingles                                                                        | 3                |
| Slate ⅜"                                                                             | 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, wire glass                                                     | 1                |
| Skylights, metal-covered                                                             | 5                |

Sec. 2314 (1) 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 accelerographs.

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.

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APPENDIX — CHAPTER 38 — FIRE-EXTINGUISHING SYSTEMS

Sec. 3807. (a) General. All basement pipe inlets shall be installed in accordance with requirements of this Section.

(b) Where Required. Basement pipe inlets shall be installed in the first floor of every store, warehouse, or factory having cellars or basements.

EXCEPTIONS: 1. Where the cellar or basement is equipped with an automatic fire-extinguishing system as specified in Section 3802.

2. Where the cellar or basement is used for the storage of permanent archives or valuables such as safe deposit vaults or similar uses adversely affected by water.

(c) Location. The location of basement pipe inlets shall be as required by the Building Official in accordance with Section 3801 (b).

(d) Detailed Requirements. All basement pipe inlets shall be of cast iron, steel, brass, or bronze with lids of cast brass or bronze.

The basement pipe inlet shall consist of a sleeve not less than 8 inches inside diameter extending through the floor and terminating flush with or through the basement or cellar ceiling and shall have a top flange recessed with an inside shoulder to receive the lid. The top flange shall be installed flush with finish floor surface. The lid shall be a solid casting and have a lift recessed in the top. This lid shall be provided with a cast-in sign reading: "FIRE DEPARTMENT ONLY, DO NOT COVER." The lid shall be installed in such a manner to permit its easy removal from the flange shoulder.
CHAPTER 48—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:

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.

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.

EXCEPTION: Where definite fire-resistive materials are specified, materials of equal fire resistance as specified in this Code may be used.

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.
CHAPTER 49 — PATIO COVERS

Sec. 4901. Patio covers are one-story roofed structures open on one or more sides and not more than 10 feet above grade. They may be provided with insect screening but such screening need not be considered as an enclosure. They may be attached or detached and are for use in conjunction with Group J, Group I or single dwelling units in Group H Occupancies but are not designed for use as habitable rooms. Carports and garages are excluded from this definition.

Sec. 4902. Patio covers shall be designed and constructed to sustain, within the stress limits of this Code, all dead loads plus a minimum vertical live load of 10 pounds per square foot except that snow loads shall be used where such snow loads exceed this minimum. Such covers shall be designed to resist the minimum horizontal wind loads set forth in Table No. 49-A. In addition they shall be designed to support a minimum wind uplift of three-fourths of the horizontal wind load acting vertically upward normal to the roof surface. When enclosed with insect screening, wind loads shall be applied to the structure assuming it is fully enclosed.

Sec. 4903. Where required windows open into a patio cover, the requirements of Sections 1305 and 1405 shall apply.

### Table No. 49-A — Design Wind Pressures for Patio Covers

<table>
<thead>
<tr>
<th>HEIGHT ZONE IN FEET</th>
<th>WIND PRESSURE — Map Areas (Pounds per Sq. Ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Less than 10</td>
<td>10</td>
</tr>
</tbody>
</table>

*See Figure No. 4 in Chapter 23 for the Wind Pressure Map (page 131).*
CHAPTER 57 — REGULATIONS GOVERNING FALLOUT SHELTERS

Purpose

Sec. 5701. The purpose of this Chapter is to establish minimum criteria which must be met before a building or building space can be constructed, occupied, used, or designated a fallout shelter.

Scope

Sec. 5702. The scope of this Chapter extends to building spaces designated for use as fallout shelters including periods of drill and instruction for this purpose.

Definitions

Sec. 5703. FALLOUT SHELTER is any room, structure, or space designated as such and providing its occupants with protection at a minimum protection factor of 40 from gamma radiation from fallout from a nuclear explosion as determined by a Qualified Fallout Shelter Analyst certified by the Office of Civil Defense. Area used for storage of shelter supplies need not have a protection factor of 40.

DUAL-USE FALLOUT SHELTER is a fallout shelter having a normal, routine use and occupancy as well as an emergency use as a fallout shelter.

