RECOMMENDED BUILDING CODE
REQUIREMENTS FOR WOOD OR
WOOD-BASE MATERIALS

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RECOMMENDED BUILDING CODE REQUIREMENTS

FOR WOOD OR WOOD-BASE MATERIALS

By

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FOREWORD

The U. S. Forest Products Laboratory has prepared these recommended building code requirements for wood construction to fulfill an agreement with the American Standards Association. These recommendations summarize recent pertinent technical information and data for consideration by code-making bodies and others interested in code requirements relating to wood. This document is not in itself intended to be a building code, nor is it intended to replace, as such, the related subject matter in currently established codes. Rather, it is intended to serve as a draft of recommended requirements in building code form, which may be considered, in whole or in part, in connection with the development or revision of code requirements. It is a summary of basic information on wood construction in a form useful to code-making bodies.

One feature of these recommended requirements is the provision for the application and use of various materials or methods of wood construction insofar as such materials or methods can be shown by structural analysis or laboratory test to meet the basic requirements; in this way, reference to specific construction details is minimized. This concept is intended to recognize the potential progress in the development of new materials and construction methods without penalizing or retarding their application when it can be demonstrated that they can be expected to render the required satisfactory service.

SUGGESTIONS TO CODE-MAKING BODIES

A number of items in these recommended building code requirements for wood construction are specifically left to the discretion of the building official. Some communities may wish to vest such discretion in an advisory committee or board rather than in a single official. Where such a committee or board is established, its title may be substituted for the term "building official" at the appropriate places where that term appears in these requirements.

These are minimum standards and cover particulars that are essential to public health and safety. Some communities may find it advisable to set higher standards for their particular conditions or needs. The requirements, being largely of a generalized rather than a specific nature, are more readily applied when supplemented by illustrations to show what is intended and how that intent can be met. To meet this need, many references to supplementary or informative materials are made. These references describe generally...
accepted good practice, and such descriptions may be taken as prima facie
evidence of compliance with the generalized requirements. The reference
material is thus advisory rather than mandatory.

Where such general terms as "recognized engineering methods" or "ac-
cepted good practice" are used, they refer to standards published by national
authorities in the building field, including the references listed in these rec-
ommended requirements. The building official should be guided by such
authorities in making his application of these general requirements to specific
cases.

For convenience of access, the reference material, or such parts of it as
are needed, may be taken from the publications listed and published as an
advisory supplement to the mandatory portion of the code. Since such a
supplement does not have the status of law, legislative action is not required
to revise it from time to time as progress in the building arts is made. With
these revisions of supplementary material, the more fundamental and gener-
alized requirements in the mandatory part of the code tend to remain up to
date, and the problems of obsolescence are greatly reduced.

While a considerable number of references are listed, it is recognized that
few communities will use all of them and many communities will use only a
few. References of most general application are: (37) Wood Handbook; (20)
National Design Specification; (38) Condensation Control in Dwelling Con-
struction; (32) Tables of Maximum Allowable Spans; (9) Wood-Frame House
Construction; (27) Timber Design and Construction Handbook; (8) American
Construction for Prefabricated Houses. A library composed of these eight
publications will outline a large part of what may be cited as examples of
good design and construction.

1. DEFINITIONS

1.1.1. --Scope. This section defines only those terms that are necessary
for interpretation of these code requirements. The definitions give mean-
ings as used herein and do not necessarily have general application. Terms
like "building" or "incombustible" that are in common use with all struc-
tural materials are omitted; it is expected that code-making bodies will de-
fine such terms according to their needs.

2 Underlined numbers in parentheses refer to literature cited at the end of
the text.

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1.1.2. --Terms Defined.

Approved. --As applied to a material, device, mode of construction, or testing agency; this means approved by the building official under the provisions of the code, or by other authority designated by law to give approval to the matter in question.

Arch. --A construction over an opening, commonly curved, in which the vertical forces from loads are resolved into horizontal or diagonal thrust.

Arch, Segmented. --An arch laminated of short pieces of wood, usually with curved outline, arranged with the widths vertical, and joined by mechanical means.

Arch, Trussed. --A framed arch with upper and lower chords joined by a system of web members, as in a truss.

Basement. --A story that is partly underground but has more than half of its clear height above the average grade of the adjoining ground (see "Cellar").

Beam. --A structural member supporting a load applied transversely to it.

Beam, built-up. --A beam made by joining layers of lumber together with mechanical fastenings, such as nails, bolts, or connectors, so that the grain of all layers is essentially parallel.

Beam, Glued-Laminated. --A beam made by bonding layers of veneer or lumber with an adhesive, so that the grain of all laminations is essentially parallel.

Bolster. --A short horizontal timber resting on the top of a column for the support of beams or girders.

Borers, Marine. --Small mollusks or crustacea inhabiting salt or brackish waters, including Teredo, Bankia, Martesia, Limnoria, Sphaeroma, Chelura, or other types that attack wood.

Bridging. --Short wood members or the equivalent that are inserted between joists, or less frequently between rafters or studs, to brace the framing members and spread the action of loads. Bridging members may be arranged diagonally, or as solid blocking.

Buildings, Farm. --Barns or other farm structures housing livestock, produce, or other farm property. Farm dwellings are not included.
Camber. --The convexity of a truss or beam to offset deflections resulting from loads or pressures.

Carriage, Stair. --A sloping stringer supporting the treads and risers of a stair.

Cellar. --A story that is partly or wholly underground and has less than half of its clear height above the average grade of the adjoining ground (see "Basement").

Chord. --The main upper or lower member of a truss or trussed arch, either continuous or spliced, extending the full length of the span.

Code, Building. --The body of laws and regulations covering the construction and use of buildings.

Code Requirements. --Requirements pertaining to wood construction and recommended for incorporation into a building code.

Corbel. --A projection from a masonry wall or column to form a support for other construction. As used on timber columns, a short piece of timber with grain vertical, joined to the side of the column.

Cornice. --A decorative element made up of molded or shaped members usually placed at or near the top of an exterior or interior wall.

Crawl Space. --A shallow space for entrance between the first story of a house and the ground, often enclosed for appearance by a skirting or facing material.

Decay-Resistant Species. --Baldcypress, redwood, northern whitecedar, southern whitecedar, western redcedar, black locust, black walnut, or other species that have heartwood with naturally high resistance to decay.

Diaphragm, Structural. --A structural element of large extent placed in a building as a wall, floor, or roof, and made use of to resist horizontal forces -- such as wind or earthquakes -- acting parallel to its own plane.

Element, Structural. --A floor, wall, roof, truss, or similar structural component of a building considered as a unit for testing or other purposes (see "Panel").
Fiberboard, Building. --A sheet material of refined or partially refined wood (or other vegetable) fibers, sometimes with added bonding agents or other materials to improve properties (see "Particle Board").

Fire Resistance. --The period of resistance to the standard fire exposure requirement such as that prescribed by the American Society for Testing Materials under the title of "Standard Methods of Fire Tests of Building Construction and Materials."

Furring. --Strips of wood or the equivalent applied to a wall or other surface to even it, to form an air space, to provide a nailing base, or to add thickness.

Girder. --A large or principal beam used to support loads from other structural members at points along its length.

Grade, Finished. --The completed surfaces of lawns, walks, and roads brought to the designed elevations.

Grade, Lumber. --The designation of the quality of a piece of lumber, in terms of permitted characteristics issued by a recognized lumber industry, association, or agency.

Grade, Stress. --A lumber grade defined in such terms that a definite working stress for structural design may be assigned to it.

Grillage. --A combination of beams laid transversely in several tiers, usually with the strongest beams in the top tier.

Gusset Plate. --A plate of plywood, steel, or other material placed at the juncture of two or more framing members to transmit forces to the members.

Hardwood. --One of the botanical groups of trees that has broad leaves in contrast to the needlelike or scalelike leaves of the conifers or softwoods. The term has no reference to the actual hardness of the wood.

Header. --A beam placed perpendicular to joists and to which joists are nailed in framing for a chimney, stairway, or other opening. The member on top of the sill around the outside of the house, to which the ends of floor joists are fastened.

Joist. --One of a series of parallel beams used to support floor and ceiling loads, and supported in turn by other structural members or by walls.
Lagging. --Boards or planks in arch centering that form a floor on which the arch material is laid.

Lintel. --A horizontal structural member that supports the load over an opening, such as a door or window.

Load, Dead. --Load caused by the weight of walls, floors, roofs, partitions, and other permanent portions or accessories of the structure.

Load, Live. --Any load other than a dead load.

Lumber. --The product of the saw and planing mill not further manufactured than by sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching.

Marquee. --A permanent hood that projects over an entrance to a building and is not supported by posts or columns.

Masonry. --Stone, brick, concrete, hollow tile, concrete block, gypsum block, or other similar building units or materials, or a combination of the same, bonded together with mortar to form a wall, pier, buttress, or similar mass. Unit masonry comprises all of the above except poured concrete.

Mow. --Space in the upper story of a barn, used for storing hay or grain.

Nominal Size of Lumber. --As applied to timber or lumber, the rough-sawed and unseasoned commercial size by which it is known and sold on the market.

Palisade Construction. --A wall construction for buildings consisting of closely spaced planks or sections of logs in a vertical position.

Panel. --A section of floor, wall, ceiling, or roof, usually prefabricated and of large size, handled as a single unit in the operations of assembly or erection (see "Element, structural").

Panel Point of Truss. --A point of juncture of one or more truss web members with a chord member marking the division of the span of the truss into parts or panels, usually of equal length.

Particle Board. --A sheet material made of small discrete pieces of wood (or other vegetable material) bonded together with an extraneous binding agent (see "Fiberboard, Building").

Partition. --A wall that subdivides spaces within any story of a building.
Partition, Bearing. --A partition that supports any vertical load in addition to its own weight.

Partition, Nonbearing. --A partition that supports no vertical load other than its own weight.

Pile, Foundation. --A heavy timber or pillar of wood or other material, forced into the earth and supporting a load on its upper end.

Pintle. --A small, short column, usually of cast iron, with suitable top and bottom plates, used at the junction of wooden beams and columns.

Plank-and-Beam Construction. --A construction for walls, floors, or roofs in which framing members are widely spaced, and loads or forces are transmitted to them by planking or equivalent means.

Plate. --A horizontal structural member placed on a wall or supported on posts, studs, or corbels to carry the roof trusses or the rafters directly.

Plate, Sole. --A shoe or base member, as of a wall or other frame, usually placed on the subfloor.

Plywood. --A sheet material made of an odd number of veneers laid crosswise and glued together to act as a structural unit.

Pole. --A round naturally tapered timber used as a building framing member.

Prefabricated Construction. --Construction in which sections or panels of various sizes are fabricated in a factory or elsewhere before erection on the building foundation.

Purlin. --A horizontal member usually laid at right angles to main rafters or trusses of a roof to support rafters or other roof framing members.

Raft Footing. --A footing spread over large area to reduce unit pressures on soft or unstable soils. The footing is said to float on the unstable material, as a raft on water.

Rafter. --One of a series of structural members of a roof designed to support roof loads.

Rafter, Hip. --A rafter that forms the intersection of an external roof angle.
Rafter, Jack. --A short rafter that extends from the hip rafter to the wall or from the valley rafter to the ridge.

Rafter, Valley. --A rafter that forms the intersection of an internal roof angle (see "Valley, roof").

Ribbon. --A narrow horizontal board let into studding to provide added support for joists.

Rigid Frame. --A building frame built in one piece or with rigid joints designed to develop moment to assist in sustaining the loads.

Roof, Lamella. --An arched roof system in which a large number of short pieces, known as lamellas, are joined in netlike fashion to form a series of intersecting skewed arches.

Sandwich, Structural. --A layered construction comprising a combination of relatively high-strength facing materials intimately bonded to and acting integrally with a low density core material. When cut to size for use in building operations, it is known as a Sandwich Panel.

Scupper. --An opening in the exterior wall of a building to carry off rain water excess from roofs or from floors, as in fire fighting operations.

Sill. --(1) The lowest member of the frame of a structure, resting on the foundation and supporting the uprights of the frame, and (2) the member forming the lower side of an opening, as a door sill or a window sill.

Softwood. --One of the botanical groups of trees that has needlelike or scalelike leaves; a conifer. The term has no reference to the actual hardness of the wood.

Specification. --A written document stipulating the kind, quality, and sometimes the quantity of materials and workmanship required for any construction or work.

Story. --That part of a building between any floor and the floor or roof next above.

Stud. --One of a series of slender wood structural members used as supporting elements in walls and partitions.

Termites.--An insect of the order Isoptera which may burrow in the wood or wood products of a building for food and shelter. Termite superficially resemble ants in size, general appearance, and habit of living in colonies; hence, they are frequently called "white ants."

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Treated Wood. --Lumber or other wood material to which a chemical substance has been applied either on the surface or penetrating deeply for preservation against decay and insects, or for retardation of fire.

Trimmer. --A beam or joist into which a header is framed in framing for a chimney, stairway, or other opening.

Truss. --A frame or jointed structure designed to act as a beam of long span, while each member is usually subjected to longitudinal stress only, either tension or compression.

Truss, Bowstring. --A form of truss in which the lower chord is straight and the upper chord curved, simulating the shape of the archery bow.

Truss, Multiple-Member. --Truss construction in which chords or other members may be composed of two or more parallel pieces, usually spaced.

Valley, Roof. --The internal angle formed by the junction of two sloping sides of a roof.

Wall, Veneered. --A wall with a masonry facing that is attached to the backing, but not bonded to exert common action under load.

Web Member. --A vertical or diagonal member in a truss used to transmit forces between the upper and lower chords.

Wood-Base Materials. --Materials composed principally or entirely of wood fiber. Certain fibrous materials not of wood are included under this general classification, and wood or wood-fiber products modified by compression with or without impregnation by resin or other substances are also included.

2. MATERIALS

2.1. --Scope. The provisions of this section shall govern the quality, workmanship, and general specifications of all wood or wood-base materials, such as lumber, plywood, sheathing materials, construction papers, and other wood materials that are used in a building. Interior and exterior trim or other decorative materials are not included.

2.2. --Accepted Practice. All materials shall conform to the standards of accepted engineering practice.
2.3. --Reuse of Materials. Lumber or any other wood or wood-base material may be reused upon approval by the building official, provided that detailed inspection shows that it is structurally adequate and of a quality commensurate with its use. Such an inspection shall consider possible effects from decay, overloading, exposure, or any other factor that may affect the structural value (43).

2.4. --Protection of Materials. All wood or wood-base materials shall be protected from rain, snow, ground moisture, or other conditions that may induce decay or otherwise impair their fitness under these code requirements or their usefulness for the purpose intended. Protection shall be provided not only during manufacture and transportation from the point of production, but also after delivery and storage at the building site (37, pp. 311-336).

2.5. --Lumber.

2.5.1. --General. All lumber shall be of quality commensurate with the requirements of its use and in accordance with the rules of the grade specified.

2.5.2. --Lumber Inspection. All lumber shall be subject to inspection by the building official or his authorized representative. Grade markings or inspection certificates of a recognized lumber grading or inspection bureau or agency may be accepted in lieu of inspection by the building official. If reinspection of lumber is required, it shall be in accordance with the rules of the inspection agency or, in the absence of such rules, shall be as directed by the building official.

2.5.3. --Seasoning. Lumber shall preferably be furnished at a moisture content near that which it will attain in service (37, pp. 311-336). When lumber at a higher moisture content is used, due consideration shall be given in design and use of the building to changes in shape or dimension that may result from shrinkage of the material as it seasons in place (37, pp. 329-334).

2.5.4. --Lumber grades. Lumber for use in important structural members or otherwise required to sustain loads or transmit forces of specific magnitude shall be of a recognized stress grade (20), or shall be selected with regard to stress grading principles to permit assignment of a safe and suitable working stress (37, pp. 137-164). Other lumber shall be of a grade generally recognized as suitable for the purpose intended (35, pp. 152-190). If not conforming to a recognized published grade, it shall be selected with specific regard to the requirements of its use.
2.5.5. --Lumber Sizes. Standard sizes for rough or finished softwood con-
struction lumber of all grades shall be those specified for softwood lumber in "American Lumber Standards for Softwood Lumber," Simplified Practice Recommen-
dation 16-53, U. S. Department of Commerce. The standard sizes for finished material from that publication shall be the minimum lum-
ber sizes used in building construction. Standard sizes for hardwood lum-
ber shall be not less than those for softwood lumber.

2.6. --End-Grain Wood Block Flooring. Wood blocks for use as flooring with end grain exposed shall be sound, well manufactured, and of uniform thick-
ness. Creosoted blocks for industrial use shall be manufactured and treated by recognized standard methods (1). The moisture content of the wood when the blocks are laid shall be near or slightly above the moisture content at which they will be in service.

2.7. --Foundation Piles.

2.7.1. --Round Timber Piles. Round timber piles shall conform to a recog-
nized pile specification (4) or shall be of suitable quality for the intended use. All piles, except those which will be continuously submerged or which are used in temporary construction, shall have preservative treatment by a recognized pressure method (33).

2.7.2. --Sawn Piles. Where sawn lumber is used for foundation or sheet pil-
ing, it shall comply with the requirements of section 2.5 for lumber.

2.8. --Glues

2.8.1. --General. Glues for use in building construction shall furnish suffi-
cient original bonding strength to enable the glued member to perform as a structural unit and shall be sufficiently durable to maintain adequate strength under service conditions throughout the expected useful life of the product. Preparation or mixing of glues and assembly and curing procedures shall be in accordance with the glue manufacturer's recommendations and with gener-
ally accepted good practice (37, pp. 233-245). Glue shall, wherever possible, conform to a nationally recognized specification, or if not so conforming, the building official shall require from the manufacturer or fabricator satisfac-
tory evidence to prove its equivalence to the specification or its fitness for the use intended.

