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 section, 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 Wis. Adm. Code sections Ind 52.22 and 55.68 (4).

(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 33⅓% 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:

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

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

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 Ashlar and rubble masonry. (1) The compressive stresses (pounds per square inch) in ashlar or carefully coarsed masonry and

rubble stone masonry, due to all dead and live loads shall not exceed the following:

Kind of Stone	Type M Mortar	Type S Mortar	Type N Mortar	Type O Mortar
Ashlar Masonry:				
Granite	800	720	640	500
Limestone or marble	500	450	400	325
Sandstone or cast stone	400	360	320	250
Rubble Stone Masonry	140	120	100	80

(2) 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.

(3) All cast stone shall be branded with a permanent identification mark of the manufacturer which shall be registered with the department of industry, labor and human relations.

History: 1–2–56; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

(4) The average compressive strength of cast stone taken on 4 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%.

(5) Tests of cast stone specimens shall be made in accordance with specifications approved by the department of industry, labor and human relations. It will be the policy of the department of industry, labor and human relations to accept specifications for cast stone issued by the American Concrete Institute, ACI Standard 704–44.

Note: Copies of the above publication are on file in the office of the secretary of state, revisor of statutes and the department of industry, labor and human relations and may be obtained for personal use from the American Concrete Institute, 7400 Second Blvd., Detroit, Michigan.

History: 1–2–56; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.05 Building brick. (1) DEFINITION. Building brick is a masonry unit, not less than 75 percent solid, having a shape approximating a rectangular prism and usually not larger than 4 inches by 4 inches by 12 inches. Brick may be made of burned clay or shale or mixtures thereof, of lime and sand or of portland cement and suitable aggregates.

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

(3) CONCRETE BUILDING BRICK. 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 manufacturer is identified.

(5) CLAY BUILDING BRICK. (a) All building brick made of burned clay or shale shall conform to the following requirement and to the requirements of standard specifications for building brick (solid masonry units made from clay or shale) of the American Society for Testing and Materials. See section Ind 51.25 (1) for the ASTM designation which refers to this product or method.

	Compressive Strength (Brick Flatwise) Lbs. Per Square Inch Average Gross Area		Water Absorption By 5 Hour Boiling Percent		C/B Ratio	
Grade	Average of 5 Bricks	Individual Minimum	Average of 5 Bricks	Individual Maximum	Average of 5 Bricks	Individual Maximum
A	8000	6650	17.0	20.0	.78	.80
B	4500	3750	17.0	20.0	.78	.80
S. W.	3000	2500	17.0	20.0	.78	.80
M. W.	2500	2200	22.0	25.0	.88	.90
N. W.	1500	1250	No Limit	No Limit	No Limit	No Limit

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

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

(d) Grade A, B and 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.

Brick used for foundation courses, retaining walls, parapet walls and similar locations shall conform to A, B, or S.W.

(e) 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.

Brick conforming to this grade may be used in an exterior wall above grade.

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

(6) CONCRETE SAND-LIME BUILDING BRICK. All building brick made from sand-lime shall conform to the following requirements and to the requirements of standard specifications for sand-lime building brick of the American Society for Testing and Materials. See sec-

tion Ind 51.25 (2) for the ASTM designation which refers to this product or method.

Designation	Minimum Compressive Strength (brick flatwise), psi, average gross area		Minimum Modulus of Rupture (brick flatwise), psi, average gross area	
	Average of 5 Brick	Individual	Average of 5 Brick	Individual
Grade SW	4500	3500	600	400
Grade MW	2500	2000	450	300
Grade NW	1500	1500	300	200

(7) CONCRETE BUILDING BRICK: All building brick made from portland cement, water, and suitable mineral aggregates shall conform to the following requirements and to the requirements of standard specifications for concrete building brick of the American Society for Testing and Materials. See section Ind 51.25 (3) for the ASTM designation which refers to this product or method.

Grade	Compressive Strength, Min., psi (brick flatwise)		Water Absorption, Max. lb. per cu. ft. (Average of 5 Units)		
	Average Gross Area		Oven-Dry Weight of Concrete, lb. per cu. ft.		
	Average of 5 Brick	Individual Brick	Over 125	From 105 to 125	105 or less
U-1, U-11	3500	3000	10	10	10
P-1, P-11	2500	2000	13	13 to 18	18
G-1, G-11	1500	1250			

(8) TESTS. Typical specimens of all types of building brick shall be tested initially to prove compliance with the provisions of this code.

(a) All concrete and sand, lime, brick shall be retested at intervals of not more than one year.

(b) All building brick manufactured from burned clay or shale shall be retested with changes in raw materials or processing and at intervals of not more than three years.

(c) Further tests may be demanded at any time there is reasonable suspicion of nonconformance to the requirements of this code.

(9) STANDARDS. The testing of all building brick shall be in accordance with the standard methods for testing brick of the American Society for Testing Materials. See section Ind 51.25 (4) for the ASTM designation which refers to this product or method.

Note: Copies of the above publications are on file in the office of the secretary of state, revisor of statutes and the department of industry, labor and human relations and may be obtained for personal use from the American Society for Testing Materials, 1916 Race Stree, Philadelphia, Pa. 19103.

History: 1–2–56; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.06 Hollow building units. (1) DEFINITIONS. Hollow building units are masonry units whose net cross-sectional area in any plane parallel to the bearing surface is less than 75% of its gross cross-sectional area measured in the same plane.

(a) 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, molded to permanent form for use as masonry units in building construction. Hollow concrete masonry units with applied facings of any type shall conform to the requirements of this code.

(2) HOLLOW TILE USED IN BEARING WALLS. All hollow tile used in bearing walls shall conform to the requirements of standard specifications for structural clay load-bearing wall tile, of the American Society for Testing Materials. See section Ind 51.25 (5) for the ASTM designation which refers to this product or method.

(a) Hollow tile subject to the action of weather or soil shall be of Grade LBX, or, if used for load-bearing purposes but not subject to the action of weather or soil, shall be of grade LB or grade LBX of this specification.

(3) 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 trademark of the manufacturer.

(4) 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 department of industry, labor and human relations. Tile shall be sampled and tested in accordance with the standard methods of sampling and testing structural clay tile of the American Society for Testing Materials. See section Ind 51.25 (6) for the ASTM designation which refers to this product or method.

(5) HOLLOW CONCRETE MASONRY UNITS. (a) *Compressive strength.* All hollow concrete masonry units 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 not be less than the above requirement. The strength of any individual test specimen shall not be less than 900 pounds per square inch gross area.

(b) *Absorption.* Hollow concrete masonry units shall not absorb more than 14 pounds of water per cubic foot of concrete actually contained.

(c) *Branding.* At least one-third of all hollow concrete masonry units shall be branded with a distinctive indentation or waterproof stencilled mark, which shall bear the name, initials, or trademark of the manufacturer. All cubes or piles of block on the job shall be easily identified by branded block which are visible. Producers having more than one plant shall register and use a separate, distinctive brand for each plant. A facsimile of each individual brand shall be filed with the department of industry, labor and human relations.

(d) *Tests.* Typical specimens of all sizes and designs of hollow concrete masonry units shall be tested in an approved manner, originally

to prove compliance with the requirements of this code, and thereafter as required by the department of industry, labor and human relations or its authorized agents. Hollow concrete masonry units shall be sampled and tested in accordance with the standard methods of sampling and testing of the American Society for Testing Materials. See section Ind 51.25 (7) for the ASTM designation which refers to this product or method.

(e) *Sampling.* Hollow concrete masonry units shall be done only by the department of industry, labor and human relations or their authorized agents. The time and place of sampling shall be at the discretion of the department of industry, labor and human relations or their authorized agents. It is intended that such tests will be made at intervals not to exceed one year.

1. At the time of the sampling, the producer or purchaser shall inform the sampling agent of the name and location of the approved testing laboratory to which the samples will be sent for testing. The sampling agent shall notify the department of industry, labor and human relations of the date, number, size, type and seal numbers of the samples selected. Compression tests shall be completed not later than 7 days after sealing. To validate the test, all seals must be accounted for in the laboratory report.

2. Producers having more than one plant will be considered as separate plants with separate samplings and tests for each plant.