SINGLE-PURPOSE FALLOUT SHELTER is a fallout shelter having no use or occupancy except as a fallout shelter.

PROTECTION FACTOR is a factor used to express the relation between the amount of fallout gamma radiation that would be received by an unprotected person and the amount that would be received by one in a shelter.

UNIT OF EGRESS WIDTH is 22 inches.

Occupancy Requirements

Sec. 5704. (a) General. Nothing in these regulations shall be construed as preventing the dual use or multiple use of normal occupancy space as fallout shelter space, providing the minimum requirements for each use are met.

(b) Mixed Occupancy. The occupancy classification shall be determined by the normal use of the building. When a normal-use space is designed to have an emergency use as a fallout shelter in addition to the normal use, the most restrictive requirements for all such uses shall be met.

(c) Occupancy Separation. No occupancy separation is required between that portion designated as a fallout shelter and the remainder of the building.

(d) Space and Ventilation. A minimum of 10 square feet of net floor area shall be provided per shelter occupant. Partitions, columns, and area for storage of federal shelter supplies also may be included in net area. A minimum of 65 cubic feet of volume shall be provided per shelter occupant. A minimum of 3 cubic feet of fresh air per minute per person shall be provided.
Shelter capacity also shall be limited by the volume of the room or space. Table No. 57-A shall be used to determine capacity of room or space in relation to available ventilation.

(e) Illumination. No special lighting levels are required.

Sec. 5705. There shall be no fewer than two widely spaced exits from a fallout shelter, leading directly to other spaces of the building or outdoors. Exits from the fallout shelter shall aggregate at least one unit of egress width for every 200 shelter occupants. In no case shall a single exit be less than 24 inches wide.

Sec. 5706. Interior surfaces of single-purpose fallout shelters shall have a flame-spread rating not exceeding 225.

Sec. 5707. (a) Dual-use Fallout Shelters. In the case of dual-use fallout shelters, design live load required for the normal use shall govern, except that concentrated loads shall be considered.

(b) Single-purpose Fallout Shelters. Minimum live loads for floor design in single-purpose fallout shelters shall be 40 pounds per square foot except that concentrated loads shall be considered.

Sec. 5708. Toilets, either flush type operating from the normal water supply system, or chemical or other types, shall be provided on the basis of one toilet per 50 fallout shelter occupants. Fifty per cent of the toilets may be provided outside the fallout shelter area. Empty water containers may be considered as fulfilling this requirement.

<table>
<thead>
<tr>
<th>TIME FOR COMPLETE AIR CHANGE (MINUTES)*</th>
<th>VOLUME OF SPACE/PERSON (CU. FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 or more</td>
<td>500</td>
</tr>
<tr>
<td>600</td>
<td>450</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>60</td>
<td>150</td>
</tr>
<tr>
<td>35</td>
<td>100</td>
</tr>
<tr>
<td>22</td>
<td>65</td>
</tr>
</tbody>
</table>

*Computed as a ratio: \[
\text{net volume of space (cu. ft.)} \div \text{fresh air supply (cfm.)}
\]
CHAPTER 70—EXCAVATION AND GRADING

Purpose

Sec. 7001. The purpose of this Chapter is to safeguard life, limb, property and the public welfare by regulating grading on private property.

Scope

Sec. 7002. This Chapter sets forth rules and regulations to control excavation, grading and earthwork construction, including fills and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

Permits Required

Sec. 7003. No person shall do any grading without first having obtained a grading permit from the Building Official except for the following:

1. Grading in an isolated, self contained area if there is no danger apparent to private or public property.
2. 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 5 feet after the completion of such structure.
3. Cemetery graves.
4. Refuse disposal sites controlled by other regulations.
5. Excavations for wells or tunnels or utilities.
6. Mining, quarrying, excavating, processing, stockpiling of rock, sand, gravel, aggregate or clay where established and provided for by law provided such operations do not affect the lateral support or increase the stresses in or pressure upon any adjacent or contiguous property.
7. Exploratory excavations under the direction of soil engineers or engineering geologists.
8. An excavation which (a) is less than 2 feet in depth, or (b) which does not create a cut slope greater than 5 feet in height and steeper than one and one-half horizontal to one vertical.
9. A fill less than 1 foot in depth, and placed on natural terrain with a slope flatter than five horizontal to one vertical, or less than 3 feet 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.

