(a) In lime or lime-cement mortars any desired part of the lime may be replaced with an equal volume of Portland cement.

(5) Cement mortar shall consist of one part of Portland cement and not more than 3 parts of approved sand, except that lime putty, or dry hydrated lime, in volume equal to not more than 15% of the volume of Portland cement may be added to the mortar.

Note: Approved sand for mortar shall conform to the Tentative Specifications for Concrete Aggregates (A.S.T.M. Designation C33—40) of the American Society for Testing Materials.

Ind 53.09 Bearing masonry walls, bearing partitions and piers. (1) GENERAL REQUIREMENTS. All masonry units used in the construction of bearing walls, bearing partitions and piers shall conform in all respects to the requirements for bearing units.

(2) UNIT STRESSES. The unit stresses in bearing masonry walls, partitions and piers shall not exceed those specified in sections Ind 53.04 and Ind 53.07.

(3) MORTARS. Cement mortar shall be used for all masonry which will have one or more faces in contact with soil. Lime-cement mortar or cement mortar shall be used for all masonry in isolated piers, parapet walls, chimneys where exposed to the weather, and for all hollow masonry units. All other masonry may be laid in cement mortar, lime-cement mortar or lime mortar.

(4) MASONRY BOND. In brick masonry, or in combination brick and other masonry units, the bonding of each tier of units to that adjoining shall be secured by means of a full header course of brick every sixth course of brick, or equivalent. The use of metal ties for bonding masonry is not approved.

(a) By equivalent, is meant that 1/6 of the surface of a wall shall be header, or bond, units.

(b) Where masonry units are larger or smaller than brick, the bond courses shall be placed at intervals not exceeding 16 inches.

(c) Stack bond. Stack bonded masonry units used in the construction of bearing walls and partitions shall be bonded with 3/16 inch diameter steel rods or metal ties of equivalent stiffness embedded in the mortar joints. The vertical distance between ties shall not exceed 16 inches.

(5) USE OF HOLLOW CLAY TILE AND HOLLOW CONCRETE MASONRY UNITS. Approved clay tile and concrete masonry units may be used in bearing and exterior walls of buildings not more than 3 stories, or 45 feet in height, or in panel walls in buildings of any height. In determining this height, the basement or foundation wall shall be considered a story if constructed of clay tile or concrete masonry units.

(6) LOADING. Concentrated loads shall be transmitted to hollow clay tile or hollow concrete block masonry by at least 3 courses of brick or equivalent concrete or by a metal plate of sufficient thickness and size to distribute the load to the webs and shells in such a manner as not to exceed the unit allowable stress.

(7) PARTY WALL CONSTRUCTION. Where hollow clay tile or hollow concrete masonry units are used in party walls, there shall be not less than 2 such units, each 8 inches in thickness as a minimum, used in making up the thickness of the wall unless solid masonry is used for

building all chases, recesses, framing of all openings, and for the support, anchorage, and protection of all joists and beams carried into such wall.

(8) WALL CONSTRUCTION. Clay tile and concrete masonry units used in bearing walls shall be well bedded in mortar. The net bearing area of all clay tile and concrete masonry units as laid in the wall shall be such that the allowable unit stress in the mortar is not exceeded.

(9) SAME. All clay tile laid with cells vertical shall be laid in Portland cement mortar. All clay tile laid with cells horizontal and all concrete masonry units shall be laid in cement-lime mortar, or better.

(10) HEIGHT AND THICKNESS. All bearing walls, party walls and standard division walls, except as hereinafter provided, shall be not less than 12 inches thick in the upper 3 stories, increasing 4 inches in thickness for each 3 stories, or fraction, below. No such 3 story height shall exceed 40 feet.

(11) WALL THICKNESS. A building not more than 3 stories in height may have 8 inch bearing walls in the upper story, provided such story is not more than 10 feet high in the clear, and the span is not more than 20 feet, and the wall is not more than 30 feet long between cross walls, offsets or pilasters.

(12) SAME. A building not more than one story in height may have 8 inch bearing walls, provided the clearstory height is not more than 12 feet, the roof span is not more than 25 feet, and the distance between cross walls, offsets or pilasters is not more than 20 feet.

(a) A building not more than one story in height may have 6-inch bearing walls provided the clearstory height is not more than 9 feet, the roof span is not more than 18 feet and the distance between cross walls, offsets, or pilasters is not more than 15 feet. All other 1-story buildings shall have all bearing walls not less than 12 inches thick.

(13) LATERAL SUPPORT. All bearing masonry walls shall have substantial lateral support at right angles to the wall face at intervals, measured either vertically or horizontally, not exceeding 18 times the wall thickness. Such lateral support shall be obtained by masonry cross walls, piers or buttresses when the limiting distance is measured horizontally, or by floors or roof when the limiting distance is measured vertically.

(14) WALLS BELOW GRADE. Masonry walls which are in contact with the soil in any story shall be increased 4 inches in thickness in that story, except that for places of abode as specified in section Ind 57.001, not over 2 stories in height, 12 inch walls will be accepted if substantial lateral supports consisting of masonry walls, offsets or pilasters are provided at intervals not to exceed 20 feet.

(15) STONE WALLS. Rubble and rough cut stone walls shall be 4 inches thicker than required for walls of artificially formed units or of ashlar masonry.