2.8.2. --Exterior Glues. Glues for use under repeated or continuous expo-
sure to water or conditions of high moisture content or humidity, as in most exterior service, or to high temperature or to a combination of these, shall be resorcinol resin, phenol resin, melamine resin, or glues equivalent thereto in strength and durability.
2.8.3. --Interior Glues. Glues not exposed to water or conditions of high moisture content or humidity or high temperature, as in most interior and some protected exterior services shall be soybean or casein glues with or without preservative, urea-resin glues, or the equivalent thereof, or may be any of the exterior type glues specified in section 2.8.2.

2.9. --Plywood. Plywood used structurally shall conform to the applicable U. S. Commercial Standard and shall be identified as to type and grade by an approved testing agency. Plywood not covered by a Commercial Standard may be accepted by the building official only on showing of satisfactory evidence that it is equivalent to that recommended in the Commercial Standard in regard to strength, stiffness, stability, and durability. Glues shall conform to the applicable provisions of section 2.8, and gluing and manufacturing techniques shall conform to accepted practice (37, pp. 275-279). The operations of manufacture of plywood shall be open to inspection by the building official or his authorized representative.

2.10. --Modified Woods. Solid or laminated wood modified by pressure or impregnation with resin or other chemical for structural use shall have strength, dimensional stability, and other mechanical properties commensurate with the requirements of its use (37, pp. 467-478). The manufacturer shall furnish to the building official a specification showing the species of raw material, nature of treatment, and properties and recommended uses of the finished product. The building official may require verification of the strength and structural stability properties by means of appropriate tests of representative samples.

2.11. --Building Fiberboards. Fiberboards or particle boards of wood- or vegetable-fiber base for building construction shall conform to recognized standards in one of the following classes (37, pp. 457-465):

- Semirigid insulating board
- Rigid insulating board
- Intermediate-density board
- Hardboard, untreated or treated
- Special densified hardboards

Insulation boards shall have the insulating qualities and the rigidity and stability necessary for their intended purpose. Harder boards shall have structural strength and stability, surface finish, and durability commensurate with the requirements of the structural use to which they are put. Fiberboards may be used in exterior service or other severe exposure only upon showing of service records or equivalent evidence of their suitability for the purpose. The building official may require the manufacturer of the
board to furnish a specification of the density, strength, water absorption, dimensional stability under weathering, surface finish, or such other evidence as is necessary to prove its fitness. In the absence of such a specification, the building official may require tests of those properties on representative samples of the fiberboard. Such tests shall be by recognized standard methods (3).

2.12. --Construction Papers and Membranes

2.12.1. --Vapor-Permeable Papers or Felts. Vapor-permeable paper shall be uncoated, tarred, or asphalt felt, kraft paper, deadening felt, or other material that resists the passage of wind and free water, but that permits the rapid passage of water vapor by diffusion (34). It shall be sufficiently strong and pliable to withstand the normal operations of laying. The building official may require the manufacturer to furnish test reports or other evidence to show compliance with these requirements.

2.12.2. --Vapor-Barrier Papers and Membranes. Paper or felt for use where required as a water-vapor barrier shall be coated or laminated with asphalt, metal foil, or metallic oxide, or shall be a polyethylene membrane, or other material that is highly resistant to wind, free water, and to the diffusion of water vapor (34). It shall be sufficiently strong and pliable to withstand the normal operations of laying. The building official may require the manufacturer to furnish test reports or other evidence to show compliance with these requirements.

2.13. --Paper Overlays. Paper overlays may be used on wood, plywood, or wood-base materials to mask imperfections, improve dimensional stability, impart strength, or improve surface characteristics. Such an overlay paper shall have strength and other properties commensurate with the requirements of its use and shall be securely and durably bonded to the wood surface to form an integral unit with the desired mechanical or structural properties (37, pp. 475-476). The manufacturer may be required to furnish a specification indicating the character of the wood and its overlay and the nature of bond between the two, with a statement as to the conditions of service for which it is recommended. Overlaid plywood used structurally shall bear the identification of a recognized industry, association, or agency as to type and grade of veneers and paper used, conformance with the applicable U. S. Commercial Standard, and whether recommended for exterior service. The building official may require any tests of representative samples necessary to verify the required properties.
2.14. --Insulating Materials. Insulating fiberboards or particle boards of a structural character shall conform to the applicable provisions of section 2.11. Nonstructural insulating materials, including rigid materials in slab or block form, flexible blankets, or loose fill substances, shall have the required resistance to transmission of heat and shall be in such form that reasonable care in application will result in an efficient heat barrier (37, pp. 445-455). Vapor barriers may be combined with thermal insulating materials, if properly located, for control of condensation (37, pp. 452-454, 38). The manufacturer may be required to furnish a specification showing heat-insulating characteristics and other pertinent physical characteristics (5).

2.15. --Treated Wood.

2.15.1. --General. Where preservative or fire-retardant treatment of lumber or other wood material is required, the treatment shall be by recognized methods that are adequate for the degree of protection required (37, pp. 346-349 and 399-428). High temperatures and durations of conditioning or treatment shall not be of types that impair seriously the strength of the wood or otherwise render it unfit for the intended use. Where the treated material is to receive a subsequent surface coating or finish, the treatment shall leave the surface of the wood in suitable condition to receive it.

2.15.2. --Preservative Treatments. (See section 13.7)

2.15.3. --Fire-Retardant Treatments. Wood may be treated for fire retardation by impregnation or coating (37, pp. 346-349). Cutting of impregnated wood shall be avoided as much as possible, but where cutting is unavoidable, any untreated surface that may be exposed to direct flame shall receive an approved fire-retardant coating. Where coatings are used, the building official may require two or more coats as necessary to give the required thickness, or renewal at intervals determined by the fire hazard and the durability of the coating.

3. GENERAL DESIGN REQUIREMENTS

3.1. --General.

3.1.1. --Scope. These requirements shall govern the structural design of wood or wood-base materials in buildings, including the assumption of design dead and live loadings, selection of allowable design stresses or loads, determination of required sizes of members, and choice of fastenings or connections.
3.1.2. --General Requirements. All design shall be by recognized engineering principles and methods. Buildings shall be designed for all dead and live loads or forces assumed to come upon them during construction or use, including uplifts or horizontal forces from wind and, where required, forces from earthquake or other loadings. Structural members and their connections shall be proportioned to provide a sound and stable structure with adequate strength and rigidity for their intended purpose. The design shall fully consider the normal deflections or deformations of wood members or normal deformations of joints under load, which may cause secondary stresses, reduce clearances, or otherwise affect the serviceability of the structure. Where changes of moisture content may occur in service, methods of design shall be used that minimize effects from the resulting shrinkage or swelling of wood. Design shall further provide reasonable and proper protection against decay or other deteriorating influences and shall take into account the effects from any such influences that may be anticipated during the service life of the building.

3.1.3. --Design of Light-Frame Construction. Dwellings and other light-frame construction may be designed by conventional methods in accordance with the provisions of section 8 which may be approved in lieu of a full engineering design. Buildings constructed by the conventional methods of section 8 shall not exceed three stories in height.

3.1.4. --Sizes. Design uses of lumber or other wood or wood-base products shall be based upon actual rather than nominal dimensions where difference between the two exists. Plans or specifications shall clearly state whether rough or surfaced lumber is to be used. Sizes of rough or surfaced lumber shall comply with the provisions of section 2.5.5.


3.3. --Allowable Stresses.

3.3.1. --General. The provisions of this section shall govern allowable stresses to be used in the design of buildings of wood or wood-base materials. Values required herein are maximum and may be decreased, if, in the judgment of the building official, there is not assurance of the use of material with dependable strength characteristics, reasonably well fabricated, protected against excessive overloads or extra-hazardous conditions of exposure, and properly maintained throughout the life of...
the structure. Increases may be made only for short-time loading as specified in section 3.3.2, or for drying benefits as specified in sections 3.3.6 or 3.3.7.

3.3.2. --Duration of Load. Allowable stresses for wood materials and working loads for fastenings of wood, unless specifically provided otherwise, are for conditions of long-time loading. Where the full design load used in computation of sizes of structural members is of less than long-time duration, allowable stresses for wood and wood-base materials or allowable loads on fastenings may be increased in accordance with recognized good practice (37, pp. 160-161). In making stress increases of this kind, sizes of structural members shall be checked to insure that allowable stresses for the permanent portion of the load are not exceeded.

3.3.3. --Stress-Grade Lumber. Allowable stresses for stress grades of lumber shall be determined from basic stress values by the application of established principles of stress grading (37, pp. 137-164). Allowable stress values for commercial stress grades of lumber recommended by recognized associations or agencies of the lumber industry (20) and based on accepted principles of stress grading and basic stresses, may be accepted for the moisture and duration-of-load conditions therein stipulated, or may be modified for other conditions (37, pp. 158-164).

3.3.4. --Other Grades of Lumber. Where studs, joists, rafters, or similar members spaced not more than 24 inches in dwellings or other light-frame construction are of nonstress-graded lumber, allowable stresses for use with them shall be determined with due reference to the strength-reducing characteristics specified or permitted in the grade or grades (32).

3.3.5. --Stresses for Treated Lumber. No adjustment of allowable stress is required for lumber given a surface preservative or fire-retardant treatment. Where lumber is exposed to high pressures or temperatures or to any other strength-reducing conditions in connection with impregnation treatments with preservative or fire-retardant substances, the allowable stresses from section 3.3.3 may be reduced by an amount in accordance with recognized good practice (37, p. 162) and as prescribed by the building official.

3.3.6. --Plywood Stresses. Allowable stresses for structural plywood shall be determined by recognized methods from the thickness and arrangement and the strength values in individual plies and the recommended stress values for the grades of veneer used (37, pp. 275-289). Recognized approximate methods (37, pp. 285-288) may be employed. Where industry-recommended
working stresses for plywood are based on recognized stress-grading principles (13, 16), they may be taken as the allowable stresses for use with the approximate methods. Where plywood is composed of plies of more than one species or grade, the differences in strength and elastic properties among species or grades shall be appropriately recognized in the determination of the allowable stresses.

3.3.7. --Stresses for Glued Laminated Wood. Allowable stresses for glued laminated wood structural members shall be determined by recognized methods, taking into account the character of the individual laminations, the effects of strength-reducing characteristics, types of joints, form factors, or other appropriate particulars (37, pp. 247-263). Where industry-recommended stresses are based on such recognized methods (10, 24, 42), they may be used as allowable stresses for the moisture and duration-of-load conditions therein stipulated, or they may be modified for other conditions.

3.3.8. --Stresses for Fiberboards. Where fiberboards or particle boards are used structurally to support specified loads, the allowable stresses shall be set not higher than one-third of the average of the 5 lowest values in not less than 25 replicate tests from not less than 5 representative boards by standard structural test methods (3). Boards for test shall be purchased on the open market, or selected under the supervision of the building official, to assure that the range of production is represented. Tests shall be made at the moisture content that represents the highest moisture condition expected in service (3). For calculating deflections, the modulus of elasticity may be the average value from five such tests, or it may be reduced to one-half of that average value where a limit must be placed on long-time deflection. Modulus of elasticity, if used to calculate the allowable stress for a long column, shall be reduced as provided above for other allowable stresses for fiberboards.

3.3.9. --Prefabricated Units. Where sandwiches, doors, stressed-skin panels, or any other prefabricated structural units of wood or wood-base material not otherwise specified in section 3.3 are used to support specified loads, the allowable stresses shall be set not higher than one-third of the minimum value in not less than three replicate tests of representative samples. The tests shall be made by approved methods at a moisture content and a rate of loading related to the conditions expected in service, and as approved by the building official. To fulfill this requirement, the building official may accept data from a recognized testing laboratory on manufacturers' samples of the product, if it appears that the tests have been made in a manner equivalent to that stipulated herein (see section 24 "Structural Performance Testing").
4. FASTENINGS

4.1. --General. All structural members shall be framed, anchored, tied, and braced to develop the strength and rigidity necessary for the purposes for which they are used. Allowable stresses or loads on joints and fastenings shall be determined in accordance with recognized principles of good practice (37, pp. 165-202), (20). Allowable loads shall also be at a level that does not cause excessive deformation of the joint. Modifications of allowable loads may be made upon approval of the building official for duration of load as provided in section 3.3.2, where the strength of the fastening is controlled by the resistance of the wood rather than by the strength of the fastening part.

4.2. --Multiple Fastenings. Where a joint or fastening consists of two or more nails, screws, or bolts, its working load shall be the sum of the allowable loads on the individual fasteners, providing that the pertinent requirements as to spacing, end distance, and edge margin are met. Working loads on multiple-connector joints shall be determined in accordance with recognized good practice (section 4.9).

4.3. --Nails and Spikes. Fastenings with nails and spikes shall be designed and proportioned in accordance with recognized good practice (37, pp. 165-175), taking into account the duration of load, size of nails and depth of penetration into the piece receiving the point, the species and moisture condition of the wood and whether the nails are driven into end or side grain. Spacings and margins with nails or spikes shall be such that excessive splitting does not occur. The design shall be such that the integrity of the structure does not depend upon the resistance of common nails or spikes highly stressed in direct withdrawal. Nails with specially formed shanks may be used to support specific loads in direct withdrawal if approved by the building official and if in accordance with recognized good practice (37, p. 170).

4.4. --Wood Screws. Allowable withdrawal or lateral loads for wood screws shall be calculated in accordance with recognized good practice (37, pp. 175-178), taking into account the duration of load, the size of screw and its depth of penetration, the species and moisture condition of the wood, and whether the screws are penetrating into end or side grain. The calculated values are applicable with lead holes, the diameter of which does not exceed 70 percent of the root diameter of the threads in softwoods or 90 percent of the root diameter of the threads in hardwoods. Screws shall be turned and not driven into the wood. Lubrication of the threaded surfaces is permitted. Care shall be taken that the withdrawal load does not exceed the allowable tensile strength of the screw at the root of the thread. Spacings and side-margin placement of screws shall be such that excessive splitting of the wood does not occur.

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4.5. --Lag Screws. Allowable withdrawal or lateral loads for lag screws shall be calculated in accordance with recognized good practice (37, pp. 178-182), taking into account the duration of load, the size of the lag screw and the depth of penetration of the threaded and unthreaded portions of its shank, the species and moisture condition of the wood, and whether penetrating end or side grain. The withdrawal load shall not exceed the allowable tensile strength of the lag screw at the root of the thread. Lateral resistances of lag screws in side grain shall recognize the direction of the applied lateral load with respect to the grain of the wood. Lead holes shall be not larger than 75 percent of the shank diameter, and in low density woods, they preferably should be less. Lag screws shall be turned and not driven into the wood. Lubrication of the threaded surfaces is permitted. Required spacings, end and edge distances, and net sections of wood members joined with lag screws shall be the same as those in joints with bolts of a diameter equal to the shank diameter of the lag screw (section 4.7).

4.6. --Wood Pins. Wood pins shall be of a high-density species and shall be of such size or number that allowable stresses in compression perpendicular to grain and shear are not exceeded. Allowable shear in any longitudinal plane of the pin from forces acting either parallel or perpendicular to the length of the pin may be taken at 50 percent greater than the allowable working stress for horizontal shear in beams (20). Shear in the transverse plane of the pin shall be limited by the allowable values in compression perpendicular to grain (20).

4.7. --Bolts. Allowable loads for bolts shall be calculated in accordance with recognized good practice (37, pp. 182-187), taking into account the duration of load, species and moisture condition of the wood, thickness of bolted members and whether of wood or steel, size and length of bolts and whether of common or special steel, and direction of applied load with respect to the grain of the wood. Bolt holes shall be accurately positioned, and their size shall not exceed the bolt diameter by more than 1/16 inch. Good practice with respect to spacing of bolts, end and edge margins, and net section of bolted members shall be observed.

4.8. --Drift Bolts. Allowable loads for drift bolts or pins shall be calculated in accordance with recognized good practice based on the species and moisture condition of the wood and the size and length of bolts (37, p. 175). Sizes of prebored holes for such bolts should be about 1/8 inch less than the diameter of the bolt.

4.9. --Timber Connectors.

4.9.1. --Types. Timber connectors, by which stresses are transferred between contiguous wood members through the medium of imbedded metal
rings or comparable parts, may be of the split-ring, toothed-ring, shearp-plate, or equivalent types. Members joined may be held in contact with bolts or lag screws.

4. 9. 2. --Design. Details of installation and allowable working loads for connector units shall be in accordance with recognized good practice (37, pp. 187-200). The allowable working loads shall include the load carried by the bolt or screw through the connector. Rings or other im- bedded parts shall be of such strength that primary failure will not occur in them at any load that may be transmitted through the wood in which they are imbedded. In the design of connector joints, due consideration shall be given to duration of load, thickness of members, species and moisture condition of the wood, angle to grain of members at which load is applied, location and spacing of connectors with respect to edges and ends of the joined members, net sections of members after holes or cuts for connectors are made, or other factors that may affect the strength and serviceability of the joint.

4. 9. 3. --Conditions of Acceptance. The designer of a connector joint shall furnish to the building official a plan and specification showing the nature and location of all connectors and their recommended working loads. The recommended working loads shall be such as not to cause excessive deformation or slip of the joint.

4.10. --Plates and Hangers. Plates or hangers used for joining wood members shall be of such dimensions and quality that their load capacity will exceed the bearing or holding power of the wood in which they are fastened or imbedded. Fastening of plates or hangers to wood with nails, screws, bolts, or other devices shall comply with the appropriate provi-sions under section 4. Grooves or cuts for plates or hangers shall be machined or otherwise accurately surfaced to insure close fit of the mat-ing parts.

4.11. --Clamps. The use of clamps for the transmission of shear stress by means of friction between tightly appressed wood parts is prohibited except as an emergency measure for a short period of time. This shall not be con-strued as prohibiting the use of clamps for restraining the opening of splits or checks (section 26.3) or otherwise restraining wood parts against separation.
5. BEAMS

5.1. General. Wood beams and girders used in buildings shall have sufficient bending strength, stiffness, and shear resistance for the purpose intended; bearing on supports shall be adequate; and dimensions and proportions shall be sufficient to insure lateral stability. All design of beams shall be in accordance with recognized engineering methods and good practice (37, pp. 203-216).

