U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

AMERICAN STANDARD BUILDING CODE REQUIREMENTS FOR MINIMUM DESIGN LOADS IN BUILDINGS AND OTHER STRUCTURES

MISCELLANEOUS PUBLICATION M179

U. S. DEPARTMENT OF COMMERCE
HENRY A. WALLACE, Secretary

NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

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By

Sectional Committee on Building Code Requirements for Minimum Design Loads in Buildings—A58

Under the Sponsorship of the
National Bureau of Standards

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FOREWORD

In the design of buildings it is necessary to use certain assumptions regarding the weight of the materials used and of the building contents, as well as the external forces to which the structure may be subjected. Building codes set minimum values that are to be assumed under given conditions. In this standard a committee chosen for its special knowledge of the subject has recorded its recommendations on assumptions as to dead, live, wind, and earthquake loads.

The standard is one of a series presenting recommended building code requirements that are being developed by technical committees under the procedure of the American Standards Association. The general building code program is under the supervision of the Building Code Correlating Committee of the Association.

The objectives of the program and information concerning the several technical committees and the Building Code Correlating Committee are given in an announcement, *Building Code Standardization*, which may be obtained from the American Standards Association.

LYMAN J. BRIGGS, *Director*

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The personnel of the Sectional Committee on Building Code Requirements for Minimum Design Loads in Buildings—A58, which developed the standard, is as follows:

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By

Sectional Committee on Building Code Requirements for Minimum Design Loads in Buildings—A58

Under the Sponsorship of the National Bureau of Standards

ABSTRACT

Building Code Requirements for Minimum Design Loads in Buildings and Other Structures (ASA—A58.1–1945) gives assumptions for dead, live, wind, and earthquake loads suitable for inclusion in building codes. This document, prepared by American Standards Association Sectional Committee A58 under the sponsorship of the National Bureau of Standards, is one of a series of building code standards prepared by various committees under the jurisdiction of the Building Code Correlating Committee of the American Standards Association. The basis of the requirements is discussed in an appendix, which also gives supplementary information useful to those engaged in preparing and administering local building codes.

SECTION 1. GENERAL

1–1. Scope.—These requirements are intended to govern assumptions for dead, live, and other loads in the design of buildings and other structures which are subject to building code requirements.

1–2. Definitions.

Building official means the officer or other person charged with the administration and enforcement of the building code, or his duly authorized representative.

Dead load means the weight of all permanent construction and equipment, including walls, framing, floors, roofs, permanent partitions, and stairways, of a building or other structure.

Live load means the load imposed by the occupancy.

Note.—The live load does not include the wind load or earthquake load.

1–3. Safe Support Required.—Buildings or other structures, and all parts thereof, shall be designed and constructed to support safely all loads, including dead loads, without exceeding the allowable stresses prescribed for the materials of construction in the structural members.

1–4. Additions to Existing Structures.—When an existing building or other structure is enlarged or otherwise altered, all portions thereof affected by such enlargement or alteration shall be strengthened, if necessary, so that all loads will be supported safely without exceeding the allowable stresses prescribed for the materials of construction in the structural members.

SECTION 2. DEAD LOADS

2–1. Weights of Materials and Constructions.—In estimating dead loads for purposes of design, the actual weights of materials and constructions shall be used, provided that in the absence of definite information values satisfactory to the building official may be assumed.

NOTE.—For information on dead loads, see appendix, table 1.

2–2. Weight of Building Equipment.—In estimating dead loads for purposes of design, the weight of plumbing stacks and risers, electric feeders, and ventilating and air-conditioning systems shall be included whenever any of these are carried by structural members.

SECTION 3. LIVE LOADS

3–1. Uniformly Distributed Floor Loads.

(a) The live loads assumed for purposes of design shall be the greatest loads that probably will be produced by the intended occupancies or uses, provided that the live loads to be considered as uniformly distributed shall be not less than the values given in the following table:

OCCUPANCY OR USE	LIVE LOAD *lb/ft²*
Apartment houses:	
Private apartments	40
Public stairways	100
Assembly halls:	
Fixed seats	60
Movable seats	100
Corridors, upper floors	100
Corridors:	
First floor	100
Other floors, same as occupancy served except as indicated.	
Courtrooms	80
Dance halls	100
Dining rooms, public	100
Dwellings	40
Hospitals and asylums:	
Operating rooms	60
Private rooms	40
Wards	40
Public space	80
Hotels:	
Guest rooms	40
Corridors serving public rooms	100
Public rooms	100
Loft buildings	125
Manufacturing, light	125
Office buildings:	
Offices	80
Lobbies	100
Schools:	
Classrooms	40
Corridors	100
Stores	125
Theaters:	
Aisles, corridors, and lobbies	100
Orchestra floor	60
Balconies	60
Stage floor	150

(b) When occupancies or uses not listed above are involved, the live load shall be determined in a manner satisfactory to the building official.

NOTE.—For information on live loads, see appendix, table 2.

3–2. Provision for Partitions.—In office buildings or other buildings where partitions might be subject to erection or rearrangement, provision for partition weight shall be made, whether or not partitions are shown on the plans, unless the specified live load exceeds 80 pounds per square foot.

3–3. Concentrated Loads.—In the design of floors, consideration shall be given to the effects of known or probable concentrations of load to which they may be subjected. Floors shall be designed to carry the specified distributed loads, or the following minimum concentrations, whichever may produce the greater stresses. The indicated concentrations shall be assumed to occupy areas 2½ feet square and to be so placed as to produce maximum stresses in the affected members.

Office floors, including corridors	2,000 lb.
Garages	Maximum wheel load.
Trucking space within building	Maximum wheel load.

3–4. Partial Loading.—When the construction is such that the structural elements thereof act together in the nature of an elastic frame due to their continuity and the rigidity of the connections, and the live load exceeds 150 pounds per square foot or twice the dead load, the effect of partial live load such as will produce maximum stress in any member shall be provided for in the design.

3–5. Impact Loads.—The live loads specified in Section 3–1 (a) may be assumed to include a sufficient allowance to cover the effects of ordinary impact. For special occupancies and loads involving unusual impacts, such as those resulting from moving machinery, elevators, craneways, vehicles, etc., provision shall be made by a suitable increase in the assumed live load.

3–6. Reduction of Live Load.

(a) No reduction shall be applied to the roof live load.