(16) SAME. Stone and similar solid facing not less than 4 inches thick may be considered as part of the required thickness of a wall if bonded to the backing as required for brickwork. No such wall shall be less than 12 inches thick.

(17) PIERS. In all buildings, the section of masonry supporting trusses or girders shall be considered as isolated piers, the least dimension of which, in inches, shall be not less than 1/30 of the span of the truss, or girder, in inches, and the height shall not exceed 12 times the minimum horizontal dimension.

(a) The height of masonry piers which are not built into, and as a part of bearing walls, shall be not more than 10 times the minimum horizontal dimension.

(b) Support for long span joist. Where long span steel joist or laminated structural wood members or precut concrete members are used on spans of more than 40 feet, and the spacing exceeds 4 feet, pilasters shall be provided to support each joist or spandrel beam supported on pilasters, or steel columns shall be provided to support the joist.

(18) CHASES, RECESSES AND OPENINGS. There shall be no chases in 8 inch walls or in any pier. No chase in any wall shall be deeper than ⅓ the wall thickness. No horizontal chase shall exceed 4 feet in length nor shall the horizontal projection of any diagonal chase exceed 4 feet. No vertical chase shall be closer than 2 feet to any pilaster, cross wall, end wall or other stiffener.

(a) The aggregate area of recesses and chases in the wall of any one story shall not exceed ¼ the whole area of the face of the wall in that story. No chases or recesses shall be permitted in any wall which will reduce the fire resistance of such wall below the minimum required by this code.

(b) The maximum percentage of openings in the horizontal cross section of any wall shall not exceed 50%, unless the wall is increased 4 inches in thickness, or such portions of the wall between openings shall be as required for piers for the entire wall height.

History: 1–2–56; am. (12) (a), Register, June, 1956, No. 6, eff. 7–1–56; am. (4) (b), Register, August, 1957, No. 20, eff. 9–1–57; r. and recr. Register, September, 1959, No. 45, eff. 10–1–59.

Ind 53.10 Non-bearing masonry walls. (1) GENERAL REQUIREMENTS. All exterior non-bearing masonry walls if constructed with one course of brick to the weather may be backed with common brick, concrete masonry units, or non-bearing clay tile, conforming to the requirements of sections Ind 53.05 and Ind 53.06. If walls are built of concrete masonry units or clay tile, with or without exterior stucco, such walls shall be constructed of concrete masonry units or clay tile conforming to the requirements of section Ind 53.06.

(2) INTERIOR NON-BEARING WALLS. Interior non-bearing partition walls may be built of materials conforming to the requirements of sections Ind 53.05 and Ind 53.06, or of gypsum block or other approved materials.

(3) TYPE OF MORTAR. Lime, lime-cement or cement mortar shall be used for all non-bearing masonry, except as follows:

(a) Lime mortar shall not be used in normally wet or damp locations.

(b) Gypsum shall be used for gypsum masonry.

(c) Gypsum may be used for interior clay tile masonry.

(4) MASONRY BOND AND ANCHORAGE. In non-load bearing brick masonry or in combinations of brick and other masonry units, the bonding of each tier of units to that adjoining, shall be secured by means of a full header course of brick or other units placed at intervals not exceeding 32 inches. The height of such bond course shall not exceed 5 inches and the width of bed joint used to effect the masonry bond shall be at least 4 inches.

(a) All exterior and interior non-bearing walls and partitions shall be securely anchored to supporting members by means of corrosion resistant ties of at least No. 13 U.S. Standard Gauge metal spaced not more than 18 inches center to center.

(b) Stack bond. Stack bonded masonry units used in the construction of non-load bearing walls and partitions shall be bonded with 3/16 inch steel rods or metal ties of equivalent stiffness embedded in the mortar joint. The vertical distance between ties shall not exceed 32 inches.

(c) Masonry veneer on frame structures shall be securely anchored to the structure with corrosion resistant ties of at least No. 13 U.S. Standard Gauge metal or equal. The maximum vertical distance between ties shall not exceed 18 inches and the maximum horizontal distance shall not exceed 36 inches and the ties in alternate courses shall be staggered.

(5) HEIGHT AND THICKNESS. Interior non-bearing masonry walls which are supported by fire-resistive construction and have tight contact with not less than 2-hour fire-resistive construction at the top, shall be not more than 36 times their thickness in clear height. Similar non-bearing walls which contact less than 2-hour fire-resistive support at the top shall be not more than 24 times their thickness in clear height. Plastering shall be included in computing the thickness.

(6) THICKNESS OF EXTERIOR NON-BEARING WALLS. The thickness of exterior non-bearing walls shall be not less than 1/24 of the clear height and not less than 1/30 of the horizontal distance between vertical supports, but in no case less than 8 inches.

History: 1–2–56; r. and recr. Register, September, 1959, No. 45, eff. 10–1–59.

Ind 53.11 Cavity walls. (1) Exterior non-bearing walls may be built with a facing of 4 inches of building brick complying with the requirements of section Ind 53.05, and a backing of either building brick complying with the requirements of section Ind 53.05, or hollow building units complying with the requirements of section Ind 53.06. Such walls shall have an air space between the facing and backing of not less than 2 inches nor more than 2½ inches, and shall be bonded to each other with galvanized metal ties at least ¼ inch thick every 16 inches in height and 24 inches in width. The maximum height between supports shall be 10 feet. For heights greater than 10 feet between supports, the thickness of the backing shall be increased 2 inches for each 5 feet, or fraction thereof. The wall shall be anchored to the supporting framework with metal ties at least ⅛ inch thick, spaced not more than 24 inches center to center.