5.2. Extreme Fiber Stress. Flexure stress in the extreme fiber of a wood beam shall be calculated from the formula \( f = \frac{Mc}{FI} \) in which \( f \) is stress in the extreme fiber in pounds per square inch, \( M \) is the maximum external moment in inch-pounds, \( F \) is a form factor coefficient (see section 5.7), \( c \) is the distance from neutral axis to extreme fiber in inches, and \( I \) is the moment of inertia of the cross section of the beam about the neutral axis in inches\(^4\). The external moment \( M \) shall be computed for simple or continuous beams by standard methods. The quantity \( I/c \) may be designated as the "section modulus."

5.3. Shearing Stress.

5.3.1. Basic Formula. The maximum shearing stress in a wood beam shall be calculated from the formula \( q = \frac{VQ}{It} \), in which \( q \) is shearing stress in pounds per square inch, \( V \) is the maximum-shear load (maximum reaction in simple spans) in pounds, \( Q \) is the statical moment of the part of the cross section above or below the point where shearing stress is calculated in inches\(^3\), that moment being computed about the neutral axis of the beam, \( I \) is the moment of inertia of the entire cross section in inches\(^4\) and \( t \) is the width of the beam in inches at the point where shearing stress is calculated. At the neutral axis of a rectangular beam \( b \) inches wide and \( d \) inches deep the formula becomes \( q = \frac{3V}{2bd} \).

5.3.2. Application. In applying the formula of section 5.3.1 to structural beams of wood, the allowable shear stresses shall be as specified in the applicable provisions of section 3.3. With these allowable unit shear stresses, the value of the reaction \( V \) may be modified by the following provisions:

(a) Take into account any relief to the beam resulting from any distribution of the load to adjacent parallel beams by flooring or other members of the construction, (b) neglect all loads within a distance from either support equal to the depth of the beam, (c) if there are moving loads, place the
largest one at three times the depth of the beam from the support or at the 
quarter point of span, whichever is closer to the support, and (d) treat all 
other loads in the usual manner.

5.3.3. --Notched Beams. Allowable shears in notched beams shall be cal-
culated by recognized methods (37, pp. 207-209), modifying the allowable 
stresses to allow for the shape of the notch and whether it is on the upper 
or lower side of the beam. The depth of any notch shall not exceed one-
third of the depth of the beam.

5.4. --Bearing on Supports. Allowable stress values in compression per-
pendicular to grain from section 3.3 shall be applied to bearings of any length 
at the ends of a beam and to bearings 6 inches or more in length at any other 
place along the beam. For bearings shorter than 6 inches located 3 inches 
or more from the end of a beam, the stresses may be increased in accord-
ance with the provisions of section 7.2. In calculating the bearing area at 
the ends of beams, no allowance need be made for the fact that, as the beam 
bends, the pressure upon the inside edge of the bearing is greater than at 
the opposite edge.

5.5. --Deflection of Beams. The values for modulus of elasticity for lumber 
from sections 3.3.3 or 3.3.4 shall be used in deflection formulas to compute 
the immediate deflection of a wood beam under load. Where it is necessary 
to restrict deflection to small amounts under long periods of loading, all 
dead or long-time loads shall be doubled for calculating the deflection from 
the above values, or an equivalent method of calculation approved by the 
building official shall be employed.

5.6. --Lateral Support. Any beam or girder that has a depth more than 
twice its breadth shall be securely fastened at its ends against twisting. 
Where the depth of a beam or girder exceeds three times the breadth, addi-
tional lateral support shall be provided in accordance with the requiremen:
t of sound engineering practice (37, pp. 215-216). Joists supporting a floor 
shall be bridged at intervals not exceeding 8 feet between bridgings or be-
tween bridging and bearing, except that when the depth of the joists exceeds 
six times their breadth, bridging shall be at intervals of not more than 6 
feet. The building official may require loading tests by recognized methods 
(section 24.4) to show the lateral stability of deep built-up beams or beams 
of unusual shape.

5.7. --Form Factors.

5.7.1. --Solid Sawn Beams. The form factor $F$ used to calculate loads or 
stresses in beams (section 5.2) shall be unity for square or rectangular
solid-sawn beams with sides vertical or for vertically laminated, mechanically joined lumber beams (section 5.8.3). The form factor of a solid wood beam of circular section shall be taken as 1.18. The form factor of a square lumber beam with the diagonal of the section vertical shall be taken as 1.414.

5.7.2. --Built-Up and Laminated Beams. The form factor $F$ for glued laminated beams and for built-up beams other than vertically laminated, mechanically joined lumber beams (section 5.8) shall be calculated from the formulas

$$F = 0.81 \left[ 1 + \left( \frac{H^2 + 143}{H^2 + 88} - 1 \right) S \right]$$

and

$$S = p^2 (6 - 8p + 3p^2) (1 - q) + q$$

where $H$ is the height of the beam in inches, and $S$ is a support factor determined from $p$, the ratio of the depth of the compression flange to the full depth of the beam, and $q$, the ratio of total thickness of web or webs to the full width of the beam.

5.8. --Built-Up Beams.

5.8.1. --General. The design of beams built up of wood or wood in combination with plywood or other material shall conform to the applicable provisions of sections 5.1 to 5.7, inclusive. All parts composing such beams shall be placed and securely joined or fastened to insure action as a unit under load and durability in service.

5.8.2. --Glued Laminated Beams. The design of glued laminated beams shall comply with the provisions of section 14.

5.8.3. --Mechanically Joined, Built-Up Beams. Built-up beams in which a number of similar pieces of lumber are joined with nails, bolts, or other mechanical fastenings to act as a unit under load, shall be designed so that each lamination extends the full depth of the beam. Pieces joined shall be at approximately the same moisture content, and, if more than one species is used they shall have similar shrinkage characteristics. Fastenings shall be sufficient in number and placed so that separation of individual pieces will not occur under load (37, pp. 211-212). Where transverse joints are permitted in any of the laminations, consideration shall be given in the design to insure adequate strength and stiffness at points where they occur. For mechanically joined laminated beams complying with these provisions, allowable stresses shall be the same as for a solid lumber beam of the same species and grade.

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Where steel strips or rods or other materials or parts are added to reinforce or prestress wood beams, they shall be securely bonded by adhesives or other means to insure full interaction of the metal and the wood under service loads. Design values for such reinforced beams shall be verified by loading tests by an approved method, if the building official requires it.

5.8.4. --Box or I-Beams. Box or I-beams shall be designed from the formulas $f = \frac{Mc}{Fl}$ (section 5.2) and $q = \frac{VQ}{It}$ (section 5.3.1), using a form factor determined in accordance with section 5.7 and allowable stresses from the applicable provisions of section 3.3. Allowable shear stresses for plywood from section 3.3.6 are such that buckling of plywood webs may be neglected in beams of the proportions ordinarily used in buildings. Unusually short and deep beams shall be checked for web buckling stress. Where it is important to limit deflections to small amounts, the calculated deflections shall be verified by suitable loading tests (section 24). All features of design, including the construction of tension and compression flanges, shear strength and stiffness of webs, and fastening of webs to flanges shall be in accordance with recognized good practice (37, pp. 263-272). The manufacturer of the beam shall furnish a complete plan and specification showing all details of design or construction that may affect the strength, stiffness, or durability of the beam, and showing also the recommended stress or loads thereon. All operations of manufacture shall be open to inspection by the building official or his authorized representative.

6. COLUMNS

6.1. --General. Wood columns used in buildings shall be of sizes and proportions that will have adequate compressive strength and lateral or torsional stability for their intended purpose. Column design shall be in accordance with recognized engineering methods and good practice (37, pp. 216-227). Column stresses shall be subject to adjustment for duration of load as provided in section 3.3.2.

6.2. --Short Columns. Allowable loads for short columns of solid wood with $L/d$ ratios (ratio of unsupported length to least dimension of cross section) not exceeding 11 shall be calculated from the working stresses in section 3.3.3. Care shall be taken that the full cross section of the column has adequate bearing at each end and that the applied load is symmetrically and uniformly distributed.
6.3. --Intermediate Columns. Allowable loads for long-time loading of symmetrically loaded rectangular or square columns of solid wood with \( L/d \) ratios in the range of 11 to 25 may be calculated from the formulas

\[
K = 0.64 \sqrt{\frac{E}{c}} \quad \text{and} \quad \frac{P}{A} = c \left[ 1 - \frac{1}{3} \left( \frac{L}{Kd} \right)^{4} \right]
\]

Where \( P \) is safe load in pounds, \( A \) is cross-sectional area of the column in square inches, \( c \) is the working stress in compression parallel to grain in pounds per square inch determined in accordance with the provisions of section 3.3.3, \( L \) is the unsupported length of the column in inches, \( d \) is the least dimension of the cross section of the column in inches, and \( E \) is the modulus of elasticity in pounds per square inch from section 3.3.3. On approval by the building official, any other formula for columns of this length may be used, or the formula for long columns may be used up to the short-column strength, if such a formula gives a satisfactory and safe approximate working value.

6.4. --Long Columns. Allowable long-time loads for symmetrically loaded rectangular or square columns of solid wood with \( L/d \) ratios in the range of 25 (section 6.3) to 50 shall be determined from the formula

\[
\frac{P}{A} = \frac{0.274E}{\left( \frac{L}{d} \right)^{2}}
\]

where the same notation as in section 6.3 is employed. The allowable load calculated by this formula shall in no instance exceed the safe short-column compressive stress (section 6.2).

6.5. --Butt Joints. Butt joints perpendicular to the direction of stress and accurately fabricated and tightly fitted may be permitted in solid columns only if adequate lateral support is provided and if bending moment is not required to be transmitted through the joint. Allowable loads shall in no case exceed 80 percent of the load permitted on an unjointed short column of the same cross section and character. Possible effects from shortening of the column when load is transmitted through a butt joint shall be considered in the design. Butt joints may be permitted in individual pieces of built-up, mechanically joined columns providing the net unjointed section at any point is adequate for all compressive and flexural stresses.

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6.6. --Built-Up Columns. Built-up rectangular or square columns, composed of parallel members with edges cover-plated or a central core with cover plates (excepting spaced columns and glued laminated columns), shall be designed to allowable stresses not to exceed the values in the following tabulation:

<table>
<thead>
<tr>
<th>Ratio of length to least cross-section dimension</th>
<th>Percent of allowable stress for solid column</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>82</td>
</tr>
<tr>
<td>10</td>
<td>77</td>
</tr>
<tr>
<td>14</td>
<td>71</td>
</tr>
<tr>
<td>18</td>
<td>65</td>
</tr>
<tr>
<td>22</td>
<td>74</td>
</tr>
<tr>
<td>26</td>
<td>82</td>
</tr>
</tbody>
</table>

Individual pieces composing such built-up columns shall be securely joined to act as a unit under load (37, pp. 220-221). Allowable load capacities of built-up parallel members mechanically joined without cover-plated edges shall be calculated as the sum of the load capacities of the individual pieces computed as if without any lateral support.

6.7. --Glued Laminated Columns. The design of glued laminated columns shall be in accordance with the applicable provisions of section 14.

6.8. --Spaced Columns. The design of spaced columns and determinations of allowable loads thereon shall be in accordance with recognized engineering methods and good practice (37, pp. 223-225). The L/d ratio of any main compression member in a spaced column shall not exceed 80. End blocks shall be provided in all spaced columns. End blocks shall have an adequate connection to the main compression members designed with regard to the L/d ratio and compressive strength of the compression members. A spacer block shall be located at midlength of each column, with additional blocks if required in very long columns. Where the spaced column is used as the upper chord of a truss, joints or connections with the web members of the truss may be considered as end or spacer blocks if meeting the requirements for location and fastening for such use. Allowable loads on spaced columns shall be subject to adjustment for duration of load in accordance with the provisions of section 3.3.2 and for moisture content of the material in accordance with recognized good practice (37, pp. 223-225).
6.9. --Stability of Column Sections. Compression stresses in columns with thin outstanding portions of the cross section (angle, H-, T-, or U-shapes) shall be reduced by a factor of 3 from the critical stress for wrinkling of such outstanding parts calculated from the formula

\[ p = 0.07E \frac{h^2}{b^2} \]

where \( p \) is critical stress in pounds per square inch, \( E \) is modulus of elasticity in pounds per square inch, \( h \) is the thickness, and \( b \) is the width of a flange or other unsupported outstanding part of the cross section. Where a column section has low torsional stiffness (such as an angle section with long thin flanges), the compression stress shall be reduced by a factor of 3 from the critical stress for twisting of the column about its own axis calculated from the formula

\[ p = 0.44E \frac{h^2}{b^2} \]

with notation of units as above.

6.10. --Round Columns. The allowable load for a column of round cross section shall be the same as that for a square column of the same cross-sectional area.

6.11. --Tapered Columns. Where round or other columns are uniformly tapered, the least dimension for use in determining the \( L/d \) ratio shall be the least diameter at a point one-third of the length from the smaller end, but in no case exceeding one and one-half times the minimum diameter at the small end. The induced compressive stress at the small end of a tapered column shall not exceed the allowable unit stress for a short column (section 6.2).

6.12. --Side Loads and Eccentricity. Wood columns with end loads eccentrically applied, lateral loads, bracket loads, or any combination of loading that produces both axial and bending stresses shall be designed by recognized principles of engineering mechanics. The designer may use one of the specialized secant formulas from textbooks in engineering mechanics, assuming pin-end conditions, or a recognized generalized formula may be used (37, pp. 219-220). The design shall recognize bending moments induced by side loads or eccentricity and the increase of eccentricity on long columns with deflections resulting from those bending moments.
7. ADDITIONAL DESIGN PROVISIONS

7.1. --Design of Tension Members. Allowable stresses in tension parallel to grain shall be in accordance with the applicable provisions of section 3.3.3. Care shall be taken in design that joints and fastenings (section 4) are adequate for the assumed tensile load. Net sections at points cut or bored to receive fastenings shall be checked for adequacy.

7.2. --Compression Perpendicular to Grain. Allowable stress values for compression perpendicular to grain in accordance with the applicable provisions of section 3.3 shall apply to bearings of any length at the ends of a wood beam and to bearings 6 inches or more in length at any other location. For bearings less than 6 inches in length and not nearer than 3 inches to the end of a member, the allowable values for such bearing areas may be multiplied by the factor \( \frac{L + 3/8}{L} \), where \( L \) is the length of bearing in inches measured along the grain of the wood. For round bearing areas, as under a washer, \( L \) shall be the diameter of the area.

7.3. --Loading at Angles to Grain. Allowable stresses or loadings for fastenings at an angle to the grain of the wood shall be calculated from the formula

\[
N = \frac{PQ}{P \sin^2 \theta + Q \cos^2 \theta}
\]

where \( N \) is the allowable stress or load acting in the direction indicated by the angle \( \theta \), \( P \) is the allowable stress or load parallel to grain, \( Q \) is the allowable stress or load perpendicular to grain, and \( \theta \) is the angle between the direction of stress or load and the direction of grain of the wood member. \( N, P, \) and \( Q \) shall be expressed in the same units, such as pounds per square inch.

7.4. --Combined Loadings.

7.4.1. --General. Where fiber stress in bending is combined with direct stress resulting from the application of end compression or tension, the combined stress shall be determined by algebraic addition of the acting stresses. Stress so combined shall not exceed allowable values as provided in this section.

7.4.2. --Flexure and Compression. Where a transversely loaded beam is also under end compression and is stayed against lateral buckling (section 5.6), the allowable stress shall be such that the sum \( \frac{P/A + M/S}{c/f} \) does not exceed unity, where \( P/A \) is direct stress induced by axial load in compression parallel to grain, \( M/S \) is flexural stress induced in bending, \( c \) is the...
allowable stress in compression parallel to grain, and f is the allowable stress in extreme fiber in bending determined in accordance with the applicable provisions of section 3.3. All stresses in this formula shall be expressed in the same units, such as pounds per square inch. The allowable stress in wood columns with side loads shall be calculated in accordance with the provisions of section 6.12.

7.4.3. --Flexure and Tension. Members subjected to both flexure and axial tension shall be so proportioned that the sum \( \frac{P/A + M/S}{f} \) does not exceed unity, where \( P/A \) is direct stress induced by axial load in tension parallel to grain, and \( M/S \) is flexural stress induced in bending, \( t \) is the allowable stress in tension parallel to grain, and \( f \) is the allowable stress in extreme fiber in bending, determined in accordance with the applicable provisions of section 3.3. All stresses in this formula shall be expressed in the same units, such as pounds per square inch.

8. LIGHT-FRAME CONSTRUCTION

8.1. --General Provisions.

8.1.1. --Scope. The provisions of this section apply to one- or two-family dwellings or other light-frame buildings not more than three stories in height, above the basements, in which structural parts are of wood or wood frames are used for support. This includes wood-frame walls with facing or veneer of masonry or stucco or other nonwood materials.

8.1.2. --Systems of Construction. It is the intent of this section to permit light-frame buildings to be of conventional construction as described, or they may be built by any other system of construction that can be shown to be equivalent in structural strength and stability. Equivalence may be demonstrated by showing the equivalence of individual parts or members, or by tests of wall or floor panels or similar elements showing conformance to a generally accepted performance standard (section 24).

8.1.3. --Structural Design. All wood or wood-base structural members shall be of sufficient size and strength, and of such quality and so conditioned, fabricated, and used to carry their imposed loads safely. Members shall be braced and fastened to each other at points of intersection to provide a sound and stable structure with adequate strength and rigidity for its intended purpose. The specification of sizes and grades of members in this section shall not be taken as exempting such members from verification of their strength and rigidity by recognized methods of structural analysis or test in any case.
where, in the judgment of the building official, such verification is necessary. All structural members shall be designed for all anticipated dead and live loads, except that consideration may be given to distribution of loads among adjacent parallel framing members if spaced not more than 24 inches apart. Due consideration shall be given in the design to the effect of changes in shape or dimension that may take place as a result of changes in moisture content or yield under long-time loading during the expected service life. The arrangement and framing of members shall be adequate to make a sound and stable structure. Construction methods for structural members shall conform to established good practice (9).