(b) For live loads of 100 pounds or less per square foot, the design live load on any member supporting 150 square feet or more may be reduced at the rate of 0.08 percent per square foot of area supported by the member, except that no reduction shall be made for areas to be occupied as places of public assembly. The reduction shall exceed neither R as determined by the following formula nor 60 percent:

$$R=100\times\frac{D+L}{4.33L},$$

in which

R=reduction in percent
D=dead load per square foot of area supported by the member
L=design live load per square foot of area supported by the member.

For live loads exceeding 100 pounds per square foot, no reduction shall be made, except that the design live loads on columns may be reduced 20 percent.

3–7. Restrictions on Loading.—It shall be unlawful to place, or cause or permit to be placed, on any floor or roof of a building or other structure a load greater than that for which such floor or roof is designed.

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3–8. Posting of Live Loads.—In every building or other structure, or part thereof, used for mercantile, business, industrial, or storage purposes, the loads approved by the building official shall be marked on plates of approved design which shall be supplied and securely affixed by the owner of the building, or his duly authorized agent, in a conspicuous place in each space to which they relate. Such plates shall not be removed or defaced but, if lost, removed, or defaced, shall be replaced by the owner or his agent.

3–9. Roof Loads (including snow loads).

(a) Ordinary roofs, either flat or pitched, shall be designed for a load of not less than 20 pounds per square foot of horizontal projection in addition to the dead load, and in addition to either the wind or earthquake load, whichever produces the greater stresses.

NOTE.—The figure of 20 pounds per square foot is a minimum. In preparing local codes, the map shown in figure 1 in the appendix should be consulted and the indicated snow load for the locality, if larger, substituted for this minimum.

(b) Roofs to be used for promenades shall be designed for a minimum load of 60 pounds per square foot in addition to the dead load. Roofs to be used for other special purposes shall be designed for appropriate loads as directed or approved by the building official.

3–10. Other Live Loads.

(a) Stair treads shall be designed to support a uniformly distributed load of 100 pounds per square foot, or concentrated loads of 300 pounds spaced 3 feet center to center each occupying an area 1 foot wide by the depth of the tread, whichever will produce the greater stresses.

(b) Sidewalks shall be designed to support either a uniformly distributed load of 250 pounds per square foot, or a concentrated load of 8,000 pounds on an area 2½ feet square placed in any position, whichever will produce the greater stresses.

(c) Driveways shall be designed to support a uniformly distributed load of 100 pounds per square foot for vehicles weighing less than 3 tons with load, 150 pounds per square foot for vehicles weighing 3 to 10 tons with load, 200 pounds per square foot for vehicles weighing over 10 tons with load, or a concentrated load equal to the maximum expected wheel load on an area 2½ feet square placed in any position, whichever will produce the greater stresses.

(d) Accessible ceilings, scuttles, and ribs of skylights shall be designed to support a concentrated load of 200 pounds occupying an area 2½ feet square, and so placed as to produce maximum stresses in the affected members.

(e) Stairway and balcony railings, both exterior and interior, shall be designed to resist a horizontal thrust of 50 pounds per linear foot applied at the top of the railing.

3–11. Load Tests.—The building official may require a load test of any construction whenever there is reason to question its safety for the intended occupancy or use.

SECTION 4. SOIL AND HYDROSTATIC PRESSURES

4–1. Pressure on Basement Walls.—In the design of basement walls and similar approximately vertical structures below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion, or the whole, of the adjacent soil is below a free-water surface, computations shall be based on the weight of the soil diminished by buoyancy, plus full hydrostatic pressure.

4–2. Uplift on Floors.—In the design of basement floors and similar approximately horizontal construction below grade, the upward pressure of water, if any, shall be taken as the full hydrostatic pressure applied over the entire area. The hydrostatic head shall be measured from the underside of the construction.

SECTION 5. WIND LOADS

5–1. Minimum Design Pressures.—Buildings or other structures shall be designed and constructed to withstand the horizontal pressures shown in the following table, allowing for wind from any direction. The height is to be measured above the average level of the ground adjacent to the building or structure.

Design wind pressures for various height zones of buildings or other structures

Height zone	Wind pressure
ft	*lb/ft²*
Less than 50	20
50 to 99	24
100 to 199	28
200 to 299	30
300 to 399	32
400 to 499	33
500 to 599	34
600 to 799	35
800 to 999	36
1,000 to 1,199	37
1,200 to 1,399	38
1,400 to 1,599	39
1,600 and over	40

NOTE.—The figures given are recommended as minimum. In preparing local codes, figure 2 and the accompanying discussion in the appendix should be consulted and larger figures substituted if necessary. These requirements do not provide for tornadoes. They are based on a design wind velocity of 75 miles per hour corresponding roughly to a 5-minute average of 50 miles per hour (indicated 63 by a 4-cup anemometer) at 30 feet from the ground.

5–2. Exterior Walls.—Every exterior wall shall be designed and constructed to withstand the pressures specified in Section 5–1, Minimum Design Pressures, acting either inward or outward.

5–3. Roofs.

(a) The roofs of all buildings or other structures shall be designed and constructed to withstand pressures, acting outward normal to the surface, equal to 1¼ times those specified for the corresponding height zone in which the roof is located. The height is to be taken as the mean height of the roof structure above the average level of the ground adjacent to the building or other structure, and the pressure assumed on the entire roof area.

(b) Roofs or sections of roofs with slopes greater than 30° shall be designed and constructed to withstand pressures, acting inward normal to the surface, equal to those specified for the height zone in which the roof is located, and applied to the windward slope only.

(c) Overhanging eaves and cornices shall be designed and constructed to withstand outward pressures equal to twice those specified in Section 5–1, Minimum Design Pressures.

(d) Adequate anchorage of the roof to walls and columns, and of walls and columns to the foundations to resist overturning, uplift, and sliding, shall be provided in all cases.

5–4. Chimneys.—Chimneys, tanks, and towers shall be designed and constructed to withstand the pressures specified in Section 5–1, Minimum Design Pressures, multiplied by the following factors, depending on shape:

Square or rectangular	1.00
Hexagonal or octagonal	0.80
Round or elliptical	0.60

5–5. Signs.

(a) Signs in which the projected area exposed to wind consists of 70 percent or more of the gross area as determined by the over-all dimensions shall be classed as solid signs; those in which the projected exposed area is derived from open letters, figures, strips, and structural framing members, the aggregate total area of which is less than 70 percent of the gross area so determined, shall be classed as open signs.