(f) *Approvals.* Approvals following original tests will remain in effect until later tests show nonconformance with the requirements of this code. To verify compliance with these requirements, the department of industry, labor and human relations may require that tests be made at its designated laboratory.

(g) *Nonapprovals.* Nonconformance with the requirements of Wis. Adm. Code section Ind 5.306 shall be determined by the failure of 3 complete tests on a particular job, as tested in an approved manner. In the event of job nonconformance, the necessary structural correction shall be made and the producer shall be barred from supplying any more units on that project.

(h) *Certification.* Testing laboratories must apply annually for certification by the department of industry, labor and human relations. Such certification shall be based on standards established by the department of industry, labor and human relations. Only those tests that are made by a certified laboratory will be accepted. To verify compliance with these standards the department of industry, labor and human relations may require that tests be made at its designated laboratory.

1. The owner or supplier shall have the choice of selecting a certified testing laboratory for any tests at his expense.

(6) CLAY TILE USED IN NONBEARING PARTITIONS. All hollow clay tile used in nonbearing partitions shall conform to the requirements of standard specifications for structural clay non-load bearing tile of the American Society for Testing and Materials. See section Ind 51.25 (8) for the ASTM designation which refers to this product or method.

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

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

(7) HOLLOW CONCRETE MASONRY UNITS USED IN NONBEARING PARTITIONS. All hollow concrete masonry units used in nonbearing partitions shall comply with the requirements of Wis. Adm. Code section Ind 53.06 (5).

(8) CLAY TILE AND HOLLOW CONCRETE MASONRY UNITS USED IN FLOOR CONSTRUCTION. (a) *General requirements.* Where clay tile and hollow concrete masonry units are used in concrete floor construction in a way that the whole or any portion of a tile or hollow concrete masonry unit is subjected to load, the requirements for such clay tile shall conform to the standard specifications for structural clay floor tile of the American Society for Testing and Materials. See section Ind 51.25 (9) for the ASTM designation which refers to clay tile. The hollow concrete masonry unit shall conform to the requirements stated in Wis. Adm. Code section Ind 53.06 (5) of the building and heating, ventilating and air conditioning code issued by the department of industry, labor and human relations.

(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 block used in partitions shall apply.

(c) *Branding.* All clay tile or concrete masonry units used in floor construction shall conform to the branding requirements of subsection (5) (c).

Note: Copies of the above publications are on file in the office of the secretary of state, revisor of statutes and the department of industry, labor and human relations and may be obtained for personal use from the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

History: 1–2–56; am. Register, December, 1962, No. 84, eff. 1–1–63; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

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 values shown in the following table.

(2) In determining the stresses in the masonry, the effects of all loads and conditions of loading and the influence of all forces affecting the design and strength of the several parts shall be taken into account. Stresses shall be calculated on actual rather than nominal dimensions.

(3) In composite walls or other structural members composed of different kinds of grades of units or mortars, the maximum stress shall not exceed the allowable stress for the weakest of the combinations of units and mortars of which the member is composed.

(4) Higher stresses than herein specified may be used if tests, materials of a higher grade, or superior workmanship under approved

inspection are provided to the satisfaction of the department of industry, labor and human relations.

Type of Construction and Compressive Strength of Masonry Units	Allowable Compressive Stresses Gross Cross-Sectional Area (except as noted)			
	Type M Mortar	Type S Mortar	Type N Mortar	Type O Mortar
	psi	psi	psi	psi
Burned clay or shale brick:				
8,000 psi plus	400	350	300	200
4,500 to 8,000 psi	250	225	200	150
2,500 to 4,500 psi	175	160	140	110
1,500 to 2,500 psi	125	115	100	75
Sand-lime or concrete brick:				
2,500 psi plus	175	160	140	110
Solid concrete masonry units:				
1,800 psi plus	175	160	140	100
1,200 to 1,800 psi	125	115	100	75
Masonry of hollow units:				
1,000 psi	85	75	70	---
Masonry of hollow units, cellular spaces filled (Note a)	105	95	90	---
Cavity walls or masonry bonded hollow walls (Note b)				
Solid units: 2,500 psi plus	140	130	110	---
Solid units: 1,500 to 2,500 psi	100	90	80	---
Hollow units	70	60	55	---
Grouted solid masonry of clay or shale brick; sand-lime or concrete brick: (Note c)				
4,500 psi plus	350	275	200	---
2,500 to 4,500 psi	275	215	155	---
1,500 to 2,500 psi	225	175	125	---

Note (a) All cellular spaces filled solidly with concrete of either Type M or S mortar.
Note (b) Allowable stresses apply to the gross cross-sectional area of wall minus area of cavity between wythes. Where cavity or masonry bonded hollow walls are loaded concentrically, the allowable stresses may be increased by 25%.
Note (c) Grouted joints require that all joints be filled full with mortar. Refer to section Ind 53.08.

(5) If the design unit stress employed for any type of masonry exceeds 175, 160, 140, 110 or 75 for mortar type M, S, N, and O respectively, the plan or specification shall note the unit stress, type of mortar and kind of joint. Notification of the type and brand of masonry unit shall be filed with the department of industry, labor and human relations, including satisfactory evidence of test.

History: 1-2-56; r. and recr. Register, October, 1967, No. 142, eff. 11-1-67.

Ind 53.08 Mortar and grout. (1) GENERAL REQUIREMENTS. All materials used as ingredients for mortar and grout shall conform to the following specifications of the American Society for Testing and Materials: See Ind 51.25 (10 thru 17) for the ASTM designation which refers to these products or methods.

(a) Hydrated lime mortar made with type N-normal hydrated lime for masonry purposes, after suction for 60 sec. shall have a water retention value of not less than 75% when tested in a standard mortar made from the dry hydrate or from putty made for the hydrate which has been soaked for a period of 16 to 24 hours.

(b) Hydrated lime mortar made with type S—special hydrated lime for masonry purposes shall have a water retention value of not less than 85%when tested in a standard mortar made from the dry hydrate.

(2) MORTAR. Mortar shall consist of a mixture of cementitious material and aggregate conforming to the requirements of the following table:

MORTAR PROPORTIONS BY VOLUME

Mortar Type	Parts by Volume of Portland Cement, or Portland Blast-Furnace Slag Cement	Parts by Volume of Masonry Cement	Parts by Volume of Hydrated Lime or Lime Putty	Aggregate Measured in a Damp, Loose Condition
M	1 1	1 (Type II) ----------	---------- ¼	Not less than 2¼ and not more than 3 times the sum of the volumes of the cement and lime used.
S	½ 1	1 (Type II) ----------	---------- Over ¼ to ½	
N	---------- 1	1 (Type II) ----------	---------- Over ½ to 1¼	
O	---------- 1	1 (Type II) ----------	---------- Over 1¼ to 2½	

(3) GROUT. Grout shall be Type M, Type S, or Type N mortar to which water is added to produce consistency for pouring without segregation of constituents.

(4) MIXING. All cementitious materials and aggregate shall be thoroughly mixed with sufficient water added to produce a mortar with workable consistency.

(5) ADDITIVES: Where metal ties, anchors or reinforcement are imbedded in masonry, chloride and nitrate base salts or materials containing same shall not be used in the masonry construction.

(6) GYPSUM MORTAR. Gypsum mortar shall be composed of one part of gypsum and not more than three parts of mortar aggregate.

(7) MORTAR PERMITTED. Masonry shall be laid in mortar of the types specified in the following table:

Kind of Masonry	Types of Mortar Permitted
Masonry in contact with earth	M
Masonry above grade or interior masonry:	
Piers of solid units	M, S, or N
Piers of hollow units	M or S
Walls of solid units	M, S, N, or O
Walls of hollow units	M, S, or N
Chimneys	M, S, or N
Cavity walls or masonry bonded hollow walls	M, S, or N
Grouted solid masonry	M, S, or N
Nonbearing partitions and fireproofing	M, S, N, O or Gypsum
Gypsum tile or block	Gypsum
Fire brick	Refractory air setting Mortar.

History: 1–2–56; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

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 Wis. Adm. Code sections Ind 53.04 and Ind 53.07.