Hazards

Sec. 7004. Whenever the Building Official determines that any existing excavation or embankment or fill on private property 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 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.

Sec. 7005. For the purposes of this Chapter the definitions listed hereunder shall be construed as specified in this Section.

**AS-GRADED** is the surface conditions extent on completion of grading.

**BEDROCK** is in-place solid rock.

**BENCH** is a relatively level step excavated into earth material on which fill is to be placed.

**BORROW** is earth material acquired from an off-site location for use in grading on a site.

**CERTIFICATION** shall mean a written engineering or geological opinion concerning the progress and completion of the work.

**CIVIL ENGINEER** shall mean a professional engineer registered in the state to practice in the field of civil works.

**CIVIL ENGINEERING** shall mean the application of the knowledge of the forces of nature, principles of mechanics and the properties of materials to the evaluation, design and construction of civil works for the beneficial uses of mankind.

**COMPACTION** is the densification of a fill by mechanical means.

**EARTH MATERIAL** is any rock, natural soil or fill and/or any combination thereof.

**ENGINEERING GEOLOGIST** shall mean a geologist experienced and knowledgeable in engineering geology.

**ENGINEERING GEOLOGY** shall mean the application of geologic knowledge and principles in the investigation and evaluation of naturally occurring rock and soil for use in the design of civil works.

**EROSION** is the wearing away of the ground surface as a result of the movement of wind, water and/or ice.

**EXCAVATION** is the mechanical removal of earth material.

**FILL** is a deposit of earth material placed by artificial means.

**GRADE** shall mean the vertical location of the ground surface.

**EXISTING GRADE** is the grade prior to grading.

**ROUGH GRADE** is the stage at which the grade approximately conforms to the approved plan.

**FINISH GRADE** is the final grade of the site which conforms to the approved plan.
SECTIONS 7005-7006—APPENDIX

Definitions (Continued)

GRADING is any excavating or filling or combination there­of.

KEY is a designed compacted fill placed in a trench excav­ated in earth material beneath the toe of a proposed fill slope.

SITE is any lot or parcel of land or contiguous combination thereof, under the same ownership, where grading is per­formed or permitted.

SLOPE is an inclined ground surface the inclination of which is expressed as a ratio of horizontal distance to vertical distance.

SOIL is naturally occurring surficial deposits overlying bed rock.

SOIL ENGINEER shall mean a civil engineer experienced and knowledgeable in the practice of soil engineering.

SOIL ENGINEERING shall mean the application of the principles of soil mechanics in the investigation, evaluation and design of civil works involving the use of earth materials and the inspection and testing of the construction thereof.

TERRACE is a relatively level step constructed in the face of a graded slope surface for drainage and maintenance pur­poses.

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) Application. The provisions of Section 301 (b) are applicable to grading and in addition the application shall state the estimated quantities of work involved.

(c) Plans and Specifications. When required by the Build­ing Official, each application for a grading permit shall be accompanied by two sets of plans and specifications, and sup­porting data consisting of a soil engineering report and engin­eering geology report. The plans and specifications shall be prepared and signed by a civil engineer when required by the Building Official.

(d) Information on Plans and in Specifications. Plans 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 they 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 location of the work and the name and address of the owner and the person by whom they were prepared.

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The plans shall include the following information:

1. General vicinity of the proposed site.

2. Property limits and accurate contours of existing ground and details of terrain and area drainage.

3. Limiting dimensions, elevations or finish contours to be achieved by the grading, and proposed drainage channels and related construction.

4. Detailed plans of all surface and subsurface drainage devices, walls, cribbing, dams and other protective devices to be constructed with, or as a part of, the proposed work together with a map showing the drainage area and the estimated runoff of the area served by any drains.

5. Location of any buildings or structures on the property where the work is to be performed and the location of any buildings or structures on land of adjacent owners which are within 15 feet of the property or which may be affected by the proposed grading operations.

Specifications shall contain information covering construction and material requirements.