(b) All signs shall be designed and constructed to withstand the horizontal pressures shown in the following table applied to the projected exposed area, allowing for wind from any direction:

Design wind pressures

Height from ground to top of sign	Wind pressure	
	Solid signs (all types)	Open signs (all types)
ft	*lb/ft²*	*lb/ft²*
Less than 50	[a] 25	[b] 35
50 to 99	30	42
100 to 199	35	49
200 to 299	38	53
300 to 399	40	56
400 to 499	42	58
500 to 599	43	60
600 to 799	44	61
800 to 999	45	63
1,000 to 1,199	46	65
1,200 to 1,399	48	67
1,400 to 1,599	49	68
1,600 and over	50	70

[a] Solid ground signs less than 50 ft in height shall be designed and constructed to withstand a wind pressure of not less than 15 lb/ft².

[b] Open ground signs less than 50 ft in height shall be designed and constructed to withstand a wind pressure of not less than 25 lb/ft².

Note.—Complete requirements for signs are being developed by Sectional Committee on Building Code Requirements for Signs and Outdoor Display Structures—A60.

5–6. Other Structures.—The building official may require evidence to support the values for wind pressure used in the design of structures not specifically covered in this section.

5–7. Shielding and Unusual Exposures.

(a) No allowance shall be made for the shielding effect of other buildings or structures.

(b) If the building or other structure is on a mountain, ocean promontory, or in any other location considered by the building official to be unusually exposed, higher wind pressures may be prescribed by the building official.

5–8. Combined Stresses.—For combined stresses due to wind, dead, live, and snow loads, the allowable stress may be increased 33⅓ percent provided the section thus found is at least as strong as that required for dead, live, and snow loads alone.

5–9. Overturning and Sliding.

(a) The overturning moment due to the wind load shall not exceed 66⅔ percent of the moment of stability of the building or other structure due to the dead load only, unless the building or other structure is anchored so as to resist the excess overturning moment without exceeding the allowable stresses for the materials used. The axis of rotation for computing the overturning moment and the moment of stability shall be taken as the intersection of the outside wall line on the leeward side and the plane representing the average elevation of the bottoms of the footings. The weight of earth superimposed over footings may be used in computing the moment of stability due to dead load.

(b) When the total resisting force due to friction is insufficient to prevent sliding, the building or other structure shall be anchored to withstand the excess sliding force without exceeding the allowable stresses for the materials used. Anchors provided to resist overturning moment may also be considered as providing resistance to sliding.

5–10. Stresses During Erection.—Provision shall be made for wind stress during erection of the building or other structure.

SECTION 6. EARTHQUAKE LOADS—GENERAL

6–1. Minimum Lateral Load.—Every building or other structure, except a farm building or like structure, shall be designed and constructed to withstand a static lateral load from any horizontal direction at least equal to 5 percent of the dead load.

6–2. Combined Stresses.—For combined stresses due to the lateral load specified in Section 6–1 together with dead, live, and snow loads, the allowable stresses may be increased 50 percent provided the section thus found is at least as strong as that required for dead, live, and snow loads alone. The section thus found shall also be compared with that found for the combination of wind, dead, live, and snow loads, and that section used which provides the greater strength.

6–3. Horizontal Torsional Moments.—The vertical structural units of a building or other structure that resist lateral load shall be so arranged that, in any horizontal plane, their center of rigidity will be coincident with the center of gravity of the dead loads of the building or other structure, or proper provision shall be made for any resulting torsional moment in the building or other structure.

6–4. Distribution of Horizontal Shear.—The total shear at any level due to the lateral load shall be assumed to be distributed to the vertical resisting units at that level in proportion to their rigidities, except as the deformation of horizontal distributing elements may modify the distribution.

6–5. Special Requirements.—Every parapet wall shall be designed and constructed to withstand a normal lateral force of 50 percent of its weight. Every tank tower, tank, and masonry chimney shall be designed and constructed to withstand a lateral force from any direction equal to 10 percent of its dead and vertical live loads.

SECTION 7. EARTHQUAKE LOADS—MAJOR EARTHQUAKES

NOTE.—It is recommended that these provisions be included in building ordinances in those communities that have experienced earthquakes of major or near-major intensity, say of intensity of VII or over in the Rossi-Forel scale.

7–1. Minimum Lateral Load.

(a) Every building or other structure shall be designed and constructed to withstand a minimum static lateral load, acting from any horizontal direction, as given by the formula

$$F=CW$$

in which

F=Horizontal lateral load in pounds
C=A numerical coefficient as given hereafter
W=The total dead load in pounds at and above the plane or elevation under consideration, except that for buildings used for storage W shall equal the total dead load plus 50 percent of the live load.

(b) The coefficient C shall have the following values (F being assumed to act from any direction), provided that for buildings not over 100 feet in height in which the ratio of height to least horizontal dimension is not over 1.5, C shall be taken as 0.10 for each story.

Values of C for parts of buildings or other structures

Part	Value of C	Direction of force
Bearing wall	0.20	Normal to surface of wall.
Division wall	.20	
Filler wall	.20	
Curtain wall	.20	
Fire wall	1.00	Normal to surface of wall.
Parapet wall	1.00	
Cantilever wall	1.00	
Exterior ornamentation	1.00	From every horizontal direction.
Exterior appendage	1.00	
Penthouse	.20	From every horizontal direction.
Tank tower	.20	
Tank plus contents	.20	From every horizontal direction.
Masonry pier	.20	
Masonry chimney	.20	
Smokestack	.20	
Marquises	.20	

7–2. Resistance of Skeleton Frame.—In every building having a skeleton frame, such frame shall be designed and constructed to withstand not less than 20 percent of the force specified for the building itself, without assistance from any walls or floors. By skeleton frame is meant a framework consisting of columns, girders, beams, and similar members supporting and transmitting all loads to the foundations.

7–3. Combined Stresses.—For combined stresses due to the lateral load specified in Section 7–1, Minimum Lateral Load, in combination with dead, live, and snow loads, the allowable stresses may be increased 50 percent provided the section thus found is at least as strong as that required for dead, live, and snow loads alone. The section thus found shall also be compared with that found for the combination of wind, dead, live, and snow loads, and that section used which provides the greater strength.

For members with stresses due only to the lateral load specified in Section 7–1, Minimum Lateral Load, the allowable stresses for the materials used may be increased not more than 66⅔ percent.

7–4. Horizontal Torsional Moments.—Those vertical structural units of the building or other structure which resist the horizontal force shall be so arranged that in any horizontal plane the center of rigidity of such resisting structural units will be coincident with the center of gravity of the vertical loads of the building or other structure, or else proper provision shall be made for the resulting torsional moment in the building or other structure.