(2) A waterproofing membrane shall be installed at the bottom of the wall cavity. It shall pass through both the exterior facing course and the backing in such a manner as to drain outward the water

which might penetrate the facing. Open vertical joints, or weep holes, shall be provided every 3 feet horizontally in the facing above the membrane.

Ind 53.12 Bonding and anchoring stone and cast stone veneers. (1) For bearing walls, stone shall be bonded to the backing every 16 inches of wall height with bond courses at least 4 inches in height, and the width of bed joint used to effect the masonry bond shall be at least 4 inches.

(2) For non-bearing walls, individual stones shall be anchored to the supporting framework and dowelled to each other at all horizontal joints, and anchored to the backing at all horizontal joints and at vertical joints so that one anchor is provided for every 6 square feet of wall surface. All anchors shall be not less than ¼ square inch in cross section and made of wrought iron galvanized after forming, or of commercial bronze.

(3) The backing of all stone or cast stone bearing or non-bearing walls shall be of brick conforming to the requirements of section Ind 53.05 or other solid material weighing at least 130 pounds per cubic foot except where the stone facing is not more than 4 inches in thickness, the backing may be of hollow masonry units conforming to the requirements of section Ind 53.06, or other similar non-corrosive material.

History: 1–2–56; r. and recr. Register, September, 1959, No. 45, eff. 10–1–59.

Ind 53.13 Parapet walls. (1) Parapet walls not less than 8 inches in thickness and 2 feet in height shall be provided on all exterior, division and party walls of masonry or concrete, where such walls connect with roofs other than roofs of fire-resistive construction; but this section shall not apply:

(3) ALLOWABLE UNIT STRESSES IN CONCRETE.

Description		Allowable unit stresses				
		For any strength of concrete in accordance with Section Ind 53.15(2) $n = \frac{30,000}{f'_c}$	Maximum value psi	For strength of concrete shown below		
				$f'_c = 2000$ psi $n = 15$	$f'_c = 2500$ psi $n = 12$	$f'_c = 3000$ psi $n = 10$
Flexure: f_c						
Extreme fiber stress in compression	f_c	$0.45f'_c$	-------	900	1125	1350
Extreme fiber stress in tension in plain concrete footings	f_c	$0.03f'_c$	-------	60	75	90
Shear: v (as a measure of diagonal tension)						
Beams with no web reinforcement	v_c	$0.03f'_c$	-------	60	75	90
Beams with properly designed web reinforcement	v	$0.12f'_c$	-------	240	300	360
Flat slabs at distance d from edge of column capital or drop panel	v_c	$0.03f'_c$	-------	60	75	90
Footings	v_c	$0.03f'_c$	75	60	75	75
Bond: u						
Deformed bars						
Top bars	------	$0.07f'_c$	245	140	175	210
In 2-way footings (except top bars)	------	$0.08f'_c$	280	160	200	240
All others	------	$0.10f'_c$	350	200	250	300
Plain bars (must be hooked)						
Top bars	------	$0.03f'_c$	105	60	75	90
In 2-way footings (except top bars)	------	$0.036f'_c$	126	72	90	108
All others	------	$0.045f'_c$	158	90	113	135
Bearing: f_c						
Walls, Piers, Pilasters and Pedestals						
On full area	f_c	$0.25f'_c$	-------	500	625	750
On ⅓ area or less	f_c	$0.375f'_c$	-------	750	938	1125
Columns: See section Ind 53.19						

(4) ALLOWABLE UNIT STRESSES IN REINFORCEMENT. (a) *Tension in longitudinal steel and web reinforcement:*

Structural grade steel rods ---------- $f_s = 18,000$

Intermediate grade and hard steel rods (Billet steel, rail steel or axle steel) ---------- $f_s = 20,000$

(b) *Compression in column verticals:*

1. Intermediate grade steel rods ---------- $f_s = 16,000$
2. Hard grade steel rods (Billet steel, rail steel or axle steel) ---------- $f_s = 20,000$
3. The symbols and notation used in the above formulas are defined as follows:

f'_c—ultimate compressive strength of concrete at age of 28 days.

f_c—compressive unit stress in extreme fibre of concrete in flexure or axial compression in concrete in columns.

v_c—unit shearing stress in concrete.

u —bond stress per unit area of surface of bar.

f_s—tensile unit stress in reinforcement.

(5) ULTIMATE STRENGTH METHOD OF DESIGN. (a) The ultimate strength method of design for reinforced concrete may be used under the following conditions if approved in writing by the industrial commission.

1. Where the ultimate strength method of design is used, all other features of the design shall conform to the requirements of the building code.

2. Positive control shall be provided for the concrete mix. This includes periodic tests of regular concrete cylinders to determine the strength of the concrete.

3. Supervision shall be provided by the supervising architect or engineer during mixing and pouring operations where this method of design is involved.

History: 1–2–56; cr. (5), Register, September, 1959, No. 45 eff. 10–1–59.

