Chapter Ind 53

STRUCTURAL REQUIREMENTS

Ind 53.001 Floor, roof and sidewalk loads. (1) DEAD LOADS. All buildings and structures, and parts thereof, shall be designed and constructed to support in addition to the minimum superimposed live loads specified in this order, the actual dead weight of all component members; and in addition thereto, an allowance for the weight of partitions, ceiling and floor finish, and concentrated loads such as safes, mechanical apparatus and similar equipment.

(2) LIVE LOADS. All buildings and structures, and parts thereof, shall be designed and constructed to support the following minimum superimposed live loads uniformly distributed in pounds per square foot of horizontal area in addition to the dead load:

(a) *Theaters and assembly halls with fixed seats:*

1. Auditorium	50
2. Lobbies, corridors and passageways	80
3. Stairways	80

(b) *Assembly halls without fixed seats:*

1. Auditorium	100
2. Lobbies, corridors and passageways	80
3. Stairways	80

(c) *School, library, museum classification:*

1. Instruction rooms, study rooms, reading rooms, exhibition rooms, art display rooms, laboratories	50
2. Vocational rooms	100
3. Library book stacks	100
4. Lobbies, corridors and passageways	80
5. Stairways	80

(d) *Apartment, hotel, place of detention classification:*

1. Living rooms, sleeping rooms	40
2. Lobbies, corridors, passageways	80
3. Offices and similar areas	60
4. Stairways	80
5. Dining Rooms	100

(e) *Office buildings:*

1. Offices	50
2. Commercial	100
3. Stairways	80

(f) *Mercantile establishments:*

1. All floor areas and stairways	100

(g) *Factories and workshops:*

1. All floor areas and stairways	100

(h) *Garages:*

1. All floor areas ________ 8000 pound axle load in any possible position or 80 pounds per square foot. (Whichever produces the greater stress.)

(i) *Grandstands, reviewing stands, bleachers:*

1. All areas	100

(j) *Stages, in theaters and assembly halls*	150
(k) *Roofs*	30
(l) *Sidewalks*	250

(3) The above live load requirements shall be considered only as a minimum. In every case where the loading is greater than this minimum, the design of the building or structure, or part thereof, shall be for the actual load and loading conditions.

(4) The following reductions in assumed live loads shall be permitted in designing girders, columns, piers and walls in fire-resistive buildings.

(a) No reduction of the assumed live load shall be allowed in the design of any slabs, joints or beams.

(b) A reduction of one per cent of the total live load used in the design of girders shall be allowed for each 20 square feet of tributary floor area, with a maximum allowable reduction of 15%. This reduction shall not be carried into the columns nor shall such reduction be used in the design of buildings to be used or occupied as warehouses or for storage purposes.

(c) For determining the total live loads carried by columns, piers and walls, the following reductions shall be permitted, based on the assumed live loads applied to the entire tributary floor area.

1. Warehouses and Storage Buildings

a. Carrying the roof	0%
b. Carrying 1 floor and roof	0%
c. Carrying 2 floors and roof	5%
d. Carrying 3 floors and roof	10%
e. Carrying 4 floors and roof	15%
f. Carrying 5 or more floors and roof	20%

2. Manufacturing Buildings, Stores and Garages

a. Carrying the roof	0%
b. Carrying 1 floor and roof	0%
c. Carrying 2 floors and roof	10%
d. Carrying 3 floors and roof	20%
e. Carrying 4 or more floors and roof	30%

3. All Other Buildings

a. Carrying the roof	0%
b. Carrying 1 floor and roof	0%
c. Carrying 2 floors and roof	10%
d. Carrying 3 floors and roof	20%
e. Carrying 4 floors and roof	30%
f. Carrying 5 floors and roof	40%
g. Carrying 6 floors and roof	45%
h. Carrying 7 or more floors and roof	50%

(5) The following reductions in assumed live loads shall be permitted in designing columns, piers and walls in buildings of mill and ordinary construction.

(a) *Warehouses and storage buildings*

1. Carrying the roof	0%
2. Carrying 1 floor and roof	0%
3. Carrying 2 floors and roof	5%
4. Carrying 3 or more floors and roof	10%

(b) *Manufacturing buildings, stores and garages*

1. Carrying the roof	0%
2. Carrying 1 floor and roof	0%
3. Carrying 2 floors and roof	10%
4. Carrying 3 or more floors and roof	20%

(c) *All other buildings*

1. Carrying the roof	0%
2. Carrying 1 floor and roof	0%
3. Carrying 2 floors and roof	10%
4. Carrying 3 floors and roof	20%
5. Carrying 4 or more floors and roof	30%

Ind 53.01 Wind pressure. (1) Every building shall be designed to resist a horizontal wind pressure of not less than 20 pounds for every square foot of exposed surface, in addition to the dead loads and the live loads specified above, except as provided in section Ind 55.68 (4) and section Ind 52.22.

(2) If the overturning moment due to wind pressure exceeds 75% of the moment of stability of the structure due to dead load only, the structure shall be anchored to its foundations, which shall be of sufficient weight to insure the stability of the structure; and sufficient diagonal bracing or rigid connections between uprights and horizontal members shall be provided to resist distortion.

(3) The overturning moment may be disregarded in a structure less than 100 feet in height if the height does not exceed twice the width.

(4) Members subject to stresses produced by a combination of wind and other loads may be proportioned for unit stresses 33-1/3% greater than those specified for dead and live load stresses, provided the section thus required is not less than that required for the combination of dead load, live load and impact (if any).

Ind 53.02 Foundations. (1) The permissible loads on natural earth shall not be more than the following, in tons per square foot:

(a) Quick sand and alluvial soils	½
(b) Soft clay	1
(c) Ordinary clay and sand together in layers, wet and spongy	2
(d) Clay or fine sand, firm and dry	3
(e) Sand, compact and well cemented	4
(f) Gravel and coarse sand, well packed	5
(g) Hard pan or shale	6
(h) Rock	Not more than 20% of the ultimate crushing strength of such rock.

(2) Where material at footing excavation level is such as to permit loads in excess of 2 tons per square foot, and the design is for loading in excess of 2 tons per square foot, 2 inch hand auger test holes shall be bored at intervals not exceeding 30 feet in any direction within the building area to a depth of at least 5 feet below the base of the footings, to determine the character of the underlying material. Allowable loading shall be in accordance with the above table for the material encountered.

(3) The maximum, or safe working load for piles shall be determined by the following formula:

$$L = \frac{2\ W\ H}{S + 0.1} \text{ for steam hammer}$$

$$L = \frac{2\ W\ H}{S + 1} \text{ for drop hammer}$$

in which formula

L = safe load in pounds
W = weight of hammer in pounds
H = fall of hammer in feet
S = penetration or sinking of the pile under the last blow, in inches.

(4) In no case shall the maximum load on a timber pile exceed 500 pounds per square inch of the section of the pile at mid length.

Ind 53.03 Masonry construction; general requirement. The requirements of sections Ind 53.03 to Ind 53.13, inclusive, herein shall apply to the construction of all masonry footings, foundations, walls, columns, piers and similar work under this code.

Ind 53.04 Natural building stone and cast stone. (1) RUBBLE MASONRY. The stresses in rubble stone masonry, due to all dead and live loads, shall not exceed 100 pounds per square inch when laid in lime-cement mortar, or 140 pounds per square inch when laid in Portland cement mortar.

(2) ASHLAR MASONRY. The stresses in ashlar or carefully coursed masonry, due to all dead and live loads shall not exceed the following at any point:

Kind of Stone	Laid In Lime-Cement Mortar (Pounds per	Laid In Cement Mortar Square Inch)
Granite	640	800
Limestone	400	500
Marble	400	500
Cast Stone	400	500
Sandstone	320	400

(3) WEATHER RESISTANCE OF STONE. All natural building stone to be used in masonry exposed to the weather or frost action shall be such that the strength and structure of the stone will not be affected by the weathering or frost action.

Note: Where the weather resistance of a stone is questioned this will require freezing and thawing tests as prescribed under the specification of the American Society for Testing Materials.

(4) All cast stone shall be branded with a permanent identification mark of the manufacturer which shall be registered with the industrial commission.

(5) The average compressive strength of cast stone taken on four representative samples at the age of 28 days or when delivered on the job shall be not less than 5000 pounds per square inch with an individual minimum of 4500 pounds per square inch, and the average absorption of such samples shall be not more than 7% of their dry weight, with an individual maximum of 8%.

(6) Tests of cast stone specimens shall be made in accordance with the "Tentative Specifications for Cast Stone" (Serial Designation P-3-A29T) of the American Concrete Institute.

Ind 53.05 Building brick. (1) DEFINITION. By *building brick* is meant a structural unit of burned clay or shale, sand lime or concrete, usually solid and about 8 inches by 3¾ inches by 2¼ inches in size.

(2) STRUCTURE. All building brick shall be rectangular in form, free from cracks, laminations and other defects which may interfere with proper laying of the brick or impair the strength or permanence of the structure.

(3) MANUFACTURE. Concrete building brick shall be manufactured from a mixture of Portland cement and approved aggregates, such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, or blast furnace slag.

(4) IDENTIFICATION. All building brick shall be of distinctive design or appearance, or marked so that the identity of the manufacturer may be known at any time.

(5) STRENGTH AND ABSORPTION. (a) The strength and absorption of all building brick manufactured from burned clay or shale shall conform to the following minimum requirements:

	Compressive Strength (bricks flatwise) lbs. per square inch Average Gross Area		Water Absorption by 5 hour boiling per cent		C/B Ratio	
Grade	Average of 5 bricks	Individual Minimum	Average of 5 bricks	Individual Maximum	Average of 5 bricks	Individual Maximum
S.W	3000	2500	17.0	20.0	0.78	0.80
M.W.	2500	2200	22.0	25.0	0.88	0.90
N.W.	1500	1250	No Limit	No Limit	No Limit	No Limit

1. The ratio C/B is the ratio of absorption by 24-hour submersion in water at room temperature to that after 5-hour submersion in boiling water.

(b) If the average compressive strength is greater than 8000 pounds per square inch and the average water absorption is less than 8% by weight after 24 hours submersion in cold water, the C/B ratio shall be waived.

(6) S. W. BRICK. Grade S. W. brick shall be used in exterior and exposed locations where a high degree of resistance to frost action is desired and the exposure is such that the brick may be frozen when permeated with water.

(a) Brick used for foundation courses, retaining walls, parapet walls and similar locations shall conform to this grade.

(7) M. W. BRICK. Grade M. W. brick may be used where exposed to temperatures below freezing but where brick are not likely to be permeated with water or where a moderate degree of resistance to frost action is permissible.

(a) Brick conforming to this grade may be used in the face of a wall above grade.

(8) N. W. BRICK. Grade N. W. brick may be used for backup or for interior construction or if exposed for use where no frost action occurs.

(9) CONCRETE AND SAND LIME BRICK. The strength of all concrete and sand lime brick used in masonry construction shall conform to the following minimum requirements:

Compressive Strength (bricks flatwise) Pounds Per Square Inch Average Gross Area		Modulus of Rupture (bricks flatwise) Pounds Per Square Inch	
Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
2500	2000	450	300

(10) TESTS. Typical specimens of all types of building brick shall be tested originally to prove compliance with the provisions of this code, and all concrete and sand-lime brick shall be retested at intervals of not more than one year. Further tests may be demanded at any time there is reasonable suspicion of non-conformance to the requirements of this code.

(11) STANDARDS. The testing of all brick shall be in accordance with the Standard Methods of Testing Brick (A. S. T. M. Designation C 67) of the American Society for Testing Materials.