7–5. Distribution of Horizontal Shear.—The total horizontal shear at any level shall be assumed to be distributed to the various resisting units at that level in proportion to their rigidities, except as the deformation of the horizontal distributing elements may modify the distribution.

7–6. Connections.—Such connections of members as resist the moments and shears of the specified horizontal force shall also be made capable of resisting moments and shears due to vertical loads in proportion to their relative stiffness.

7–7. Utilization of Permanent Structural Elements.—Reinforced-concrete or masonry walls and all other permanent structural elements capable of providing resistance shall be assumed to act integrally with the structural frames in resisting the shears and moments due to the specified horizontal force, unless specifically designed and constructed to act independently.

APPENDIX

This Appendix consists of explanatory and supplementary material designed to assist local building code committees and building officials in applying the recommended code requirements. It is not a part of American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures—A58.1; but is provided as background material for users of the standard. In some cases it will be necessary to adjust specific values in the standard to local conditions; in others, a considerable amount of detailed information is needed to put the general provisions into effect. This Appendix provides a place for supplying material that can be used in these situations and also is intended to create a better understanding of the recommended requirements through brief explanations of the reasoning employed in arriving at them.

The subdivisions of the Appendix are numbered to correspond with the section numbers in the Code requirements. Since it is not necessary to have Appendix matter for every section in the Code, there are gaps in the numbering in the Appendix.

General.—Since 1924, when a report of the Department of Commerce Building Code Committee entitled "Minimum Live Loads Allowable for Use in Design of Buildings" was published by the National Bureau of Standards, the recommendations contained in that document have been widely used in revision of local building codes and have been quoted in many textbooks. The recommendations made at that time were based on a study of data obtained from many sources and represented the considered judgment of experienced architects and engineers.

At the present time, a continuation of development of building code recommendations is being carried on by various sectional committees operating under the procedure of the American Standards Association, with the Building Code Correlating Committee providing the necessary guidance and correlation. The Sectional Committee on Building Code Requirements for Minimum Design Loads in Buildings—A58 is one of these sectional committees. It has considered the work of the previous committee which brought out the 1924 report and has taken into account facts developed in later investigations so as to provide requirements suitable for use under present conditions. It has also endeavored to cover a wider field than in the earlier report, and has provided information on the various kinds of loads to which structures may be subjected. Loads have been construed to include weight of materials and equipment, weight of occupants and of movable contents, wind pressures, and earthquake forces. Some of these loads will be the same regardless of the location of the structure and others will vary with local conditions. Information is provided to make it possible to deal with the whole range of circumstances that may have to be taken into account.

2–1. Weights of Materials and Constructions.—Values for weights of different materials and constructions are based on a schedule prepared in the Office of the Supervising Architect, Public Buildings Administration, Federal Works Agency. They have been reviewed by the National Bureau of Standards and by a number of other agencies with respect to particular items on which the agency had information.

To establish uniform practice among designers it is desirable to present a list of materials generally used in building construction together with their proper weights. Many building codes prescribe the minimum weights for only a few building materials and in other instances no guide whatsoever is furnished on this subject. In some cases the codes are so drawn up as to leave the question of what weights to use to the discretion of the building official without providing him with any authoritative guide. This practice, as well as the use of incomplete lists, has been subjected to much criticism. The solution chosen has been to present an extended list in this Appendix which will be useful to the designer and official alike. However, special cases will unavoidably arise, and so authority is granted to the building official to deal with these.

For ease of computation, most values are given in terms of weight per square foot of given thickness. Cubic-foot values consistent with the square-foot values are also presented in somes cases.

TABLE 1.—*Minimum design dead loads* [a]

WALLS	lb/ft^2
4-inch clay brick, high absorption	34
4-inch clay brick, medium absorption	39
4-inch clay brick, low absorption	46
4-inch sand-lime brick	38
4-inch concrete brick, heavy aggregate	46
4-inch concrete brick, light aggregate	33
8-inch clay brick, high absorption	69
8-inch clay brick, medium absorption	79
8-inch clay brick, low absorption	89
8-inch sand-lime brick	74
8-inch concrete brick, heavy aggregate	89
8-inch concrete brick, light aggregate	68
12½-inch clay brick, high absorption	100
12½-inch clay brick, medium absorption	115
12½-inch clay brick, low absorption	130
12½-inch sand-lime brick	105
12½-inch concrete brick, heavy aggregate	130
12½-inch concrete brick, light aggregate	98
17-inch clay brick, high absorption	134
17-inch clay brick, medium absorption	155
17-inch clay brick, low absorption	173
17-inch sand-lime brick	138
17-inch concrete brick, heavy aggregate	174
17-inch concrete brick, light aggregate	130
22-inch clay brick, high absorption	168
22-inch clay brick, medium absorption	194
22-inch clay brick, low absorption	216
22-inch sand-lime brick	173
22-inch concrete brick, heavy aggregate	216
22-inch concrete brick, light aggregate	160
4-inch brick, 4-inch load-bearing structural clay tile backing	60
4-inch brick, 8-inch load-bearing structural clay tile backing	75
9-inch brick, 4-inch load-bearing structural clay tile backing	102
8-inch load-bearing structural clay tile	42
12-inch load-bearing structural clay tile	58
8-inch concrete block, heavy aggregate	55
12-inch concrete block, heavy aggregate	85
8-inch concrete block, light aggregate	35
12-inch concrete block, light aggregate	55
2-inch furring tile, one side of masonry wall, add to above figures	12

[a] Weights of masonry include mortar but not plaster. For plaster, add 5 lb/ft^2 for each face plastered. Values given represent averages. In some cases there is a considerable range of weight for the same construction. For such ranges, see pages 16 and 17.