Ind 53.23 Reinforced gypsum concrete. (1) MATERIALS. (a) The term "gypsum" as used in this chapter shall mean calcined gypsum manufactured from gypsum meeting the requirements of the American Society for Testing Materials' Standard Specifications for Gypsum C22–25, (American Standard A49.1–1933).

(b) Gypsum concrete shall consist of a mixture of gypsum and water, with or without wood chips, fiber or other approved aggregate.

(c) Precast gypsum concrete shall contain not more than 3% and cast-in-place gypsum concrete not more than 12½% of wood chips, shavings, or fiber measured as a percentage by weight of the dry mix.

(d) Wood chips, shavings, or fiber used in gypsum concrete shall be dry, soft wood, uniform and clean in appearance. They shall pass a 1-inch screen and shall be not more than $\frac{1}{16}$ inch in thickness.

(e) Steel bar and wire reinforcing shall meet the requirements of section Ind 53.14 (5).

(2) MINIMUM THICKNESS. (a) The minimum thickness of gypsum concrete in floors and roofs shall be 2 inches except the suspension system, which shall be not less than 3 inches thick. Hollow precast gypsum concrete units for roof construction shall be not less than 3 inches thick and the shell not less than ½ inch thick.

(b) Precast gypsum concrete units for floor and roof construction shall be reinforced and unless the shape or marking of the unit is such as to insure its being placed right side up, the reinforcing shall be symmetrical so that the unit can support its load either side up.

(3) DESIGN. (a) Reinforced gypsum concrete shall be designed by methods admitting of rational analysis according to established principles of mechanics, to support the loads and withstand the forces to which it is subject without exceeding the stresses allowed in this chapter for the materials thereof except as hereinafter provided. The general assumptions and principles established for reinforced concrete shall also apply to reinforced gypsum concrete insofar as they are pertinent.

(b) For precast gypsum structural units which can not be analyzed in accordance with established principles of mechanics, the safe uniformly distributed carrying capacity shall be taken as ⅙ of the

total load causing failure in a full size test panel with the load applied along 2 lines each distant ¼ of the clear span from the support.

(c) Reinforced gypsum concrete shall not be used where exposed directly to the weather or where subjected to frequent or continuous wetting.

(4) STRENGTH. (a) Gypsum concrete shall be classified according to mixture, and concrete of each class shall have a minimum strength in compression as follows:

1. Class 1	Neat (Containing gypsum and water only)	1800 lbs. per sq. in.
2. Class 2	Containing not more than 3% by weight of wood chips or fiber	1000 lbs. per sq. in.
3. Class 3	Containing not more than 12½% by weight of wood chips or fiber	500 lbs. per sq. in.

(b) *Bolting up.* As erection progresses, the work shall be securely bolted up or welded to take care of all dead load, wind and erection stresses.

(c) *Erection stresses.* Wherever piles of material, erection equipment or other loads are carried during erection, proper provision shall be made to take care of stresses resulting from the same.

(d) *Alignment.* No riveting or welding shall be done until the structure has been properly aligned.

(e) *Riveting.* Rivets driven in the field shall be heated and driven with the same care as those driven in the shop.

(f) *Turned bolts.* Holes for turned bolts to be inserted in the field shall be reamed in the field.

(g) *Field painting.* All field rivets and bolts, also all serious abrasions to the shop coat, shall be spot painted with the material used for the shop coat, or an equivalent, and all mud and other firmly attached and objectionable foreign materials shall be removed, before general field painting.

1. Responsibility for this touch-up and cleaning, as well as for general field painting, shall be allocated in accordance with accepted local practices and this allocation shall be set forth explicitly in the contract.

(14) LIGHT GAUGE STEEL STRUCTURAL MEMBERS. *(a) Scope.* The requirements of this section shall apply to the design of structural members formed of sheet or strip steel less than 3/16 inch thick and used for load carrying purposes in buildings and structures within the scope of this code. All such structural members shall be capable of supporting all required loads without exceeding the allowable unit stresses specified in this section and shall be designed in accordance with recognized engineering practice.

(b) Material. 1. Steel shall conform to the specifications of the American Society for Testing Materials for Light Gauge Structural Quality Flat Rolled Carbon Steel Serial Designation A-245 and A-246. The terms C, B and A used herein to designate grades of steel refer to the grades provided by those A.S.T.M. specifications.

2. Steel of higher strength than is covered by the above mentioned A.S.T.M. specifications may be used at the unit stresses, herein specified for "other grades" of steel provided the design is based upon the minimum properties of those grades of steel as guaranteed by the manufacturer. When requested by the industrial commission, the manufacturer shall furnish certified data showing the properties of such grades of steel.

(c) Basic design stresses. Allowable working stress. 1. Tension on the net section of tension members, and tension and compression, f_b, on the extreme fibers of flexural members shall not exceed the values specified in the following table except as otherwise provided in this section.