Ind 53.06 Hollow building units. (1) DEFINITIONS. (a) Hollow tile are the products of surface clay, shale, fireclay, or admixtures thereof, moulded to permanent hollow form for use as masonry units in building construction.

(b) Hollow concrete masonry units are the products of Portland cement and suitable aggregates such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale or blast-furnace slag, moulded to permanent hollow form for use as masonry units in building construction.

(2) HOLLOW TILE USED IN BEARING AND EXTERIOR WALLS. *(a) Strength and Absorption.* All hollow tile used in bearing and exterior walls shall conform to the following minimum requirements for strength absorption:

Compressive Strength (Based on Gross Area) Pounds per square inch				Absorption per cent		
End Construction Tile		Side Construction Tile				
Average of Five Tests	Individual Minimum	Average of Five Tests	Individual Minimum	Average of Five Tests	Individual Maximum	Individual Minimum
1400	1000	1000	900	5 to 16	19	4

(3) NUMBER OF CELLS. Load bearing tile shall conform to the following requirements as to the minimum number of cells per unit in the direction of wall thickness:

Nominal Horizontal Thickness of Tile as Laid in Wall, in inches	Minimum Number of Cells in Direction of Wall Thickness
4	1
6	2
8	2
10	2
12	3

Note: Cells, as used herein, are hollow spaces enclosed within the perimeter of the exterior shells, and having a minimum dimension of not less than ½ inch and a cross sectional area of not less than one square inch.

(4) DOUBLE-SHELL TILE. In double-shell tile the 2 voids between exterior and interior shells on either side of the tile shall be considered as one cell in thickness of wall when their combined width is not less than ½ inch, provided the short webs between the inner and outer shells are not greater in number and thickness than the long transverse webs holding the inner shells.

(5) SHELL AND WEB THICKNESS. The average over-all thickness of the shells, measured between the inner and extreme outer surfaces of end-construction hollow tile, shall be not less than ¾ inch, except that in double-shell tile the combined average over-all thickness of the inner and outer shell shall be not less than ¾ inch. The thickness of the webs shall be not less than ½ inch.

(6) AVERAGE THICKNESS. The average over-all thickness of the shells, measured between the inner and extreme outer surfaces of side-construction hollow tile, shall be not less than ⅝ inch, except that in

double-shell tile the combined average over-all thickness of the inner and outer shell shall be not less than ¾ inch. The thickness of the webs shall be not less than ½ inch.

(7) BRANDING. All clay tile shall be branded with a distinctive indentation on the shell. Clay tile which comply with all requirements for exterior construction and bearing walls shall have the word BEARING impressed on them. All clay tile shall bear the name, initials or trade-mark of the manufacturer.

(8) TESTS. Typical specimens of all sizes and designs of hollow tile used in exterior or bearing walls shall be tested originally to prove compliance with this code, and thereafter as directed by the industrial commission. Tile shall be sampled and tested in accordance with the Standard Methods of Sampling and Testing Structural Clay Tile (A.S.T.M. Designation C–112) of the American Society for Testing Materials.

(9) HOLLOW CONCRETE MASONRY UNITS USED IN BEARING AND EXTERIOR WALLS.

(a) Compressive strength. All hollow concrete masonry units used in exterior and bearing walls shall have a compressive strength of not less than 1000 pounds per square inch gross area as laid in the wall.

1. The average strength of any group of test specimens of hollow concrete masonry units shall be not less than the above requirements. The strength of any individual test specimen shall be not less than 900 pounds per square inch gross area.

(b) Absorption. Hollow concrete masonry units used in walls which will be exposed to the weather or soil in finished work shall not absorb more than 14 pounds of water per cubic foot of concrete actually contained. Units which are protected from the weather or soil with one course of brick or its equivalent need not conform to these absorption requirements.

(c) Branding. All hollow concrete masonry units used in exterior or bearing walls shall be branded with a distinctive indentation or waterproof stencilled mark, and shall bear the name, initials, or trade-mark of the manufacturer. A facsimile of each individual brand shall be filed with the Industrial Commission.

(d) Tests. Typical specimens of all sizes and designs of hollow concrete masonry units used in exterior or bearing walls shall be tested in an approved manner, originally to prove compliance with the requirements of this code, and thereafter at intervals of not more than one year. Further tests may be demanded at any time there is reasonable suspicion of non-conformance to the requirements of this code.

1. Hollow concrete masonry units shall be sampled and tested in accordance with the methods of sampling and testing concrete masonry units (A.S.T.M. Designation C 140–39) of the American Society for Testing Materials.

(10) CLAY TILE USED IN NON-BEARING PARTITIONS.

(a) Weight. The weight of hollow clay tile used in non-bearing partitions shall be not less than the following:

Dimension	Minimum No. of cells in unit	Minimum No. of cells in direction of wall thickness	Minimum Average Weight, lb. per sq. ft. of tile	Individual Minimum Weight, lb. per square foot of tile
2x12x12	3	1	14	13
3x12x12	3	1	15	14
4x12x12	3	1	16	15
6x12x12	3	1	22	21
6x12x12	4	2	25	24
8x12x12	4	2	30	28
10x12x12	4	2	35	33
12x12x12	4	2	40	38

1. The weights above are for scored tile. If any of the faces are unscored, the weights shall be increased 0.5 lb. per square foot of unscored area.

2. No dimension shall vary more than 3% from the specified dimensions for any form of tile.

3. The requirements for minimum weights of hollow clay tile used in non-bearing partitions shall be waived if the over-all thickness of the shells, measured between the inner and extreme outer surfaces, is not less than ⅝ inch and the thickness of webs is not less than ½ inch.

(b) Shape and structure. All hollow clay tile used in non-bearing partitions shall be reasonably free from laminations and from such cracks, blisters, surface roughness and other defects which would interfere with the proper setting of the tile, or impair the strength, permanence or fire protection value of the construction.

1. The depth of curvature or warpage of any face, shall not exceed 3% of the greatest dimension of such face, but in no case more than ¼ inch.

2. Surfaces of all tile intended for the direct application of plaster or stucco shall be scratched or scored. When scored, each groove shall be not less than ⅛ inch nor more than 3/16 inch in depth, nor more than 1 inch in width. The area covered by the grooves shall not exceed 50% of the area of the scored faces.

(c) Branding. All hollow clay tile used in non-bearing partitions shall be branded with a distinctive indentation. All hollow clay tile not suitable for use in bearing and exterior walls but used in non-bearing partitions shall have the word PARTITION impressed on them.

1. All hollow clay tile used in partition work shall bear the name, initials or trade-mark of the manufacturer.

(11) HOLLOW CONCRETE MASONRY UNITS USED IN NON-BEARING PARTITIONS. All hollow concrete masonry units used in non-bearing partitions shall comply with the requirements for use in bearing and

exterior walls, or shall be branded with a distinctive impression to identify them for use only in non-bearing partitions.

(12) CLAY TILE AND HOLLOW CONCRETE MASONRY UNITS USED IN FLOOR CONSTRUCTION.

(a) General requirements. Where hollow clay tile or hollow concrete masonry units are used in concrete floor construction in a way that the whole or any portion of a tile or block is subjected to a load, the requirements which apply to tile or block used in exterior and bearing construction shall be complied with.

(b) Tile and masonry floor units. Where hollow clay tile or hollow concrete masonry units are used in concrete floor construction in a way that no portion of a tile or block is subjected to a load, the requirements which apply to tile or blocks used in partitions shall be complied with.

(c) Branding. All clay tile or concrete masonry units used in floor construction shall bear the name, initials or trade-mark of the manufacturer.

Ind 53.07 Allowable unit stresses in masonry. (1) The compressive stresses in masonry walls, partitions, piers and similar bearing masonry shall not exceed the following in pounds per square inch:

Kind of Masonry	Kind of Mortar		
	Lime	Lime-Portland Cement	Portland Cement
Brick	90	140	175
Hollow Concrete Masonry Units	----	85	100
Hollow Clay Tile	----	85	100

(2) Where a combination of 2 or more building units is used, the minimum requirements shall apply to the masonry.

Ind 53.08 Mortar. (1) All cement used in the making of mortar for embedding masonry and for other structural purposes under this code shall conform to the requirements of the standard specifications for these materials issued by the American Society for Testing Materials having designation listed as follows:

Specifications for Portland Cement—C 150-41

(2) Lime putty for mortar shall be made by slaking quicklime to a smooth paste, and shall be stored and protected for a period of not less than 10 days before being used in the making of mortar. Where pulverized quicklime is used, the storing period may be reduced to 48 hours.

(a) Hydrated lime shall be considered the equivalent of lime putty for all uses hereunder.

(3) Lime mortar shall consist of one part lime putty, or dry hydrated lime, to not more than 3 parts of approved sand, all measurements by volume.

(4) Lime-cement mortar shall consist of one part of lime putty, or dry hydrated lime, and one part of Portland cement added to not more than 6 parts of approved sand, all measurements by volume.

(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 ⅙ of the volume 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.

(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 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.

(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.

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 habitually 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 columns and supporting members by means of substantial ties of at least No. 13 U. S. Standard gauge metal, spaced not more than 24 inches center to center.

(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. Simi-

lar 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.

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.

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:

(a) To buildings where frame construction would be permitted under the provisions of this code.

(b) To walls which face streets, or alleys.

(c) To walls where not less than 10 feet of vacant space is maintained between the wall and the boundary line between premises.

(d) To walls which are not less than 10 feet from other buildings on the same premises.

(2) All parapet walls shall be properly coped with incombustible, weatherproof material.

Ind 53.14 Concrete materials. (1) PORTLAND CEMENT. Portland cement shall conform to the "Standard Specifications for Portland Cement" (A.S.T.M. Serial Designation: C-150-49).

(2) CONCRETE AGGREGATES. Concrete aggregates, except lightweight aggregates, shall conform to the "Standard Specifications for Concrete Aggregates" (A.S.T.M. Designation C-33-49) including the method of sampling and testing.

(3) LIGHTWEIGHT AGGREGATES. Lightweight aggregates for concrete shall conform to the "Standard Specifications for Lightweight Aggregates for Concrete" (A.S.T.M. Designation C-130-42) including the methods of sampling and testing.

(a) The maximum size of the aggregate shall not be larger than ⅕ of the narrowest dimension between sides of the forms of the member for which the concrete is to be used nor larger than ¾ of the minimum clear spacing between reinforcing bars.

(4) WATER. Water used in mixing concrete shall be clean, and free from injurious amounts of oil, acid, alkali, organic matter, or other harmful substances.

(5) METAL REINFORCEMENT. Metal reinforcement shall conform to the requirements of the "Standard Specifications for Billet-Steel Bars for Concrete Reinforcement" (A.S.T.M. Serial Designation: A15-50T) or for "Rail Steel Bars for Concrete Reinforcement" (A.S.T.M. Serial Designation: A16-50T) or for "Welded Steel Wire Fabric for Concrete Reinforcement" (A.S.T.M. Serial Designation A-185-37).

(a) Deformed bars. Deformed reinforcing bars shall conform to the "Standard Specifications for Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement" (A.S.T.M. Serial Designation: A-305-50T). Bars not conforming to these specifications shall be classed as plain bars.

(b) Wire mesh. Wire mesh with welded intersections not further apart than 6 inches in the direction of the principal reinforcement and with cross wires not smaller than No. 10 W and M gauge may be rated as deformed bars.