TABLE 1.—*Minimum design dead loads*[a]—Continued

	lb/ft²
PARTITIONS	
3-inch clay tile	17
4-inch clay tile	18
6-inch clay tile	28
8-inch clay tile	34
10-inch clay tile	40
2-inch gypsum block	9½
3-inch gypsum block	10½
4-inch gypsum block	12½
5-inch gypsum block	14
6-inch gypsum block	18½
2-inch solid plaster	20
4-inch solid plaster	32
4-inch hollow plaster	22
4-inch concrete block, heavy aggregate	30
6-inch concrete block, heavy aggregate	42
8-inch concrete block, heavy aggregate	55
12-inch concrete block, heavy aggregate	85
4-inch concrete block, light aggregate	20
6-inch concrete block, light aggregate	28
8-inch concrete block, light aggregate	38
12-inch concrete block, light aggregate	55
Wood studs 2×4, unplastered	4
Wood studs 2×4, plastered one side	12
Wood studs 2×4, plastered two sides	20
GLASS-BLOCK MASONRY	
4-inch glass-block walls and partitions	18
SPLIT FURRING TILE	
1½-inch	8
2-inch	8½
CONCRETE SLABS	
Concrete, reinforced-stone, per inch	12½
Concrete, reinforced-cinder, per inch	9¼
Concrete, reinforced, lightweight, per inch	9
Concrete, plain stone, per inch	12
Concrete, plain cinder, per inch	9
Concrete, plain, lightweight, per inch	8½

[a] See footnote on page 11.

TABLE 1.—*Minimum design dead loads* [a]—Continued

RIBBED SLABS

Depth *in.*	Width of rib, in inches					
	4	5	6	7	8	Add for tapered ends
12-inch clay-tile fillers:	lb/ft^2	lb/ft^2	lb/ft^2	lb/ft^2	lb/ft^2	
4 plus 2	49	51	52	54	------	
6 plus 2	60	63	65	67	------	
8 plus 2½	79	82	85	87	------	
10 plus 3	96	100	103	106	------	
12 plus 3	108	112	116	120	------	
20-inch metal fillers:						lb/ft^2
6 plus 2	41	43	45	47	------	4
8 plus 2½	51	54	57	60	------	5
10 plus 3	63	67	70	74	------	5
12 plus 3	69	74	78	82	86	5
14 plus 3	75	81	86	90	95	5
30-inch metal fillers:						
6 plus 2½	41	43	45	47	------	3
8 plus 2½	45	48	50	52	------	4
10 plus 3	56	59	61	63	------	4
12 plus 3	------	63	67	70	73	4
14 plus 3	------	69	72	76	80	4
2-way clay-tile fillers (12×12):						
4 plus 2	61	62	64	------	------	
6 plus 2	87	89	90	------	------	
8 plus 2½	100	103	107	------	------	
10 plus 3	121	126	131	------	------	
12 plus 3	136	141	146	------	------	
2-way metal fillers (16×16):						
4 plus 2	44	47	50	------	------	
6 plus 2	55	60	63	------	------	
8 plus 2½	72	78	83	------	------	
10 plus 3	91	96	103	------	------	
12 plus 3	103	111	118	------	------	
14 plus 3	116	125	133	------	------	
2-way metal fillers (20×20):						
4 plus 2	42	44	46	------	------	
6 plus 2	50	54	58	------	------	
8 plus 2½	66	71	76	------	------	
10 plus 3	83	88	94	------	------	
12 plus 3	93	100	107	------	------	
14 plus 3	105	113	120	------	------	

[a] See footnote on page 11.

TABLE 1.—*Minimum design dead loads* [a]—Continued

FLOOR FINISH AND FILL

	Finish floor to top slab, in.	lb/ft²
Double ⅞ wood on sleepers, light-concrete fill	4	19
Do	5	26
Double ⅞ wood on sleepers, stone-concrete fill	4	28
Do	5	40
Single ⅞ wood on sleepers, light-concrete fill	4	23
Do	5	30
Single ⅞ wood on sleepers, stone-concrete fill	4	38
Do	5	50
3-inch wood block on mastic, no fill	3	10
⅞-inch wood block on stone-concrete fill	4	40
1-inch cement fin. on stone-concrete fill	4	48
1-inch terrazzo on stone-concrete fill	4	48
Clay tile on stone-concrete fill	4	48
Marble and mortar on stone-concrete fill	4	50
Linoleum on stone-concrete fill	4	46
Do	5	58
Linoleum on light-concrete fill	4	27
Do	5	34

FLOOR FINISH

	Thickness, in.	lb/ft²
1½-inch asphalt mastic flooring	1½	18
3-inch wood block on ½-inch mortar base	3½	16
Solid flat tile on 1-inch mortar base	2	23
2-inch asphalt block, ½-inch mortar	2½	30
1-inch terrazzo, 2-inch stone concrete	3	38

WATERPROOFING

Five-ply membrane	½	5
Five-ply membrane, mortar, stone concrete	5	55
2-inch split tile, 3-inch stone concrete	5	45

FLOOR FILL

Cinder concrete, per inch	------	9
Lightweight concrete, per inch	------	7
Sand, per inch	------	8
Stone concrete, per inch	------	12

WOOD-JOIST FLOORS (NO PLASTER) DOUBLE WOOD FLOOR

	12-inch spacing	16-inch spacing
Joist sizes, in inches:	*lb/ft²*	*lb/ft²*
2 x 6	6	5
2 x 8	6	6
2 x 10	7	6
2 x 12	8	7
3 x 6	7	6
3 x 8	8	7
3 x 10	9	8
3 x 12	11	9
3 x 14	12	10

[a] See footnote on page 11.

TABLE 1.—*Minimum design dead loads* [a]—Continued

CEILINGS	*lb/ft²*
Plaster on tile or concrete	5
Suspended metal lath and gypsum plaster	10
Suspended metal lath and cement plaster	15
Plaster on wooden lath	8
ROOF COVERINGS	
Asbestos shingles	4
Asphalt shingles	6
Copper or tin	1
Corrugated iron	2
Clay tile (for mortar add 10 lb):	
2-inch book tile	12
3-inch book tile	20
Roman	12
Spanish	19
Ludowici	10
Cement tile	16
Composition:	
Three-ply ready roofing	1
Four-ply felt and gravel	5½
Five-ply felt and gravel	6
Sheathing, per inch thickness	3
Slate, 3/16-inch	7
Slate, ¼-inch	10
Skylight, metal frame, ⅜-inch wire glass	8
Wood shingles	3
MATERIALS	*lb/ft³*
Cast-stone masonry (cement, stone, sand)	144
Cinder fill	57
Concrete, plain:	
Stone (including gravel)	144
Slag	132
Cinder	108
Haydite (burned-clay aggregate)	90
Expanded-slag aggregate	100
Concrete, reinforced:	
Stone (including gravel)	150
Slag	138
Cinder	111
Masonry, brick:	
Hard (low absorption)	130
Medium (medium absorption)	115
Soft (high absorption)	100
Masonry, ashlar:	
Granite	165
Limestone, crystalline	165
Limestone, oolitic	135
Marble	173
Sandstone	144
Masonry, rubble mortar:	
Granite	153
Limestone, crystalline	147
Limestone, oolitic	138
Marble	156
Sandstone	137
Terra cotta, architectural:	
Voids filled	120
Voids unfilled	72
Timber, seasoned:	
Ash, commercial white	41
Cypress, southern	32
Fir, Douglas, coast region	34
Oak, commercial reds and whites	45
Pine, southern yellow	39
Redwood	28
Spruce, red, white, and Sitka	28

[a] See footnote on page 11.