Grade of Steel	Minimum Yield Point Pounds Per Sq. In.	Allowable Working Stress Pounds Per Sq. In.
C	33,000	18,000
B	30,000	16,500
A	25,000	13,500
Other Grades	Allowable Stress	Minimum Yield Point Divided by 1.85

2. Compression on unstiffened elements. Compression f_c, in pounds per square inch on flat unstiffened elements, shall not exceed the values in accordance with the following formula:

a. For w/t not greater than 12, $f_c = f_b$

b. For w/t greater than 12 but not over 30

$f_c = [1.67\ f_b - 5330] - (1/18)\ (f_b - 8150)\ w/t$

c. For w/t over 30 but not over 60

$f_c = 12{,}600 - 148.5\ (w/t)$

In the above formula w/t = Ratio of flat width to thickness of an element.

3. Allowable web shear.

a. The maximum average web shear stress, v, in pounds per square inch on the gross area of a flat web shall not exceed the values in accordance with the following formula:

$$v = \frac{64{,}000{,}000}{(h/t)^2} \text{ with a maximum of } 2/3\ f_b.$$

In the above formula

t = web thickness

h = clear distance between flanges

f_b = allowable working stress as specified in (c).

b. Where the web consists of 2 or more sheets, each sheet shall be considered as a separate member carrying its share of the stress. If, in such cases, the sheets are joined together by continuous welds or by rows of spot welds parallel to the flanges, "h" shall be the vertical distance between the rows of welds or between a row of welds and the flange, whichever is the greater, (rather than the distance between flanges) provided the longitudinal spacing of welds along each row of welds does not exceed h/3.

(d) Maximum slenderness ratio. 1. The maximum allowable ratio $\frac{L}{r}$ of unsupported length, L, to radius of gyration, r, of compression members shall be as follows:

a. Columns, and other primary compression members 120

b. Load-bearing studs 160

c. Secondary members 200

(15) PLASTIC DESIGN AND FABRICATION. The design, fabrication and erection of structural steel for buildings and structures by the plastic design method shall conform with recognized good engineering practice as approved by the industrial commission.

Note: It will be the policy of the industrial commission to accept methods of plastic design which conform with the Rules for Plastic Design and Fabrication of Structural Steel issued by the American Institute of Steel Construction.

History: 1–2–56; cr. (9)(d)(7.) Register, October, 1957, No. 22, eff. 11–1–57; cr. (15), Register, September, 1959, No. 45, eff. 10–1–59.

Ind 53.25 Steel joist construction (1) DEFINITION. Steel joist construction shall consist of decks or top slabs defined in section Ind 53.25 (7), supported by separate steel members referred to as steel joists. Any steel member suitable for supporting floors and roofs between the main supporting girders, trusses, beams, or walls when used as hereinafter stipulated shall be known as a "steel joist". Such steel joists may be made of hot or cold formed sections, strip or sheet steel, riveted or welded together, or by expanding.

(2) LIMIT OF SPAN AND SPACING. The clear span of steel joist shall not exceed 24 times the depth of the steel portion of the steel joist.

(a) The spacing of steel joist shall not exceed 24 inches on centers for floors. In no case shall the joist spacing exceed the safe span of the top slab, deck, or flooring over the said joist. The spacing of steel joist for roofs shall not exceed the safe span of the top slab or roof deck.

(b) Where these spans or spacings are exceeded, the requirements for steel joist construction shall not apply, but the steel members shall be designed in accordance with the requirements of section Ind 53.24.

(3) MATERIALS. All steel joist used in the construction of buildings and structures shall be fabricated from materials of uniform quality and free from defects that would impair the strength or stability of the structure.

(a) All steel joist shall receive one coat of asphalt base paint or an equivalent protective covering before leaving the fabricating shop.

Note: It will be the policy of the industrial commission to approve, subject to the provisions of this section, steel joist that conform to the following Standard Specifications of the American Society for Testing Materials.

1. Steel for bridges and buildings, A.S.T.M. Designation A–7.
2. Flat rolled carbon steel sheets of structural quality, Grade C, A.S.T.M. Designation A 245.
3. Hot rolled carbon steel strip of structural quality, Grade C, A.S.T.M. Designation A 303.

(4) DESIGN OF STEEL JOIST. An open web steel joist built up of bars or other sections, or one fabricated by expanding a rolled section shall be designed as a truss. The compressive stress in chord members and diagonals of the joist shall not exceed those given in section Ind 53.24 for main members. The tensile stress shall not exceed 20,000 pounds per square inch in any member. The minimum shear to be used in designing the web members at any point in an open web steel joist shall not be less than 50 per cent of the required maximum and reaction for such steel joist.

(a) A solid web steel joist shall be designed as a beam in accordance with the requirements of section Ind 53.24.

(b) In the completed structure, the top chords of open web steel joist or the top flanges of solid web steel joist may be considered as being stayed laterally when the deck or top slab over the steel joist complies with the provisions of section Ind 53.25 (7).

(c) All joints and connections of an open web steel joist shall be capable of withstanding a load at least 3 times the designed load and shall be sufficiently rugged to resist the stresses incident to transportation and erection when handled in a reasonable manner.

(d) All elements of an open web joist shall have their lines of center of gravity meet at a point if practicable; if not, stresses arising from eccentricity shall be included with other stresses in designing these elements.

(e) Ends of steel joist shall be designed to resist the bending produced by the eccentricity of the reaction at the support.