8.1.4. --Fastenings. All structural members shall be framed, anchored, tied, and braced to develop the strength and rigidity necessary for their intended purpose (9, pp. 22-47, 39). Fastenings and connections at the intersections of structural members shall be adequate to sustain or transmit without failure at least 2-1/4 times the load for which they are designed.

8.1.5. --Erection. Neither structural members nor fastenings shall be overstressed or unnecessarily damaged during erection.

8.2. --Columns and Posts. Wood posts or columns shall have sufficient size and lateral stability to carry safely the loads coming upon them. Wood columns in basements shall bear on concrete, masonry, or other approved bases extending not less than 3 inches above a finished floor, nor 6 inches above a dirt or rough floor.

8.3. --Girders.

8.3.1. --Design. The design of wood girders shall comply with the appropriate provisions of section 5. Allowable stresses shall be in accordance with the appropriate provisions of section 3.3. The maximum deflection caused by design live load shall not exceed 1/360 of the length of the span. The width of a rectangular wood girder shall be not less than one-fourth of its depth.

8.3.2. --Bearing. Girders shall have bearing of not less than 3-5 8 inches in length on wood members or metal hangers and not less than 4 inches on masonry. Where the ends of girders are supported on a wood-frame wall, there shall be extra studs or other means for safely transmitting the load to the foundations.

8.3.3. --Fastening. All girders shall be securely anchored to masonry foundations or wood-frame walls or to other intersecting or abutting girders to stay in place and resist safely all uplifts and horizontal forces assumed in the design.
8.3.4. --Built-Up Girders. Built-up girders shall comply with the design provisions of section 5.8.3. Individual pieces shall be securely spiked (9, pp. 23-25), so that separation will not occur under load. Girders made up of two or more separate members shall be securely blocked at intervals of not more than 4 feet. There shall be no transverse joints in built-up girders on simple spans, unless the net unjointed section between supports has enough strength and stiffness for the assumed loads. When continuous girders are made up of joists nailed side by side, joints in joists shall be between one-sixth and one-fourth of the span length from an intermediate support, provided that no two adjoining joists, nor more than one-half the total number, shall be joined on the same side of the support. Glued laminated girders shall comply with the provisions of section 14.

8.3.5. --Notches and Holes. No notches shall be allowed in wood girders. Holes bored in girders shall be in such locations and of sizes that do not impair seriously the strength or stiffness.

8.4. --Joists.

8.4.1. --Design. Required sizes and spacings and permissible spans of joists may be determined by structural analysis, taking into consideration bending and shear stresses and allowable deflections. For dwellings they may be taken from recognized span tables (32). Maximum deflections of joists in dwellings caused by design live load shall not exceed 1/360 of the span when supporting a plastered ceiling, or 1/240 if the ceiling is unplastered. The nominal thickness of any joist shall be not less than 2 inches nor its nominal depth less than 4 inches. Joists shall not be spliced except over supports.

8.4.2. --Bearing. Joists shall have a minimum length of bearing of 1-5/8 inches on wood except where nailed to studs and supported on a ribbon board.

8.4.3. --Fastenings. Joists shall be well spiked or otherwise securely fastened to plates or girders on which they bear, or to studs or headers at outer walls, and to any intersecting, abutting or lapping joists (9, pp. 25-28).

8.4.4. --Bridging. Joist systems shall be bridged for lateral support and distribution of loads at intervals not exceeding 8 feet.

8.4.5. --Framing around Openings. Wood headers at openings shall be of the same depth as the joists and shall be of adequate strength and stiffness for the support of the tail beams framing into them. Ends of tail beams shall be securely spiked or otherwise fastened to headers, and ends of headers shall be securely fastened to the trimmer joists (9, pp. 25-28). Trimmer joists
into which headers are framed shall be doubled, where necessary, or shall be otherwise provided with the necessary strength and stiffness for the loadings assumed in the design.

8.4.6. -Notches and Holes. Joists shall not be notched in the center half of the span. Notches outside the center half of the span shall not exceed one-sixth of the depth unless computations show that allowable shear and bending stresses are not exceeded (37, pp. 207-209). Holes in joists shall have a maximum diameter of 2-1/2 inches and shall be of such size and in such position that they will not be closer than 2 inches to either edge. Where excessive cutting is unavoidable, strength requirements shall be met by the addition of joists or by other means approved by the building official.

8.5. -Flooring.

8.5.1. -Subflooring. Subflooring shall be used in all light-frame constructions except in dwellings where the finish flooring is of lumber at least 3/4 inch in actual thickness or its equivalent in strength and stiffness. Lumber subflooring on joists spaced not more than 24 inches apart, center to center, may be laid diagonally or at right angles to joists and shall be well nailed or otherwise securely fastened (9, pp. 28-31) to the floor framing to resist the lateral loads and pressures assumed in the design. Where lumber subflooring is laid at right angles to joists, finish flooring shall be at right angles to the subfloor. End joints in lumber subflooring shall not be made between supports, unless the boards are end matched or otherwise keyed at their ends. Plywood not less than 1/2 inch thick with face grain perpendicular to joists spaced 16 inches, or any material of equivalent strength and stiffness, may be used for subflooring. A vapor-barrier membrane (section 2.12.2) shall be laid on the subflooring of first stories over crawl spaces.

8.5.2. -Single-Course Flooring. Single-course flooring of lumber shall be not less than 3/4 inch, nor of plywood less than 1/2 inch in actual thickness on joists spaced 16 inches. For greater joist spacings, the flooring shall be thicker to attain the desired strength and stiffness. Boards shall be side and end matched, tightly laid and securely nailed or otherwise fastened (9, pp. 128-131). Single-course plywood flooring shall be laid with face grain at right angles to the supporting joists, and solid blocking shall be installed under all edges at right angles to the joists.

8.5.3. -Laminated Flooring. Where 2-inch planks are laid on edge to form a laminated floor and are supported on beams or girders spaced more than 24 inches, they shall be not less than 3 inches in nominal width and shall be securely spiked together with spikes not less than 4 inches long. The spacing of supporting beams and the width of planks shall be such that the strength
is adequate for the assumed loads and such that the maximum deflection under
design live load does not exceed 1/240 of the span between beams. There
shall be no joints between supports, unless there is satisfactory evidence
from load tests that the proposed construction has the necessary strength
and stiffness under the assumed loads.

8.6. **Wall Framing.**

8.6.1. **Studding.** Studs for exterior walls or bearing partitions in one- or
two-story buildings with stories not exceeding 9 feet in height shall be not
less than 2 by 4 inches (nominal) and shall be spaced not more than 24 inches
on centers. For three-story buildings or buildings with stories more than
9 feet in height, the maximum spacing of 2- by 4-inch studs shall be 16 in-
ches, or the building official may require 2- by 6-inch studs, bridging of
studs, or other means for developing the necessary strength and stiffness
of the wall against horizontal and vertical loads. Posts at exterior corners
or where partition walls are joined shall consist of not less than three 2-
by 4-inch studs or equivalent, securely fastened to each other to act together
under load. All junctions of studs with plates or other framing members
shall be well nailed (9, pp. 31-39), or otherwise securely fastened to resist
all loads assumed in the design. Notches to receive bracing or ribbon boards
may be 1 inch deep, or holes to receive piping may be up to 1-1/2 inches in
diameter; but if more severe cutting is unavoidable, additional studs or
other provision shall be made to give the necessary strength and stiffness.
When properly supported at each floor level, studs may be continuous through
two or three stories, or, if studs are not continuous at floor levels, means
shall be provided through sheathing or otherwise to assure adequate struc-
tural continuity between stories.

8.6.2. **Sills and Anchorage.** Sills resting on masonry shall be not less than
2 by 6 inches (nominal) and shall be anchored to the masonry with 1/2-inch
bolts spaced not more than 8 feet apart, or equivalent. Bolts shall be em-
bedded to a depth of 6 inches in concrete. In unit masonry, the depth shall
be at least 15 inches, with a 2-inch round or equivalent washer bearing against
the bolt head. A washer of not less than 1-3/8 inches diameter shall be placed
between the nut and the sill.

8.6.3. **Plates.** Sole and top plates shall be of the same width as the studs
and shall be not less than 2 inches in nominal thickness. Plates at the tops
of exterior walls shall be doubled. Joints in the members of doubled plates
shall be staggered, corners shall be lapped, and ties shall be made where
partitions intersect the wall (9, pp. 31-39). Where plates are notched, they
shall be reinforced.
8.6.4. --Bracing. Diagonal bracing in wall constructions shall consist of 1-by 4-inch (nominal) boards of good quality or the equivalent thereto, let into the outer edges of the studs and plates and well nailed (9, pp. 31-39) or otherwise securely fastened to both studs and plates. Bracing in each wall shall extend in both directions at an angle between 40° and 50° from the vertical. At least one brace in each wall shall extend from the highest practicable point on each corner post to the bottom of the sole plate. Diagonal bracing shall be so arranged that it does not terminate at the framing of a door or window opening. Bracing may be omitted from walls sheathed with lumber placed diagonally, plywood in 4- by 8-foot sheets with face grain vertical and adequately nailed or other sheathing shown by racking test (2) to be equivalent to approved (section 8.7.2) horizontal wood board sheathing with corner bracing.

8.6.5. --Ribbon Boards. Ribbon boards used to support joists shall be not less than 1 by 4 inches (nominal) and shall be let into the studs and nailed with two eightpenny nails or otherwise securely fastened to each stud.

8.6.6. --Lintels. Lintels and trusses over wall openings shall be designed to provide strength and rigidity adequate for the assumed wall loadings upon them. In no case shall a lintel over a door or window opening consist of less than two 2- by 4-inch (nominal) pieces set on edge, or the equivalent thereto.

8.6.7. --Framing around Openings. Doubled studs or other adequate construction shall be applied around openings to transmit vertical and horizontal loads without serious deformation (9, pp. 31-35).

8.6.8. --Tops of Walls. The tops of all frame walls shall have adequate horizontal anchorage to resist safely all assumed lateral forces, including the horizontal components of loads on sloping roofs, the spreading action of rafters not tied at the plate line, and wind or earthquake loads.

8.6.9. --Partition Wall Framing. Framing of bearing partitions shall conform to the provisions for exterior wall framing. Bearing partitions unsupported by walls shall be supported on girders or multiple joists or on sole plates, if placed at an angle to the joists. Non-bearing partitions shall be framed with not less than 2- by 3-inch studs spaced not more than 24 inches, with at least one bottom plate 2 inches (nominal) thick the same width as the studs.

8.7. --Wall Sheathing and Coverings.
8.7.1. --General. Exterior wall coverings shall provide adequate protection from weather and shall have sufficient strength and stiffness to resist puncture or damage from ordinary transverse forces or impact of moving objects. Where diagonal bracing is omitted from exterior wall framing, the wall coverings or sheathing shall supply sufficient strength and rigidity to resist racking forces acting in the plane of the wall. Where studs are not continuous from one story to the next, sheathing shall be applied to provide satisfactory structural continuity between stories.

8.7.2. --Wood Sheathing. Wood sheathing for exterior walls shall be not less than 11/16 inch in actual thickness with 16-inch stud spacing or 25/32 inch in actual thickness with 24-inch stud spacing, and shall be well nailed (9, pp. 47-53) or otherwise securely fastened to each stud. Diagonal sheathing shall be securely fastened to top and bottom plates as well as to the studs.

8.7.3. --Plywood Sheathing. Plywood sheathing may be of either exterior or interior type (section 2.9), except that where plywood forms the outermost cover of an exterior wall, it shall be of exterior type. Plywood for sheathing with stud spacing of 16 inches shall in no case be less than 5/16 inch thick, and where forming the exterior surface it shall be not less than 3/8 inch thick. Corresponding minimum thicknesses with stud spacing of 24 inches shall be 3/8 inch and 5/8 inch, respectively. Plywood shall be well nailed or otherwise securely fastened (9, pp. 47-53) to top and bottom plates or sills as well as to the studs.

8.7.4. --Fiberboard Sheathing. Fiberboard sheathing shall be "Rigid insulating board" (section 2.11) or equivalent grade, suitably treated for water or wind resistance. Where fiberboard forms the outermost cover of a wall it shall be "Intermediate-density" or higher grade, suitable for exterior service (section 2.11). The thickness shall be sufficient to sustain and transmit the loads that come upon it to the framing members, but not less than 1/2 inch in any instance. Nailing shall conform to recognized good practice (9, pp. 47-53). Exterior finish over fiberboard sheathing shall be fastened to the studs or to nailing strips. Fiberboard is not acceptable as a nailing base unless some special method of attachment approved by the building official is used.

8.7.5. --Sheathing Paper. Sheathing paper meeting the requirements of section 2.12.1 shall be placed on the outer surface of all exterior wall sheathing that is to receive a masonry veneer. Paper shall also be placed on the outer surface of all wood sheathing; it shall be placed on plywood and fiberboard sheathing if ordered by the building official to prevent damage to the sheathing from water infiltrating through the exterior wall covering; providing only that where sheathing forms the outermost cover of the wall, no sheathing paper is required. Paper shall be carefully laid to seal all joints against the entrance of wind and free water.

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8.7.6. --Siding. Siding of wood or wood materials shall be of such type that it can be applied to form a tight covering and shall be well nailed (9, pp. 79-87) or otherwise securely fastened to studs or to nailing strips attached to the studs.

8.7.7. --Inner Coverings. Coverings used on the inner surfaces of exterior walls or on partition walls shall have sufficient strength and stiffness to resist puncture or damage from ordinary transverse forces or impact of moving objects.

8.8. --Ceilings. The framing of ceilings shall conform to the requirements for floor framing with suitable adjustments of dead and live loads as required. Ceiling coverings shall have sufficient strength and stiffness for self support and to withstand the hazards of handling and erection, or any accidental impacts that may be expected in service.

8.9. --Insulation.

8.9.1. --Thermal Insulation. Where thermal-insulating material is placed in or on a wall or ceiling, it shall be installed in accordance with recognized good practice (9, pp. 100-108) to stay in place and fulfill its intended function.

8.9.2. --Vapor Barriers. A vapor-resistant membrane or other barrier meeting the provisions of section 2.12.2 shall be placed on or near the inner surface of walls or ceilings enclosing heated space in dwellings located north of the 35° F. January isotherm. Similar protection shall be furnished in other buildings of light-frame construction similarly located if required by the building official to control condensation of moisture. In old work, a vapor-resistant paint covering consisting of not less than two coats of oil-base, rubber-base, or aluminum-pigmented paint may be substituted for the membrane upon approval of the building official. Care shall be taken in installing vapor barriers to insure that joints or other breaks that may permit passage of water vapor are tightly closed (9, pp. 109-110).

8.10. --Roof Framing.

8.10.1. --Flat Roof Decks. Framing of roof decks with slopes of 5° or less from the horizontal and to which there is ready access for human occupancy shall conform to the requirements for floor framing with suitable adjustments of dead and live loads as required.

8.10.2. --Rafters for Sloping Roofs. Required sizes and permissible spans of rafters may be determined by engineering analysis, taking into consideration bending and shear strengths and allowable deflections, or they may be taken
from recognized span tables (32). Maximum deflections of rafters under full live load shall not exceed 1/360 of the slope distance between supports when the under side of the roof is plastered, 1/240 of the slope distance if unplastered but finished, or 1/180 of the slope distance if unfinished. No rafter shall be less than 2 by 4 inches (nominal) in size. Rafters of 2-inch nominal thickness more than 6 inches deep and more than 15 feet in slope length shall be adequately cross-bridged at 8-foot intervals. Where the slope of rafters is less than 4 inches per foot, either the rafters or the ridge board shall be vertically supported with struts or posts. In roofs with slope of 4 or more inches per foot, the spreading action of the rafters shall be resisted by the members of the attic floor system or by horizontal ties of adequate strength located somewhere below the upper third of the length of each pair of rafters. Bending moments induced in rafters by ties not at the plate line shall be considered in determining the size of rafters. Hip and valley rafters shall be increased in size or number to provide additional strength in accordance with the loads supported. Framing around dormers shall be in accordance with recognized good practice (9, pp. 40-46). All rafters and ties shall be well nailed (9, pp. 40-46) or otherwise securely fastened at their intersection with other framing members to resist or transmit all assumed loads including horizontal forces and uplift caused by wind.

8.10.3. --Light Roof Trusses.

8.10.3.1. --Design. Roof trusses to be spaced not more than 24 inches shall be designed by recognized engineering methods (25, 44), taking into account all applicable vertical and horizontal loadings. Material shall be of a recognized stress grade of lumber or an equivalent approved by the building official. Bending moments on chord members from roof or ceiling loads shall be adequately provided for in the design. Fastenings shall be adequate for the loads imposed. Roof overhang shall be provided by extension of the upper chord, so that the heel joint shall in all instances be directly over the plate or other support of the truss. A camber of 1/2 inch shall be provided for trusses with mechanical fastenings on spans of 20 to 32 feet, or equivalent amounts with other spans. Trusses with glued gusset-plate joints may be designed with 1/4-inch camber, provided that good practice in gluing is followed (section 18.8). The building official shall be furnished complete plans and specifications for the trusses, showing stress analysis and types and grades of material and fastenings in all members. Where the design includes elements of indeterminacy in the stress analysis, the building official may require load tests of one or more representative trusses by approved methods (section 24).

8.10.3.2. --Fabrication and Erection. Trusses shall be fabricated in accordance with recognized good practice according to the structural plan, using
jigs or templates as necessary. The layout shall include the required camber of the truss. Adequate nailing for pressure on glued gusset plates is permitted. All cutting and boring for joints or fastenings shall be carefully done to insure proper fitting of the parts. Care shall be taken in handling and erection to avoid excessive bending stress perpendicular to the plane of the truss. Adequate temporary lateral bracing of trusses shall be provided until permanent lateral support is developed from the roof or ceiling constructions. Trusses shall be securely anchored at supports against any uplift forces required to be assumed in the design.

8.10.3.3. --Heavier Trusses. Heavier trusses for spacings greater than 24 inches may be used in light-frame construction, provided that they meet the requirements of section 18, and provided that the building official is supplied with full structural information showing adequate vertical and lateral support of the trusses and showing roof or ceiling systems that will sustain and transmit all loads between the trusses.