(3) MORTARS. Masonry shall be laid in mortar conforming to the types specified in Wis. Adm. Code section 53.08 (6).

(4) MASONRY BOND. Masonry shall be bonded longitudinally in each wythe, transversely between wythes, and at intersections as follows:

(a) *Longitudinal bond.* Not less than 60% of the units in any transverse vertical plane shall lap the ends of units above and below a distance not less than 2 inches or one-third the height of the unit, whichever is greater, or the masonry shall be reinforced longitudinally as required for masonry laid in stack bond.

(b) *Transverse bond.* In brick masonry or in combinations of brick and other masonry units the facing and backing (adjacent wythes) shall be bonded by one of the following methods:

1. Bonding with headers. The facing and backing shall be bonded by a full header course of brick extending not less than ⅓ their length into the backing and spaced at intervals not greater than every sixth course of brick or equivalent. By equivalent is meant that ⅙ of the wall surface shall be header or bond units. The clear distance between bond courses shall not exceed 16 inches. Where the backing consists of 2 or more wythes, the headers shall extend not less than 4 inches into the most distant wythe or the backing wythe shall be bonded together with separate headers whose area and spacing conform to the foregoing.

2. Bonding with metal ties. Reinforcement for embedment in the horizontal mortar joints shall consist of metal ties conforming to section Ind 53.11 (3) (a) or of a continuous tie assembly with not less than #9 wire deformed longitudinal rods and #9 gauge cross wires. Cross wires shall be weld connected, spaced not more than 16 inches along the longitudinal rods, and shall be galvanized or coated with other approved corrosion-resistant material. The coating shall be not less than 0.8 oz. per sq. ft. Out-to-out spacing of longitudinal rods shall be approximately 2 inches less than the nominal thickness of the wall or wythe in which reinforcement is used. Tie assemblies shall be spaced at vertical intervals not exceeding 16 inches. Where the space between metal tied wythes is solidly filled with mortar, the allowable stresses and other provisions for masonry bonded walls shall apply. Where the space is not filled, metal tied walls shall conform to the allowable stresses, lateral support, thickness (excluding cavity), and height requirements for cavity walls as stated in section Ind 53.11.

(c) *Stack bond.* Load bearing walls having one or more wythes with inadequate longitudinal masonry bond shall be tied and reinforced as described in section Ind 53.09 (4) (b) 2.

1. Reinforcement for bearing walls having a single wythe shall consist of a continuous tie assembly with the equivalent of not less than #9 gauge deformed longitudinal rods and #9 gauge cross wires spaced at vertical intervals not exceeding 16 inches.

(d) *Bonding at intersections.* Where two bearing walls meet or intersect, the intersections shall be bonded by one of the following methods:

1. By laying in a true bond at least 50% of the units at the intersection.

2. By regular toothing or blocking with 8 inch maximum offsets and the joints provided with the equivalent of not less than 1¼ inch or ¼ inch by 24 metal anchors with hooked or cross pinned ends for anchorage. Such anchors shall be spaced not more than 4 feet apart.

3. By alternate details which are designed to permit differential movements at the intersections of interior and exterior walls provided such details are consistent with the requirements for lateral stability of the walls.

(5) USE OF HOLLOW CLAY TILE AND HOLLOW CONCRETE MASONRY UNITS. Approved clay tile and hollow concrete masonry units may be used in bearing walls of buildings not more than 3 stories, or 40 feet in height. In determining this height, the basement or foundation wall shall be considered a story if constructed of clay tile or concrete masonry units.

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

(7) PARTY WALL CONSTRUCTION. Where hollow clay tile or hollow concrete masonry units are used in party walls, there shall be not less than 2 such units, each 8 inches in thickness as a minimum, used in making up the thickness of the wall unless solid masonry is used for building all chases, recesses, framing of all openings, and for the support, anchorage, and protection of all joists and beams carried into such wall.

(8) WALL CONSTRUCTION. All hollow concrete masonry units and other hollow units not designed for the same loading in either a horizontal or vertical position shall be laid with the cells in a vertical position, when used in a bearing wall.

(a) *Clay tile or concrete masonry unit construction.* In clay tile or concrete masonry unit construction, all vertical and horizontal joints designed to receive mortar or grout shall be completely filled.

(b) *Height and thickness.* All hollow concrete masonry bearing walls shall be limited to the following values:

		Thickness in Inches	Maximum Height in Feet	Maximum Roof or Floor Span in Feet	Maximum Spacing of Crosswalls or Pilasters in Feet	Pilasters Minimum Size in Inches*
Single Story		6 8 10 12	9 12 15 18	18 25 30 40	15 20 25 None Required	12 12 14 16
Top Story of Buildings Not Over 3 Story		8	10	20	30	12
Multi-Story	Upper 40 ft. or 3 Stories	12	3 Stories or 40 Feet		18	16

*Size is for lateral stability only. See section Ind 53.09 (8).

1. Masonry crosswalls or pilasters may be omitted on hollow concrete masonry bearing walls 12 inches or more in thickness where such walls are supported horizontally by floors or roofs at heights not exceeding 18 times the wall thickness.

2. Stiffened walls. Where solid masonry bearing walls are stiffened at distances not greater than 12 feet apart by masonry cross walls or by reinforced concrete floors, they may be of 12-inch thickness for the uppermost 50 feet, measured downward from the top of the wall, and shall be increased 4 inches in thickness for each successive 50 feet or fraction thereof.

3. Brick masonry bearing walls shall have a thickness of at least $\frac{1}{20}$ of their unsupported height or width, whichever is the shorter. In addition, the thickness of such bearing walls shall be not less than 6 inches for walls 10 feet or less in height and the minimum thickness shall be increased 1 inch for each successive 10 feet or fraction thereof in height.

(c) *Pilaster.* An unreinforced masonry section bonded to the adjoining wall by one of the following methods:

1. By the use of pilaster blocks by alternate course bond of masonry with adjoining wall.

2. Pilasters. The least dimension in inches for pilasters carrying beams, trusses, and girders shall be not less than 1/40 the span and the height shall not exceed 12 times the least dimension for solid or hollow masonry. Joists with spans not more than 40 feet and spacings not more than 6 feet on center shall not be considered as beams or girders if a continuous bond beam is used for spacings of over 4 feet. A bond beam made up of not less than 8 inch lintel blocks may be used if 2 No. 4 bars are embedded in 3000 p.s.i. concrete fill. An equivalent bond beam of other materials is acceptable.

3. The dimension of pilasters used for lateral stability only, shall be no less than 4 inches greater in thickness than the principal wall nor less than 16 inches in length.

(d) *Piers.* An isolated column of masonry. A bearing wall not bonded at the sides into associated masonry shall be considered a pier when its horizontal dimension measured at right angles to the thickness does not exceed four times its thickness. The least dimension shall not be less than 1/30 of the span, in inches, and the height shall not exceed 10 times the least dimension for solid or grouted masonry piers or 6 times the least dimension for hollow masonry piers.

(e) *Walls below grade.* Masonry walls which are in contact with the soil shall be of sufficient strength and thickness to resist the lateral pressure from the adjacent earth and to support their vertical loads without exceeding the allowable stresses. The minimum thickness for masonry walls below grade shall be 4 inches greater than the required thickness for the walls of the supported structures except that 12 inch walls will be accepted for buildings not more than 2 stories in height if substantial lateral support consisting of masonry walls, offsets or pilasters are provided at intervals of not to exceed 20 feet.

(f) *Stone walls.* Rough or random or coursed rubble stone walls shall be 4 inches thicker than is required by Wis. Adm. Code section 53.09 (8) (a) but in no case less than 16 inches thick.

1. Stone 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, see section Ind 53.09 (4) (b) 1 or 2. No such wall shall be less than 12 inches thick.

(g) *Chases, recesses and openings.* There shall be no chases in 8 inch walls or in any pier. No chase in wall greater than 8 inches 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.

(h) *Eccentric loads.* Walls supporting eccentrically applied loads including eccentric loads produced by the deflection of floor and roof members shall be analyzed for stability and strength. Maximum unit stresses shall not exceed those specified in sections Ind 53.04 and Ind 53.07.