(5) ERECTION. The ends of steel joist shall extend a distance of at least 4 inches on to masonry or reinforced concrete supports and at least 2½ inches on steel supports. In floor construction every third steel joist and in roof construction every steel joist supported on concrete or masonry supports shall be anchored thereto with an anchor equivalent to a ⅜ inch round bar. All steel joist supported on steel beams shall be secured thereto by welding or with an anchor made of not less than 3/16 inch bar fastened over the flanges of the supporting beams.

(a) The ends of long span steel joist shall extend a distance of not less than 6 inches on masonry or reinforced concrete supports and at least 4 inches on steel supports.

(b) During the construction period, care shall be exercised to prevent excessive concentrated or moving loads. The construction contractor shall provide for adequate distribution of such loads so that the carrying capacity of any steel joist is not exceeded during that period. When erected and bridged, the total concentrated load on any one steel joist shall not exceed 800 pounds and in the case of open web steel joist, such concentrated load shall not be imposed between panel points.

(6) BRIDGING. As soon as steel joist are erected, bridging shall be installed between the joist before the application of construction loads. This bridging shall be adequate to support the top chords or flanges against lateral movement during the construction period and shall hold the steel joist in a vertical plane passing through the bearings.

(a) Horizontal bridging shall consist of two continuous horizontal steel members, one of which is attached to the top chord and the other attached to the bottom chord. Attachment to the joist shall be made by welding or by mechanical means, and the attachments shall be capable of resisting a horizontal force of not less than 500 pounds. The ration of unbraced length to the least radius of gyration $\left(\frac{L}{r}\right)$ of the bridging member shall not exceed 300. Where a round bar is used for bridging the diameter shall be at least ½ inch.

(b) Diagonal cross bridging may be used for joist spacing up to 30 inches. The ratio of unbraced length to the least radius of gyration $\left(\frac{L}{r}\right)$ shall not exceed 200. Connections to the top and bottom chords of the joist shall be made by positive mechanical means or by welding.

(c) In roof construction, where the slope is perpendicular to the

longitudinal axis of the joist, sag rods may be used in lieu of bridging. The rods shall not be less than ½ inch in diameter and the number of lines shall be the same as specified for bridging.

(d) In no case shall the spacing of bridging be greater than specified in the following table.

Clear Span	*Number of Lines of Bridging*
Up to 14 feet	One row near center.
14 to 21 feet	Two rows placed at ⅓ point of span.
21 to 32 feet	Three rows placed at ¼ point of span.
32 to 40 feet	Four rows placed at ⅕ point of span.
40 to 48 feet	Five rows placed at ⅙ point of span.

(e) Bridging for long span joist shall consist of cross bracing with an $\frac{L}{r}$ ratio of not more than 200. The maximum spacing of lines of bridging for long span joist shall not exceed the following:

Joist Depth in Inches	*Maximum Spacing of Lines of Bridging*
18 to 24 inches, inclusive	10 feet
Over 24 to 36 inches, inclusive	12 feet
Over 36 inches	16 feet

(7) DECKS AND TOP SLABS. Decks or top slabs over steel joist may be of concrete or gypsum poured on metal lath centering attached to the top chords or flanges of steel joist as required elsewhere in this section or on removable centering provided the top chords or flanges of the steel joist are properly stayed by the concrete or gypsum slab. Other equally suitable permanent centering may be used, provided it is substantially attached to the top chords or flanges as required elsewhere in this section and provided these attachments (or the centering itself) are securely anchored into the concrete or gypsum slab. Precast concrete or precast gypsum slabs when securely attached to the top chords or flanges and anchored thereto and brought to a firm bearing, wood decks as stipulated below, and corrugated or other steel roof decks securely anchored to the top chords or flanges may be used over steel joist. Any attachment or pair of attachments when applied shall be capable of staying the top chord or flange laterally in both directions and in the case of open web steel joist, shall be spaced not farther apart than the panel point spacing. Decks or top slabs over steel joist shall not be assumed to carry any part of the compression stress in the steel joist.

(a) Flat wood decks of single thickness of one inch nominal material shall not have a span of more than 20 inches for floors, or 30 inches for roofs. All such decks shall be securely fastened to the joist.

(b) Poured structural slabs of concrete, gypsum or other similar material shall not be less than 2 inches thick. They shall be poured upon ⅜ inch ribbed metal lath weighing not less tthan 4 pounds per square yard for spans not exceeding 24 inches and upon ¾ inch rib lath weighing not less than 4.5 pounds per square yard for spans not exceeding 30 inches. Other material equally suitable as a form or centering for casting concrete or gypsum slabs may be used in

place of rib lath. Rib lath or other centering which remains in place shall be substantially attached to the top chord or flange of each steel joist at intervals of not over 8 inches. Such slabs shall be reinforced with mesh or rods, in addition to the rib lath, except that when slabs are to be covered with a wood strip top floor, the rib lath or centering may, if adequate, serve also as the reinforcement.

(c) Any material used as centering for the top slab shall be installed so as not to exert an undue lateral pull on the top chords or flanges of the steel joist.

History: 1–2–56; r. and recr., Register, September, 1959, No. 45, eff. 10–1–59.