(c) Placing metal reinforcement. Metal reinforcement shall be accurately placed and adequately secured in position by concrete or metal chairs or spacers. The minimum clear distance between parallel bars, except in columns, shall be equal to the nominal diameter of the bars. In no case shall the clear distance between the bars be less than one inch, nor less than one and one-third the maximum size of the coarse aggregate. Where reinforcement in beams or girders is placed in 2 or more layers, the clear distance between layers shall not be less

than one inch and the bars in the upper layers shall be placed directly above those in the bottom layer.

(6) STORAGE OF MATERIALS. Cement and aggregates shall be stored in such a manner as to prevent deterioration or the intrusion of foreign matter. Any material which has deteriorated or which has been damaged shall be removed completely from the premises.

Ind 53.15 Concrete proportions, mixing and strength. (1) PROPORTIONS. The proportions of aggregate to cement for any concrete shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcement with the method of placing employed on the work, but without permitting the materials to segregate or excess free water to collect on the surface.

(a) The methods of measuring concrete materials shall be such that the proportions can be controlled accurately and checked easily at any time during the work. Wherever practicable, such measurement shall be by weight rather than by volume.

(2) MIXING. The concrete shall be mixed until there is a uniform distribution of the materials and the mass is uniform in color and homogeneous. In machine mixing, only batchmixers shall be used. Each batch shall be mixed not less than one minute after all the materials are in the mixer and must be discharged completely before the mixer is recharged. Machine mixers shall have a peripheral speed of approximately 200 feet per minute.

(a) Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in the "Standard Specifications for Ready-mixed Concrete" (A.S.T.M. Serial Designation C94–48).

(3) STRENGTH. For the design of reinforced concrete structures, the value of f'_c used for determining the working stresses as stipulated in section Ind 53.22 (3) shall be based on the specified minimum 28-day compressive strength of the concrete, or on the specified minimum compressive strength at the earlier age at which the concrete may be expected to receive its full load. All plans, submitted for approval or used on the job, shall show clearly the assumed strength of concrete at the specified age for which all parts of the structure were designed.

(a) All concrete exposed to the action of the weather shall have a water-content of not to exceed 6 gallons per sack of cement.

(b) When average aggregates are to be used and no preliminary tests are to be made, the water content to be used for various desired strengths of concrete shall be as indicated in the following table:

Water-Content, U. S. Gallons per 94 lb. Sack of Cement	7½	6¾	6
Assumed Compressive Strength at 28 Days, lb. per sq. in.	2000	2500	3000

(c) In computing the water-content, surface water carried by the aggregates must be included. Water-content other than shown in the above table may be used, provided that the strength-quality of the concrete proposed for use in the structure shall be established by tests made in advance of the start of the work, using suitable consistencies and in accordance with the "Standard Method of Making Compression Tests of Concrete" (A.S.T.M. Serial Designation: C39–49).

(d) A curve representing the relation between the water-content and the average 28-day compressive strength or earlier strength at which the concrete is to receive its full working load, shall be established for a range of values including all the compressive strengths indicated on the plans.

(e) The curve shall be established by at least 3 points, each point representing average values from at least 4 test specimens. The maximum allowable water-content for the concrete for the structure shall be as determined from this curve and shall correspond to a strength which is 15% greater than that indicated on the plans. No substitutions shall be made in the materials used on the work without additional tests in accordance herewith to show that the quality of the concrete is satisfactory.

(4) CURING AND PROTECTION AGAINST COLD WEATHER. In all concrete structures, concrete made with normal Portland cement shall be maintained in a moist condition for at least the first 7 days after placing, and high-early-strength concrete shall be so maintained for at least the first 3 days.

(a) Adequate equipment shall be provided for heating the concrete materials and protecting the concrete during freezing weather. No frozen materials or materials containing ice shall be used.

(b) All concrete materials and all reinforcements, forms, fillers, and ground with which the concrete is to come in contact, shall be free from frost. Whenever the temperature of the surrounding air is below 40 degrees Fahrenheit, all concrete when placed in the forms shall have a temperature of between 60 and 90 degrees Fahrenheit and shall be maintained at a temperature of not less than 50 degrees Fahrenheit for at least 72 hours for normal concrete or 24 hours for high-early-strength concrete, or for as much more time as is necessary to insure proper rate of curing of the concrete. The housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heating is discontinued. No dependence shall be placed on salt or other chemicals for the prevention of freezing.

(5) FORMS AND SHORING FOR CONCRETE STRUCTURES. Forms shall be substantially constructed to carry dead and live loads and impact imposed during pouring operations. Forms shall conform to the shape, lines, and dimensions of the members as called for on the plans, and shall be sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together so as to maintain position and shape.

(a) Forms shall be removed in such manner as to insure the complete safety of the structure. Where the structure as a whole is supported on shores, the removable floor forms, beam and girder sides, column and similar vertical forms may be removed after 24 hours, provided the concrete is sufficiently hard not to be injured thereby. In no case shall the supporting forms or shoring be removed until the members have acquired sufficient strength to support safely their weight and the load thereon. The results of suitable control tests may be used as evidence that the concrete has attained such sufficient strength.

Ind 53.16 Flexure of beams, frames, and slabs. (1) CONDITION OF DESIGN. All members of frames or continuous construction shall be designed to resist at all sections the maximum moments and shears produced by dead load, live load and wind load, as determined by some one of the approximate methods of elastic frame analysis. Any reasonable assumptions may be adopted as to relative stiffness of columns and floor members. The assumptions made should be consistent throughout the analysis. The following will serve as a guide to satisfactory design.

(a) The stiffness, K, of a member is defined as EI divided by l or h. The modulus of elasticity for concrete shall be assumed as 1000 f'_c, and that for steel as 30,000,000 lbs. per sq. in. In the analysis of continuous frames, center to center distances, l and h, shall be used in the determination of moments.

(b) In computing the value of I of slabs, beams, girders, and columns, the reinforcement may be neglected. In T-shaped sections allowance shall be made for the effect of the flange. The additional width of haunched floor members near supports may be neglected in computing moments, but may be considered to resist moment and shear. The additional depth of haunched floor members may be considered as resisting moment only when a complete analysis is made taking into account the variation in depth. Otherwise the minimum depth should be used to find moment and to resist the resulting moment. However, in any case, the actual depth may be assumed to resist shear.

(c) Moments at faces of supports may be used for design of beams and girders. Solid or ribbed slabs with clear spans of not more than 10 feet that are built integrally with their supports may be designed as continuous slabs on knife edge supports with spans equal to the clear spans of the slab and the width of beams otherwise neglected. The span length of members that are not built integrally with their supports shall be the clear span plus the depth of the beam or slab but shall not exceed the distance between centers of supports.

(d) The clear distance between lateral supports of a beam shall not exceed 32 times the least width of compression flange.

(2) REQUIREMENTS FOR T-BEAMS. In T-beam construction, the slab and beam shall be built integrally or otherwise effectively bonded together. The effective flange width to be used in the design of symmetrical T-beams shall not exceed ¼ of the span length of the beam, and its overhanging width on either side of the web shall not exceed 8 times the thickness of the slab nor ½ the clear distance of the next beam.

(a) For beams having a flange on one side only, the effective overhanging flange width shall not exceed 1/12 of the span length of the beam, nor 6 times the thickness of the slab, nor ½ the clear distance to the next beam.

(b) Where the principal reinforcement in a slab which is considered as the flange of a T-beam (not a joist in concrete joist floors) is parallel to the beam, transverse reinforcement shall be provided in the top of the slab. This reinforcement shall be designed to carry the load on the portion of the slab assumed as the flange of the T-beam. The spacing of the bars shall not exceed 5 times the thickness of the flange, nor in any case 18 inches.

(c) Provision shall be made for the compressive stress at the support in continuous T-beam construction, care being taken that the provisions relating to the spacing of bars, and the placing of concrete shall be fully met.

(d) The overhanging portion of the flange of the beam shall not be considered as effective in computing the shear and diagonal tension resistance of T-beams.

(e) Isolated beams in which the T-form is used only for the purpose of providing additional compression area, shall have a flange thickness not less than ½ the width of the web and a total flange width not more than 4 times the web thickness.

(3) COMPRESSION STEEL IN FLEXURAL MEMBERS. Compression steel in beams, girders, or slabs shall be anchored by ties or stirrups not less than ¼ inch in diameter spaced not farther apart than 16 bar diameters, or 48 tie diameters. Such stirrups or ties shall be used throughout the distance where the compression steel is required.

(4) CONCRETE JOIST FLOOR CONSTRUCTION. Concrete joist floor construction consists of concrete joists and slabs placed monolithically with or without burned clay or concrete tile fillers. The joists shall not be farther apart than 30 inches face to face. The joists shall be not less than 4 inches wide, nor of a depth more than 3 times the width.

(a) When burned clay or concrete tile fillers, of material having a unit compressive strength at least equal to that of the designed strength of the concrete in the joists are used, and the fillers are so placed that the joints in alternate rows are staggered, the vertical shells of the fillers in contact with the joists may be included in the calculations involving shear or negative bending moment. No other portion of the fillers may be included in the design calculations.

(b) The concrete slab over the fillers shall be not less than one and one-half inches in thickness, nor less in thickness than 1/12 of the clear distance between joists.

(c) Where removable forms or fillers are used, the thickness of the concrete slab shall not be less than 1/12 of the clear distance between joists and in no case less than 2 inches. Such slab shall be reinforced at right angles to the joists with a minimum of .049 sq. in. of reinforcing steel per foot of width, and in slabs on which the prescribed live load does not exceed 50 lbs. per sq. ft., no additional reinforcements shall be required.

(d) When the finish used as a wearing surface is placed monolithically with the structural slab in buildings of the warehouse or industrial class, the thickness of the concrete over the fillers shall be ½ inch greater than the thickness used for design purposes.

(e) Where the slab contains conduits or pipes, the thickness shall not be less than ½ inch plus the total over-all depth of such conduits or pipes at any point. Such conduits or pipes shall be so located as not to impair the strength of the construction.

(5) FLAT SLABS AND TWO-WAY SLABS WITH SUPPORTS ON 4 SIDES. Structures of these types shall be designed in accordance with the provisions of the 1940 Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, or the building regulations for reinforced concrete of the American Concrete Institue (A.C.I. 318-56).

Ind 53.17 Shear and diagonal tension. (1) GENERAL. Due to the composite character of reinforced concrete beams, the action of reinforcement in resisting diagonal tension is not susceptible of exact analysis. Hence, the design of web reinforcement is based on empirical or modified rational methods which have been developed from tests and the observations of existing structures.

(a) Vertical stirrups, bent-up longitudinal bars or both, add greatly to the resistance to shear or diagonal tension. This is especially true if adequate bond resistance is provided, either in the form of low bond stress or effective anchorage of the reinforcement. The importance of bond resistance is such that high working stresses are permitted only when all of the reinforcement is anchored properly. Therefore, the requirements of section Ind 53.18 on bond and anchorage are intimately related to the provisions of this section.

(2) UNIT SHEARING STRESS. The shearing unit stress used as a measure of diagonal tension shall be computed by the formula $v = \frac{V}{bjd}$. For beams of I or T section, the width of the concrete web or stem shall be used.

(a) In concrete joist floor construction where burned clay or concrete tile are used, the shells of the tile in contact with the joists may be used in computing the shearing stress provided that the net compressive strength of the shells of tile equals that of the concrete in the joists and provided that the joints in alternate rows of tile are staggered.

(3) USE OF WEB REINFORCEMENT. Where the shearing unit stress in a beam or joist exceeds 0.03 f'_c, web reinforcement shall be provided at all sections for the shear in excess of this amount.