Range in Weights.—Some constructions for which a single figure is given actually have a considerable range in weight. The average figure given is suitable for general use; but when there is reason to suspect a considerable deviation from this, the actual weight should be determined.

Examples of the range in weight that have been found for some constructions follow. It will be noted that there is a difference of over 25 percent in some cases.

Range in weight of masonry construction

Construction	Unplastered	One side plastered	Both sides plastered
WALLS			
	lb/ft²	*lb/ft²*	*lb/ft²*
4-inch clay brick, high absorption	33 to 35	38 to 40	43 to 45
4-inch clay brick, medium absorption	38 to 40	43 to 45	48 to 50
4-inch clay brick, low absorption	45 to 47	50 to 52	55 to 57
4-inch sand-lime brick	35 to 40	40 to 45	45 to 50
4-inch concrete brick, heavy aggregate	45 to 47	50 to 52	55 to 57
4-inch concrete brick, light aggregate	30 to 35	35 to 40	40 to 45
8-inch clay brick, high absorption	64 to 73	69 to 78	74 to 83
8-inch clay brick, medium absorption	74 to 83	79 to 88	84 to 93
8-inch clay brick, low absorption	84 to 93	89 to 98	94 to 103
8-inch sand-lime brick	67 to 80	72 to 85	77 to 90
8-inch concrete brick, heavy aggregate	84 to 93	89 to 98	94 to 103
8-inch concrete brick, light aggregate	60 to 75	65 to 80	70 to 85
12½-inch clay brick, high absorption	90 to 110	95 to 115	------------
12½-inch clay brick, medium absorption	105 to 125	110 to 130	------------
12½-inch clay brick, low absorption	120 to 140	125 to 145	------------
12½-inch sand-lime brick	95 to 115	100 to 120	------------
12½-inch concrete brick, heavy aggregate	120 to 140	125 to 145	------------
12½-inch concrete brick, light aggregate	85 to 110	90 to 115	------------
17-inch clay brick, high absorption	120 to 148	125 to 153	------------
17-inch clay brick, medium absorption	141 to 168	146 to 173	------------
17-inch clay brick, low absorption	159 to 187	164 to 192	------------
17-inch sand-lime brick	125 to 150	130 to 155	------------
17-inch concrete brick, heavy aggregate	160 to 187	165 to 192	------------
17-inch concrete brick, light aggregate	115 to 145	120 to 150	------------
22-inch clay brick, high absorption	150 to 186	155 to 191	------------
22-inch clay brick, medium absorption	177 to 211	182 to 216	------------
22-inch clay brick, low absorption	198 to 234	203 to 239	------------
22-inch sand-lime brick	157 to 188	162 to 193	------------
22-inch concrete brick, heavy aggregate	198 to 234	203 to 239	------------

Range in weight of masonry construction—Continued

Construction	Unplastered	One side plastered	Both sides plastered
WALLS—Continued			
	lb/ft²	*lb/ft²*	*lb/ft²*
22-inch concrete brick, light aggregate	140 to 180	145 to 185	------------
8-inch load-bearing structural clay tile	37 to 46	42 to 51	47 to 56
12-inch load-bearing structural clay tile	50 to 65	55 to 70	60 to 75
8-inch concrete block, heavy aggregate	50 to 60	55 to 65	60 to 70
12-inch concrete block, heavy aggregate	75 to 95	80 to 100	85 to 105
8-inch concrete block, light aggregate	30 to 43	35 to 48	40 to 53
12-inch concrete block, light aggregate	45 to 65	50 to 70	55 to 75
PARTITIONS			
2-inch gypsum block	8 to 11	13 to 16	18 to 21
3-inch gypsum block	8. 5 to 12. 5	13. 5 to 17. 5	18. 5 to 22. 5
4-inch gypsum block	10 to 14. 5	15 to 19. 5	20 to 24. 5
6-inch gypsum block	15 to 22	20 to 27	25 to 32
4-inch concrete block, heavy aggregate	27 to 35	32 to 40	37 to 45
6-inch concrete block, heavy aggregate	38 to 50	43 to 55	48 to 60
8-inch concrete block, heavy aggregate	47 to 60	52 to 65	57 to 70
12-inch concrete block, heavy aggregate	80 to 90	85 to 95	90 to 100
4-inch concrete block, light aggregate	17 to 23	22 to 28	27 to 33
6-inch concrete block, light aggregate	23 to 32	28 to 37	33 to 42
8-inch concrete block, light aggregate	27 to 40	32 to 45	37 to 50
12-inch concrete block, light aggregate	50 to 60	55 to 65	60 to 70
GLASS-BLOCK MASONRY			
4-inch glass-block walls and partitions	17 to 19	------------	------------

3–1 (a) Uniformly Distributed Floor Loads.—A selected list of occupancies and uses more commonly encountered is given in Section 3–1 (a) and the building official is given authority to pass on occupancies not mentioned. Table 2 below is offered as a guide in the exercise of such authority.

TABLE 2.—*Minimum uniformly distributed live loads*

	lb/ft²
Air-conditioning (machine space)	[a] 200
Amphitheater:	
Fixed seats	60
Movable seats	100
Amusement park structure	[a] 100
Armories	150
Attic:	
Nonstorage	25
Storage	[e] 80
Bakery	150
Balcony:	
Exterior	100
Interior (fixed seats)	60
Interior (movable seats)	100
Boathouse, floors	[e] 100
Boiler room, framed	[a] 300
Broadcasting studio	100
Catwalks	25
Ceiling, accessible furred	10
Cold storage:	
No overhead system	[h] 250
Overhead system—	
Floor	150
Roof	250
Dormitories:	
Partitioned	40
Nonpartitioned	80
Drill rooms	125
Driveways (*see* Garages).	
Elevator machine room	[a] 150
Fan room	[a] 150
File room:	
Letter	[e] 80
Card	[e] 125
Addressograph	[e] 150
Fire escape	100
Foundries	[a] 600
Fuel rooms, framed	400
Grandstands (*see* Reviewing stands).	
Garages:	
Cars, with load, less than 3 tons	[f] 100
Trucks, with load, 3 to 10 tons	[f] 150
Trucks, with load, above 10 tons	[f] 200
Greenhouses	150
Gymnasiums	100
Hangars	[f] 150
Incinerator charging floor	100
Kitchens, other than domestic	[a] 150
Laboratories, scientific	100
Laundries	[a] 150