Ind 53.26 Wrought iron. (1) The requirements for design, fabrication and erection of steel for buildings and structures under section Ind 53.24 shall apply to wrought iron, except that the following stresses in pounds per square inch shall not be exceeded:

(a) Tension on net section 12,000
(b) Compression, on short lengths or where lateral deflection is prevented 10,000
on gross section of columns

$$12{,}000 - 60\,\frac{L}{r}$$

in which L = length in inches
r = radius of gyration in inches
(c) Bending. On extreme fibres if lateral deflection is prevented 12,000

(2) Wrought iron shall conform to the Standard Specifications for Refined Wrought Iron Plates, Serial Designation A42–18.

Ind 53.27 Cast iron. (1) The following unit stresses in pounds per square inch shall not be exceeded in cast iron:

(a) Tension on net section 0
(b) Compression, on short lengths or where lateral deflection is prevented 10,000
on gross section of columns

$$10{,}000 - 40\,\frac{L}{r}$$

in which L = length in inches
r = radius of gyration in inches

(c) Tension in the extreme fibre if lateral deflection is prevented 3,000

(2) The material and workmanship of cast iron members shall be equal in all respects to that described in the American Society for Testing Materials Specifications for Gray-Iron Castings, Serial Designation A48–29.

(3) All columns resting on, or supporting, other columns shall have their ends machine faced to a plane surface perpendicular to the axis.

Ind 53.28 Wood construction. (1) Quality of material. The quality and design of all wood used in the construction of all buildings and structures or parts thereof, shall conform to the minimum standards under this section.

(a) All members shall be so framed, anchored, tied and braced together as to develop the maximum strength and rigidity necessary for the purpose for which they are used. No member shall be stressed in excess of the strength of its details and connections.

(b) All wood structural members shall be of sufficient quality, size and strength, as to carry their imposed loads safely and without exceeding the allowable working stresses as specified in this section.

(c) The requirements stated are a minimum standard and apply primarily to conventional types of construction.

(d) The substitution of materials other than those called for in the code will be permitted when shown by an approved authority to be equal to or better than those specified.

(e) Workmanship in fabrication, preparation, installation, joining of wood members and the connectors and mechanical devices for the fastening thereof, shall conform throughout to good engineering practice.

(f) Where wood is used in parts of a building or structure habitually exposed to moisture, ample ventilation or sufficient preservative treatment, or both, shall be provided.

(2) Allowable working stresses. In the design of wood structural members and the construction of structures of wood, the following unit stresses in pounds per square inch shall not be exceeded.

(a) Stresses that exceed those given in the following table for the lowest grade of any species shall be used only when the higher grade of that species is identified by the grade mark or a certificate of inspection issued by a recognized lumber grading or inspection agency.

(a) Girders shall be anchored to the walls and fastened to each other where they intersect or abut to resist safely an outward force equal to the wind pressure.

(b) Floor joists framing into the side of wood girders shall be supported on metal joist hangers or on a bearing strip or ledger board on the side of the girders. Size of ledger shall be at least 2 by 3 inches. The notch in the end of the joist shall be not more than ¼ of the joist depth.

(c) The ends of joists, whether resting upon girders or bearing partitions or abutted against the girders, shall be securely tied to the girders or to each other so as to resist safely an outward thrust on the walls equal to the required wind pressure, or spreading action on the roof, whichever is the greater.

(d) The top or bottom edges of joists may be notched in the outer ¼ of the length not to exceed ⅛ of the joist depth. Notching the top or bottom edge of joists will not be permitted in the middle half of the length of any joist.

(e) Header joists over 6 feet long, and tail joists over 12 feet long, shall be hung in approved stirrup irons or joist hangers.

(f) Joists under bearing partitions and running parallel thereto shall be multiple, well spiked, or separated by solid bridging not more than 16 inches on centers to permit the passage of pipes.

(g) Wood cross bridging shall be placed between joists if the span is over 8 feet. The distance between lines of bridging or between bridging and bearing shall not exceed 8 feet. Wood cross bridging properly fitted and securely nailed to joists shall be not less than 3 square inches in cross sectional area.

(h) Metal cross bridging of equal or greater strength may be used in place of the wood cross bridging.

(i) Solid bridging extending the full height of the joist shall be placed between floor joists which cross bearing partitions. Solid bridging shall be placed between joists at the edge of flooring where the attic space is only partially covered.

(6) Fire stopping. Fire stops shall be provided at all intersections of interior and exterior walls with floors, ceilings and roof in such manner as to effectively cut off communication by fire through hollow concealed spaces and prevent both vertical and horizontal drafts.

(a) Furred walls shall have fire stopping placed immediately above and below the junction of any floor construction with the walls, or shall be fire stopped the full depth of the joist.

(b) All spaces between chimneys and wood framing shall be solidly filled with incombustible material at floor levels.

(c) All fire stopping as required in this section shall be not less than 2 inches in thickness and not less in width than the enclosed space within the partition except as provided for chimneys.

(7) Floors supported on masonry walls. Every girder and beam which enters, or rests on, a masonry wall shall have a bearing of at least 4 inches thereon.

(a) Wood members entering masonry party or fire walls shall be separated from the opposite side of the wall and from beams entering the opposite side of the wall by 4 inches of masonry. The ends of the joists, beams and girders shall be splayed or firecut to a bevel of not less than 3 inches in their depth.

(b) Where girders and beams enter masonry they shall be provided with wall plates, boxes or anchors of an approved self-releasing type so arranged as to leave an air space of not less than ½ inch at sides and ends of member. The ends of girders shall not be sealed in; provided, that where ends of timbers are pressure treated with creosote or other approved preservative, they may be sealed in.