(a) Web reinforcement may consist of vertical or inclined stirrups or bent-up longitudinal reinforcement or a combination thereof. Bars inclined at an angle less than 15 degrees with the axis of the beam shall not be considered as web reinforcement.

(b) Stirrups or bent-up longitudinal bars to be considered effective as web reinforcement shall be anchored at both ends in accordance with the requirements of section Ind 53.18.

(4) SPACING OF WEB REINFORCEMENT. Where web reinforcement is required, it shall be so spaced that every 45 degree line (representing a potential crack) extending from the mid-depth of the beam to the longitudinal tension bars shall be crossed by at least one line of web reinforcement. If a shearing unit stress in excess of 0.06 f'_c is used, every such line shall be crossed by at least 2 such lines of web reinforcement.

Ind 53.18 Bond and anchorage. (1) UNIT BOND STRESS. In flexural members in which the tensile reinforcement is parallel to the compression face, the bond stress at any cross section shall be computed by the formula $u = \frac{V}{\Sigma_0 \, jd}$. In beams of variable depth to which this formula does not apply, special provision must be made for the end anchorage of all tensile reinforcement.

(2) ANCHORAGE FOR LONGITUDINAL STEEL AND WEB REINFORCEMENT. Tensile negative reinforcement in any span of a continuous restrained or cantilever beam, or in any member of a rigid frame shall be adequately anchored by bond, hooks or mechanical anchors in or through the supporting member. Within any such span, every reinforcing bar, whether required for positive or negative reinforcement, shall be extended at least 12 diameters beyond the point at which it is no longer needed to resist stress. The maximum tension in any bar must be developed by bond on a sufficient straight or bent embedment or by other anchorage. If preferred, the bar may be bent across the web at an angle of not less than 15 degrees with the longitudinal portion of the bar and made continuous with the reinforcement which resists moment of opposite sign.

(a) Of the positive reinforcement in continuous beams not less than ¼ of the area shall extend along the same face of the beam into the support a distance of 6 inches.

(b) In simple beams, or at the freely supported end of continuous beams, at least ⅓ the required positive reinforcement shall extend along the same face of the beam into the support a distance of 6 inches.

(c) Plain bars in tension shall terminate in standard hooks except that hooks shall not be required on the positive reinforcement at interior supports of continuous members.

(d) Single separate bars used as web reinforcement shall be anchored at each end by one of the following methods:

1. By welding to longitudinal reinforcement.
2. By hooking tightly around the longitudinal reinforcement through 180 degrees.
3. The extreme ends of bars forming simple U or multiple stirrups shall be anchored as specified in 1 or 2 or shall be bent through an angle of 90 degrees tightly around a longitudinal reinforcing bar not less in diameter than the stirrup bar and shall project beyond the bend at least 12 diameters of the stirrup bar.
4. In all cases, web reinforcements shall be carried as close to the compression surface of the beam as fire and rust protection regulations and the proximity of other steel will permit.

Ind 53.19 Columns. (1) LIMITING DIMENSIONS. The following sections apply to a short column, for which the unsupported height is not greater than 10 times the least lateral dimension. When the unsupported height exceeds this value, the design shall be modified as shown in section Ind 53.19. The unsupported height may be defined as the distance from the bottom of a slab, column capital, or beam to the top of the floor below. Principal columns in buildings shall have a minimum diameter or thickness of 10 inches. Posts, bearing walls, piers, or mullions that are not continuous from story to story shall have a minimum diameter or thickness of 6 inches.

(2) SPIRAL COLUMNS. The maximum allowable axial load on columns reinforced with longitudinal bars and closely spaced spirals enclosing a circular core shall be as follows:

$$P = A_g\ (0.225\ f'_c + f_s p_g)$$

Wherein

A_g = The gross area of the column.

f'_c = Compressive strength of the concrete.

f_s = Nominal allowable stress in vertical column reinforcement to be taken at 40 per cent of the minimum specification value of the yield point; namely, for rail or hard grade steel—20,000#; for intermediate grade steel—16,000#

p_g = Ratio of the effective cross sectional area of vertical reinforcement to the gross area A_g. The ratio p_g shall not be less than 0.01 nor more than 0.08.

(a) *Vertical bars.* The minimum number of vertical bars shall be 6, and the minimum diameter of bar shall be ⅝ inch. Spirals shall be at least ¼ inch in diameter and shall not be spaced less than 1½ inches nor more than 3 inches apart.

(b) *Spiral reinforcement.* The ratio of spiral reinforcement p′ shall not be less than the value given by the following formula:

$$p' = 0.45 \left(\frac{A_g}{A_c} - 1 \right) \frac{f'_c}{f'_s}$$

Wherein

p′ = Ratio of volume of spiral reinforcement to the volume of the concrete core (out to out of spirals).

f'_s = Useful limit stress of spiral reinforcement to be taken as 40,000# per sq. in. for hot rolled rods of intermediate grade, 50,000# per sq. in. for rods of hard grade, and 60,000# per sq. in. for cold drawn wire.

(3) TIED COLUMNS. The maximum allowable axial load on columns reinforced with longitudinal bars and separate lateral ties shall be 80% of that given by the formula for spirally reinforced columns.

(a) The minimum number of vertical bars shall be 4, and the minimum diameter of bar shall be ⅝ inch. Lateral ties shall be at least ¼ inch in diameter and shall be spaced apart not over 16 bar diameters, 48 tie diameters, or the least dimension of the column. When there are more than 4 vertical bars, additional ties shall be provided so that every longitudinal bar is held firmly in its designed position.

(4) LONG COLUMNS. The maximum allowable load P′ on an axially loaded reinforced concrete column having a height, h, greater than 10 times its least lateral dimension, d, is given by the formula:

$$P' = P \left[1.3 - .03 \frac{h}{d} \right]$$

in which P = the allowable axial load on a normal short column.

(5) BENDING MOMENTS IN COLUMNS. Columns in building frames shall be designed to resist the maximum moments and shears produced by dead load, live load, and wind load, as determined by some approximate method of elastic frame analysis. Assumptions as to relative rigidity of columns and floor members shall be consistent throughout and agree with the methods used in the analysis of floor members. Recognized methods of analysis shall be followed in calculating the stresses due to combined axial load and bending. The gross area of both spiral and tied columns may be used in these computations.

(a) Where lapped splices in the column verticals are used, the minimum amount of lap shall be as follows:

1. For deformed bars with concrete having a strength of 3000# per sq. in. or above, 20 diameters of bar of intermediate or hard grade steel. For bars of higher yield point, the amount of lap shall be increased one diameter for each 1000# per sq. in. by which the allowable stress exceeds 20,000# per sq. in. When the concrete strengths are less than 3000# per sq. in., the amount of lap shall be ⅓ greater than the values given above.

2. For plain bars, the minimum amount of lap shall be twice that specified for deformed bars.

3. Welded splices or other positive connections may be used instead of lapped splices. Welded splices shall preferably be used in cases where the bar diameter exceeds 1¼ inches. An approved welded splice shall be defined as one in which the bars are butted and welded and that will develop in tension at least the yield point stress of the reinforcing steel used.

Ind 53.20 Plain and reinforced concrete walls and piers. (1) Definitions. Plain concrete walls shall be defined as concrete walls where the area of the horizontal reinforcement is less than 0.0025 and the area of the vertical reinforcement is less than 0.0015 times the cross sectional area of the wall where bars are used and not less than ¾ this amount where welded wire fabric of not less than No. 10 A. S. & W. gauge is used.

(2) Thickness. The thickness of reinforced concrete bearing walls shall not be less than 6 inches for the upper 15 feet of their height, and for each successive 25 feet downward, the minimum thickness shall be increased 1 inch.

(a) Reinforced concrete bearing walls shall have a thickness of not less than 1/25 of the unsupported height or width, whichever is the shorter.

(b) Exterior basement walls, foundation walls, and party walls of either plain or reinforced concrete shall be not less than 8 inches thick.

(c) The limit of thickness and quantity of reinforcement may be waived when structural analysis shows adequate strength and stability, if approved by the industrial commission.

(3) Working stresses. The allowable working stresses in reinforced concrete bearing walls with minimum reinforcement specified above shall be 0.25 f'_c for walls having a ratio of height to thickness of 10 or less and shall be reduced proportionally to 0.15 f'_c for walls having a ratio of height to thickness of 25. When the reinforcement in bearing walls is designed, placed, and anchored in position as for tied columns, the allowable working stresses for tied columns may be used. The length of wall to be considered effective for each concentrated load shall not exceed the width of the bearing plus 4 times the wall thickness, nor shall it exceed the center to center distance between loads. The ratio p'_g shall not exceed 0.04.

(4) Non-bearing walls. Non-bearing panel and enclosure walls of reinforced concrete shall have a thickness of not less than 4 inches and not less than 1/30 the distance between supporting or enclosing members.

History: 1-2-56; r. and recr. Register, August, 1957, No. 20, eff. 9-1-57.

Ind 53.21 Footings. (1) BENDING MOMENT. The external moment on any section shall be determined by passing through the section a vertical plane which extends completely across the footing, and computing the moment of the forces acting over the entire area of the footing on one side of said plane.

(a) The greatest bending moment to be used in the design of an isolated footing shall be the moment computed in the manner just described at sections located as follows:

1. At the face of the column, pedestal or wall, for footings supporting a concrete column, pedestal or wall.

2. Halfway between the middle and the edge of the wall, for footings under masonry walls.

3. Halfway between the face of the column or pedestal and the edge of the metallic base, for footings under metallic bases.

4. The width resisting compression at any section shall be assumed as the entire width of the top of the footing at the section under consideration.

(b) In one-way reinforced footings, the total tensile reinforcement at any section shall provide a moment of resistance at least equal to the bending moment and the reinforcement thus determined shall be distributed uniformly across the full width of the section.

(c) In two-way reinforced footings, the total tensile reinforcement at any section shall provide a moment of resistance at least equal to 85% of the bending moment.

(d) In two-way square footings, the reinforcement extending in each direction shall be distributed uniformly across the full width of the footing.

(e) In two-way rectangular footings, the reinforcement in the long direction shall be distributed uniformly across the full width of the footing. In the case of the reinforcement in the short direction, that portion determined by the following formula shall be uniformly distributed across a band-width (B) centered with respect to the center line of the column or pedestal and having a width equal to the length of the short side of the footing. The remainder of the reinforcement shall be uniformly distributed in the outer portions of the footing.

$$\frac{\text{Reinforcement in band-width (B)}}{\text{Total reinforcement in short dimension}} = \frac{2}{(S + 1)}$$

In this formula, "S" is the ratio of the long side to the short side of the footing.

(2) ANCHORAGE OF BARS IN FOOTING SLABS. Plain bars in footing slabs shall be anchored by means of standard hooks. The outer faces of these hooks and the ends of deformed bars shall not be less than 3 inches nor more than 6 inches from the face of the footing.

(3) SHEAR AND BOND. The critical section for shear to be used as a measure of diagonal tension shall be assumed as a vertical section obtained by passing a series of vertical planes through the footing,

each of which is parallel to a corresponding face of the column, pedestal, or wall and located a distance therefrom equal to the effective depth for footings on soil, and ½ the effective depth for footings on piles.

(a) Each face of the critical section as defined above shall be considered as resisting an external shear equal to the load on an area bounded by said face of the critical section for shear, 2 diagonal lines drawn from the column or pedestal corners and making 45 degree angles with the principal axes of the footing, and that portion of the corresponding edge or edges of the footing intercepted between the 2 diagonals.