(e) Soil Engineering Report. The soil engineering report required by Subsection (c) shall include data regarding the nature, distribution and strength of existing soils, conclusions and recommendations for grading procedures and design criteria for corrective measures when necessary, and opinions and recommendations covering adequacy of sites to be developed by the proposed grading.

Recommendations included in the report and approved by the Building Official shall be incorporated in the grading plans or specifications.

(f) Engineering Geology Report. The engineering geology report required by Subsection (c) shall include an adequate description of the geology of the site, conclusions and recommendations regarding the effect of geologic conditions on the proposed development, and opinions and recommendations covering the adequacy of sites to be developed by the proposed grading.

Recommendations included in the report and approved by the Building Official shall be incorporated in the grading plans or specifications.

(g) Issuance. The provisions of Section 302 are applicable to grading permits. The Building Official may require that grading operations and project designs be modified if delays occur which incur weather generated problems not considered at the time the permit was issued.

Sec. 7007. (a) Plan-checking Fee. For excavation and fill on the same site, the fee shall be based on the volume of the

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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.

**TABLE NO. 70-A — PLAN-CHECKING FEES**

<table>
<thead>
<tr>
<th>50 cubic yards or less</th>
<th>No Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 to 100 cubic yards</td>
<td>$10.00</td>
</tr>
<tr>
<td>101 to 1000 cubic yards</td>
<td>$15.00</td>
</tr>
<tr>
<td>1001 to 10,000 cubic yards</td>
<td>$20.00</td>
</tr>
<tr>
<td>10,001 to 100,000 cubic yards</td>
<td>$20.00 for the first 10,000 cubic yards plus $10.00 for each additional 10,000 cubic yards or fraction thereof.</td>
</tr>
<tr>
<td>100,001 to 200,000 cubic yards</td>
<td>$110.00 for the first 100,000 cubic yards plus $6.00 for each additional 10,000 cubic yards or fraction thereof.</td>
</tr>
<tr>
<td>200,001 cubic yards or more</td>
<td>$170.00 for the first 200,000 cubic yards, plus $3.00 for each additional 10,000 cubic yards or fraction thereof.</td>
</tr>
</tbody>
</table>

The plan checking fee for a grading permit authorizing additional work to that under a valid permit shall be the difference between such fee paid for the original permit and the fee shown for the entire project.

(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**

<table>
<thead>
<tr>
<th>50 cubic yards or less</th>
<th>$10.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 to 100 cubic yards</td>
<td>$15.00</td>
</tr>
<tr>
<td>101 to 1000 cubic yards</td>
<td>$78.00 for the first 100 cubic yards, plus $7.00 for each additional 100 cubic yards or fraction thereof.</td>
</tr>
<tr>
<td>1001 to 10,000 cubic yards</td>
<td>$132.00 for the first 10,000 cubic yards, plus $6.00 for each additional 1000 cubic yards or fraction thereof.</td>
</tr>
<tr>
<td>10,001 to 100,000 cubic yards</td>
<td>$375.00 for the first 100,000 cubic yards, plus $15.00 for each additional 10,000 cubic yards or fraction thereof.</td>
</tr>
</tbody>
</table>

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.

Sec. 7008. Bonds. The Building Official may require bonds in such form and amounts as may be deemed necessary to assure that the work, if not completed in accordance with the approved plans and specifications, will be corrected to eliminate hazardous conditions.

In lieu of a surety bond the applicant may file a cash bond or instrument of credit with the Building Official in an amount equal to that which would be required in the surety bond.

Sec. 7009. (a) General. Unless otherwise recommended in the approved soil engineering and/or engineering geology report cuts shall conform to the provisions of this Section.

(b) Slope. The slope of cut surfaces shall be no steeper than is safe for the intended use. Cut slopes shall be no steeper than two horizontal to one vertical.

(c) Drainage and Terracing. Drainage and terracing shall be provided as required by Section 7012.

Sec. 7010. (a) General. Unless otherwise recommended in the approved soil engineering report fills shall conform to the provisions of this Section.

In the absence of an approved soil engineering report these provisions may be waived for minor fills not intended to support structures.