(i) *Design.* The minimum thickness of masonry bearing walls may be decreased, except for walls below grade, and the height or length to thickness ratio may be increased when data is submitted to the department of industry, labor and human relations which justifies a reduction in the requirements specified in this code.

History: 1–2–56; am. (12) (a), Register, June, 1956, No. 6, eff. 7–1–56; am. (4) (b), Register, August, 1957, No. 20, eff. 9–1–57; r. and recr. Register, September, 1959, No. 45, eff. 10–1–59; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.10 Nonbearing masonry walls. (1) EXTERIOR NONBEARING WALLS. All exterior nonbearing walls, if constructed with one wythe of brick to the weather may be backed with S.W. or M.W. classified clay or shale brick, concrete masonry units or clay tile conforming to the requirements of sections Ind 53.05 and 53.06. If such walls are

built of concrete masonry units or clay tile, such units shall conform to the requirements of Ind 53.06.

(2) INTERIOR NONBEARING WALLS. Interior nonbearing masonry walls may be built of materials conforming with the requirements of sections Ind 53.05 and 53.06, or of gypsum block or other approved material.

(3) TYPE OF MORTAR. Mortar used in non-load-bearing masonry shall conform to the types specified in Wis. Adm. Code section 53.08 (6).

(4) MASONRY BOND AND ANCHORAGE. Exterior and interior non-load-bearing masonry walls shall be bonded longitudinally in each wythe and transversely between wythes as required for bearing walls. See section Ind 53.09 (4) (a) through (b) 2. For stone walls see section Ind 53.09 (8) (e).

(a) NON-LOAD-BEARING WALLS. Non-load-bearing walls shall be anchored to each other at intersections and to supporting masonry by means of masonry bond or corrosion-resistant corrugated metal ties or equivalent. Corrugated metal ties shall be not less than ⅞ inches wide and No. 22 gauge in thickness and shall be located at vertical intervals not more than 16 inches on center or shall be equivalent to the foregoing.

(b) *Anchorage.* Anchorage to steel or concrete supports shall be by means of not less than as specified in (a) above or equivalent methods. Anchorage at exterior walls shall be adequate to transmit wind and other lateral loads to the supports.

(c) *Stack bond.* Non-load-bearing walls, or wythes thereof, laid in stack bond or otherwise with inadequate longitudinal bond, shall be tied and reinforced as required in Wis. Adm. Code section 53.09 (4) (c) except that for interior non-load-bearing partitions the maximum spacing of joint reinforcement shall be 24 inches.

(d) *Masonry veneer.* Masonry veneer or wood frame structures shall be securely attached to the backing by corrosion-resistant corrugated metal ties, not less than No. 22 gauge in thickness and ⅞ inches in width or equivalent. One tie shall be used for at least each 2 square feet of wall area and the distance between ties shall not exceed 24 inches or by No. 13 gauge metal ties or equivalent located 36 inches horizontally and 18 inches vertically.

(5) HEIGHT AND THICKNESS—INTERIOR NONBEARING MASONRY WALLS. Walls which are supported by fire-resistive construction and have tight contact with not less than 2-hour fire-resistive construction at the top, shall be not more than 36 times their thickness in clear height. Similar nonbearing 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 NONBEARING WALLS. The thickness of exterior nonbearing walls shall be not less than $\frac{1}{24}$ of the clear height but in no case less than 8 inches. Where 8 inch or 10 inch

walls are used, the horizontal distance between vertical supports shall be not less than 30 times the wall thickness.

(7) WALLS BELOW GRADE. See Wis. Adm. Code section Ind 53.09 (8) (e).

(8) DESIGN. The minimum thickness of non-load-bearing walls may be decreased and the height or length to thickness ratio may be increased when data is submitted to the department of industry, labor and human relations which justifies a reduction in the requirements specified in this code.

History: 1–2–56; r. and recr. Register, September, 1959, No. 45, eff. 10–1–59; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.11 Cavity walls. (1) LOAD-BEARING AND NON-LOAD-BEARING. Load-bearing and non-load-bearing walls of the cavity type may be built of solid or hollow masonry units or combinations thereof subject to the following requirements as well as other applicable requirements of this code. The description of a cavity wall is determined by its nominal out-to-out dimension. (a) For allowable unit stresses see Wis. Adm. Code section Ind 53.07 for masonry. In computing the unit stresses, the effective cross sectional area of the cavity walls shall be taken as the gross cross sectional area minus the area of the cavity.

(b) For mortar requirements see Wis. Adm. Code section Ind 53.08 (6).

(2) THICKNESS. The facing and backing of cavity walls shall each have a thickness of at least 4 inches and the space between the facing and backing shall be not less than 2 inches nor more than 3 inches in width. The backing wythe shall be at least as thick as the facing wythe.

(a) The maximum height between supports shall be 10 feet for 10 inch cavity walls. For other wall thicknesses, it shall not exceed 18 times the sum of the nominal thickness of the inner and outer wythes. The overall height of a 10 inch cavity wall shall not exceed 25 feet. The overall height of all other cavity walls shall not exceed 35 feet.

(3) BONDING. The facing and backing of cavity walls shall be bonded with $\frac{3}{16}$ inch diameter metal unit ties or the equivalent or with the equivalent of metal reinforcement having #9 inch longitudinal rods and #9 gauge cross wires. Metal ties shall be of corrosion-resistant metal or coated with a corrosion-resistant metal, or other approved protective coating.

(a) *Metal ties.* There shall be one $\frac{3}{16}$ inch steel rod or metal tie of equivalent strength or stiffness for not more than each 4½ square feet of wall area. Ties in alternate courses shall be staggered, the maximum vertical distance between ties shall not exceed 18 inches, and the maximum horizontal distance shall not exceed 36 inches. Ties bent to rectangular shape shall be used with hollow masonry units laid with the cells vertical; in other walls the ends of ties shall be bent to 90-degree angles, Z shaped, to provide hooks not less than 2 inches long. Additional bonding ties shall be provided at

all openings spaced not more than 3 feet apart around the perimeter and within 12 inches of the opening.

(b) *Cross-wire ties.* Cross wires (at least #9 gauge or larger) of masonry joint reinforcement shall be spaced to provide equivalent strength and stiffness across the cavity space to that provided by $\frac{3}{16}$ inch Z shaped ties for each 4½ square feet of wall area.

(c) *Installation.* Ties specified above shall be installed in the first mortar joint below floor and roof bearing courses.

(4) CAVITY DRAIN. In exterior walls of cavity construction, suitable flashing shall be installed at the bottom of the cavity so as to drain outwardly any water which penetrates the facing. Open vertical joints, or weep holes, shall be provided every 2 to 3 feet horizontally in the facing above the flashing.

(5) STACK BOND. Masonry joint reinforcement shall conform to the requirements as specified in this section.

(6) CAVITY WALLS BELOW GRADE. Cavity walls shall not be built below grade unless designed to resist the lateral pressure due to backfilling operations and earth pressure.

History: 1–2–56; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

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

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

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

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

Ind 53.13 Parapet walls. (1) Parapet walls not less than 8 inches in thickness and 2 feet in height shall be provided on all exterior walls of masonry or concrete, where such walls connect with roofs other than roofs that are of incombustible construction throughout; 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.

(3) Parapet walls not less than 8 inches in thickness and 3 feet in height shall be provided on all division and party walls of masonry or concrete where such walls connect with roofs of other than 2-hour fire-resistive construction, or better.

History: 1–2–56; am. Register, December, 1962, No. 84, eff. 1–1–63.

Ind 53.14 Concrete requirements. (1) ADOPTED STANDARDS. The following American Concrete Institute standards are adopted as part of the building, heating, ventilating and air conditioning code issued by the Wisconsin department of industry, labor and human relations. See section Ind 51.26 for the ACI designation which refers to this product or method.

(a) Building code requirements for reinforced concrete.

(b) Minimum standard requirements for precast concrete floor and roof units.

(c) Minimum requirements for thin-section precast concrete construction.

(2) RECOMMENDED STANDARDS: The following standards which are a part of the standards stated in (1) are recognized by the Wisconsin department of industry, labor and human relations as being good engineering practice but are not included as part of the building, heating, ventilating and air conditioning code issued by the Wisconsin department of industry, labor and human relations.