(b) Critical sections for bond shall be assumed at the same planes as those prescribed for bending moment; also at all other vertical planes where changes of section or of reinforcement occur.

(c) Computations for shear to be used as a measure of bond shall be based on the same section and loading as prescribed for bending moment.

(d) The total tensile reinforcement at any section shall provide a bond resistance at least equal to the bond requirement as computed from the following percentages of the external shear at the section:

1. In one-way reinforced footings, 100%.
2. In two-way reinforced footings, 85%.

(e) In computing the external shear on any section through a footing supported on piles, the entire reaction from any pile whose center is located 6 inches or more outside the section shall be assumed as producing shear on the section; the reaction from any pile whose center is located 6 inches or more inside the section shall be assumed as producing no shear on the section. For intermediate positions of the pile center, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straightline interpolation between full value at 6 inches outside the section and zero value at 6 inches inside the section.

(4) TRANSFER OF STRESS AT BASE OF COLUMN. The stress in the longitudinal reinforcement of a column or pedestal shall be transferred to its supporting pedestal or footing either by extending the longitudinal bars into the supporting member, or by dowels.

(a) In case the transfer of stress in the reinforcement is accomplished by extension of the longitudinal bars, they shall extend into the supporting member the distance required to transfer to the concrete, by allowable bond stress, their full working value.

(b) In cases where dowels are used, their total sectional area shall be not less than the sectional area of the longitudinal reinforcement in the member from which the stress is being transferred. In no case shall the number of dowels per member be less than 4 and the diameter of the dowels shall not exceed the diameter of the column bars by more than ⅛ inch.

(c) Dowels shall extend up into the column or pedestal a distance at least equal to that required for lap of longitudinal column bars and down into the supporting pedestal or footing the distance required to transfer to the concrete, by allowable bond stress, the full working value of the dowel.

(d) The compressive stress in the concrete at the base of a column or pedestal shall be considered as being transferred by bearing to the top of the supporting pedestal or footing. The unit compressive stress on the loaded area shall not exceed the bearing stress allowable for the quality of concrete in the supporting member as limited by the ratio of the loaded area to the supporting area.

(e) In sloped or stepped footings, the supporting area for bearing may be taken as the top horizontal surface of the footing, or assumed as the area of the lower base of the largest frustum of a pyramid or cone contained wholly within the footing and having for its upper base the area actually loaded, and having side slopes of one vertical to 2 horizontal.

(5) PEDESTALS AND FOOTINGS (PLAIN CONCRETE). The allowable compressive unit stress on the gross area of a concentrically loaded pedestal shall not exceed $0.25f'_c$. Where this stress is exceeded, reinforcement shall be provided and the member designed as a reinforced concrete column.

(a) The depth and width of a pedestal or footing of plain concrete shall be such that the tension in the concrete shall not exceed $.03\ f'_c$ and the average shearing stress shall not exceed $.02\ f'_c$ taken on sections as prescribed heretofore for reinforced concrete footings.

(6) FOOTINGS SUPPORTING ROUND COLUMNS. In computing the stresses in footings which support a round or octagonal concrete column or pedestal, the "face" of the column or pedestal shall be taken as the side of a square having an area equal to the area enclosed within the perimeter of the column or pedestal.

(7) MINIMUM EDGE-THICKNESS. In reinforced concrete footings, the thickness above the reinforcement at the edge shall be not less than 6 inches for footings on soil, nor less than 12 inches for footings on piles.

(a) In plain concrete footings, the thickness at the edge shall be not less than 8 inches for footings on soil, nor less than 14 inches above the tops of the piles for footings on piles.

Ind 53.22 Allowable working stresses. (1) CONCRETE STRENGTH. The strength of concrete is fixed by the water content as described in section Ind 53.15 (3). Reinforced concrete used under this code shall have a compressive strength of at least 2000# per sq. in. and no credit shall be given for strengths in excess of 3000# per sq. in. unless approved in writing by the industrial commission.

(2) MODULAR RATIO. The modular ratio, n, shall be assumed equal to $n = \dfrac{30,000}{f'_c}$

(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 longitundinal 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.

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) The strength of gypsum concrete shall be determined by compressive tests of 5 cylinders, 6 inches in diameter and 12 inches in length, from each 25 tons or fraction thereof. The test specimens shall be dried at a temperature of not less than 70 degrees Fahrenheit nor more than 100 degrees Fahrenheit in an atmosphere of not more than 50% relative humidity. The specimens shall be weighed at 1-day intervals until constant weight is attained. The method of testing and application of load shall be in accordance with the requirements specified in sections 19 and 20 of Standard Methods of Making Compression Tests of Concrete, A.S.T.M. C39–39. The average of the 5 specimens shall not fall below the specified minimum and in no case shall any specimen show a strength of less than 80% of the specified minimum.

(5) MODULUS OF ELASTICITY. (a) In the design of structural members of reinforced gypsum concrete the following values shall be used for the modulus of elasticity:

1.	Class 1	Neat	1,000,000 lbs. per sq. in.
2.	Class 2	Containing not more than 3% by weight of wood chips or fiber	600,000 lbs. per sq. in.
3.	Class 3	Containing not more than 12½% by weight of wood chips or fiber	200,000 lbs. per sq. in.

(6) ALLOWABLE STRESSES. (a) In the design of structural members of reinforced gypsum concrete the stresses in the concrete shall not exceed the following allowable values:

1. Compressive stress in bending .... $0.25f_g$
2. Axial compressive or bearing stress .... $0.20f_g$
3. Bond stress (reinforcement anchored) .... $0.02f_g$
4. Shearing stress (reinforcement anchored) .... $0.02f_g$
5. In this table (f_g) indicates the compressive strength of the gypsum concrete as specified in Section (4) (a).

(b) The tensile stresses in reinforcing steel shall be as specified for reinforced concrete made with Portland cement.

(7) SUSPENSION SYSTEM. In the construction of floors or other slabs the reinforcing shall consist of wires with continuity through multiple spans and anchored at the ends. The wires shall be supported in the top of the slab by the roof or floor beams and shall be tightly drawn down as nearly to the bottom of the slab at midspan as fire protection requirements will allow. Provision shall be made in the framing of the end bays of this system for resisting the forces due to end anchorage of the wires. The wires shall be designed for a tension in pounds per foot width of slab equal to:

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

in which

w is the total load in lbs. per sq. ft.
L is the clear span in feet
d is the sag of the wires in feet

Ind 53.24 Structural steel. (1) MATERIAL. (a) Structural steel shall conform to the "Standard Specifications for Structural Steel for Bridges and Buildings". (A.S.T.M. Serial Designation A7-52T).

Note: All arc welding electrodes shall conform to the requirements of the "Specifications for Iron and Steel Arc Welding Electrodes" of the American Welding Society. Electrodes shall be suitable for the positions and other conditions of intended use.

(b) With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and amperage (and polarity if direct current) for all uses and welding positions for which the electrode is suitable.

(2) COMBINED STRESSES. *(a) Axial and bending.* Members subject to both axial and bending stresses shall be so proportioned that the quantity

$\frac{f_a}{F_a} + \frac{f_b}{F_b}$ shall not exceed unity, in which

F_a = axial unit stress that would be permitted by this section if axial stress only existed.

F_b = bending unit stress that would be permitted by this section if bending stress only existed.

f_a = axial unit stress (actual) axial stress divided by area of member.

f_b = bending unit stress (actual) bending moment divided by section modulus of member.

(b) Shear with tension or compression. Rivets, bolts, and welds subject to shearing and externally applied tensile or compressive forces shall be so proportioned that the combined unit stress will not exceed the unit stress allowed for shear in 4 (a).

(3) EFFECTIVE SPAN LENGTH. *(a) Simple spans.* Beams, girders, and trusses shall ordinarily be designed on the basis of simple spans whose effective length is equal to the distance between centers of gravity of the members to which they deliver their end reactions.

(b) End restraint. When designed on the assumption of end restraint, full or partial, due to continuous, semi-continuous or cantilever action, the beams, girders and trusses, as well as the sections of the member to which they connect, shall be designed to carry the shears and moments so introduced, as well as all other forces, without exceeding at any point the unit stresses prescribed in 4(a); except that some non-elastic but self-limiting deformation of a part of the connection may be permitted when this is essential to the avoidance of overstressing of a weld.

(4) ALLOWABLE UNIT STRESSES. All parts of the structure shall be so proportioned that the unit stress in pounds per square inch shall not exceed the following values except as provided in section Ind 53.001.

(a) Structural steel, rivets, bolts and weld metal.

1. TENSION.

a. Structural steel, net section	20,000
b. Butt welds, section through throat	20,000
c. Rivets, on area based on nominal diameter	20,000
d. Bolts and other threaded parts, on nominal area at root of thread	20,000

2. COMPRESSION.

Columns, gross section

a. For axially loaded columns with values $\frac{l}{r}$ not greater than 120 .... $17{,}000 - 0.485 \frac{l^2}{r^2}$

b. For axially loaded columns (bracing and other secondary members) with values of $\frac{l}{r}$ greater than 120 (for main members, see 5 (b)) ....

$$\frac{18{,}000}{1 + \frac{l^2}{18{,}000r^2}}$$

in which l is the unbraced length of the column, and r is the corresponding radius of gyration of the section, both in inches.

c. Plate girder stiffeners, gross section 20,000

d. Webs of rolled sections at toe of fillet (Crippling, see 10 (g)) 24,000

e. Butt welds—Section through throat (crushing) 20,000

3. BENDING.

a. Tension on extreme fibers of rolled sections, plate girders, and built-up members 20,000

b. Compression on extreme fibers of rolled sections, plate girders, and built up members.

With $\frac{ld}{bt}$ not in excess of 600 20,000

With $\frac{ld}{bt}$ in excess of 600 .... $\frac{12{,}000{,}000}{\frac{ld}{bt}}$

in which l is the unsupported length and d the depth, of the member; b is the width, and t the thickness, of its compression flange; all in inches; except that l shall be taken as twice the length of the compression flange of a cantilever beam not fully stayed at its outer end against translation or rotation.

e. Stress on extreme fibers of pins 30,000

f. Fiber stresses in butt welds, due to bending shall not exceed the values prescribed for tension and compression, respectively.

g. Fully continuous beams and girders may be proportioned for negative moments which are maximum at interior points of support, at a unit bending stress 20% higher than above stated; provided that the section modulus used over supports shall not be less than that required for the maximum positive moments in the same beam or girder, and provided that the compression flange shall be regarded as unsupported from the support to the point of contraflexure.

h. For columns proportioned for combined axial and bending stresses, the maximum unit bending stress Fb, Sect. (2) (a) may be taken at 24,000 pounds per square inch, when this stress is induced by the gravity loading of fully or partially restrained beams framing into the columns.

4. SHEARING.

a. Rivets	15,000
b. Pins, and turned bolts in reamed or drilled holes	15,000
c. Unfinished bolts	10,000
d. Webs of beams and plate girders, gross section	13,000
e. Weld Metal	
1. on section through throat of fillet weld, or on faying surface area of plug or slot weld	13,600
2. on section through throat of butt weld	13,000

(Stress in a fillet weld shall be considered as shear on the throat, for any direction of applied stress. Neither plug nor slot welds shall be assigned any values in resistance to stresses other than shear.)