(b) Fill Location. Fill slopes shall not be constructed on natural slopes steeper than two to one or where the fill slope toes out within 12 feet horizontally of the top of existing or planned cut slopes.

(c) Preparation of Ground. The ground surface shall be prepared to receive fill by removing vegetation, noncomplying fill, topsoil and other unsuitable materials as determined by the soil engineer, and, where the slopes are five to one or steeper, by benching into sound bedrock or other competent material.

(d) Fill Material. Earth materials which have no more than minor amounts of organic substances and have no rock or similar irreducible material with a maximum dimension greater than 8 inches shall be used.

(e) 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. Field density shall be determined in accordance with U.B.C. Standard No. 70-2 or equivalent as approved by the Building Official.
(f) **Slope.** The slope of fill surfaces shall be no steeper than is safe for the intended use. Fill slopes shall be no steeper than two horizontal to one vertical.

(g) **Drainage and Terracing.** Drainage and terracing shall be provided and the area above fill slopes and the surfaces of terraces shall be graded and paved as required by Section 7012.

### Sec. 7011.

The tops and the toes of cut and fill slopes shall be set back from property boundaries as far as necessary for safety of the adjacent properties and to prevent damage resulting from water runoff or erosion of the slopes.

The tops and the toes of cut and fill slopes shall be set back from structures as far as is necessary for adequacy of foundation support and to prevent damage as a result of water runoff or erosion of the slopes.

Unless otherwise recommended in the approved soil engineering and/or engineering geology report and shown on the approved grading plan, setbacks shall be no less than shown in Table No. 70-C.

### TABLE NO. 70-C — SETBACKS

<table>
<thead>
<tr>
<th>H IN FEET</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 10</td>
<td>3'</td>
<td>2'</td>
<td>3'</td>
<td>5'</td>
</tr>
<tr>
<td>11 – 30</td>
<td>(H/2)'</td>
<td>3'</td>
<td>(H/2)'</td>
<td>7'</td>
</tr>
<tr>
<td>31 and Over</td>
<td>15'</td>
<td>3'</td>
<td>15'</td>
<td>10'</td>
</tr>
</tbody>
</table>
Sec. 7012. (a) General. Unless otherwise indicated on the approved grading plan, drainage facilities and terracing shall conform to the provisions of this Section.

(b) Terrace. Terraces at least 6 feet in width shall be established at not more than 30-foot vertical intervals to control surface drainage and debris. Suitable access shall be provided to permit proper cleaning and maintenance.

Swales or ditches on terraces shall have a minimum gradient of five per cent and must be paved with reinforced concrete not less than 3 inches in thickness or an approved equal paving. They shall have a minimum depth at the deepest point of 1 foot and a minimum paved width of 5 feet.

A single run of swale or ditch shall not collect runoff from a tributary area exceeding 13,500 square feet (projected) without discharging into a down drain.

(c) Subsurface Drainage. Cut and fill slopes shall be provided with subsurface drainage as necessary for stability.

(d) Disposal. All drainage facilities shall be designed to carry waters to the nearest practicable drainage way approved by the Building Official and/or other appropriate jurisdiction as a safe place to deposit such waters. If drainage facilities discharge onto natural ground, riprap may be required.

At least two per cent gradient toward approved drainage facilities from building pads will be required unless waived by the Building Official for nonhilly terrain.

EXCEPTION: The gradient from the building pad may be one per cent where building construction and erosion control will be completed before hazardous conditions can occur.

Sec. 7013. (a) Slopes. The faces of cut and fill slopes shall be prepared and maintained to control against erosion. This control may consist of effective planting. The protection for the slopes shall be installed as soon as practicable and prior to calling for final approval. Where cut slopes are not subject to erosion due to the erosion-resistant character of the materials, such protection may be omitted.

(b) Other Devices. Where necessary, check dams, cribbing, riprap or other devices or methods shall be employed to control erosion and provide safety.

Sec. 7014. (a) General. All grading operations for which a permit is required shall be subject to inspection by the Building Official. When required by the Building Official, special inspection of grading operations and special testing shall be performed in accordance with the provisions of Section 305 and Subsection 7014 (c).