(a) Recommended practice for evaluation of compression tests results of field concrete.

(b) Recommended practice for cold weather concreting.

(c) Recommended practice for hot weather concreting.

(d) Recommended practice for selecting proportions for structural lightweight concrete.

(e) Manual of standard practice for detailing reinforced concrete structures.

(f) Recommended practices for welding reinforced steel, metal inserts and connections in reinforced concrete construction.

(g) Arc and gas welding in building construction.

(h) Mild steel arc-welding electrodes.

(i) Standard qualification procedure.

History: 1–2–56; r. and recr. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.15 History: 1–2–56; r. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.15 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 ⅛ inch in thickness.

(e) Steel bar and wire reinforcing shall meet the requirements of Wis. Adm. Code subsection Ind 53.14.

(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 subsection (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

History: 1–2–56; renum. from Ind 53.23 to be Ind 53.15, Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.16 History: 1–2–56; r. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.16 Structural steel. (1) MATERIAL. (a) *Minimum yield point.* The minimum yield point in pounds per square inch for structural steel used in buildings and structures under this code shall be as follows:

Steel for bridges and buildings, Designation A-7	33,000
Structural steel for welding, Designation A–373	32,000
Structural steel, Designation A-36	36,000
High-strength structural steel, Designation A–440	42,000—50,000
High-strength low-alloy structural manganese vanadium steel, Designation A–441	42,000—50,000
High-strength low-alloy structural steel, Designation A–242	42,000—50,000

1. Certified test reports shall be submitted as evidence of conformity with the specifications when requested by the department of industry, labor and human relations.

2. Unidentified steel, if free from surface imperfections, may be used for parts of minor importance, or for unimportant details, where the precise physical properties of the steel and its weldability would not affect the strength of the structure.

(b) *Other metals.* Cast steel shall conform to one of the following specifications:

Mild-to-medium-strength carbon-steel castings for general application, Designation A-27, Grade 65–35.

High-strength steel castings for structural purposes, Designation A–148, Grade 80–50.

1. Certified test reports shall be submitted as evidence of conformity with the specifications when requested by the department of industry, labor and human relations.

2. Steel forgings shall conform to one of the following specifications:

a. Carbon steel forgings for general industrial use, Designation A-235, Class C1, F and G. (Class C1 forgings that are to be welded shall be ordered in accordance with supplemental requirements S5 of A-235.)

b. Alloy steel forgings for general industrial use, Designation A-237, Class A.

3. Certified test reports shall be submitted as evidence of conformity with the specifications when requested by the department of industry, labor and human relations.

(c) *Rivet steel.* Rivet steel shall conform to one of the following specifications:

Structural rivet steel, Designation A–141.
High-strength structural rivet steel, Designation A–195.
High-strength structural alloy rivet steel, Designation A–406.

1. Certified test reports shall be submitted as evidence of conformity with the specifications when requested by the department of industry, labor and human relations.

(d) *Bolts.* High-strength steel bolts shall conform to one of the following specifications:

High-strength steel bolts for structural joints, Designation A-325.

Quenched and tempered alloy steel bolts and studs with suitable nuts, Designation A-354, Grade BC.

1. Other bolts shall conform to the specification for low-carbon steel externally and internally threaded standard fasteners, Designation A-307, hereinafter designated as A-307 bolts.

2. Manufacturer's certification shall be submitted as evidence of conformity with the specifications when requested by the department of industry, labor and human relations.

(e) *Filler metal for welding.* Welding electrodes for manual shielded metal arc welding shall conform to the E60 or E70 series of the specification for mild steel arc welding electrodes, Designation A-233.

1. Bare electrodes and granular fusible flux used in combinations for submerged arc welding shall be capable of producing weld metal having the following tensile properties when deposited in a multiple pass weld:

a. Grade SA-1

Tensile strength	62,000 to 80,000 psi
Yield point, min.	45,000 psi
Elongation in 2 in., min.	25%
Reduction in area, min.	40%

b. Grade SA-2

Tensile strength	70,000 to 90,000 psi
Yield point, min.	50,000 psi
Elongation in 2 in., min.	22%
Reduction in area, min.	40%

2. Manufacturer's certification shall be submitted as evidence of conformity with the specifications when requested by the department of industry, labor and human relations.

(2) ALLOWABLE UNIT STRESSES. All components of the structure shall be so proportioned that the unit stresses in pounds per square inch shall not exceed the following values except as specified in Wis. Adm. Code section Ind 53.01.

(a) *Structural steel.* 1. Tension. a. On the net section, except as pin holes

$$F_t = 0.60F_y$$

b. On the net section at pin holes in eyebars, pin-connected plates or built-up members

$$F_t = 0.45\ F_y$$

Note: F_t = Allowable tensile stress
F_y = Minimum yield point of type of steel used

2. Shear. On the gross section of beam and plate girder webs

$$F_v = 0.40F_y$$

3. Compression. a. On the gross section of axially loaded compression members when $\frac{1}{r}$, the largest slenderness ratio of any unbraced segment is less than C_c

(FORMULA 1)

$$F_a = \frac{\left[1 - \frac{\left(\frac{1}{r}\right)^2}{2C_c^2}\right] F_y}{F.S.}$$

Where

$$F.S. = \text{factor of safety} = \frac{5}{3} + \frac{3\left(\frac{1}{r}\right)}{8C_c} - \frac{\left(\frac{1}{r}\right)^3}{8C_c^3}$$

and

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

b. On the gross section of axially loaded columns when $\frac{1}{r}$ exceeds C_c

(FORMULA 2)

$$F_a = \frac{149{,}000{,}000}{\left(\frac{1}{r}\right)^2}$$

c. On the gross section of axially loaded bracing and secondary members, when $\frac{1}{r}$ exceeds 120

(FORMULA 3)

$$F_{a'} = \frac{F_a \text{ (by Formula 1 or 2)}}{1.6 - \frac{1}{200r}}$$

d. On the gross area of plate girder stiffeners

$$F_a = 0.60\ F_y$$

e. On the web of rolled shapes at the toe of the fillet.

$$F_a = 0.75\ F_y$$

4. Bending. a. Tension and compression on extreme fibers of rolled shapes and built-up members having an axis of symmetry in the plane of loading and proportions meeting the requirements of compact sections, when the member is supported laterally at intervals no greater than 13 times its compression flange width

$$F_b = 0.66\ F_y$$

b. Beams and girders which meet the requirements of the preceding paragraph and are continuous over supports or are rigidly framed to columns by means of rivets, high-strength bolts or welds, may be proportioned for 9/10 of the negative moments produced by gravity loading which are maximum at points of support provided that, for such members, the maximum positive moment shall be increased by 1/10 of the average negative moments. This reduction shall not apply to moments produced by loading on cantilevers. If the negative moment is resisted by a column rigidly framed to the beam or girder, the 1/10 reduction may be used in proportioning the column for the combined axial and bending loading, provided that the unit stress, due to any concurrent axial load on the member, does not exceed $0.15F_y$.

c. Tension and compression on extreme fibers of unsymmetrical members supported in the region of compression stress as specified in section 4. a.

$$F_b = 0.60F_y$$

d. Tension and compression on extreme fibers of box-type members whose proportions do not meet the provisions of compact sections, but do conform to the provisions of section 5—Width-Thickness Ratio.

$$F_b = 0.60F_y$$

e. Tension on extreme fibers of other rolled shapes, built-up members, and plate girders.

$$F_b = 0.60F_y$$

f. Compression on extreme fibers of rolled shapes, plate girders, and built-up members having an axis of symmetry in the plane of their web (other than box-type beams and girders), the larger value computed by formulas (4) and (5), but not more than $0.60F_y$

(FORMULA 4)

$$F_b = \left[1.0 - \frac{\left(\frac{l}{r}\right)^2}{2C_c^2 C_b}\right] 0.60F_y$$