(c) Anchors for each tier of joists more than 5 feet above grade shall be provided where they enter masonry walls, and also where they are parallel to masonry walls. Such anchors shall be $\frac{3}{16}$ inch by 1¼ inch iron, or equal, not less than 20 inches long, fitted with a ⅜ inch by 6 inch pin at the wall end, and shall be spaced not more than 6 feet apart. The pin shall be placed horizontally in the wall and 4 inches from the opposite face of such wall. Such anchors shall in all cases occur on the opposite ends of the same run of joists, and where the length of joists is less than the distance across a building, the end of joists shall be lapped and spiked so as to form a continuous tie across the building. Anchors shall be placed across the top of joists that run parallel to the wall, and shall be fastened to the ends of joists below the neutral axis.

(8) Wood trusses and built-up members. Wood trusses and similar framing shall have all joints accurately cut and fitted together so that each bearing is true and drawn tightly to full bearing.

(a) All wood trusses shall be securely fastened to the supports and each truss shall be secured in position laterally by bracing the top and bottom chords at points not more than 25 feet apart.

(b) All girders and beams built up of strips, boards or dimension lumber shall be fastened together by glueing, nailing, spiking or bolting in a manner to develop the full strength of the parts. The stiffness of all members, and the strength of all joints, splices and laps, shall be fully developed.

(9) POST AND COLUMNS. Wood posts, when used in basements, shall bear on a cement base which shall extend at least 3 inches above the finish floor. The base shall bear directly on the post footing.

(a) Short columns are those having an $\frac{l}{d}$ ratio of 10 or less in which l = unsupported length in inches and d the least side in inches.

(b) Safe load for short columns may be obtained by the formula

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

in which $\frac{P}{A}$ represents the working stress for the column and S represents the safe unit compressive stress parallel to the grain given in the table of working stresses.

(c) Safe load for long columns of square or rectangular shape may be obtained by the formula:

$$\frac{P}{A} = \frac{0.30E}{\left(\frac{l}{d}\right)^2}$$

Where E is the modulus of elasticity as given in the table on working stresses. The value $\frac{P}{A}$ calculated by this formula shall in no case exceed S.

(10) Structural glued laminated lumber.

(a) The term "structural glued laminated lumber" as used herein refers only to those glued laminated structural members in which the grain of all laminations of a member is approximately parallel.

(b) The following allowable unit stresses shall be used in design of structural glued laminated members.

ALLOWABLE UNIT STRESSES FOR STRUCTURAL GLUED LAMINATED LUMBER

Species and Combinations of Lumber Grades			Allowable Unit Stresses in Pounds Per Square Inch							
Outer Laminations		Inner Laminations	Extreme Fibre in Bending "f"		Tension Parallel to Grain "t"		Compression Parallel to Grain "c"		Horizontal Shear "H"	Compression perpendicular to Grain "c"
Grade	Number Each Side	Grade	Laminations		Laminations		Laminations			
			4 to 14	15 or more	4 to 14	15 or more	4 to 14	15 or more		
DOUGLAS FIR, COAST REGION										
Select Structural	1/5 of total	Construction	2,600	2,600	2,400	2,600	2,000	2,000	165	415
Dense Construction	All	Dense Construction	2,400	2,600	2,600	2,600	2,200	2,300	165	455
Dense Construction	1/14 of total	Construction	2,400	2,600	2,200	2,400	1,900	2,000	165	455
Select Structural	One	Construction	2,200	2,600	2,400	2,600	1,900	2,000	165	415
Select Structural	1/5 of total	Standard	2,200	2,200	2,000	2,400	1,800	1,900	165	415
Select Structural	One	Standard	2,000	2,200	2,200	2,400	1,900	2,000	165	390
Construction	All	Construction	2,000	2,200	2,000	2,400	1,800	1,900	165	390
Standard	All	Standard	1,600	2,000	2,000	2,400	1,800	1,900	165	390
PINE, SOUTHERN										
No. 1	All	No. 1	2,600	2,600	2,600	2,600	2,100	2,100	200	385
B & B Dense	1/14 of total	No. 2	2,400	2,600	2,600	2,600	2,000	2,000	200	450
B & B	One	No. 2	2,400	2,400	2,600	2,600	2,000	2,000	200	385
No. 1	1/5 of total	No. 2	2,400	2,600	2,400	2,600	2,000	2,000	200	385
No. 2 Dense	All	No. 2 Dense	2,000	2,600	2,600	2,600	2,200	2,300	200	450
No. 2 Dense	1/14 of total	No. 2	2,000	2,600	2,200	2,600	1,900	2,000	200	450
No. 2	All	No. 2	1,800	2,200	2,200	2,600	1,900	2,000	200	385

The Modulus of Elasticity (E) is 1,800,000 pounds per square inch for dry conditions of use.
Allowable stresses are for normal conditions of load and dry conditions of use.

History: 1–2–56; am. (9); (9) (a); (9) (b); (9) (c), Register, June, 1956, No. 6, eff. 7–1–56; r. (2) and recr. (2); and cr. (10), Register, August, 1957, No. 20, eff. 9–1–57; r. and recr. (9), Register, September, 1959, No. 45, eff. 10–1–59.