(b) Grading Designation. All grading in excess of 5000 cubic yards shall be performed in accordance with the ap-
proved grading plan prepared by a civil engineer, and shall be designated as "engineered grading." Grading involving less than 5000 cubic yards shall be designated "regular grading" unless the permittee, with the approval of the Building Official chooses to have the grading performed as "engineered grading."

(c) Engineered Grading Requirements. For engineered grading it shall be the responsibility of the civil engineer who prepares the approved grading plan to incorporate all recommendations from the soil engineering and engineering geology reports into the grading plan. He shall also be responsible for the professional inspection and certification of the grading within his area of technical specialty. This responsibility shall include, but need not be limited to, inspection and certification as to the establishment of line, grade and drainage of the development area. The civil engineer shall act as the coordinating agent in the event the need arises for liaison between the other professionals, the contractor and the Building Official. The civil engineer shall also be responsible for the preparation of revised plans and the submission of as-graded grading plans upon completion of the work.

Soil engineering and engineering geology reports shall be required as specified in Section 7006. During grading all necessary reports, compaction data and soil engineering and engineering geology recommendations shall be submitted to the civil engineer and the Building Official by the soil engineer and the engineering geologist.

The soil engineer's area of responsibility shall include, but need not be limited to, the professional inspection and certification concerning the preparation of ground to receive fills, testing for required compaction, stability of all finish slopes and the design of buttress fills, where required, incorporating data supplied by the engineering geologist.

The engineering geologist's area of responsibility shall include, but need not be limited to, professional inspection and certification of the adequacy of natural ground for receiving fills and the stability of cut slopes with respect to geological matters, and the need for subdrains or other ground water drainage devices. He shall report his findings to the soil engineer and the civil engineer for engineering analysis.

The Building Official shall inspect the project at the various stages of the work requiring certification and at any more frequent intervals necessary to determine that adequate control is being exercised by the professional consultants.

(d) Regular Grading Requirements. The Building Official may require inspection and testing by an approved testing agency.

The testing agency's responsibility shall include, but need not be limited to, certification concerning the inspection of
cleared areas and benches to receive fill, and the compaction of fills.

When the Building Official has cause to believe that geologic factors may be involved the grading operation will be required to conform to "engineered grading" requirements.

(e) Notification of Noncompliance. If, in the course of fulfilling their responsibility under this Chapter, the civil engineer, the soil engineer, the engineering geologist or the testing agency finds that the work is not being done in conformance with this Chapter or the approved grading plans, the discrepancies shall be reported immediately in writing to the person in charge of the grading work and to the Building Official. Recommendations for corrective measures, if necessary, shall be submitted.

(f) Transfer of Responsibility for Certification. If the civil engineer, the soil engineer, the engineering geologist or the testing agency of record are changed during the course of the work, the work shall be stopped until the replacement has agreed to accept the responsibility within the area of their technical competence for certification upon completion of the work.

Sec. 7015. (a) Final Reports. Upon completion of the rough grading work and at the final completion of the work the Building Official may require the following reports and drawings and supplements thereto:

1. An As-Graded grading plan prepared by the civil engineer including original ground surface elevations, as graded ground surface elevations, lot drainage patterns and locations and elevations of all surface and subsurface drainage facilities. He shall provide certification that the work was done in accordance with the final approved grading plan.

2. A Soil Grading Report prepared by the soil engineer including locations and elevations of field density tests, summaries of field and laboratory tests and other substantiating data and comments on any changes made during grading and their effect on the recommendations made in the soil engineering investigation report. He shall provide certification as to the adequacy of the site for the intended use.

3. A Geologic Grading Report prepared by the engineering geologist including a final description of the geology of the site including any new information disclosed during the grading and the effect of same on recommendations incorporated in the approved grading plan. He shall provide certification as to the adequacy of the site for the intended use as affected by geologic factors.

(b) Notification of Completion. The permittee or his agent shall notify the Building Official when the grading operation is
Completion of Work (Continued)  ready for final inspection. Final approval shall not be given until all work including installation of all drainage facilities and their protective devices and all erosion control measures have been completed in accordance with the final approved grading plan and the required reports have been submitted.
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