(FORMULA 5)

$$F_b = \frac{12{,}000{,}000}{\frac{ld}{A_f}}$$

where l is the unbraced length of the compression flange; r is the radius of gyration of a tee section comprising the compression flange plus 1/6 of the web area, about an axis in the plane of the web; A_f is the area of the compression flange; C_c is defined in section 3. a. and C_b, which can conservatively be taken as unity, is equal to

$$C_b = 1.75 - 1.05\left(\frac{M_1}{M_2}\right) + 0.3\left(\frac{M_1}{M_2}\right)^2, \text{ but not more than } 2.3$$

where M_1 is the smaller and M_2 the larger bending moment at the ends of the unbraced length, taken about the strong axis of the member,

and where $\frac{M_1}{M_2}$, the ratio of end moments, is positive when M_1 and M_2 have the same sign (single curvature bending) and negative when they are of opposite signs (reverse curvature bending). When the bending moment at any point within an unbraced length is larger than that at both ends of this length the ratio $\frac{M_1}{M_2}$ shall be taken as unity.

g. Compression on extreme fibers of channels, the value computed by formula (5), but not more than

$$F_b = 0.60F_y$$

h. Tension and compression on extreme fibers of large pins.

$$F_b = 0.90F_y$$

i. Tension and compression on extreme fibers of rectangular bearing plates.

$$F_b = 0.75F_y$$

5. Bearing (on contact area). a. Milled surfaces and pins in reamed, drilled or bored holes, pounds per square inch

b. Finished stiffeners pounds per square inch

$$F_p = 0.80\ F_y$$

$$F_p = 0.90F_y$$

c. Expansion rollers and rockers, pounds per linear inch

$$F_p = \left(\frac{F_y - 13{,}000}{20{,}000}\right) 660d$$

where d is the diameter of roller rocker in inches

d. Rivets and bolts. Allowable unit tension and shear stresses on rivets, bolts and threaded parts (pounds per square inch of area of rivets before driving or unthreaded body area of bolts and threaded parts) shall be as given in table 1.

TABLE 1

Description of Fastener	Tension (F_t)	Shear (F_v)	
		Friction-type Connections	Bearing-type Connections
A141 hot-driven rivets	20,000	----------	15,000
A195 and A406 hot-driven rivets	27,000	----------	20,000
A307 bolts and threaded parts of A7 and A373 steel	14,000	----------	10,000
Threaded parts of other steels	$0.40F_y$	----------	$0.30F_y$
A325 bolts when threading is *not* excluded from shear planes	40,000	15,000	15,000
A325 bolts when threading is excluded from shear planes	40,000	15,000	22,000
A354, Grade BC, bolts when threading is *not* excluded from shear planes	50,000	20,000	20,000
A354, Grade BC, when threading is excluded from shear planes	50,000	20,000	24,000

Allowable bearing stress on projected area of bolts in bearing-type connections and on rivets.

$$F_p = 1.35F_y$$

(Bearing stress not restricted in friction-type connections assembled with A325 and A354, Grade BC, bolts).

Welds (stress in pounds per square inch throat area).

Fillet, plug, slot and partial penetration groove welds.

Fillet, plug, slot and partial penetration groove welds made with A233 Class E60 series electrodes and fillet welds made by submerged arc welding Grade SA–1—13,600.

Fillet, plug, slot and partial penetration groove welds made with A233 Class E70 series electrodes and fillet welds made by submerged arc welding Grade SA–2—15,800.

Complete penetration groove welds.

On complete penetration groove welds the allowable tension, compression, bending, shear and bearing stresses shall be the same as those allowed by section (2) in the connected material.

e. Cast steel and steel forgings.

1. Tension (on net section) F_t $0.60F_y$
2. Shear (on gross section) F_v $0.40F_y$
3. Compression—same as provided under section (2) (a) 3. a.
4. Bending (on extreme fibers) F_b $0.60F_y$
5. Bearing—same as provided under section (2) (a) 5.

f. Wind stresses. (See Wis. Adm. Code section Ind 53.01)

(3) COMBINED STRESSES. (a) *Axial compression and bending.* Members subject to both axial compression and bending stresses shall be proportioned to meet the requirements of both Formula (6) and Formula (7).

FORMULA (6)

$$\frac{f_a}{F_a} + \frac{C_m f_b}{\left(1 - \frac{f_a}{F'_e}\right) F_b} \leq 1.0$$

FORMULA (7)

$$\frac{f_a}{0.6F_y} + \frac{f_b}{F_b} \leq 1.0 \text{ (applicable only at braced points)}$$

where

F_a = axial stress that would be permitted if axial stress alone existed

F_b = bending stress that would be permitted if bending stress alone existed

$F'_e = \frac{149{,}000{,}000}{\left(\frac{l}{r_b}\right)^2}$ (May be increased ⅓ in accordance with Wis. Adm. Code section Ind 53.01)

l = actual unbraced length in the plane of bending

r_b = radius of gyration about axis of bending

f_a = computed axial stress

f_b = computed bending stress at the point under consideration
C_m = 0.85, except as follows:

1. When $\frac{f_a}{F_a} \leq 0.15$. (For this case the member selected shall meet the limitation that

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0$$

2. For restrained compression members in frames braced against joint translation but not subject to transverse loading between their supports in the plane of loading, C_m may be taken as 0.6 plus 0.4 $\left(\frac{M_1}{M_2}\right)$, where $\frac{M_1}{M_2}$ is the ratio of smaller to larger moments at the ends of the critical unbraced length of the member. $\frac{M_1}{M_2}$ is positive when the unbraced length is bent in single curvature and negative when it is bent in reverse curvature.
3. For restrained compression members in frames braced against joint translation in the plane of loading and subject to transverse loading between their supports (joints) in the plane of loading, a value of C_m may be determined by rational analysis.

(b) *Shear and tension.* Rivets and bolts subject to combined shear and tension due to force applied to the connected parts, shall be so proportioned that the tension stress produced by the force shall not exceed the following:

For A141 rivets	$F_t = 28{,}000 - 1.6f_v \leq 20{,}000$
For A195 and A406 rivets	$F_t = 38{,}000 - 1.6f_v \leq 27{,}000$
For A307 bolts	$F_t = 20{,}000 - 1.6f_v \leq 14{,}000$
For A325 bolts in bearing-type joints	$F_t = 50{,}000 - 1.6f_v \leq 40{,}000$
For A354, Grade BC, bolts in bearing-type joints	$F_t = 60{,}000 - 1.6f_v \leq 50{,}000$

where f_v, the shear stress produced by the same force, shall not exceed the value for shear given in section (2) 5. (d).

For bolts used in friction-type joints, the shear stress allowed in section (2) 5. (d) shall be reduced as follows:

For A 325 bolts $F_v \leq 15{,}000 \left(1 - \frac{f_t A_b}{T_b}\right)$

For A 354, Grade BC, bolts $F_v \leq 20{,}000 \left(1 - \frac{f_t A_b}{T_b}\right)$

where f_t is the tensile stress due to applied load and T_b is the proof load of the bolt.

(4) SLENDERNESS RATIOS. (a) *Definition.* In determining the slenderness ratio of an axially loaded compression member, l shall be taken as its effective length and r the corresponding radius of gyration.

(b) *Sidesway prevented.* The effective length of compression members in trusses, and in frames where lateral stability is provided by diagonal bracing, shear walls, attachment to an adjacent structure having adequate lateral stability, or by floor slabs or roof decks secured horizontally by walls or bracing systems parallel to the plane of the frame, shall be taken as the actual unbraced length, unless analysis shows that a shorter length may be used.

(c) *Sidesway not prevented.* The effective length of compression members in a frame which depends upon its own bending stiffness for lateral stability, shall be determined by a rational method and shall not be less than the actual unbraced length.

(d) *Maximum ratios.* The slenderness ratio of compression members shall not exceed 200. The slenderness ratio of tension members, other than rods, preferably should not exceed:

For main members ---------- 240
For bracing and other secondary members ---------- 300

(5) WIDTH-THICKNESS RATIOS. (a) *Projecting elements under compression.* 1. 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:

Single-angle struts; double-angle struts with separators ---- $\frac{2,400}{\sqrt{F_y}}$

Struts comprising double angles in contact; angles or plates projecting from girders, columns or other compression members; compression flanges of beams; stiffeners on plate girders $\frac{3,000}{\sqrt{F_y}}$

Stems of tees ---------- $\frac{4,000}{\sqrt{F_y}}$

2. The width of plates shall be taken from the free edge to the first row of rivets, bolts, or welds; the width of legs of angles, channels and zees, and of the stems of tees, shall be taken as the full nominal dimension; the width of flanges of beams and tees shall be taken as 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.