8.11. --Roof Coverings.

8.11.1. --General. Roof coverings shall provide a weathertight surface and adequate strength and stiffness under the imposed loads. In structures where the roof system acts as a diaphragm to resist horizontal forces, the strength and fastening of the sheathing shall be adequate for the assumed loads.

8.11.2. --Eave Protection. Eave protection consisting of roll roofing weighing not less than 1/2 pound per square foot, or other equally impenetrable material, shall be laid in not less than 36-inch widths upon the sheathing adjoining gutters or valleys in dwellings located north of the 35° F. January isotherm. Similar protection shall be given to other buildings of light-frame construction similarly located, if required by the building official to prevent damage from infiltration of water dammed behind ice in the gutters. This provision is not required where roll roofing or other fully waterproof roof surfacing is used.

8.11.3. --Lumber Sheathing. Lumber roof sheathing over rafters or trusses spaced not more than 24 inches shall have a minimum nominal thickness of 1 inch. Boards shall not exceed 8 inches in width except that boards at 15 percent or lower moisture content may be up to 12 inches wide. Transverse joints shall be over framing members unless end-matched boards are used. Sheathing shall be well nailed (9, pp. 53-56) or otherwise securely fastened to the roof frames to resist all forces, including uplift from wind, that may be assumed to come upon it. Roof sheathing of dwellings shall be laid without space between boards, except that 1-inch (nominal) boards 3 inches or more in nominal width may be spaced under wood shingles according to shingle exposure complying with the provisions of section 8.11.5.
8.11.4. --Plywood Sheathing. Plywood roof sheathing shall be of exterior grade in accordance with the provisions of section 2.9. Plywood shall not be used as the outermost cover of a roof. The thickness of plywood roof sheathing shall be adequate for the superimposed load and the span between roof framing members, but in no case shall it be less than 3/8 inch. Plywood shall be applied with the grain of outer plies perpendicular to the framing members. Where plywood less than 1/2 inch thick is used under wood shingles, 1- by 2-inch (nominal) nailing strips spaced according to shingle exposure shall be applied. Plywood sheathing shall be well nailed (9, pp. 53-56) or otherwise securely fastened to the roof frame to resist all forces, including uplift from wind, that may come upon it. Plywood sheathing for porch decks intended for human occupancy or on flat roofs shall be of thicknesses specified in section 8.5 for flooring.

8.11.5. --Wood Shingles. Wood shingles for sloping roofs shall be edge grained, with a minimum thickness of 5 butts in 2 inches, and shall be laid and well nailed or otherwise securely fastened in accordance with recognized good practice (9, pp. 65-66). Nails or other fastenings shall be of rust-resistant type. The maximum exposure shall be one-fourth of the length for roofs flatter than 5 in 12, or one-third of the length for roofs with slope of 5 in 12 or steeper. Wood shingles shall not be used on roofs with a slope less than 4 in 12.

8.11.6. --Insulation. Where thermal insulating material is placed in a roof, it shall be installed in accordance with recognized good practice (9, pp. 100-108) to stay in place and fulfill its intended function.

8.11.7. --Roof Deck Slabs.

8.11.7.1. --General. Roof deck slabs for use with framing members spaced wider than 24 inches shall be fabricated from lumber, rigid insulating fiberboard, or other material with the necessary strength, stiffness, and insulating properties for the intended use. Deflection of the decking on the span between roof framing members under the design live load shall not exceed 1/240 of the span. Lumber decking shall be fabricated at a moisture content of not more than 19 percent in any piece nor more than 15 percent average. Decking shall be securely spiked or otherwise fastened to the supports, and all exposed nailing shall be galvanized, aluminum, or other rust-resistant type.

8.11.7.2. --Laminated Roofs. Where 2-inch planks are laid on edge to form a laminated roof, they shall be not less than 3 inches in nominal width and shall be securely spiked together with spikes not less than 4 inches long.
There shall be no joints between supports, unless there is satisfactory evi-
dence from load tests that the proposed construction has the necessary
strength and stiffness under the assumed loads.

8.11.7.3. --Slabs of Flatwise Planking. Where planks are laid flatwise to
form a roof deck slab, the edges of planks shall be side-matched, splined,
or otherwise keyed to insure proper distribution of load. Such planks shall
be not less than 1 inch in actual thickness. Pieces more than 4 inches wide
shall not have end joints except over the supports. Pieces 4 inches or less
in width may be end jointed between supports, but each piece so end jointed
shall bear upon at least one support and shall be spiked to the adjacent piece
with two or more spikes not less than 2-1/2 times as long as the width of the
piece and spaced not more than 3 feet. End joints not over supports shall be
spaced not less than 24 inches in adjacent pieces. The building official shall
be furnished a complete specification of the slab with acceptable supporting
data to show the strength, stiffness, insulating value, moisture resistance,
or other pertinent particulars for the intended use. In the absence of acceptable
supporting data, the building official may require tests to be made on not
less than three representative samples of the deck slab at the moisture con-
tent expected in service.

8.12. --Firestopping. Firestopping shall be applied in conventional light-
frame construction to all wall spaces continuous in height for more than one
story and to all openings in floors or walls for ducts or shafts. Firestopping
shall be arranged to cut off all concealed draft openings and form an effec-
tive fire barrier between basement and first story, between stories, and be-
tween the upper story and the roof space. Firestopping shall consist of not
less than 1 inch actual thickness of incombustible insulating material or
1-5/8 inches actual thickness of wood. Installations of firestopping shall
conform to recognized good practice (37, pp. 341-345). Firestopping shall
not be concealed from view until the building official has had opportunity to
inspect it.

8.13. --Protection of Heating Units.

8.13.1. --Furnaces and Stoves. All furnaces, stoves, and smoke pipes there-
from shall be separated from wood construction by the distances and materi-
als specified, or by distances recommended by the manufacturer of the heat-
ing unit. Clearances from wood construction without protection shall in no
instance be less than 6 inches. Smoke pipes passing through walls of wood
construction shall be protected by double metal ventilated thimbles not less
than 8 inches larger in diameter than the pipe, or by an equivalent construc-
tion satisfactory to the building official. No smoke pipe shall pass through a
floor, ceiling, or roof of wood construction.
8.13.2. --Radiant Heating. Heating units embedded in floors or walls of wood construction shall be controlled so they do not operate at temperatures exceeding 150° F.

8.13.3. --Fireplaces. Wood construction around fireplaces shall be made in a workmanlike manner, using clearances and protective materials in accordance with recognized good practice (9, pp. 174-177).

8.13.4. --Chimneys. No girders, joists, rafters, furring, baseboard, or flooring of wood in light-frame construction shall be placed within 2 inches of the outside face of a chimney or of masonry enclosing a flue, except that this distance may be reduced to 1/2 inch, if the intervening space is fully filled with asbestos insulating board or equivalent material. Light-frame wood construction around chimneys shall be made in accordance with recognized standards of good practice (9, pp. 171-177).


8.14.1. --General. The requirements of this section shall apply to plank-and-beam floors, ceilings, or roofs, and to post- and lintel-types of walls used in lieu of the conventional stud-and-joist framing in light-frame construction. All plank-and-beam construction shall be designed and built to provide the necessary strength and stiffness for the assumed loads and the insulating and moisture-resistance values necessary for the service intended. The construction shall include adequate bracing or other provision to develop the required resistance to wind or other lateral forces.

8.14.2. --Beams and Posts. Beams, lintels, or posts shall be of stress-grade lumber or an equivalent approved by the building official. Moisture content of wood or wood-product beams or posts when installed in light-frame construction shall be as near as practicable to the value that they will reach in service. Sizes of beams or posts shall be determined by recognized methods (sections 5 and 6) (40), to sustain all forces or loads that are assumed in design. Fastenings shall be adequate for all assumed loads, including horizontal forces and uplift (section 4).

8.14.3. --Planks. Planks shall be designed and selected to carry safely the required design loads with deflections under full live load not more than 1/240 of the length of span (40). They shall be installed at a moisture content as near as practicable to that which they will reach in service. Planks shall be not less than 2 inches in nominal thickness, and unless used with a finish floor or siding of wood laid at an angle to the plank or of plywood 5/8 inch or more in thickness, shall be tongued and grooved, splined, or otherwise keyed to retain their alinement in service. Planks shall be laid at
right angles to the supporting beams or posts, and transverse joints shall be made only on supports. Planks shall be well spiked or otherwise securely fastened to each beam or post on which they are supported.

8.14.4. --Panels. Spaces between beams or posts may be covered with panels of the required size in lieu of planking, provided that the building official shall be furnished with a complete plan and specification of the panels showing adequate strength, stiffness, insulating value, and moisture resistance for the intended service. In the absence of such a specification, the building official may require tests of not less than three representative samples of each proposed construction (section 24).

9. MASONRY-WALL-AND-JOIST CONSTRUCTION

9.1. --Scope. The requirements of this section are applicable to wood structural parts used with exterior walls of masonry in masonry-wall-and-joist construction (sometimes known as ordinary construction) of multi-family, commercial, or industrial buildings. The construction may be multi-story or one-story with wood roof trusses or arches.

9.2. --Columns. Wood columns in masonry-wall-and-joist buildings shall be of the size and character necessary to sustain all design loads, but shall in no case be less than 6 inches (nominal) in any dimension. Wood columns shall be solid or built up without concealed openings or spaces. Column footings shall be elevated not less than 6 inches above the surrounding floor.

9.3. --Floor Systems.

9.3.1. --General. Requirements for framing and covering of wood floors shall be not less than those of section 8 for light-frame construction. Where floors of masonry-wall-and-joist buildings are subjected to loads greater than those commonly encountered in dwellings, the entire floor system, including bearing areas and supporting columns, shall be subjected to structural analysis to make certain that each member or part has adequate strength and stiffness.

9.3.2. --Minimum Thicknesses. Wood joists shall be not less than 2 inches in nominal thickness, and girders shall have a thickness not less than that of two joists.

9.3.3. --Bearing. Girders shall bear in not less than 4 inches length and joists in not less than 3 inches length when on masonry walls. Joists or girders resting on opposite sides of a masonry wall shall be separated by at least 4 inches.
of solid masonry. There shall be adequate provisions for ventilation of the ends of wood girders or joists entering masonry, or the building official may require preservative treatment of girders or joists if conditions favor decay or insect attack. Joists set flush with girders shall be supported on metal stirrups or other fasteners of a type approved by the building official as adequate for the applied load. When the joist is supported on a stirrup, the length of bearing shall be not less than 3 inches.

9.3.4. --Anchorage. Every girder and not less than every fourth joist entering masonry shall be tied to the masonry with anchors adequate to resist or transmit all assumed horizontal forces. Where girders or joists rest on masonry walls, any wall plates, boxes, hangers, or ties shall be arranged so they are self releasing in case of fire. The ends of girders or joists entering masonry walls shall have a 3-inch fire cut or bevel in their depth.

9.4. --Interior Walls. Wood-frame partition walls shall be of a construction equivalent to that specified in sections 8.6.9 and 8.7.7, or better if ordered by the building official to meet special use requirements.

9.5. --Roof Framing. Roof systems of masonry-wall-and-joist buildings shall meet the requirements of section 8.10 for light-frame roof construction. In addition, no wood rafter, truss member, or any other roof framing member shall be less than 2 inches in nominal thickness. Built-up constructions in trusses or other types of wood framing shall not have concealed openings or spaces. Roof trusses shall have a bearing on masonry not less than 6 inches long. Masonry walls shall have adequate provision through pilasters or otherwise for the transfer of truss reactions to the foundation of the wall.

9.6. --Firestopping. The appropriate provisions of section 8.12 for firestopping and 8.13 for heating units shall be applied to masonry-wall-and-joist buildings with the following additional provisions. Closets shall not be located under stairs. Attic spaces shall be divided into areas, if required by fire area provisions, by means of tightly fitted, draft-stop partitions consisting of two thicknesses of 1-inch lumber with joints broken, or the equivalent. Doors through such partitions shall be of similar construction and shall be provided with devices for automatic closing in case of fire. Cornices built or framed of wood or wood products, and extending to more than one building or across fire or party walls, shall be either firestopped or entirely separated at such points.
10. HEAVY-FRAME CONSTRUCTION

10.1. --General. All load-bearing members or structural parts in buildings of heavy-frame construction shall be designed for the assumed loads appropriate to the intended occupancy (section 3.2). Glued laminated wood structural members may be used when having adequate structural properties. Glued laminated members shall have fire resistance equivalent to that in solid sawn lumber of the same sizes (37, pp. 345-346).

10.2. --Timber Foundations.

10.2.1. --Piles. Wood piles shall be of quality conforming to the provisions of section 2.7 and shall be located and driven to required bearing as determined by standard engineering practice and formulas (23, 27). Damage to piles from overdriving in resistant foundation materials shall be avoided.

10.2.2. --Grillages. Grillages of timber for the support of foundation loads shall be of sufficient size and base area to distribute the load so that excessive settlement does not occur. Wood pieces used to construct a grillage shall be not less than 2 inches in nominal thickness. Grillages or mats, unless completely below permanent water level, or for temporary use, shall be pressure-treated with a suitable preservative (37, pp. 399-428)(33). The design of lumber raft footings that spread foundation loads over large areas of yielding earth shall be verified by analysis of stresses and deflections. All grillage footings shall be made available for inspection by the building official or his authorized representative before any superstructure is placed thereon.

10.3. --Wood Columns. Wood columns in heavy-timber construction shall be of adequate size and quality for the loads supported, but in no case less than 8 inches (nominal) in any dimension. All corners shall be rounded or chamfered. Columns shall be solid, or built up without concealed openings or spaces. Joints and fastenings in members of built-up columns shall be structurally adequate (section 4). Ends of columns shall be carefully squared and fitted to insure full bearing. Column footings shall be of a design approved by the building official and shall be elevated not less than 6 inches above the surrounding floor. Columns that are stressed to more than 75 percent of allowable stress values shall be placed on properly designed metal bearing plates. Columns carrying eccentric loads shall meet the design requirements of section 6.12. Columns shall be superimposed throughout all stories on each other, or on reinforced concrete or metal post caps, or shall be connected by properly designed steel or iron caps, pintles and base plates, or by splice blocks affixed to the columns with devices or connectors housed within the contact faces (27). Columns shall not bear on wood beams or girders.
10.4. --Beams and Girders.

10.4.1. --General. Wood beams or girders in heavy-frame construction shall be of size and character adequate for the applied loads, but in no case less than 6 by 10 inches in nominal dimension. If built up of two or more pieces, the pieces shall be closely joined so that there are no concealed openings or spaces. Joints and fastenings in members of built-up beams shall be structurally adequate (section 5.8).

10.4.2. --Bearing. Beams or girders may rest on bolsters, corbels, brackets, or other devices adequate for the imposed loads. Wall plates, boxes, hangers, or anchors, arranged so they are self-releasing in case of fire (27) shall be provided where beams or girders rest on masonry walls. Wooden beams and girders supported by masonry walls shall have at least 8 inches of masonry between their ends and the outside face of the wall or the ends of other beams framed into the opposite face of the wall. There shall be adequate provision for ventilation of the ends of wood beams or girders entering masonry, or the building official may require preservative treatment of such beams or girders if conditions favor decay or insect attack. Where beams or girders meet columns, the supports shall be such that no open space occurs at the ends of the beams. Beams framed into girders may be supported by suitable stirrups, brackets, or other devices approved by the building official.

10.4.3. --Ties. All beams or girders at their intersection with or abutment against other beams, girders, or columns, shall be tied by embedded metal parts or other means approved by the building official to resist or transmit all assumed horizontal forces.

10.5. --Floors. Wood floors in heavy-timber construction shall have adequate strength and stiffness for the assumed loads. Floors of flatwise planks shall be constructed of planks not less than 3 inches in nominal thickness, tongued and grooved, splined, or otherwise keyed to leave no openings or cracks through the floor, and covered with 1-inch (nominal) flooring laid crosswise or diagonally. Where planks are laid on edge to form a laminated floor, the planks shall be not less than 4 inches in nominal width and shall be securely spiked together, and covered with 1-inch (nominal) flooring. The building official may approve substitution of other floor types for plank flooring only if it is shown that such substitute types have satisfactory strength and rigidity for the assumed loads and have fire resistance equivalent to that of the plank floor specified above. Wood flooring shall not extend closer than 1/2 inch to walls, and the space thus left shall be covered so that the transverse swelling of the floor due to wetting is not obstructed. Floors shall be designed with a low pitch, suitable drains or scuppers, or other means approved by the building official for drainage of water used in fire fighting.
operations. The building official may require all floors of industrial or commercial buildings to be posted as to their load capacity.

10.6. --Partitions. Partitions shall be structurally adequate for all service loadings and shall be constructed in such locations and of such character as may be specified for the required fire resistance.

10.7. --Roofs.

10.7.1. --General Requirements. Roof constructions shall have adequate strength and stiffness for the assumed loads. Framing members of wood trusses used to support roofs in heavy-timber construction shall be not less than 4 by 6 inches in nominal dimension, except that spaced members not less than 3 inches in nominal thickness may be used when the spaces are tightly closed by a continuous wood cover plate of not less than 2 inches nominal thickness secured to the under side of the member. Splices or scabs shall be not less than 3 inches in nominal thickness. Beams and girders supporting roof loads shall be not less than 6 by 10 inches in nominal dimension. Where the roof covering consists of flatwise planks, the planks shall be not less than 2 inches in nominal thickness, tongued and grooved, splined or otherwise keyed to leave no cracks or openings. Where planks are laid on edge to form a laminated roof, the planks shall be not less than 3 inches in nominal width and shall be securely spiked together.

10.7.2. --Anchorage. Every roof truss or girder and not less than every alternate roof beam shall be anchored to an exterior or interior wall or to an interior column; roof planking, where supported by a wall, shall be anchored to such wall at intervals not exceeding 20 feet; every monitor or saw-tooth construction shall be anchored to the main roof construction. Anchorage shall consist of steel or iron bolts or straps or other devices adequate to resist all assumed horizontal forces or uplift.