5. BEARING.	Double Shear	Single Shear
a. Rivets	40,000	32,000
b. Turned bolts in reamed or drilled holes	40,000	32,000
Unfinished bolts	25,000	20,000
c. Pins	32,000	
Contact Area		
e. Milled Stiffeners and Other Milled Surfaces	30,000	
f. Fitted stiffeners	27,000	
g. Expansion rollers and rockers (Pounds per linear inch) in which d is diameter of roller or rocker in inches.	600d	

(5) SLENDERNESS RATIO. (a) The ratio of unbraced length to least radius of gyration $\frac{l}{r}$ for compression members and for tension members other than rods shall not exceed:

1. For main compression members 120
2. For bracing and other secondary members in compression 200
3. For main tension members 240
4. For bracing and other secondary members in tension 300

(b) The slenderness of a main compression member may exceed 120, but not 200, provided that it is not ordinarily subject to shock or vibratory loads and provided that its unit stress under full design loading shall not exceed the following fraction of that stipulated under 4 (a) for its actual ratio $\frac{l}{r}$.

$$1.6 - \frac{l}{200r}$$

(6) DEPTH RATIO. *(a) Simple spans.* The depth of beams and girders in floors shall be not less than 1/24 of the span, and where subject to shocks or vibrations not less than 1/20. If members of less depth are used, the unit stress in bending shall be decreased in the same ratio as the depth is decreased from above recommended.

(b) The depth of roof purlins shall not be less than 1/30 of the span except in the case of corrugated sheeting roofs, with a slope of not less than 4¾ in 12.

(c) Beams and girders supporting plastered ceilings shall be so proportioned that the maximum live load deflection will not exceed 1/360 of the span.

(7) MINIMUM THICKNESS OF MATERIAL. *(a) General.* The minimum thicknesses required for protection against crippling, buckling, and shear are prescribed in paragraphs (b) and (c) of this section and in paragraph (b) of (10), respectively. Those stipulations assume that the material is straight and true as erected within the limits prescribed in (13), and is not reduced by corrosion.

1. No further stipulations as to minimum thickness shall apply to steelwork exposed to conditions no more seriously corroding than an indoor atmosphere controlled for human comfort, subject always to the requirements of 12 (a).

2. The following stipulations (a) and (b) as to minimum thickness shall apply to exterior steelwork enclosed in a non-impervious envelope or exposed to frequent rain or snow, and to interior steelwork subject to atmospheric exposure more corrosive than that mentioned in the preceding paragraph.

(a) Columns, studs, lintels, girders and beams; exterior trusses, exterior bracing members; ¼ inch minimum.

(b) Purlins, girts, trusses and bracing members sheltered from direct exposure to rain and snow; $\frac{3}{16}$ inch minimum.

(c) The controlling thickness of rolled shapes, for the purposes of stipulations (a) and (b), shall be taken as the mean thickness of their flanges, regardless of web thickness.

3. Steelwork exposed to industrial fumes or vapor shall be given special protection, either by increasing the thickness of the material or by effective protection.

(a) Projecting elements under compression. Projecting elements of members subjected to axial compression or compression due to bending shall have ratios of width to thickness not greater than the following:

1. Single angle struts; 12.

2. Double angle struts, angles or plates projecting from girders, columns or other compression members; compression flanges of beams; stiffeners on plate girders; flanges or stems of tees; 16.

3. The width of plates shall be taken from the free edge to the first row of rivets or welds; the width of legs of angles, channels and zees, and of stems of tees, shall be taken as the full nominal dimension; the width of flanges of beams and tees shall be taken as ½ the full nominal width. The thickness of a sloping flange shall be measured halfway between a free edge and the corresponding face of the web.

4. When a projecting element exceeds the width-to-thickness ratio prescribed in the preceding paragraph, but would conform to same and would satisfy the stress requirements with a portion of its width considered as removed, the member will be considered acceptable without the actual removal of the excess width.

(c) *Compression members.* 1. In compression members, the unsupported width of web, cover or diaphragm plates between the nearest lines of rivets or welds, or between the roots of the flanges in case of rolled sections, shall not exceed 40 times the thickness.

2. When the unsupported width exceeds this limit, but a portion of its width no greater than 40 times the thickness would satisfy the stress requirements, the member will be considered acceptable.

3. The unsupported width of cover plates perforated with a succession of access holes, only the least net width across holes being assumed available to resist compression, may exceed 40, but shall not exceed 50 times the thickness.

(8) CONNECTIONS. (a) *Minimum connections.* Connections carrying calculated stresses, except for lacing, sag bars, and girts, shall be designed for not less than 10,000 pounds, if welded; or if riveted or bolted, shall have no fewer than 2 rivets or 2 bolts.

(b) *Unrestrained members.* Except as otherwise indicated by the designer, all connections of beams, girders, or trusses shall be designed as flexible, and may ordinarily be proportioned for the reaction shear only. If, however, the eccentricity of the connection is excessive, provision shall be made for the resulting moment.

1. Flexible beam connections shall permit the ends of the beam to rotate sufficiently to accommodate its deflection by providing for a horizontal displacement of the top flange as determined as follows:

e = .007d if the beam is designed for full uniform load and for live load deflection not exceeding 1/360th of the span (6a);

or

$e = \frac{f\,L}{3{,}625{,}000}$ if the beam is designed for full uniform load producing the unit stress f at mid-span;

where

e = the horizontal displacement between the top and bottom of the beam at its end, in inches.
f = the flexural unit stress in the beam at mid-span; p.s.i.
d = the depth of the beam, in inches.
L = the span of the beam, in feet.

(9) WELDS. *(a) Type of welds.* Butt, fillet, plug or slot welds, or a combination of these types, may be used in making joints and joining component parts.

(b) Qualification of weld details. The details of all joints (including for butt welds, the groove form, root face, root spacing etc.) to be employed under this order without qualification shall comply with all of the requirements for joints which are accepted without qualification test by the industrial commission. No joint form not included in the foregoing shall be employed until it shall have been qualified to the satisfaction of the industrial commission.

Note: It will be the policy of the industrial commission to approve of weld details, processes and methods conforming to the requirements of the standard code for Arc and Gas Welding in Building Construction of the American Welding Society.

(c) Operator qualifications. All welding shall be done by skilled workmen who shall give satisfactory proof of their skill and ability with process to be used on the proposed work.

(d) Qualifications and inspection requirements for welding operations and operators. 1. The state building code provides that the industrial commission shall determine necessary data, tests and other evidence required to prove the merits of materials, methods of construction and devices used in the construction, alteration and equipment of buildings or structures, and further, in connection with welding, requires such work to be done by skilled welders who must give satisfactory proof of their skill and ability.

2. In conformance with these provisions, the following regulations are adopted and promulgated to apply to all welding operations on buildings and structures coming within the scope of the state building code.

3. All welding operators employed as such in executive work covered by the Wisconsin state building code shall be previously qualified by tests as prescribed herein. These qualification tests shall be performed under the supervision of an approved testing laboratory or commercial testing engineer who will certify to the industrial commission that the operator has passed the perscribed qualification tests.

4. The industrial commission shall issue, to any operator who has successfully passed the prescribed qualification tests, a certificate bearing the operator's name, address and signature, and the record of the extent of his successful qualification testing. This certificate shall remain in force for one year provided the operator is engaged in welding without an interruption of more than 3 consecutive months' duration, in which latter case the certificate shall automatically become void. The renewal of a certificate shall be granted only upon successful completion of new qualification tests.

5. The procedure for qualification of welding operators shall be as specified in appendix D of the Code for Arc and Gas Welding in Building Construction, latest edition, as published by the American Welding Society. This consists essentially of tests for the making of both groove and fillet welds in 4 positions each. One test is required for each position for fillet welds, and for groove welds one test for each position in material up to and including ¾ inch thick shall be made in material ⅜ inch thick, except that if the construction involves welding of material over ¾ inch thick one test weld shall be made for each position in material of the maximum thickness to be used, but need not exceed one inch in thickness, if a test weld is made in the maximum or one inch thickness, no test weld is necessary in the ⅜ inch thickness.

6. All welding shall be subject to examination by a competent inspector approved by the industrial commission, who shall certify to the industrial commission that all welding has been completed in accordance with the approved plans and specifications and with the provision of the Wisconsin state building code. The methods and procedures of such inspection shall be in accordance with the provisions of Section 5 of the Code for Arc and Gas Welding in Building Construction, latest edition, as published by the American Welding Society.

7. The form SB-13A "Certificate of Competency—WELDER" is issued pursuant to Ind 53.24 (9) (c).

(10) PLATE GIRDERS AND ROLLED BEAMS. *(a) Proportioning.* Riveted and welded plate girders, cover-plated beams, and rolled beams shall in general be proportioned by the moment of inertia or gross section. No deduction shall be made for standard shop or field rivet holes in either flange, except that in special cases where the reduction of the area of either flange by such rivet holes, exceeds 15% of the gross flange area, the excess shall be deducted. If such members contain other holes, as for bolts, pins, countersunk rivets, or plug or slot welds, the full deduction for such holes shall be made. The deductions thus applicable to either flange shall be made also for the opposite flange if the corresponding holes are there present.

(b) Web. Plate girder webs shall have a thickness of not less than 1/170 of the unsupported distance between flanges.

(c) Flanges. The thickness of outstanding parts of flanges shall conform to the requirements of 7(c).

1. Each flange of welded plate girders should in general consist of a single plate rather than 2 or more plates superimposed. The single plate may comprise a series of shorter plates, laid end to end and butt welded at their junctions.

2. Unstiffened cover plates on riveted girders shall not exceed more than 16 times the thickness of the thinnest outside plate beyond the outer row of rivets connecting them to the angles. The total cross-sectional area of cover plates of riveted girders shall not exceed 70% of the total flange area.

3. If the girder is subjected to substantial fluctuations in loading, stiffeners, lateral plates or other appurtenant material shall not be welded to the tension flange, except at points where the maximum flange stress is less than half the allowable.

(d) Flange development. Rivets and welds connecting flange to web, or cover plates to flange, shall be proportioned to resist the maximum horizontal shear at the plane in question, resulting from the bending forces on the girder. Additionally, rivets and welds connecting flange to web shall be proportioned to transmit any loads applied directly to the flange.

(e) Stiffeners. Bearing stiffeners shall be placed in pairs on the webs of plate girders at unframed ends and at points of concentrated loads. Such stiffeners shall have a close bearing against the loaded flanges, and shall extend as closely as possible to the edge of the flange plates or flange angles. They shall be designed as columns subject to the provision of 4(a); assuming the column section to comprise the pair of stiffeners and a centrally located strip of the web equal to not more than 25 times its thickness at interior stiffeners or a strip equal to not more than 12 times its thickness when the stiffeners are located at the end of the web. The column length shall be taken as not less than ¾ of the length of the stiffeners in computing the ratio $\frac{l}{r}$. Only that portion of the stiffener outside of the angle fillet or the flange-to-web welds shall be considered effective in bearing. Angle bearing stiffeners shall not be crimped.

If $\frac{h}{t}$ is equal to or greater than 70, intermediate stiffeners shall be required at all points where v exceeds

$$\frac{64{,}000{,}000}{\left(\frac{h}{t}\right)^2}$$

h = the clear depth between flanges, in inches.
t = the thickness of the web, in inches.
v = the greatest unit shear in the panel, in pounds per square inch, under any condition of complete or partial loading. The clear distance between intermediate stiffeners, when stiffeners are required by the foregoing, shall not exceed 84 inches or that given by the formula

$$d = \frac{11{,}000\ t}{\sqrt{v}}$$ where

d = the clear distance between stiffeners, in inches.

1. Intermediate stiffeners may be applied in pairs, one on each side of the web, or if preferred, may alternate on opposite side of the web.