3. 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 acceptable.

(b) *Compression elements supported along 2 edges.* 1. In compression members the unsupported width of web, cover or diaphragm plates, between the nearest lines of fasteners or welds, or between the roots of the flanges in case of rolled sections, shall not exceed $\frac{8,000}{\sqrt{F_y}}$ times its thickness.

2. When the unsupported width exceeds this limit, but a portion of its width no greater than $\frac{8,000}{\sqrt{F_y}}$ 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, may exceed $\frac{8,000}{\sqrt{F_y}}$, but shall not exceed $\frac{10,000}{\sqrt{F_y}}$, times the thickness. The gross width of the plate less the width of the widest access hole shall be assumed available to resist compression.

(6) SIMPLE AND CONTINUOUS SPANS. (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 full or partial end restraint, due to continuous, semi-continuous or cantilever action, the beams, girders and trusses, as well as the sections of the members 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 section (2) (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 fasteners.

(7) DEFLECTIONS. (a) Beams and girders supporting floors and roofs shall be proportioned with due regard to the deflection produced by the design loads.

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

(c) The depth of beams and girders supporting flat roofs shall be not less than $\frac{F_y}{1,000,000}$ times their span length whether designed as simple or continuous spans.

(8) CONNECTIONS. (a) *Minimum connections.* Connections carrying calculated stresses, except for lacing, sag bars, and girts, shall be designed to support not less than 6,000 pounds.

(b) *Eccentric connections.* Axially stressed members meeting at a point shall have their gravity axes intersect at a point if practicable; if not, provision shall be made for bending stresses due to the eccentricity.

(c) *Placement of rivets, bolts and welds.* Except as hereinafter provided, the rivets, bolts or welds at the ends of any member transmitting axial stress into that member shall have their centers of gravity on the gravity axis of the member unless provision is made for the effect of the resulting eccentricity. Except in members subject to repeated variation in stress, disposition of fillet welds to balance the forces about the neutral axis or axes for end connections of single

angle, double angle, and similar type members is not required. Eccentricity between the gravity axes of such members and the gauge lines for their riveted or bolted end connections may be neglected.

(d) *Unrestrained members.* Except as otherwise indicated by the designer, connections of beams, girders or trusses shall be designed as flexible, and may ordinarily be proportioned for the reaction shears only. 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 determined as follows:

$e = 0.007d$, when the beam is designed for full uniform load and for live load deflection not exceeding 1/360 of the span

$= \frac{f_b \, L}{3{,}600{,}000}$, when the beam is designed for full uniform load producing the unit stress f_b at mid-span

where

e = the horizontal displacement of the end of the top flange, in the direction of the span, in inches

f_b = the flexural unit stress in the beam at mid-span, in pounds per square inch

d = the depth of the beam, in inches

L = the span of the beam, in feet

(e) *Restrained members.* Fasteners or welds for end connections of beams, girders and trusses not conforming to the requirements of section (8) (d) shall be designed for the combined effect of end reaction shear and tensile or compressive stresses resulting from moment induced by the rigidity of the connection when the member is fully loaded.

(9) 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 in accordance with the following requirements:

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

2. Column bases other than rolled steel bearing plates shall be planed for all bearing surfaces (except as noted under requirement 3. of this section).

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

(10) SHOP PAINTING. (a) *General requirements.* Unless otherwise specified, steelwork which will be concealed by interior building finish need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned in accordance with the following paragraph, by brush, spray, roller coating, flow coating, or dipping, at the election of the fabricator.

(b) *Cleaning.* After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand-wire brushing, or by other methods elected by the fabricator, of loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent. Steelwork specified to have no shop paint, after fabrication, shall be cleaned of oil or grease by solvent cleaners and shall be cleaned of dirt and other foreign material by thorough sweeping with a fiber brush.

(c) *Protection for short period of exposure.* The shop coat of paint is intended to protect the steel for only a short period of exposure, even if it is a primer for subsequent painting to be performed in the field by others.

(d) *Inaccessible surfaces.* Surfaces inaccessible after assembly shall be treated in accordance with subsection (10) (a) before assembly.

(e) *Contact surfaces.* Contact surfaces shall be cleaned in accordance with subsection (10) (a) before assembly but shall not be painted.

(f) *Finished surfaces.* Machine finished surfaces shall be protected against corrosion by a rust-inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) *Surfaces adjacent to field welds.* Unless otherwise provided, surfaces within 2 inches of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

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

(b) *Carrying.* 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 such loads.

(c) *Adequacy of temporary connections.* As erection progresses, the work shall be securely bolted, or welded, to take care of all dead load, wind and erection stresses.

(d) *Alignment.* No riveting, permanent bolting or welding shall be done until as much of the structure as will be stiffened thereby has been properly aligned.

(e) *Field welding.* Any shop paint on surfaces adjacent to joints to be field welded shall be wire brushed to reduce the paint film to a minimum.

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

(12) PLASTIC DESIGN AND FABRICATION. (a) The design, fabrication and erection of structural steel for buildings and structures by the plastic design method shall conform with recognized good engineering practice as approved by the department of industry, labor and human relations.

Note: It will be the policy of the department of industry, labor and human relations to accept methods of plastic design which conform with the rules for plastic design and fabrication of structural steel issued by the American Institute of Steel Construction.

(13) 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 rule without qualification shall comply with all of the requirements for joints which are accepted without qualification test by the department of industry, labor and human relations. No joint form not included in the foregoing shall be employed until it shall have been qualified to the satisfaction of the department of industry, labor and human relations.

Note: It will be the policy of the department of industry, labor and human relations 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 department of industry, labor and human relations 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 department of industry, labor and human relations that the operator has passed the prescribed qualification tests.

4. The department of industry, labor and human relations 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 sucecssful 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 consist 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 department of industry, labor and human relations, who shall certify to the department of industry, labor and human relations that all welding has been completed in accordance with the approved plans and specifications and with the provisions of the Wisconsin state building code.

Note: 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 subsection (13) (c).

Note: Section Ind 53.24 is based on the American Institute of Steel Specification dated November 30, 1961. For members and connections subject to repeated variation of stress, plate girders, composite construction, fabrication, shop practice, and plastic design, see A.I.S.C. Specification.

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

Note: It will be the policy of the department of industry, labor and human relations to approve, subject to the provisions of this section, steel that conforms to the following standard specifications of the American Society for Testing Materials:

a. Flat-rolled carbon steel sheets of structural quality. Designation A245
b. Hot rolled carbon strip of structural quality. Designation A303
c. High-strength low-alloy cold rolled steel sheets and strip. Designation A374
d. High-strength low-alloy hot rolled steel sheets and strip. Designation A375

2. Steel of higher strength than is covered by the above mentioned 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 department of industry, labor and human relations, the manufacturer shall furnish certified data showing the properties of such grades of steel.

(c) *Basic design stress. Allowable working stresses.* 1. Tension on the net section of tension members, and tension and compression f_b on extreme fiber 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	20,000
B	30,000	18,000
A	25,000	15,000
Other Grades	Minimum Yield Point Divided by 1.65	

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 $\frac{w}{t}$ not greater than 10, $f_c = f_b$ except that when f_b exceeds 30,000 psi, the maximum $\frac{w}{t}$ ratio for which f_c may be taken equal to f_c shall not exceed $\frac{300{,}000}{f_b}$

b. For $\frac{w}{t}$ greater than 10 but not greater than 25 $f_c = (1.667 f_b - 8640) - (1/15) \quad (f_b - 12950) \frac{w}{t}$

For steels with a yield point in excess of 50,000 psi, the value of f_b to be used in the determination of f_c when $\frac{w}{t}$ exceeds 10 shall be 30,000 psi.

c. For $\frac{w}{t}$ from 25 to 60

For angle struts $f_c = \frac{8{,}090{,}000}{\left(\frac{w}{t}\right)^2}$

For all other sections $f_c = 20{,}000 - 282\left(\frac{w}{t}\right)$

In the above formula $\frac{w}{t}$ = 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:

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

In the above formula

t = web thickness

h = clear distance between flanges

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

b. Where the web consists of 2 or more sheets, each sheet shall be considered as a separate member carrying its share of the shear.

c. Maximum slenderness ratio.