10.8. --Bracing. All roofs of heavy-frame buildings shall be provided with a system of sway bracing designed and constructed in accordance with recognized good practice (27). Diagonal bracing in walls or floors may be required where necessary to resist horizontal forces or to provide lateral support for walls (section 17).
11. FARM BUILDINGS

11.1. --Scope. The provisions of this section may be applied to rural or farm buildings for private use and not open to public occupancy. Rural buildings used for instructional purposes or otherwise open to the public shall conform to the appropriate provisions of sections 8, 9, or 10. Buildings 16 feet or less in height or 1,000 square feet or less in ground area are exempted.

11.2. --Farm Dwellings. One- or two-family farm dwellings, if placed under building code provisions, shall conform to the requirements of section 8 for light-frame construction.

11.3. --Farm Work Buildings.

11.3.1. --General. Barns, cribs, or other farm work buildings of wood more than 1,000 square feet in ground area or more than 16 feet high shall be designed and constructed of materials as specified in section 2. Design requirements shall follow generally recognized good practice (18, 28, 29, and 30) or shall conform to the applicable provisions of sections 3 to 10, inclusive, in structures open to the public. All structural parts shall be of such size and character, and spaced and joined to sustain safely all assumed loads and to form a strong and stable structure adequate for the intended use.

11.3.2. --Anchorage. Where farm work buildings rest upon approved masonry foundations, they shall be anchored with 5/8-inch bolts spaced not more than 8 feet, or equivalent, securely anchored or embedded in the masonry. Each sill member shall contain not less than 3 anchor bolts, and there shall be a bolt within 12 inches of each end of each sill member. Bolts shall be embedded to a depth of 6 inches in concrete. In unit masonry, the depth shall be at least 15 inches, with a 2-inch round or equivalent washer bearing against the bolt head. A washer not less than 1-3/8 inches in diameter shall be placed between the nut and the sill. Sills of buildings resting on approved posts or pedestals shall be securely anchored.

11.3.3. --Framing. All framing members shall be adequate in size and grade for the assumed loads and shall be joined in conformance to standards of recognized good practice (18, 28, 29, and 30). Framing members shall be proportioned and spaced for the loads carried, including side pressures from stored grains. Where sloping rafters rest on lintels above doors, there shall be adequate provision for resisting horizontal as well as vertical components of the rafter thrust. Floor framing shall be securely tied to any exterior wall that it meets. Large unsupported expanses of exterior wall shall be stiffened against wind forces by means of suitable trusses, diaphragms, or equivalent constructions framed into the roof, floor, or adjoining walls, in accordance with recognized good practice (18, 28, 29, and 30).

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11.3.4. --Bracing. Diagonal bracing consisting of not less than 1- by 4-inch nominal boards or the equivalent shall be installed in each exterior wall and in curved roofs without interior supports except that bracing may be omitted on approval of the building official where walls are sheathed with plywood or lumber applied diagonally or the equivalent in strength and racking resistance. Knee bracing shall be provided at suitable intervals in joist or rafter systems, or at the intersection of major framing members as required for good construction (18, 29, and 30). All bracing shall be installed in accordance with recognized methods of good practice (18, 28, 29, and 30).

11.3.5. --Flooring. Flooring shall be designed and constructed to carry all assumed loads safely. Flooring under second-story driveways for implements or machinery shall be doubled, or equivalent means shall be provided for transferring concentrated loads to the joists.

11.3.6. --Condensation Control. Provision shall be made in livestock barns for control of water vapor condensation by any or all of the following: suitable ventilation, insulation, or vapor barriers, each in accordance with recognized good practice for climatic conditions (26). A vapor-barrier membrane (section 2.12.2) or equivalent covering or coating shall be applied to the lower surface of any floor separating ground-level quarters for livestock from an unheated mow or space above. Openings in such floors shall be similarly sealed during periods of low outside temperature.

12. AUXILIARY CONSTRUCTION

12.1. --General. Constructions of wood shall conform to recognized engineering principles and accepted good practice in design and fabrication. They shall conform to recognized safety standards (8). Structural materials or members required to sustain loads or transmit forces of definite magnitude shall be designed with the allowable stresses of section 3.3 with adjustments for duration of load (section 3.3.2) as approved by the building official.

12.2. --Wood Scaffolds. All wood scaffolds and their supports shall be designed and constructed in accordance with recognized good practice (8, pp. 49-66) to carry safely the assumed loads. Fastenings and bracing shall be adequate for lateral stability as well as for the vertical loadings. Lumber shall be of a grade giving adequate strength and stiffness for its use (section 2.5.4). Appropriate requirements for resistance to the spread of fire may be imposed by order of the building official on large scaffold structures.
Scaffold constructions shall be maintained in good condition and shall be inspected as necessary to assure their safety. Scaffolds shall not be used for storage of material except that being currently used, and they shall not be overloaded in any way.

12.3. --Concrete Forms.

12.3.1. --General. Concrete forms of wood or wood products shall be made of such materials and designed and fabricated to be tight and have adequate strength and rigidity for the loads or forces expected on them in use (22). Complete plans and specifications of formwork for concrete structures exceeding 6 feet in height, or structures involving unusually large masses of concrete or other special conditions may be required by the building official. If required, they shall be subject to detailed review and verification of their structural adequacy.

12.3.2. --Materials. Lumber used in concrete formwork shall be of a grade generally recognized as suitable for the intended purpose (35) or shall be shown to have been selected to be equivalent to such a recognized grade. Plywood shall be of a concrete-form type with sealed edges recommended by a recognized agency (13, 16). Hardboards or other wood-base materials shall conform to any applicable provisions in section 2.11.

12.3.3. --Design. All members or structural parts of concrete formwork shall be of such size and quality and framed, fastened, tied, and braced to safely sustain or transmit the assumed loads and forces. Assumed loadings shall include dead loads from the formwork and the concrete, any live loads from construction operations, wind, or other cause, and full hydrostatic pressures arising from the depth of concrete that may be placed during any hour of pouring. Allowable stresses may be increased for short-time loading not more than 25 percent above the allowable levels for long-time loading. Deflections of framing members under full load shall not exceed 1/270 of the length of the span. Formwork for horizontal beams or girders shall have suitable camber so that the beam or girder under full dead load will assume its proper position. Panels of formwork shall be of adequate strength and stiffness and shall be designed and constructed so that they can be handled and erected without structural damage. Fastenings of structural parts or members shall be in accordance with recognized good practice and with any applicable provisions of section 4.

12.3.4. --Support and Bracing. Adequate foundations and supports shall be provided for all concrete formwork of wood or wood products. Sufficient ties, braces, spreaders, wedges, or combination thereof, shall be provided to hold the forms in proper alinement against the weight or spreading action of the concrete or other forces assumed to come upon them.

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12.3.5. **Stripping.** Where concrete forms are partially stripped with some portions left for a longer time to support the weight of beams or slabs, care shall be taken that those remaining portions are adequate in strength and stiffness for the imposed loads.

12.3.6. **Reuse.** Lumber or wood products in concrete formwork may be reused in accordance with the provisions of section 2.3. Material shall be cleaned of any adhering concrete and recoiled as required to put it in suitable condition for reuse.

12.4. **Arch Centering.** Wood centering for the support of structural arches during construction shall be designed to carry the dead load of the centering and arch, any live loads incidental to construction operations, and wind or other loads as required. Foundations shall be adequate for the loads with a minimum of settlement. Provision shall be made for horizontal as well as vertical components of arch loadings and for temporary unbalanced loadings resulting from successive placements of portions of the arch material. Lagg ing supporting concrete arches shall be tight and shall be of sufficient thickness and quality and supported so that the weight of the concrete is safely carried. Provision shall be made for insertion of suitable wedges or other means for taking up elastic deflection or inelastic slip of joints as loads are applied, so that the fully loaded centering will be true to line and elevation. In removal of centering, provision shall be made by loosening of wedges or other means, for the transfer of load gradually from the centering to the arch without damaging impact effects. Centering plans and specifications for large arches shall be carefully checked by a structural engineer familiar with the requirements of construction of this type.

13. **DECAY AND INSECT PROTECTION**

13.1. **General.** Wood or other material consisting in whole or in part of cellulose shall have protection if subjected to the hazard of decay or to infestation by termites, beetles, or other wood borers. All wood buildings shall be subject to the applicable provisions of sections 13.2 to 13.7, inclusive, relating to building-site conditions, wood debris, garages and carports, moisture control, naturally durable woods, and preservative treatments. The provisions of section 13.8 on termites, section 13.9 on beetles, and section 13.10 on marine borers, may be waived where, in the judgment of the building official, there is no danger of attack. Lumber or other wood materials infested by insects shall not be used in building construction.

13.2. **Drainage of Building Site.** Adequate surface drainage shall be provided at all building sites by sloping the surface of the ground away from the
buildings at least 2 feet for dwellings and other small structures or 3 feet for larger structures. Crawl spaces shall be graded so that water does not drain into them. Downspouts shall discharge at the surface not closer than 2 feet from the building, or shall be connected to storm sewers, gutters, or cisterns at the same distance.

13.3. --Wood Debris. All stumps, wood, or other cellulose-containing debris shall be removed from the building site before construction is begun. Scraps of lumber or other wood debris shall not be buried or left about the building site or in crawl spaces when construction is completed. All grade stakes, spreader sticks, and form boards shall be removed as soon as they have served their purpose.

13.4. --Garages and Carports. Protective measures required for houses shall also apply to attached or detached garages and carports.

13.5. --Moisture Control.

13.5.1. --Wood Clearance. Wood parts such as girders shall be placed at least 12 inches above ground, so there is adequate ventilation. Joists shall be placed at least 18 inches above ground to permit access as well as provide sufficient ventilation. Distance of wood construction above ground around the outside of a building shall be not less than 6 inches. This distance shall be more if directed by the building official in cases of special hazard of decay or insect attack. Access doors or openings shall be provided to crawl spaces under buildings. Wood columns, piers, and posts in basements or crawl space areas, and exterior appendages shall bear on concrete or other approved bases, extending at least 6 inches above the dirt or a rough floor, or 3 inches above a finished floor in basements. There shall be at least 2 inches of clearance between wood skirting and the ground, or between wood fences and the building.

13.5.2. --Foundation Wall Vents. Vent openings in walls enclosing crawl spaces under buildings shall be well spaced around the perimeter and shall have a minimum net area equal to 1/150 of the enclosed area. Where the building site is relatively wet at frequent periods, the area of openings shall be appropriately increased. Vents shall be installed in accordance with accepted good practice (38) and shall not be placed where they are likely to become obstructed by shrubbery or other objects. Where soil covers complying with the provisions of section 13.5.3 are used, these requirements for ventilation may be appropriately reduced on approval by the building official.

13.5.3. --Soil Covers. Soil covers consisting of roll roofing weighing not less than 1/2 pound per square foot, or the equivalent in moisture proofing and
durability, shall be provided in crawl spaces under buildings where, in the judgment of the building official, the soils beneath are damp enough to require their use.

13.5.4. --Attic Ventilation. Attics or spaces under roofs shall be adequately ventilated by louvers, eave openings, or equivalent means, and protected by suitable screens (9, 38).

13.5.5. --Condensed Moisture. Construction shall be such that moisture condensed from the air will not form or drip on wood or other cellulose products. Water pipes located in basements shall be suspended away from contact with wood members.

13.5.6. --Flashing. Adequate flashing shall be used over doors and windows, around roof openings, or elsewhere to insure ready drainage of water and minimize its absorption by wood or wood products. Flashing shall also be installed where necessary to prevent moisture from penetrating to wood-frame construction behind masonry veneer or stucco.

13.5.7. --Waterproof Membrane. A sheathing paper or equivalent membrane meeting the requirements of section 2.12.1 shall be securely attached to a wood framework back of masonry veneer. A vapor-barrier paper or equivalent shall be laid on subflooring of the first story in crawl-space dwellings (section 8.5.1). A vapor-barrier paper or membrane (section 2.12.2) shall be placed on the lower side of concrete slabs on ground (9).

13.6. --Naturally Durable Woods. If naturally durable wood is relied upon as a means of protection, it shall be the heartwood of one of the decay-resistant species defined in section 1.1.2.

13.7. --Preservative Treatments for Decay and Insect Control.

13.7.1. --Treatment Requirements. Treatment for the preservation of wood products against damage by decay, common termites, or other wood borers shall be by a recognized method approved by the building official (37, pp. 399-428). Where wood or wood products are wetted for more than short periods, or are exposed in other ways to conditions that constitute a severe hazard of decay or termites, an approved pressure treatment (33, 37, pp. 399-428) shall be used. When a common termite hazard exists for wood above the treated material, one of the measures outlined in section 13.8 shall be required in addition to the preservative treatment.

13.7.2. --Paintability. Where treated wood is to be painted or will come into contact with finished materials, a paintable type of preservative treatment shall be used.

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13.7.3. --Retreatment of Cut Surfaces. Wood shall be completely framed before preservative treatment whenever possible, but when cutting after treatment is unavoidable, the cut surfaces shall be retreated by an approved method (37, pp. 399-428).

13.8. --Additional Means of Termite Control.

13.8.1. --Soil Poisoning. Soil treatments for control of termites shall be done with a poisonous chemical applied so that toxic effects to persons or to beneficial plant or animal life will not result from its use. The chemical shall have been found effective in service tests of 5 years or more. The amount of application shall be not less than that indicated by the service tests. The building official shall satisfy himself that proper provision has been made for renewal of the poison at intervals, as required.

13.8.2. --Foundations. All foundations shall be made impervious to termites. Skirting of wood or wood products surrounding crawl spaces shall be pressure treated with a suitable preservative and shall be kept clear of the ground. If unit masonry is used in foundations, it shall be capped with 4 inches of reinforced concrete, or other material providing an equivalent barrier without joints or cracks. Adequate termite shields of metal (31) unbroken or with tight joints capping the foundation shall be required where, in the opinion of the building official, their use is necessary.

13.8.3. --Porches. Porches, steps, and terraces shall be adequately insulated (31) from all other woodwork of buildings to prevent termites from gaining access by this means.

13.8.4. --Expansion Joints. Expansion joints, joints around anchors, openings around pipes and other penetrations of concrete slabs, concrete caps or termite shields shall be sealed with coal-tar pitch (roofing grade) or other acceptable resilient, noncellulose material.

13.9. --Beetles or Other Wood Borers. Where wood is exposed to the hazard of infestation by beetles or other terrestrial wood borers, it shall be adequately protected by recognized preservative treatments (37, pp. 386-393) or by other means approved by the building official.

13.10. --Marine Borers. Building foundations of wood that are exposed to borer attack in salt or brackish water shall be protected by tight sleeves or casings of metal, concrete, or the equivalent, or they shall be given a heavy pressure treatment with a suitable preservative (33). Those portions of wood members that are to be exposed to salt water shall not be cut or bored after treatment.
14. GLUED LAMINATED STRUCTURAL MEMBERS

14.1. — General. Glued laminated structural members shall be fabricated only where there are adequate facilities for accurate sizing and surfacing of boards, uniform application of glue, prompt assembly, and application of adequate pressure and temperature for setting and curing of the glue. Design and fabrication shall be in accordance with established engineering principles and recognized good practice (10, 15, 24, and 42). The manufacturer may be required to furnish the building official a recommendation for allowable stress and a specification showing grade and moisture content of lumber, types and locations of joints in laminations, kind and amount of glue spread, assembly pressure, time and temperature during curing, and other details of materials and fabrication that may affect the quality of the finished product. All operations of manufacture and fabrication shall be open to inspection by the building official or his authorized representative.

14.2. — Design. The design of glued laminated wood structural members shall be in accordance with established engineering principles and shall take into consideration the species and grade or grades of lumber used, distribution of knots, type and location of end joints in laminations, depth of beams, curvature of arches, and moisture content expected in service (37, pp. 247-263). Beams for spans greater than 24 feet shall be designed with a camber of one and one-half times the dead-load deflection, or the equivalent as directed by the building official.

14.3. — Materials. Lumber used in laminations shall not contain decay, knots, or other characteristics affecting strength in excess of the size or amount permitted by the manufacturer's specification. The moisture content shall approach as nearly as practicable that expected in service and shall in no case exceed 16 percent at the time of gluing. Moisture contents of individual laminations in a structural member shall not differ by more than 5 percent at the time of gluing. Lumber at the time of gluing shall have a true and even surface with uniform thickness to insure satisfactory glue spread and distribution of pressure during the setting period. Glue shall be of a type suitable for the intended service of the structural member and shall conform to the applicable provisions of section 2.8.

14.4. — Fabrication. All equipment and operations of scarfing, glue spread, assembly, pressing, curing, or any other processes in connection with the fabrication of glued laminated structural members shall be in accordance with recognized good practice and shall be types that assure a well-bonded and well-finished member of true size and shape according to the specification (15).
14.5. --Preservative Treatment. Where fire-retardant treatments or preservative treatments against decay are applied to a glued laminated structural member, due consideration shall be given to the effect of the treatment upon the glued joints, particularly where water-borne chemicals are used. Where preservative treatments are applied to individual laminations before gluing, care shall be taken that the surfaces to be glued are left true to line and contour, free from objectionable deposits that may impair adhesion or proper setting of the glue, and at a suitable moisture content for gluing (15). Glued members shall not be subjected in treatment to conditions of high moisture or high temperature that may impair their strength or the integrity or durability of the glued joints.

15. STRUCTURAL SANDWICHES

15.1. --General. Sandwiches used as structural elements in building construction shall be adequately designed for their intended service and shall be manufactured or fabricated only where there are adequate facilities for gluing or otherwise bonding cores to facings to insure a strong and durable product (37, pp. 291-298). The manufacturer or fabricator may be required to furnish to the building official a specification showing types and properties of core and facing materials, nature of the bonding medium, strength, stiffness, fire resistance, insulating properties and recommendations as to the conditions of service for which they are suitable. All operations of manufacture and fabrication shall be open to inspection by the building official or his authorized representative.