	lb/ft²
Libraries:	
Reading rooms	60
Corridors	[e] 100
Stacks	([b])
Manufacturing:	
Ice	300
Stockroom (*see* Storage).	
Marquise	[g] 60
Morgue	125
Office buildings:	
Files (*see* File room).	
Business machine equipment	[a] 100
Penal institutions:	
Cell blocks	40
Corridors	100
Stairways, public	100
Printing plants:	
Composing rooms	100
Linotype rooms	100
Press rooms	[a] 150
Paper storage	([d])
Public rooms	100
Railroad tracks	([c])
Ramps, driveway (*see* Garages).	
Ramps, pedestrian (*see* Sidewalks in sec. 3–10 (b); also Corridors in sec. 3–1.)	
Ramps, seaplane (*see* Hangars).	
Rest rooms	60
Reviewing stands and grandstands	[i] 100
Rink, ice skating	250
Roof (*see* fig. 1 and sec. 3–9).	
Stairways	100
Storage:	
Light	[e] 125
Heavy	[e] 250
Hay or grain	[e] 300
Telephone exchange	[a] 150
Theaters:	
Dressing rooms	40
Grid-iron floor or fly gallery—	
Grating	60
Well beams, 250 lb/lin. ft per pair.	
Header beams, 1,000 lb/lin. ft.	
Pin rail, 250 lb/lin. ft.	
Projection room	100
Toilet rooms	60
Transformer rooms	[a] 200
Vaults, in offices	[e] 250

[a] Use equipment when greater.
[b] Book stacks 20 lb/ft³.
[c] As required by railroad company.
[d] Paper storage 50 lb/ft of clear story height.
[e] Increase when occupancy exceeds this amount.
[f] Also subject to maximum wheel concentrations.
[g] Minimum uplift of 20 lb/ft² with no downward live load.
[h] Plus 150 lb for trucks.
[i] For detailed recommendations, see American Standard Specifications for Portable Steel and Wood Grandstands, Z20.1–1941, or latest revision thereof.

For purposes of estimating live loads caused by accumulations of various materials, a list of weights is given in table 3. Some of the items may also be useful in connection with estimation of dead loads.

TABLE 3.—*Minimum design loads for materials*

Material	lb/ft³
Bituminous products:	
Asphaltum	81
Graphite	135
Paraffine	56
Petroleum, crude	55
Petroleum, refined	50
Petroleum, benzine	46
Petroleum, gasoline	42
Pitch	69
Tar	75
Brass	526
Bronze	552
Cement, portland, loose	70
Cement, portland, set	125
Cinders, dry, in bulk	45
Coal, anthracite, piled	52
Coal, bituminous, piled	47
Coal, lignite, piled	47
Coal, peat, dry, piled	23
Charcoal	12
Copper	556
Cork, compressed	14.4
Earth (not submerged):	
Clay, dry	63
Clay, damp	110
Clay and gravel, dry	100
Silt, moist, loose	78
Silt, moist, packed	96
Silt, flowing	108
Sand and gravel, dry, loose	100
Sand and gravel, dry, packed	110
Sand and gravel, wet	120
Earth (submerged):	
Clay	80
Soil	70
River mud	90
Earth (submerged)—Continued	
Sand or gravel	60
Sand or gravel, and clay	65
Gold, solid	1,205
Gold bars, stacked	1,133
Gold coin in bags	1,084
Gypsum, loose	65
Ice	57.2
Iron, cast	450
Iron, wrought	480
Lead	710
Lime, hydrated, loose	32
Lime, hydrated, compacted	45
Mortar, hardened:	
Cement	130
Lime	110
Riprap (not submerged):	
Limestone	83
Sandstone	90
Slag, bank	70
Slag, bank screenings	108
Slag, machine	96
Slag, sand	52
Silver, solid	656
Silver bars, stacked	590
Silver coin in bags	590
Slate	172
Steel, cold-drawn	489
Stone, quarried, piled:	
Basalt, granite, gneiss	96
Limestone, marble, quartz	95
Sandstone	82
Shale	92
Greenstone, hornblende	107
Tin	459
Water, fresh	62.4
Water, sea	64
Zinc, rolled, sheet	449

3–6. Reduction of Live Load.—The proposed live-load-reduction formula in Section 3–6 (b) differs from conventional treatment but is believed to offer a more logical approach than is found in most building codes. The provisions are based upon a consideration of data available on distribution of loads in different occupancies, and more particularly a survey made by the Public Buildings Administration covering loads in a number of Federal buildings. The results of this survey are to be published in the Proceedings of the American Society of Civil Engineers.

The system proposed for live-load reduction consists essentially of a basic live load equal to the maximum to be allowed on any panel and a rapid reduction to a minimum load based upon the relation of live and dead loads in such a manner that overstress on any member, due to full basic load throughout the structure, cannot exceed a predetermined value. Moreover, the system should be such that only a very small portion of the structure will be overstressed by the probable actual live loads.

It is proposed that:

1. The basic live load shall be the maximum average live load intended to be allowed on any panel.
2. The basic live load may be reduced for the design of any member at the rate of 0.08 percent per square foot of area supported by the member.
3. The reduction shall exceed neither R percent as determined by the following formula nor 60 percent:

$$R=100\times\frac{D+L}{4.33L},$$

in which

R=reduction, in percent
D=dead load per square foot of area supported by the member
L=design live load per square foot of area supported by the member.

The maximum reduction is such that if a member supports an area large enough to allow the maximum reduction, and if the member is loaded with the full design live load, the overstress will not exceed 30 percent. The formula is derived as follows:

Let

D and L have the values given above
K=proportional reduction
R=% reduction=100K.

Then

$$L+D=1.3[D+(1-K)L]$$
$$L+D=1.3D+1.3L-1.3KL$$
$$1.3KL=0.3D+0.3L$$

$$K=\frac{L+D}{4.33L}$$

$$R=100\times\frac{L+D}{4.33L}.$$

It has been found by comparing the results of this formula with actual load conditions in a number of buildings that only a small portion of the structure would be overstressed.