1. The maximum allowable ratio $\frac{L}{r}$ of unsupported length L to radius of gyration r, of compression members shall not exceed 200.

History: 1–2–56; cr. (9) (d) 7. Register, October, 1957, No. 22, eff. 11–1–57; cr. (15), Register, September, 1959, No. 45, eff. 10–1–59; am. Register, December, 1962, No. 84, eff. 1–1–63; renum. from Ind 53.24 to be Ind 53.16, Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.17 History: 1–2–56; r. Register, October, 1967, No 142, eff. 11–1–67.

Ind 53.17 Steel joist construction. (1) DEFINITION. Steel joist construction shall consist of decks or top slabs defined in subsection (7), supported by separate steel members referred to as steel joists. Any steel member suitable for supporting floors and roofs between the main supporting girders, trusses, beams, or walls when used as hereinafter stipulated shall be known as a "steel joist". Such steel joists may be made of hot or cold formed sections, strip or sheet steel, riveted or welded together, or by expanding.

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

(a) The spacing of steel joist for floors shall not exceed the safe span for the top slab or flooring. Where the joist spacing for floors exceeds 24 inches on centers, the bridging shall be adequate to distribute concentrated loads between joist. The spacing of steel joist for roofs shall not exceed the safe span of the top slab or roof deck.

(b) Where these spans or spacings are exceeded, the requirements for steel joist construction shall not apply, but the steel members shall be designed in accordance with the requirements of Wis. Adm. Code section Ind 53.16.

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

Structural steel for bridges and buildings: Designation A-7; Minimum yield point, 33,000

Structural steel: Designation A-36; Minimum yield point, 36,000

Flat rolled carbon steel sheets of structural quality: Designation A-245; Minimum yield point, 33,000

Hot rolled carbon steel strip of structural quality: Designation A–303; Minimum yield point, 33,000

High strength low alloy manganese, Vanadium steel; Designation A-441; Minimum yield point, 42,000—50,000

High strength structural steel: Designation A–440; Minimum yield point, 42,000—50,000

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

(4) DESIGN OF STEEL JOIST. An open web steel joist shall be 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 diagnonals of the joist shall not exceed those given in Wis. Adm. Code section Ind 53.16 for main members. The tensile stress shall not exceed 0.60 of the yield point of the grade of steel used in any member. The minimum shear to be used in designing the web members shall not be less than 20% of the rated end reaction at midspan and shall be increased lineally to 30% of the rated end reaction at a distance 0.35 from the end supports.

(a) A solid web steel joist shall be designed as a beam in accordance with the requirements of section Ind 53.16

(b) In the completed structure, the top chord of open web steel joist or the top flanges of solid web steel joist may be considered as being stayed laterally when the deck or top slab over the steel joist complies with the provisions of Wis. Adm. Code subsection (7).

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

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

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

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

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

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

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

(a) Horizontal bridging shall consist of two continuous horizontal steel members, one of which is attached to the top chord and the other attached to the bottom chord. Attachment to the joist shall be made by welding or by mechanical means, and the attachments shall be capable of resisting a horizontal force of not less than 500 pounds.

The ratio of unbraced length to the least radius of gyration $\left(\frac{L}{r}\right)$ of the bridging member shall not exceed 300. Where a round bar is used for bridging the diameter shall be at least ½ inch.

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

(c) In roof construction, where the slope is perpendicular to the longitudinal axis of the joist, sag rods may be used in lieu of bridging. The rods shall not be less than ½ inch in diameter and the number of lines shall be the same as specified for bridging.

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

Clear Span	*Number of Lines of Bridging*
Up to 14 feet	One row near center.
14 to 21 feet	Two rows placed at 1/3 point of span.
21 to 32 feet	Three rows placed at ¼ point of span.
32 to 40 feet	Four rows placed at 1/5 point of span.
40 to 48 feet	Five rows placed at 1/6 point of span.

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

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

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

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

(b) Poured structural slabs of concrete, gypsum or other similar material shall not be less than 2 inches thick. They shall be poured upon ⅜ inch ribbed metal lath weighing not less 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 joist.

History: 1–2–56; r. and recr., Register, September, 1959, No. 45, eff. 10–1–59; am. Register, December, 1962, No. 84, eff. 1–1–63; renum. from Ind 53.25 to be Ind 53.17, Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.18 History: 1–2–56; r. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.18 Wrought iron. (1) The requirements for design, fabrication and erection of steel for buildings and structures under Wis. Adm. Code section Ind 53.16 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 fibers 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.

History: 1–2–56; renum. from Ind 53.26 to be Ind 53.18, Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.19 History: 1–2–56; am. Register, December, 1962, No. 84, eff. 1–1–63; r. Register, October, 1967, No. 142., eff. 11–1–67.

Ind 53.19 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 fiber 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.

History: 1–2–56; renum. from Ind 53.27 to be Ind 53.19, Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.20 History: 1–2–56; r. and recr. Register, August, 1957, No. 20, eff. 9–1–57; r. Register, October, 1967, No. 142, eff. 11–1–67.

Ind 53.20 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				Modulus of Elasticity
				Tension and Extreme Fiber in Bending	Maximum Horizontal Shear	Compression Perpendicular to Grain	Compression Parallel to Grain	
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	

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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	
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		1,400	1,500,000
	1900 # f Grade	J & P–B&S		1,700	130	550	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	

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	
PINE, NORWAY	Prime Structural	J & P	Northern Hemlock & Hardwood Manufacturers Assn.	1,110	65	----------	800	1,200,000
	Common Structural	J & P		1,000	65	325	700	
	Utility Structural	J & P		850	65	----------	575	
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	

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	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	
	Industrial 50 KD	1″, 1¼″ & 1½″ thick	Southern Pine	1,350	110	350	1,000	
	Industrial 86	1″, 1¼″ & 1½″ thick	Inspection Bureau	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 ⅛ of the joist depth. Notching the top or bottom edge of joists will not be permitted in the middle half of the length of any joist.

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

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

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

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

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

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

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

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

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

(7) FLOORS SUPPORTED ON MASONRY WALLS. Every girder and beam which enters, or rests on, a masonry wall shall have a bearing of at least 4 inches thereon.

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

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

(c) Anchors for each tier of joists more than 5 feet above grade shall be provided where they enter masonry walls, and also where they are parallel to masonry walls. Such anchors shall be $\frac{1}{8}$ inch by 1¼ inch iron, or equal, not less than 20 inches long, fitted with a ⅜ inch by 6 inch pin at the wall end, and shall be spaced not more than 6 feet apart. The pin shall be placed horizontally in the wall and 4 inches from the opposite face of such wall. Such anchors shall in all cases occur on the opposite ends of the same run of joists, and where the length of joists is less than the distance across a building, the end of joists shall be lapped and spiked so as to form a continuous tie across the building. Anchors shall be placed across the top of joists that run parallel to the wall, and shall be fastened to the ends of joists below the neutral axis.

(8) WOOD TRUSSES AND BUILT-UP MEMBERS. Wood trusses and similar framing shall have all joints accurately cut and fitted together so that each bearing is true and drawn tightly to full bearing.

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

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

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

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

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

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

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

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

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

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

(10) STRUCTURAL GLUED LAMINATED LUMBER.

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

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

ALLOWABLE UNIT STRESSES FOR STRUCTURAL GLUED LAMINATED LUMBER

Species and Combinations of Lumber Grades			Allowable Unit Stresses in Pounds Per Square Inch							
Outer Laminations		Inner Laminations	Extreme Fibre in Bending "f"		Tension Parallel to Grain "t"		Compression Parallel to Grain "c"		Horizontal Shear "H"	Compression perpendicular to Grain "c"
			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; r. and recr. (9), Register, September, 1959, No. 45, eff. 10-1-59; renum. from Ind 53.28 to be Ind 53.20, Register, October, 1967, No. 142, eff. 11-1-67.