15.2. --Cores. Sandwich cores shall be of such character and thickness as to give the required lateral support to stressed facings and to sustain or transmit the assumed loads or stresses. Where insulating or fire-resisting properties are required, the cores shall be adequate in that respect. They shall be of material that resists the effects of decay or of exposure to the expected temperatures or moisture conditions, or they shall be treated to make them resistant. And, they shall maintain the required strength and durability under the conditions of service for which their use is recommended.

15.3. --Facings. Facings shall have sufficient strength and rigidity to resist stresses that may come upon them when fabricated into a sandwich construction, and they shall be thick enough to resist puncture or denting that may be expected in normal usage. Facings in exterior service or under exposures of equivalent severity shall be of such material or shall be coated or otherwise treated to be dimensionally stable and durable under the expected conditions.
15.4. --Fabrication. In the fabrication of structural sandwiches, care shall be taken that surfaces of cores and facings to be joined shall be true and even and shall be cleaned or otherwise conditioned to permit satisfactory adhesion. Cores of wood or wood-base materials shall not be exposed to destructively high temperatures in bonding to metal facings.

15.5. --Tests. Panels of sandwich construction shall be subject to testing of representative samples if ordered by the building official to verify properties or specifications. Tests shall be performed by recognized methods (2) and shall include, as applicable, one or more of the following: edgewise compression, flatwise compression, transverse bending strength and stiffness, racking, shear in the flatwise plane, dimensional stability with moisture or temperature changes, and resistance to penetration or spread of fire.

16. PREFABRICATED PANELS

16.1. --General.

16.1.1. --Scope. The provisions of this section shall apply to the design and construction of premanufactured or prefabricated sections of floors, walls, roofs, or equivalent parts in building construction which is not of conventional light-frame construction as specified in section 8. This section shall apply to prefabrication, whether at a manufacturing plant, on or near the building site, or at some intermediate point. Structural sandwiches used as building panels shall be designed and constructed in accordance with the provisions of section 15.

16.1.2. --General Provisions. The design, materials, and workmanship of prefabricated panels of wood or wood products shall be of types that will result in a structurally sound and stable product with adequate strength, rigidity, and insulating and fire-resisting properties for its intended use. All manufacturing operations, whether in a manufacturing plant, at the building site, or elsewhere, shall be subject to inspection by the building official or his authorized representative. The building official may require the prefabricator to furnish a complete plan and specification showing size and nature of all parts, methods of joining or fastening, recommended loadings and conditions of service, or any other factors that may affect the safety and serviceability of the product. Where prefabricated panels are not susceptible to structural analysis by established procedures, the manufacturer shall furnish data from laboratory tests by standard methods (2) to verify the essential structural properties.
16.2. --Design. Prefabricated panels shall be designed in accordance with recognized engineering methods, taking into account requirements for insulation against moisture and extremes of temperature as well as structural strength, stiffness, and stability (36, pp. 211-241). Flat panels shall not be considered as having stressed facings if the thickness of framing members is not at least twice the thickness of either cover, unless prescribed requirements for proportioning thickness of facing to distance between framing members are met, and unless facings are bonded to frames with glue or other means that fully prevent relative movements of the joined parts throughout the expected service life. Allowable plywood stresses for use in determining working loads on panels with stressed plywood facings shall be in accordance with the provisions of section 3.3.6. Openings in panels shall be adequately reinforced in accordance with the requirements of their intended use.

16.3. --Tests. Panels shall be subject to testing of representative samples if ordered by the building official to verify the structural properties. Structural tests shall be performed by recognized methods (2) and shall include, as applicable, one or more of the following: edgewise compression, edgewise tension (if tensile load is to be applied in service), transverse bending, concentrated load, impact load, and racking load.

16.4. --Joints and Fastenings.

16.4.1. --Fastenings Within Panels. Joints and fastenings of the various parts composing a prefabricated wood or wood-base panel shall be in accordance with the applicable provisions of section 4. Glues shall conform to the requirements of section 2.8.

16.4.2. --Fastenings Between Panels. Joints and fastenings between prefabricated panels shall be adequate to sustain or transmit the assumed loads or forces and in addition shall be weathertight and have satisfactory insulating properties (36, pp. 230-235). Each joint between panels shall be supported by framing members or fastenings of such nature that the joint will retain its alignment and tightness for its expected service life. Bolts or other parts used in joining panels shall not be of such nature or so located as to cause excessive transmission of heat under the temperature conditions in which the panel is used. Fastenings of panels to floors or foundations shall furnish adequate anchorage against overturning from wind or other horizontal forces. Fastening of roof panels to walls shall be adequate to resist the assumed horizontal and uplift forces from wind and thrust from a sloping roof as well as forces acting downward.

16.4.3. --Tolerance in Dimensions. Prefabricated panels or the parts thereof shall be cut and finished to tolerances that will insure proper mating of parts.
or joining of panels, giving due consideration to the shrinkage characteristics of wood in the longitudinal, radial, and tangential directions. Surfaces to be glued shall be finished to a tolerance of 1/64 inch.

16.5. --Fabrication of Panels. All prefabricated panels, whether made in a manufacturing plant or at the building site, shall be fabricated in accordance with recognized good practice (36, pp. 241-281). Moisture contents of parts shall be as near as practicable to the conditions expected in service. Jigs used in the assembly of the parts shall be made to insure proper fitting and shall be inspected and maintained in good condition throughout their use. All insulation, vapor barriers, or fixtures that will be concealed in the interior of panels shall be carefully installed in accordance with the requirements of use of the respective parts. Installation of concealed parts shall be subject to inspection by the building official or his authorized representative before facings of the panels are placed. Facings shall be carefully placed and securely fastened in accordance with the requirements of their structural functions. Stressed facings shall be secured to frames or cores by glue or other means that fully prevents relative movement of the joined parts throughout the expected service life. Pressure for the setting of glues that join the parts of prefabricated panels may be furnished by presses or clamps, or by nailing if nails are adequate in kind and number to insure intimate contact in all parts of the glued surfaces. Preservative or fire-retardant treatments or coatings shall be applied by recognized methods and in accordance with the applicable provisions of section 2.15 of these code requirements.

16.6. --Storage and Shipment. Care shall be taken to protect prefabricated panels against damage during storage and shipment. Glued panels shall not be highly stressed in handling before glues are fully set. Where wood or wood-base panels are stored at the building site or elsewhere, they shall be protected from rain, snow, or ground moisture that may cause swelling of seasoned parts or otherwise impair the panel's serviceability.

16.7. --Assembly and Erection. The assembly and erection of prefabricated panels shall be in accordance with accepted good practices (36, pp. 281-293). Foundations or platforms for structures shall be finished to a true and even surface that will permit close fitting and satisfactory fastening of the panels. Large panels shall be securely braced during erection to prevent damage from wind or other forces. Joints between panels shall be well drawn together to insure strength and weather tightness. Caulking of joints after panel erection or an equivalent method of sealing shall be employed where necessary. Panels or parts thereof shall not be damaged by over tightening joints or forcing poorly matched mating parts.
17. WOOD DIAPHRAGMS AND HORIZONTAL BRACING SYSTEMS

17.1. --General. The provisions of this section are applicable where special wood constructions are used for resistance to horizontal forces from winds, earthquake, blast, or other cause. Such construction may take the form of bracing systems, horizontal diaphragms, vertical diaphragms, or any combination thereof. Such construction is used to resist static or dynamic horizontal forces and to transmit them through the foundations to the earth without damage to the structure. All construction for this purpose shall be designed according to sound engineering principles and built in accordance with accepted good practices (27, pp. 139-141 and 313-316). Provision shall be made for adequate foundation anchorage to resist the assumed sliding, uplift, or overturning moment. Where bracing systems or horizontal diaphragms are not symmetrical with respect to the center of mass of the structure, possible unbalanced loadings and rotational effects in a horizontal plane shall be considered in connection with earthquake loadings.

17.2. --Bracing Systems. Bracing systems shall consist of rods, struts, stiffening trusses or girders, or any combination of these or other elements to accomplish the desired purpose. Wood girders or trusses for stiffening large expanses of wall against wind or other forces shall conform to the applicable provisions of sections 5 or 18. Where bracing systems are applied horizontally, consideration shall be given to stresses from vertical forces caused by the weight of the construction or of loads that may be placed upon it. Braces shall be preferably designed to act only in tension, or, if this is not possible, long slender braces shall be adequately stiffened against buckling from the combination of axial compressive loads and the transverse loading because of the weight of the construction. Where wood struts or tension members may become loosened by changes in dimension from a change in moisture content or other cause, provision shall be made for tightening as required.

17.3. --Horizontal Diaphragms. Horizontal diaphragms of wood or plywood shall be designed and constructed for strength and stiffness to resist the assumed horizontal forces and to transmit those forces to the walls without exceeding the permissible deflections or deformations of any attached structural elements. Floors, ceilings, or roofs, if meeting this requirement, may be considered as horizontal diaphragms. Any such horizontal diaphragm shall be designed and supported to maintain its original plane or shape and to offer the required resistance to the assumed horizontal forces under all expected conditions of dead or live vertical loading. Individual parts of horizontal diaphragms may be joined by gluing or with mechanical fastenings. Where nails or other mechanical fastenings are used, consideration shall be
given to any loosening that may result from seasoning of the wood in service, so that the required stiffness is maintained. Special stiffening constructions around the edges of horizontal diaphragms shall be adequately designed and built to perform their intended function. Where the strength and stiffness of a diaphragm cannot be shown by ordinary structural analysis, the building official may require loading tests of one or more representative constructions under moisture conditions related to those expected in service. In such tests, loading shall preferably be uniformly distributed along the edge of the diaphragm, or it shall be applied at enough points and so spaced as to give a reasonable approximation to uniform loading.

17.4. --Vertical Diaphragms. Vertical diaphragms of wood or plywood shall be designed and constructed for strength and stiffness to resist horizontal forces applied to them and to transmit those forces without excessive deformation to the foundations of the structure. The walls of a building, if meeting this requirement, may be considered as vertical diaphragms. Individual parts of vertical diaphragms may be joined by gluing or with mechanical fastenings. Where nails or other mechanical fastenings are used, consideration shall be given to any loosening that may result from seasoning of the wood in service, so that the required stiffness is maintained. Where the strength and stiffness of a vertical diaphragm cannot be shown by ordinary structural analysis or reference to acceptable racking test data, the building official may require racking tests by recognized methods (2) on one or more representative constructions under moisture contents related to those expected in service. Performance in such racking tests shall be as required in section 24.

17.5. --Fastenings. Fastenings of all bracing systems or diaphragms shall comply with the requirements of section 4 and shall be adequate to transmit the assumed loadings to the adjacent structural elements without excessive slip or deformation. Foundation anchorages shall be adequate to resist sliding, uplifting, or overturning from the assumed horizontal forces. Provision shall be made for tightening of fastenings that may loosen as a result of seasoning of the wood in service or from other cause.
18. WOOD TRUSSES

18.1. --General. Trusses or trussed rafters using wood or structural wood products shall be designed and built according to recognized engineering methods (23, 27). Shapes and proportions shall be types that will produce a sound and stable structure in accordance with standard engineering practice. Materials shall comply with the applicable provisions of section 2. All members shall be adequate in strength and stiffness for all dead or live loads that are assumed to come upon them. Joints and fastenings shall contain adequate connecting devices, located and spaced in accordance with standard practice (section 4). The design shall be checked for the effect of secondary stresses that may result from slip of joints or deflection of the truss under load. Trusses placed in an inclined or a horizontal plane shall be suitably supported or designed for lateral stresses resulting from their own weight. Truss members composed of two or more parallel or spaced pieces shall be framed so that proper distribution of load and unit action among pieces under stress is assured. The building official may require from the designer a complete plan and specification, showing stress analysis for dead and live loads, size and grade of members, or any other particulars that may affect the strength and safety of the truss.

18.2. --Application of Loads. Concentrated loads from sources outside the truss shall be applied only at panel points or joints of a truss. Roof, ceiling, or other uniformly distributed loads may be applied between panel points of upper or lower chord members if it is shown that all such loads are fully considered in the design of the truss as a whole and that flexural strength of chord members is adequate. Where chord members are subjected to combined flexural and direct stresses, they shall be designed in accordance with the principles of section 7.4. In the design of chord members for flexural stress or stiffness, no fixity or transmission of moment at panel points shall be assumed, unless the chord is actually continuous and unspliced at the panel point. Where loads from canopies or other appendages are eccentrically hung from a truss, there shall be full provision for resisting the resulting torsional forces on the truss.

18.3. --Support of Trusses. All wood trusses shall have adequate bearing without overstressing at points of vertical support. Sufficient lateral support or bracing shall be provided to restrain effectively all horizontal movements in either transverse or longitudinal directions. Any bearing area on wood at the end of a truss may be entirely on end grain or on side grain, but not partly on end and partly on side grain. A moisture seal approved by the building official shall be placed on any bearing of wood on masonry. Where the bearing is on a recess in masonry, an air space of 2 inches shall be provided at the sides and the end of the truss.
18.4. --Camber and Deflection. All wood trusses having horizontal upper or
lower chords shall be fabricated with camber determined from the formula

\[ D = \frac{0.000032L^3 + KL^2}{H} \]

in which \( D \) is the camber in inches, \( L \) is the span of the truss in feet, \( H \) is
the midspan height of the truss in feet, and \( K \) is a constant with a value of
0.0028 for trusses with splices in the upper chord and 0.00063 for bowstring
or other trusses with a continuous upper chord. In any truss, the design of
joints and fastenings shall be such that inelastic slip of joints under full load
is minimized and excessive deflection is prevented. The design of flat-
topped roof trusses shall be such that deflections under load will not cause
water to be ponded on the roof, except where, upon approval by the building
official, provision is made for such ponding for cooling or other purpose.

18.5. --Compression Members. Upper chords or other compression mem-
bers of wood trusses, whether single, built up, spaced, or glued laminated,
shall conform to accepted principles for column design (section 6). Com-
pression members shall be designed for stability against buckling either
parallel or perpendicular to the plane of the truss. Curved compression
members shall be adequate for the combined stresses of compression and of
bending resulting from the curvature. Where cuts are made for connectors
or for other purposes, care shall be taken that the net cross section is ade-
quate for the compression load. Consideration may be given to lateral sup-
port of upper chords from roof joists or sheathing if of such nature and so
framed or fastened to the chord as to provide the required support.

18.6. --Tension Members. Tension members shall be designed and construc-
ted so that the net cross section is adequate at all points where cuts are made
for connectors or other purposes.

18.7. --Joints and Splices. Joints in which one member bears on the side or
at an angle to another member shall be proportioned and fitted so that full
bearing is obtained and allowable stresses (section 7.3) are not exceeded.
Members of multiple-member trusses shall be of such thickness and so fitted
that all connectors in the joints will have adequate bearing. Eccentric or
unbalanced joints shall be avoided wherever possible. Where such joints are
unavoidable, the moments or other effects from eccentricity or unbalance
shall be fully considered in the design (27). All splices of spaced chord
members shall be securely blocked to retain their alinement and act as a
unit under load. Nailed joints or splices shall not be used on lumber more
than 2 inches thick. Where seasoning of lumber will take place after the
truss is assembled, the effects of the resulting shrinkage on the joint shall
be provided for by increased end distances, stitch bolting, or otherwise, as
directed by the building official.
18.8. --Glued Trusses. Glued wood trusses may be used for light-frame construction providing that good practices in gluing (37, pp. 233-245) are observed. Glues shall comply with the requirements of section 2.8. Glued joint connections of members meeting at an angle shall be made through the medium of plywood gusset plates. Splice plates for gluing to members in line shall be of wood with grain parallel to the members. Adequate nailing may be used to provide the required pressure while the glue sets. Glued trusses shall not be used in situations where the moisture content of wood is subject to repeated variations exceeding about 5 percent.

18.9. --Trussed Beams. Where wood beams are strengthened by trussing with tension rods, the effects of combined flexural and compressive stresses thus induced on the beam shall be fully considered in the design (section 7.4). Struts between the beam and the tension rod or rods shall have adequate bearing area on both the beam and the rod. Where steel tension rods bear on the end or inclined surface of the beam, sufficient bearing area shall be provided by washers or other means so that allowable compression stresses are not exceeded (section 7.3).

18.10. --Fabrication and Assembly. Truss members shall be marked by template or carefully laid out on a flat surface for marking of bolt holes, connector grooves, daps, or other cuts. The layout for cutting shall be in the cambered position of the truss. Holes or grooves for connector joints shall be located within a tolerance of 1/32 inch. Daps or cuts for direct bearing of members shall be cut and fitted to a tolerance of 1/64 inch. Mating surfaces of members joined with connectors shall be surfaced to insure full contact of the connectors. Tension rods and all bolts or screws in joints shall be well tightened, but not overtightened to an extent that will result in excessive mashing of the wood under bolt heads or washers. Fabrication of glued material in trusses shall conform to recognized standards of good practice (37, pp. 233-245). Wood truss materials stored out-of-doors shall be protected from rain, snow, ground moisture, or other causes of deterioration. All end cuts of truss members shall receive an application of sealer approved by the building official, to reduce subsequent moisture changes.

18.11. --Erection. Trusses shall be erected in accordance with accepted good practice avoiding overstress or other damage in handling. The suspension of trusses during erection shall be such that damage from reversal of design stresses will not result. Particular attention shall be paid to compression joints that may be subjected to tension during erection. Slings for hoisting shall be of rope, or if wire or wire rope is used, the truss member shall be protected by blocks from excessive cutting by the sling. Due safety precautions (8) shall be observed during hoisting of large or heavy truss units to elevated positions.
18.12. -- Anchorage. Trusses shall be securely anchored at points of support or elsewhere against tipping or displacement under any assumed horizontal forces or uplift from wind or other cause. Temporary bracing or anchorage shall be provided during erection and until the permanent construction is installed.