2. Intermediate angle stiffeners may be crimped over the flange angles. Intermediate stiffeners employed to stay the web plate against buckling, and not for the transfer of concentrated loads from flange to web, shall be of a section not less than that required by the formula

I_s = $0.00000016\ H^4$, in which
H = Total depth of web.
I_s = Moment of inertia of the stiffeners or stiffener (figured with a common axis at the centerline of web for stiffeners in pairs and with the axis at the interface between stiffener and web for single stiffeners).

3. Rivets connecting stiffeners to the girder web shall be spaced not over 8 times their diameter, or more closely if so required in order to transmit the stress due to concentrated loads.

(f) Horizontal forces. The flanges of plate girders supporting cranes or other moving loads shall be proportioned to resist the horizontal forces produced by such loads.

(g) Web crippling of beams. Rolled beams shall be so proportioned that the compressive stress at the web toe of the fillets, resulting from concentrated loads not supported by bearing stiffeners, shall not exceed the value of 24,000 pounds per square inch allowed in 4(a). The governing formulas shall be

For interior loads $\frac{R}{t\ (N + 2k)}$ = not over 24,000

For end reactions $\frac{R}{t\ (N + k)}$ = not over 24,000

where

R = concentrated interior load or end reaction in pounds.
t = thickness of web, in inches.
N = length of bearing, in inches.
k = distance from outer face of flange to web toe of fillet, in inches.

(11) COLUMN BASES. *(a) Loads.* Proper provision shall be made to transfer the column loads, and moments if any, to the footings and foundations.

(b) Alignment. Column bases shall be set level and to correct elevation with full bearing on the masonry.

(c) Finishing. Column bases shall be finished to accord with the following requirements:

1. Rolled steel bearing plates, 2 inches or less in thickness, may be used without planing, provided a satisfactory contact bearing is obtained; rolled steel bearing plates, over 2 inches but not over 4 inches in thickness, may be straightened by pressing; or, if presses are not available, by planing on all bearing surfaces, to obtain a satisfactory contact bearing; rolled steel bearing plates, over 4 inches in thickness, shall be planed on all bearing surfaces (except as noted under 3).

2. Column bases other than rolled steel bearing plates shall be planed on all bearing surfaces (except as noted under 3).

3. The bottom surfaces of bearing plates and column bases which rest on masonry foundations and are grouted to insure full bearing contact need not be planed.

4. Anchor Bolts. Anchor bolts shall be of sufficient size and number to develop the computed stress.

(12) SHOP PAINTING. *(a) Shop coat.* After inspection and approval and before leaving the shop, all steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, spatter, slag or flux deposit, oil, dirt and other foreign matter. Except where encased in concrete, and excepting edges and surface areas adjacent to edges, to be field welded, all steel work shall be given one coat of approved metal protection, applied thoroughly and evenly and well worked into the joints and other open spaces. All paint shall be applied to dry surfaces.

(b) Inaccessible parts. Parts inaccessible after assembly shall be given 2 coats of shop paint, preferably of different colors.

(c) Contact surfaces. Contact surfaces shall be cleaned, by effective means, before assembly, but not painted.

(d) Finished surfaces. Machine-finished surfaces shall be protected against corrosion by a suitable coating.

(e) Surfaces to be field welded. Surfaces which are to be welded after erection shall, where practicable, not receive a shop coat of paint. If painted, such paint shall be removed before field welding, for a distance of at least 6 inches on either side of the joint.

(13) ERECTION. (a) *Bracing.* The frame of all steel skeleton buildings shall be carried up true and plumb, and temporary bracing shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment, and the operation of same. Such bracing shall be left in place as long as may be required for safety.

(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:

$$v = \frac{64\,000{,}000}{(h/t)^2}$$ 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 carryin'? 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

History: 1–2–56; cr. (9)(d)(7.) Register, October, 1957, No. 22, eff. 11–1–57.

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) LIMITS OF SPAN AND SPACING. The span of steel joists shall not exceed 24 times the depth of the steel portion of the steel joist. The span of open web steel joists shall not exceed 550 times the least radius of gyration of the top chord around a vertical axis, and in case the top chord consists of a flat top section continuous with a center web, the radius of gyration of the top plate alone shall be taken.

(a) The spacing of steel joists shall not exceed 24 inches on centers for floors nor 30 inches on centers for roofs, except when used to support steel or wood roof decks. In no case shall the spacing exceed the safe span of the top slab, deck, or flooring over the said joists.

(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 used shall conform to the "Standard Specifications for Steel for Bridges and Buildings" (A.S.T.M. Serial Designation: A7–39). All steel joists shall receive one coat of asphalt base paint applied by dipping or spraying, or an equivalent protective covering, before leaving the shop.

(4) DESIGN OF STEEL JOISTS. 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 18000 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% of the required maximum end 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, except that the basic working stress shall not exceed 18000 pounds per square inch.

(b) In the completed structure, the top chords of open web steel joists or the top flanges of solid web steel joists may be considered as being stayed laterally when the deck or top slab over the steel joists 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 joists shall be designed to resist the bending produced by the eccentricity of the reaction at the support.

(5) ERECTION. The ends of steel joists shall extend a distance of at least 4 inches onto masonry or reinforced concrete supports and at least 2½ inches on steel supports. Every third steel joist on concrete

or masonry supports shall be anchored thereto with an anchor equivalent to a ⅜ inch round. The ends of all steel joists supported on masonry walls shall be bedded in mortar. All steel joists supported on steel beams shall be secured thereto with an anchor made of not less than a 3/16 inch bar fastened over the flanges of the supporting beams.

(a) 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 joists, such concentrated load shall not be imposed between panel points.

(6) BRIDGING. As soon as steel joists have been erected, bridging shall be installed between them before the application of construction loads. This bridging shall be adequate to safely support the top chords or flanges against lateral movement during the construction period and shall hold the steel joists in a vertical plane passing through the bearings. The steel joists at the ends of panels shall be braced laterally by anchors or ties at each line of bridging. If diagonal bridging is used in which all diagonal members will resist only tension, they shall not be less than 3/16 inch rod, and these diagonals shall be supplemented by a continuous strut adequately attached to the top chords or flanges of all steel joists so bridged. This top strut shall be equivalent as a strut to a ½ inch round steel bar. If diagonal members are used which are capable of resisting both tension and compression, the top strut may be omitted. In case bridging in the form of horizontally placed beam or angle sections is provided, it must be so connected to the steel joists that it will support the top chords or flanges against lateral movement and hold the steel joists in a vertical plane. Fourteen gauge wire diagonals shall be used to secure the bottom chords or flanges at each line of bridging of this type. Wire may be omitted when bridging which restrains both top and bottom chords or flanges is used. When the spacing of steel joists exceeds 30 inches on centers in roofs, sag rods may be used in lieu of any of the above types of bridging. Rows of bridging shall be not more than 7 feet apart, or more than 7 feet from supports.

(7) DECKS AND TOP SLABS. Decks or top slabs over steel joists may be of concrete or gypsum poured on metal lath centering attached to the top chords or flanges of steel joists as required elsewhere in this section or on removable centering provided the top chords or flanges of the steel joists 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 joists. 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 joists, shall be spaced not farther apart than the panel point spacing. Decks or top slabs over steel joists 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 wood nailer strips.

(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 than 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 joists.

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.

ALLOWABLE WORKING STRESSES FOR WOOD

Species	Commercial Grade		Rules Under Which Graded	Allowable Unit Stresses in Pounds Per Square Inch: Tension and Extreme Fiber in Bending	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity
ASH, WHITE	2150 # f Grade	J & P	National Hardwood Lumber Association	1,950	130		1,550	
	1900 # f Grade	J & P-B&S		1,700	130		1,400	
	1700 # f Grade	J & P-B&S		1,550	130		1,200	1,500,000
	1450 # f Grade	J & P-B&S		1,300	110		1,050	
	1300 # f Grade	B & S		1,150	110	550	950	
BEECH	2150 # f Grade	J & P	National Hardwood Lumber Association	1,950	130		1,575	
	1900 # f Grade	J & P-B&S		1,700	130	550	1,375	1,600,000
	1700 # f Grade	J & P-B&S		1,550	130		1,225	
	1450 # f Grade	J & P-B&S		1,300	110		1,050	
BIRCH	2150 # f Grade	J & P	National Hardwood Lumber Association	1,950	130		1,575	
	1900 # f Grade	J & P-B&S		1,700	130		1,375	
	1700 # f Grade	J & P-B&S		1,550	130	550	1,225	1,600,000
	1450 # f Grade	J & P-B&S		1,300	110		1,050	
CHESTNUT	1450 # f Grade	J & P	National Hardwood Lumber Association	1,300	110		1,075	
	1200 # f Grade	J & P-B&S		1,100	110	325	850	1,000,000
	1075 # c Grade	P & T					975	
CYPRESS, SOUTHERN	1700 # f Grade	J & P-B&S	National Hardwood Lumber Association	1,550	130		1,275	
	1300 # f Grade	J & P-B&S		1,150	110	325	1,025	
	1450 # c Grade	P & T					1,300	1,200,000
	1200 # c Grade	P & T					1,075	
DOUGLAS FIR— COAST REGION	Dense Select Structural	L F	West Coast Lumber Inspection Bureau	1,950	120	410	1,400	
	Select Structural	L F		1,700	120	375	1,300	
	1500 f Industrial	L F		1,350	120	350	1,100	
	1200 f Industrial	L F		1,100	95	350	900	
	Dense Select Structural	J & P		1,950	120	410	1,500	
	Select Structural	J & P		1,700	120	375	1,400	
	Dense Construction	J & P		1,600	120	410	1,300	1,600,000
	Construction	J & P		1,350	120	350	1,100	
	Standard	J & P		1,100	95	350	900	

ALLOWABLE WORKING STRESSES FOR WOOD—Continued

Species	Commercial Grade		Rules Under Which Graded	Allowable Unit Stresses in Pounds Per Square Inch				Modulus of Elasticity
				Tension and Extreme Fiber in Bending	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	
DOUGLAS FIR—COAST REGION—Continued	Dense Select Structural	B & S		1,950	120	410	1,400	
	Select Structural	B & S		1,700	120	375	1,300	
	Dense Construction	B & S		1,600	120	410	1,100	
	Construction	B & S		1,350	120	350	900	
	Dense Select Structural	P & T		1,950	120	410	1,500	
	Select Structural	P & T		1,700	120	375	1,400	
	Dense Construction	P & T		1,350	120	410	1,300	
	Construction	P & T		1,100	120	350	1,100	
DOUGLAS FIR—INLAND REGION	Select Structural	J & P	Western Pine Association	1,950	130	410	1,575	1,600,000
	Structural	J & P		1,700	90	360	1,250	1,500,000
	Common Structural	J & P		1,300	85	340	1,125	1,500,000
	Select Structural	P & T		---	---	410	1,575	1,600,000
	Structural	P & T		---	---	360	1,250	1,500,000
	Common Structural	P & T		---	---	340	1,125	1,500,000
ELM, ROCK	2150 # f Grade	J & P	National Hardwood Lumber Association	1,950	130	---	1,575	
	1900 # f Grade	J & P-B&S		1,700	130	---	1,375	
	1700 # f Grade	J & P-B&S		1,550	130	550	1,225	1,300,000
	1450 # f Grade	J & P-B&S		1,300	110	---	1,025	
	1550 # c Grade	P & T		---	---	---	1,400	
	1450 # c Grade	P & T		---	---	---	1,300	
	1200 # c Grade	P & T		---	---	---	1,075	
GUM, BLACK & RED	1700 # f Grade	J & P	National Hardwood Lumber Association	1,550	110	---	1,100	
	1450 # f Grade	J & P-B&S		1,300	110	325	950	1,200,000
	1200 # f Grade	J & P-B&S		1,100	110	---	800	
	1075 # c Grade	P & T		---	---	---	975	
HEMLOCK, EASTERN	Select Structural	J & P-B&S	Northern Hemlock & Hardwood Manufacturers Assn.	1,200	75	---	775	
	Prime Structural	J & P		1,100	55	325	700	1,100,000
	Common Structural	J & P		1,000	55	---	600	
	Utility Structural	J & P		850	55	---	550	
	Select Structural	P & T		---	---	---	775	