19. ARCHES AND RIGID FRAMES

19.1. -- General. Wood arches or rigid frames shall be designed and built in accordance with accepted structural engineering principles to resist the assumed loads including horizontal forces from wind or earthquake and unbalanced vertical loadings (27). Working stresses shall be determined in accordance with the applicable provisions of section 3.3. The building official may require a complete plan and specification of any arch or rigid frame that shows load assumptions and allowable stresses employed, character and grades of material used, details of all structural parts and fabricating operations, recommended loadings and conditions of use, and any other particulars that may affect the strength and safety of the arch or frame.

19.2. -- Trussed Arches. Trussed arches fabricated of wood shall conform to the applicable provisions of section 18 on wood trusses. Calculation of stresses shall take into account any secondary stresses that may develop as a result of deformation of the wood or slip of its joints and fastenings under load. Adequate lateral bracing shall be provided at both the upper and lower chords of trussed arches.

19.3. -- Segmented Arches. Vertically laminated arches composed of mechanically joined longitudinal segments of wood may be used upon approval of the building official and upon showing that they are structurally sound and stable. All segments shall extend through the full effective depth of the cross section of the arch. All transverse joints shall be so located and spaced that the net unjointed section at any point in the arch will be adequate for the assumed loads. Transverse joints in adjacent laminations shall be spaced not less than 16 inches. Calculation of stresses shall take into account any secondary stresses that may develop as a result of deformation of the wood or slip in the joints. Segments shall be well nailed (18, 28, 29, and 30) or otherwise securely fastened to act together under load. Where arches are of such depth or so loaded that the roof deck does not provide sufficient lateral support, additional bracing between arches shall be used. Where the design of the arch is not susceptible to structural analysis of strength and stiffness, the building official may require load tests of one or more representative arches at a moisture content related to that expected in service.
19.4. --Glued Laminated Arches. The design and fabrication of glued laminated arches shall be in accordance with engineering principles and recognized good practice (15, 37, pp. 233-263) and with the provisions of section 14 of these code requirements. Full consideration shall be given to effects of curvature upon the strength properties. Tapered sections shall be designed and fabricated in accordance with recognized methods (15). All operations of manufacture shall be open to inspection by the building official or his authorized representative. Glued laminated curved roof rafters shall be not less than 1-1/2 inches in actual thickness, and the depth of cross section shall not exceed 5 times the thickness.

19.5. --Rigid Frames. No member supporting or framing a roof shall be considered to be a rigid frame unless the component parts are joined by glue to fully prevent relative movement of the joined parts throughout their expected service life. Glued laminated portions of rigid frames shall conform to the requirements of section 14. Plywood stresses shall be in accordance with section 3.3.6. Where members are bent around a knee joint, consideration shall be given to effects of curvature upon the strength properties (15). Tapered sections shall be designed and fabricated in accordance with recognized methods (15). All operations of manufacture shall be open to inspection by the building official or his authorized representative.

19.6. --Erection. Arches and rigid frames of wood shall preferably be assembled in a flatwise position and hoisted into place as a unit; where this is impractical, adequate falsework (section 12.4) shall be provided.

20. LAMELLA ROOFS

20.1. --General. Lamella roofs of wood shall be designed and built in accordance with recognized engineering principles and good practice (27). The design shall be based on the same balanced or unbalanced assumed load distributions that are used for roof arches. Full consideration shall be given to the effects on stress from deformation or slip of the lamella joints under load. Eccentricity of thrust at each lamella joint shall be adequately resisted by the moment of inertia in the unspliced lamella, by the roof sheathing, or by both. Thrust components in both transverse and longitudinal directions of the building because of skewness of the lamella arches shall be adequately resisted by suitable transverse and longitudinal tie rods or by other approved means. The longitudinal component of thrust may be designed to be taken by the roof sheathing or by the roof sills. Fastening of all tie rods, sheathing, or sills to the lamella arch system shall be adequate for the forces to be transmitted. End arches shall be designed to
transmit thrust and resist shear from those lamellas that terminate thereon (23). The designer may be required to furnish to the building official a complete plan and specification, with stress analysis clearly indicating the load and design assumptions employed.

20.2. --Lamellas. Wood lamellas shall be of a grade of lumber that is adequate in strength and stiffness to sustain the assumed loads and forces, including thrust from vertical or horizontal loadings and bending moments from eccentricity of the splices. Lamellas shall be seasoned before use to a moisture content approximating that which they will reach in service; except that the building official may approve the use of unseasoned lamellas on showing that proper provision has been made for tightening of joints and that shortening of the arch due to possible slippage has been taken into account in the design. Lamella splices or joints shall be proportioned so that allowable stresses at bearing of the spliced lamella on the unspliced lamella or bearing under the heads or washers of splice bolts are not exceeded.

20.3. --Construction. All lamella joints shall be accurately cut and fitted to give full bearing without excessive deformation or slip. Bolts at lamella splices shall be adequate to hold the members in their proper position and shall not be overtightened to cause bending of the lamellas or mashing of wood under the bolt heads. Connections of lamellas to end arches shall be adequate to transmit the thrust or other forces. Sufficient falsework shall be provided for the support of lamella roofs during construction operations.

21. MISCELLANEOUS CONSTRUCTION

21.1. --General. Where towers, signs, display structures, marquees, or other structural appurtenances are of wood construction, they shall be designed and built in accordance with sound engineering principles and recognized good practice (27). The design shall take into account wind and any other loads that are assumed to come upon the structure. Wood columns in towers supporting tanks or other loads shall be of such proportions and so stayed and braced that they resist displacement or buckling under the anticipated horizontal or vertical loads. Construction or erection operations shall be carried on in a manner that will not cause damage to the special construction or to the building to which it is applied, or hazard to the safety of persons constructing or using the building. The building official may require the builder to furnish complete plans and specifications, indicating load assumption and stress analysis employed, size and character of all structural members, and any other particulars that may affect the stability or safety of the structure.
21.2. --Wood Ladders. Wood ladders shall be made of such materials
and so proportioned and joined that they are structurally safe for their
intended loadings (6). Wood ladders shall be used at their intended pitch
(6). Ladders shall be maintained in good condition and, when not in use,
shall be stored in a dry ventilated place and not exposed to excessive
heat or dampness. Periodic detailed inspection of ladders shall be made
to insure that they are in good condition and safe for use. Ladders shall
not be overloaded or used for purposes or in ways for which they were
not designed (6).

22. LOG CONSTRUCTION

22.1. --Logs. Logs used in log building construction shall be free of ex-
cessive sweep or taper and shall be peeled free of all bark. As much
seasoning as is practicable shall be attained before construction, to mini-
mize subsequent shrinkage in the walls.

22.2. --Log Walls. Logs for horizontal-log walls shall be not less than
6 inches in diameter and shall be fitted and laid with tenon, saddle, or
other corner framing to provide adequate strength and rigidity. Logs
shall not be in contact with the ground unless pressure treated, but they
shall be laid on masonry or other approved foundations. Notching or fit-
ting where one log rests on another shall be done so that notches or cuts
will be self-draining to minimize retention of moisture. Vertical pins
through adjacent logs may be required by the building official for log
structures of large size or in logs adjoining wall openings. All cutting
and fitting of logs in walls shall be done in accordance with recognized
good practice (14).

22.3. --Wall Openings. The framing of openings in horizontal-log walls
shall include vertical splines not less than 1-1/2 by 1-1/2 inches in size,
or equivalent members so framed into the wall logs that they prevent
horizontal displacement but permit vertical settlement as the logs shrink.
Such members shall not be nailed to the logs. The first log above a wall
opening shall have suitable space (14) above the framing of the opening
so that, as the wall settles from shrinkage, the space may close up with-
out causing the wall logs to become separated. Fireplaces and chimneys
shall be based and constructed independently from log walls to permit
settlement of the latter without impairing the integrity of the structure.

22.4. --Partitions. Partitions shall be vertically splined or otherwise
suitably framed into horizontal-log walls but shall not be nailed or spiked
thereto. Space above partitions for settlement of the walls shall be left
as required in section 22.3 for wall openings.

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22.5.--Joists, Rafters, and Purlins. Log joists, rafters, or purlins shall be of a size necessary to support the imposed loads (see section 5.7.1 for form factor of round beams), but in no instance shall joists be less than 4 inches or rafters less than 3 inches in diameter.

22.6.--Palisade Construction. Log slabs or sections of logs used in a vertical position in so-called palisade construction shall be not less than 2 inches in average thickness and not less than 4 inches wide. They shall be peeled free of all bark. They shall be securely spiked to a foundation sill that is not less than 1-5/8 inches in actual thickness. Splines or tongues between logs shall be at least 3/8 inch thick, projecting not less than 1/2 inch and fitting snugly into the groove of the adjacent member. A top plate made up of not less than two 2- by 6-inch (nominal) pieces or the equivalent shall be securely spiked into the upper ends of the logs. Walls of palisade construction shall be provided with diagonal bracing of a type approved by the building official but not less than that required for conventional light-frame construction in section 8.6.4.

23. POLE FRAMING (NONRESIDENTIAL)

23.1.--General. Walls of nonresidential wood buildings may be framed with wood poles set in the ground provided that the poles are of adequate size and quality, pressure treated for preservation against decay, and set in the ground in such a way that they resist the assumed vertical and horizontal forces, and provided that other elements of the structure are securely fastened to the poles.

23.2.--Poles. Poles for building framing shall be of American Standard (7) or equivalent grade and shall be essentially straight and of uniform taper. All poles shall be pressure treated by an approved method (37, pp. 399-428) for preservation against decay. All cuts or gains for fastenings shall be made before treatment, or if cutting after treatment is unavoidable, the cut surfaces shall be given two brush coats of a suitable preservative. No cuts after treatment shall be made below groundline or in the first 3 feet above the groundline of the pole. Poles shall have a top diameter of not less than 4 inches, or more if necessary, to receive and properly hold the required fastenings to other structural members.

23.3.--Allowable Stresses. The sum of all stresses from the assumed vertical and horizontal forces at any point on poles meeting the requirements of section 23.2 shall not exceed one-fourth of the American Standard (7) fiber-stress value.
23.4. --Fastenings. Fastenings of poles to other structural members shall meet the applicable requirements of section 4. Poles where connector fastenings are to be applied shall be framed or gained to a flat surface not less than 2 inches wide, except that such gaining is not required where fastenings designed for application to curved surfaces are used.

23.5. --Setting. Poles for building framing shall be set in the ground to a sufficient depth, and the ground shall be tamped or otherwise stabilized as necessary to resist the assumed horizontal forces from wind or other causes without damage or excessive deformation to the structure. Poles extending 16 feet or more above ground shall be set to a depth of not less than 4 feet. The diameter of the hole shall be enough larger than the butt diameter of the pole to permit proper tamping to ensure side bearing. In constructing a building, the poles shall first be set loosely, cross-framing members shall be applied, and the whole structure plumbed, after which filling and tamping around the poles shall be completed. Pads or footings of crushed stone, concrete, or the equivalent shall be placed under the butts of poles in soft soils or where especially heavy vertical loads are to be supported, if the building official requires.

24. STRUCTURAL PERFORMANCE TESTING

24.1. --General. Tests of wood structural members or elements shall be conducted by approved methods. Loading shall simulate as nearly as practical the actual loadings expected in service. In all tests, the design load shall be applied and significant deformations read, the load shall be removed, and observations of residual deformations made. Two and one-quarter times the design load shall then be applied, the deformations read, and the load shall be removed and observations of set made. Observations for damage or structural failure shall be made during and after each load application. The time of application of design load or any multiple thereof shall be not less than 5 minutes. Holding of load for 24 hours or more, testing to failure, or other special load applications may be required by the building official to meet the needs of special service uses. The building official or his authorized representative shall be given the opportunity to witness all performance tests. If the tested member or element is to be placed in service, care shall be taken that incipient failures resulting from the test do not seriously affect its serviceability.

24.2. --Required Performance. Performance requirements in load testing shall be as specified in standard test methods. In the absence of such standards, the general requirements shall be as follows: Design load
shall cause neither structural damage nor deformation in excess of the usual limitations (41). Two and one-quarter times design load shall cause only minor structural damage, and the deformation shall not be enough to cause damage to other elements or to members to be attached in the building. The residual deformation after removal of two and one-quarter times design load shall not be such that it seriously impairs the serviceability of the member or element or of the building in which it is to be used.

24.3.--Tests of Panels. Floor, wall, ceiling, or roof panels shall be tested by standard methods (2). Performance shall be in accordance with commonly accepted performance requirements (41). The kind or kinds of tests and the number required shall be as specified by the building official, taking into account the information required and the properties that are important in the intended use (41).

24.4.--Tests of Beams. Load testing of wood beams or girders shall be done with end supports and under load either uniformly distributed or applied at two points not less than one-third of the span length apart, except that other loading conditions may be specified for special types or uses of the members tested. Deflections shall be observed at the midpoint of the span or wherever else maximum deflection may occur.

Deep or narrow beams to be used without lateral support shall be examined for lateral stability while under load by applying a force to cause a small lateral deflection and observing if the beam returns quickly to its original shape when that force is removed.

24.5.--Tests of Trusses. Load shall be applied to test trusses in a manner to cause not only axial stresses in the members, but also bending stresses representing the effects of roof loadings on upper chords or ceiling loadings on lower chords, where applicable. Test trusses shall be given lateral support comparable to that which they will receive in service. Deflections of trusses shall be observed at midspan and at any other points that may be made necessary from the expected conditions of use.

24.6.--Tests of Columns. Provision shall be made in tests of long columns, by initial small eccentricity of load, initial small deflections, or other means to assure that the sustained load on the column does not exceed the Euler load.

24.7.--Models. Model testing may be permitted only on approval by the building official and subject to the provisions of this section. Models of one-piece structural members or of built-up members whose parts are joined by gluing shall be scaled to the full-size members by recognized

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principles of engineering mechanics (19); results from model tests of built-up members joined by mechanical fastenings shall not be accepted. Loadings shall be scaled to those on full-size members by recognized engineering principles (19). The scale used shall be such that no wood parts are less than 3/4 inch in any dimension. Natural characteristics, such as knots shall be scaled in the model as nearly as possible to the scale of the sizes of parts or members.

25. INSPECTION OF WOOD BUILDINGS

25.1. --Structural Materials. The inspection of wood or wood-base materials in the structural parts of buildings shall include observations of species and grade, estimation of present or probable moisture contents and temperatures, examination for decay or insect damage, evidence of chemical or thermal deterioration, and any other particulars that may affect structural strength and stability (27 and 43). Heavily loaded wood or wood-base structural members shall be inspected as to their adequacy for the strength requirements of their use. Evidence of possible overloading or of incipient failure in misshapen, distorted, or sagged members shall be considered. Glued members shall be inspected for possible delaminated areas or separated glue joints. Treated material shall be examined for untreated areas or zones that may have become exposed in service.

25.2. --Joints and Fastenings. All joints and fastenings of wood members shall be examined for their present condition, with attention to alinement, tightness, or other particulars that affect their strength and rigidity. Metal parts shall be inspected for rusting that may have reduced seriously their strength or caused deterioration of the adjacent wood. Joints designed for fastening with connectors may be loosened for examination or probed, if there is reason to suspect that connectors have been omitted.

25.3. --Decay. Bases of columns, construction near the ground, or any other points where moisture may collect and remain on wood or wood-base materials shall be carefully examined for evidence of decay (37, pp. 381-398)(31). Any exposed joints or interstices shall be given particular attention. Inspection may be aided by sounding or probing, if necessary.

25.4. --Insect Damage. All wood or wood-base material in buildings shall be examined as required by the building official for evidence of damage to structural parts by termites or other insects or borers (31). Examination may be aided by sounding, probing, or removal of concealing parts, as necessary.
26. MAINTENANCE AND REPAIR

26.1. --Trash and Waste. Piles of trash or wood waste shall not be allowed to accumulate where their presence may cause a fire hazard, or where they may afford contact with the ground for entrance of decay or termites to the structural parts of wood buildings.

26.2. --Coatings. Where paint, sealers, or preservative coatings are permitted for the protection of wood against deteriorating agencies, the coating shall be renewed at such intervals and in such thickness as is necessary for the required purpose.

26.3. --Splits and Checks. Splits and checks resulting from the seasoning of wood in service or from other cause shall not be allowed to progress to an extent that may seriously affect the integrity of structural parts. If splits or checks in large structural members are restrained by cross bolts, clamps, or equivalent means, care shall be taken to see that clamps or bolts are not overtightened, and that the net cross section of wood tension members is adequate where holes are bored for cross bolts in the stressed portions of the members. Splits of large extent or in critical locations may require replacement of members, if they offer a serious hazard to the integrity of the structure (17 and 43).

26.4. --Reinforcements. Structural members of wood or wood products that become endangered by overloading or other cause shall be supported by bracing or shoring, reinforced by tie rods, plates, or other means, or additional members shall be provided to carry the load. The design and application of the reinforcement shall be subject to structural analysis by the building official or his authorized representative to ascertain that all members or structural parts comply with the applicable provisions of these code requirements and that they are adequate for the redistributed loads or forces that will come upon them.

26.5. --Replacements of Members. Structural members or parts of wood or wood products used for replacement shall conform to the appropriate provisions in these code requirements for new material and shall have adequate strength and stability for their intended use. Where single pieces of a mechanically joined, laminated, or trussed structural member are replaced, the new pieces shall be of the same or equivalent species and moisture content, and the repair shall be so designed that the new pieces will assume their share of the load before excessive deformations can
occur in the remainder of the structural member. Replacements of single pieces in a glued laminated structural member shall not be made except on showing of satisfactory evidence that all glue bonds will be equivalent in strength and stability to the original and will be adequate for their intended use. To insure satisfactory gluing of replaced pieces or parts, the building official may require unloading or partial dismantling of the structure or such other measures as are necessary (36, pp. 294-311).

26.6. --Maintenance of Joints and Fastenings. Where joints or mechanical fastenings in wood or wood products may become loosened from shrinkage of the material in seasoning or from other cause, provision shall be made for tightening of such joints at appropriate intervals so that proper contact of mating surfaces or parts will be maintained (27). Where nailed joints have suffered serious loss of strength from shrinkage or other cause, the joint shall be renailed, avoiding old nail holes and observing spacing and margins so that serious splitting or breakage does not occur (section 4.3).
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