ALLOWABLE WORKING STRESSES FOR WOOD—Continued

Species	Commercial Grade		Rules Under Which Graded	Allowable Unit Stresses in Pounds Per Square Inch: Tension and Extreme Fiber in Bending	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity
HEMLOCK, WEST COAST	1600 # f Select Structural	J & P	West Coast Bureau of Lumber Grades & Inspection	1,450	90	325	1,000	1,400,000
	1450 # f No. 1	J & P-B&S		1,300	90	325	975	
	1100 # f No. 2	J & P		1,000	80	325	775	
	No. 1 Hemlock Timbers	P & T					1,000	
HICKORY	2150 # f Grade	J & P-B&S	National Hardwood Lumber Association	1,950	130		1,550	1,800,000
	1900 # f Grade	J & P-B&S		1,700	130	650	1,400	
	1700 # f Grade	J & P-B&S		1,550	130		1,225	
	1550 # c Grade	P & T					1,400	
	1450 # c Grade	P & T					1,300	
	1325 # c Grade	P & T					1,200	
LARCH	Select Structural	J & P	Western Pine Association	1,950	130	410	1,575	1,300,000
	Structural	J & P		1,700	110	375	1,300	
	Common Structural	J & P		1,300	110	350	1,200	
	Select Structural	P & T				410	1,575	
	Structural	P & T				375	1,300	
	Common Structural	P & T				350	1,200	
MAPLE, HARD	2150 # f Grade	J & P	National Hardwood Lumber Association	1,950	130		1,575	1,600,000
	1900 # f Grade	J & P-B&S		1,700	130		1,375	
	1700 # f Grade	J & P-B&S		1,550	130	550	1,225	
	1450 # f Grade	J & P-B&S		1,300	110		1,025	
	1550 # c Grade	P &T					1,400	
	1450 # c Grade	P & T					1,300	
	1200 # c Grade	P & T					1,075	
OAK, RED & WHITE	2150 # f Grade	J & P	National Hardwood Lumber Association	1,950	130	550	1,400	1,500,000
	1900 # f Grade	J & P-B&S		1,700	130		1,250	
	1700 # f Grade	J & P-B&S		1,550	130		1,075	
	1450 # f Grade	J & P-B&S		1,300	110		950	
	1300 # f Grade	B & S		1,150	110		850	
	1325 # c Grade	P & T					1,200	
	1200 # c Grade	P & T					1,075	
	1075 # c Grade	P & T					975	
PINE, NORWAY	Prime Structural	J & P	Northern Hemlock & Hardwood Manufacturers Assn.	1,110	65	325	800	1,200,000
	Common Structural	J & P		1,000	65		700	
	Utility Structural	J & P		850	65		575	

ALLOWABLE WORKING STRESSES FOR WOOD—Continued

Species	Commercial Grade		Rules Under Which Graded	Allowable Unit Stresses in Pounds Per Square Inch: Tension and Extreme Fiber in Bending	Allowable Unit Stresses in Pounds Per Square Inch: Maximum Horizontal Shear	Allowable Unit Stresses in Pounds Per Square Inch: Compression Perpendicular to Grain	Allowable Unit Stresses in Pounds Per Square Inch: Compression Parallel to Grain	Modulus of Elasticity
PINE, SOUTHERN	Dense Structural 86 KD	2″ thick only	Southern Pine Inspection Bureau	2,700	150	410	2,000	
	Dense Structural 72 KD	2″ thick only		2,250	135	410	1,800	
	Dense Structural 65 KD	2″ thick only		2,000	120	410	1,600	
	Dense Structural 58 KD	2″ thick only		1,850	110	410	1,500	
	No. 1 Dense KD	2″ thick only		1,850	120	410	1,600	
	No. 1 KD	2″ thick only		1,600	120	350	1,350	
	No. 2 Dense KD	2″ thick only		1,600	110	410	1,200	
	No. 2 KD	2″ thick only		1,350	110	350	1,000	
	Dense Structural 86	2″ thick only		2,600	135	410	2,000	1,760,000
	Dense Structural 72	2″ thick only		2,100	120	410	1,600	
	Dense Structural 65	2″ thick only		1,800	110	410	1,450	
	Dense Structural 58	2″ thick only		1,600	95	410	1,300	
	No. 1 Dense	2″ thick only		1,600	110	410	1,400	
	No. 1	2″ thick only		1,350	110	350	1,200	
	No. 2 Dense	2″ thick only		1,250	95	410	900	
	No. 2	2″ thick only		1,100	95	350	800	
	Dense Structural 86	3″ & 4″ thick		2,600	135	410	2,000	
	Dense Structural 72	3″ & 4″ thick		2,100	120	410	1,600	
	Dense Structural 65	3″ & 4″ thick		1,800	110	410	1,450	
	Dense Structural 58	3″ & 4″ thick		1,600	95	410	1,300	
	No. 1 Dense SR	3″ & 4″ thick	Southern Pine Inspection Bureau	1,600	110	410	1,600	
	No. 1 SR	3″ & 4″ thick		1,350	110	350	1,350	
	No. 2 Dense SR	3″ & 4″ thick		1,250	95	410	900	
	No. 2 SR	3″ & 4″ thick		1,100	95	350	800	
	Dense Structural 86	5″ thick & up		2,150	135	410	1,600	1,760,000
	Dense Structural 72	5″ thick & up		1,800	120	410	1,400	
	Dense Structural 65	5″ thick & up		1,600	110	410	1,250	
	Dense Structural 58	5″ thick & up		1,450	95	410	1,200	
	No. 1 Dense SR	5″ thick & up		1,450	110	410	1,350	
	No. 1 SR	5″ thick & up		1,250	110	350	1,200	
	No. 2 Dense SR	5″ thick & up		1,250	95	410	900	
	No. 2 SR	5″ thick & up		1,100	95	350	800	
	Industrial 86 KD	1″, 1¼″ & 1½″ thick		2,350	150	350	1,750	
	Industrial 72 KD	1″, 1¼″ & 1½″ thick		2,000	135	350	1,500	
	Industrial 65 KD	1″, 1¼″ & 1½″ thick		1,800	120	350	1,400	
	Industrial 58 KD	1″, 1¼″ & 1½″ thick		1,600	110	350	1,250	

ALLOWABLE WORKING STRESSES FOR WOOD (Continued)

Species	Commercial Grade		Rules Under Which Graded	Allowable Unit Stresses in Pounds Per Square Inch: Tension and Extreme Fiber in Bending	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	Modulus of Elasticity
PINE, SOUTHERN —Continued	Industrial 50 KD	1", 1¼" & 1½" thick	Southern Pine Inspection Bureau	1,350	110	350	1,000	
	Industrial 86	1", 1¼" & 1½" thick		2,250	135	350	1,700	
	Industrial 72	1", 1¼" & 1½" thick		1,800	120	350	1,400	
	Industrial 65	1", 1¼" & 1½" thick		1,600	110	350	1,200	1,760,000
	Industrial 58	1", 1¼" & 1½" thick		1,350	95	350	1,100	
	Industrial 50	1", 1¼" & 1½" thick		1,100	95	350	800	
RED CEDAR, WESTERN	Structural		West Coast Lumbermen's Assn. 1-1-41	1,000	100	200	800	1,000,000
REDWOOD	Dense Structural	J & P-B & S	California Redwood Association	1,550	100	290	1,300	
	Heart Structural	J & P-B & S		1,150	85	----------	1,000	1,200,000
	Dense Structural	P & T		----------	----------	----------	1,300	
	Heart Structural	P & T		----------	----------	----------	1,000	
SPRUCE, EASTERN	1450 # f Structural	J & P	Northeastern Lumber Mfgrs. Assn.	1,300	100	----------	950	
	1300 # f Structural	J & P		1,150	85	270	875	1,200,000
	1200 # f Structural	J & P		1,050	85	----------	800	

ABBREVIATIONS: J & P—Joist and Plank
B & S—Beams and Stringers
P & T—Posts and Timbers
KD—Kiln Dried
SR—Stress Rated
LF—Light Framing

(3) Exterior walls. Walls shall be designed to carry safely not less than the designated wind load (see chapter on Working Stresses) acting inwardly or outwardly combined with the dead load and one-half the full live load, or dead and full live load, whichever is the greater.

(a) Anchorage shall be provided to resist safely the vertical lifting forces (see 1.) and to prevent any sliding or overturning. This shall include not only anchorage to the foundation, but also anchorage of the roof to the walls. Proper tying of the walls at the corners shall be required.

1. As a specific basis for design of roofs and anchorage, a suction or vertical lifting force of 20 pounds per square foot shall be used, assuming ⅔ of the dead load is acting to resist the vertical force.

(b) Ledger or ribbon boards used to support joists shall be not less than 1 by 4 inches nominal, shall be recessed into the studs, and securely nailed with not less than 2 tenpenny nails to each stud. The ends of joists adjoining studs shall be securely spiked to the studs.

(c) In bearing walls and partitions no stud shall be cut more than ⅓ its depth to receive piping and duct work. If more depth is required, the partition studs shall be increased accordingly.

(4) Interior partitions. Walls shall be designed to carry safely the full dead and live loads.

(a) In stud construction the bearing partitions shall be provided at the top with double plates, each at least 2 inches (nominal) thick and of same width as the stud. When the joists are placed directly above each stud, a single top plate may be used. If properly fire stopped, studs may run through the floor and rest on girders or on partition plates.

(b) Partitions not resting upon girders, or of which the studs do not rest on partition plates below, shall have sole plates of dimensions not less than that of the studs.

(c) Partitions unsupported by walls shall be supported on girders or 2 or more joists, or on sole plates if placed at an angle to the joists.

(d) Non-bearing partitions of stud construction shall be provided with at least one 2 inch plate on top and bottom of same width as stud or be otherwise properly fire stopped at floor lines.

(e) Angles at corners where stud walls or partitions meet shall be framed solid so no lath can extend from one room to another.

(f) Openings in stud partitions and walls shall be framed around with double studs at each side and double headers across the top resting on the short stud at each end. The double header shall be placed on edge and shall be trussed above for all openings over 4 feet in width, or where more than 2 studs are cut away.

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

(5) Floors supported on wooden framework. When enclosing walls are of wood, each joist, beam, and girder in the wall shall be securely spiked or anchored to the wall construction so as to stay in place and to resist safely all lifts and inward and outward pressures as prescribed in this code.

(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 ⅙ 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) Wooden 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) Posts and columns. Wood posts, when used in basements, shall bear on a cement base which shall extend not less than 3 inches above the finish floor. The base shall bear directly on the post footing.

(a) Short columns or posts 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:

$$\frac{P}{A} = \frac{0.3E}{\left(\frac{L}{d}\right)^2}$$

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 Fire in Bending "f"		Tension Parallel to Grain "t"		Compression Parallel to Grain "c"		Horizontal Shear "H"	Compression perpendicular to Grain "c"
			Laminations		Laminations		Laminations			
Grade	Number Each Side	Grade	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.