The proposed system is, of course, based on the assumption, as any such system must be, that excessive overloading will be prevented through posting of allowable loads and adequate inspection. The system when so safeguarded should provide a suitable basis for design of buildings without:

(1) The incorporation of so much unused strength as heretofore;
(2) Significant overstress in members from probable loadings;
(3) Danger of structural failure in the remote contingency of full basic loading on the entire area supported by any member.

Since public-assembly occupancies, such as theaters, must be assumed to be fully occupied under normal conditions, any reduction would be unwarranted. An exception has therefore been made in the case of these occupancies.

In the case of occupancies involving relatively heavy basic live loads, such as storage buildings, several adjacent floor panels may be fully loaded. However, data obtained in actual buildings indicate that rarely is any story loaded with an average actual live load of more than 80 percent of the average rated live load. It appears that the basic live load should be unreduced for the floor-and-beam design but that it could be reduced a flat 20 percent for the design of columns. Accordingly, this principle has been incorporated in the recommended code requirement.

3–9. Roof Loads (including snow loads).—Figure 1 showing isopleths connecting points of equal snow load is based upon a map prepared by the United States Weather Bureau. Values for any particular location not on an isopleth may be found by interpolating along the shortest line through the location between isopleths or between an isopleth and point having different values. The values shown are probably conservative since they are based upon maximum depth of snow on the ground rather than on roofs.

The pressures shown on this map are based upon the maximum undrifted snow depth on the ground as reported by first order Weather Bureau stations during the period from the beginning of record to December 1938, inclusive, and on the assumption that 6.5 inches of snow have the same water content as 1 inch of rain. This assumed density may vary in different localities.

Isopleths have been omitted in the region between the Pacific Coastal Section and Longitude 117° W. due to the irregular distributions associated with rugged terrain.

3–11. Load Tests.—A specific method of test for completed construction has not been given in the requirements, since it may be found advisable to vary the procedure according to conditions. Some codes require the construction to sustain a superimposed load equal to twice the design live load for 24 hours without evidence of damage. Other provide for a superimposed test load equal to one-half of the dead load plus one and one-half times the live load, with the evident intention of increasing the stresses in the affected members by a definite percentage of the allowable stress. Recovery of at least three-quarters of the maximum deflection within 24 hours after the load is removed is a common requirement. Concrete and masonry construction should be at least 60 days old when tested.

5–1. Minimum Design Wind Pressures.—The requirements in Section 5, Wind Loads, are intended for more or less average conditions. There is considerable variation in wind-velocity pressures in different parts of the country, as will be seen by reference to figure 2. This map has been prepared at the National Bureau of Standards, from data obtained from the United States Weather Bureau. Local building code committees should consult this map and also obtain any other available facts on conditions in their own areas. With this information in hand, any necessary adjustments in requirements can be made.

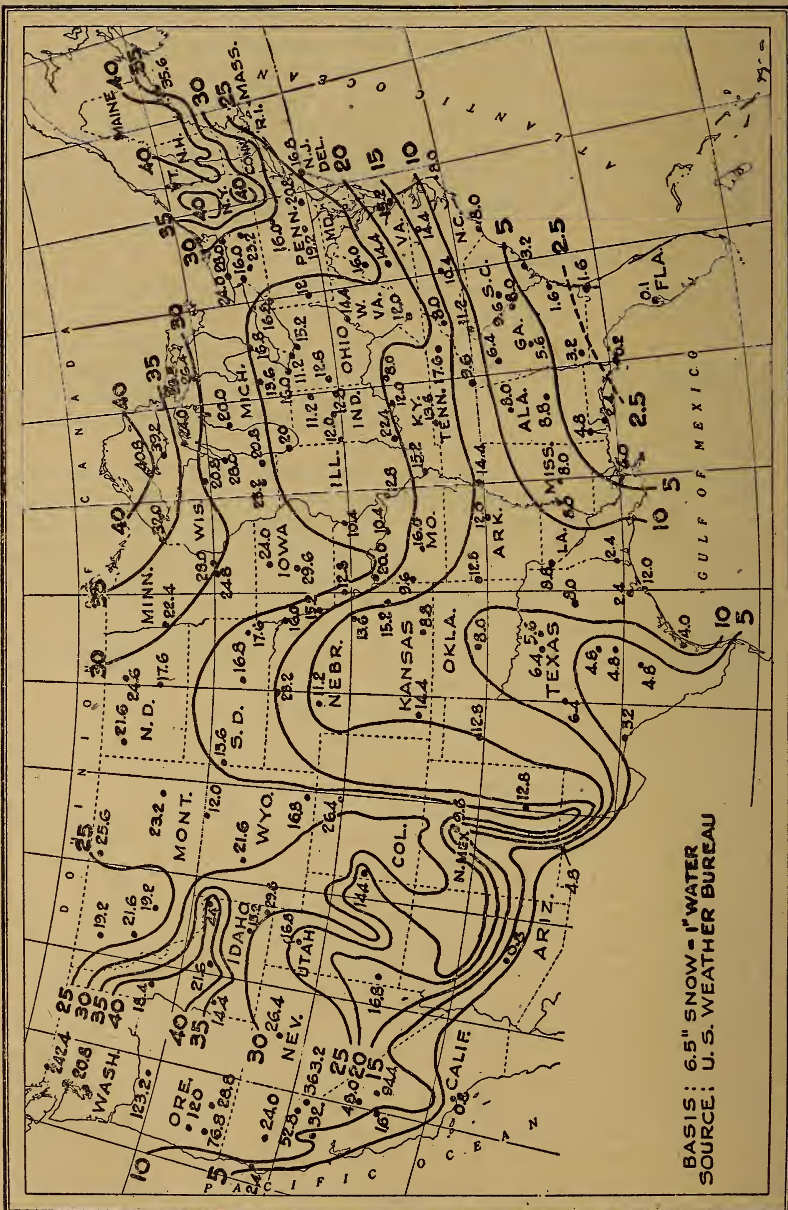

FIGURE 1.—*Snow loads (in pounds per square foot).*

The design wind load, which should not be confused with the velocity pressure shown on figure 2, is the product of the velocity pressure and a shape coefficient determined by the geometrical form of the structure. The velocity pressure is influenced by geographical location, height above ground, and exposure. It is the computed pressure on a square foot of surface perpendicular to the wind, representing the kinetic energy of moving air. The design wind pressure, on the other hand, is the actual pressure of wind on a square foot of surface and is affected by the ratio between height and width of the surface and by other factors.

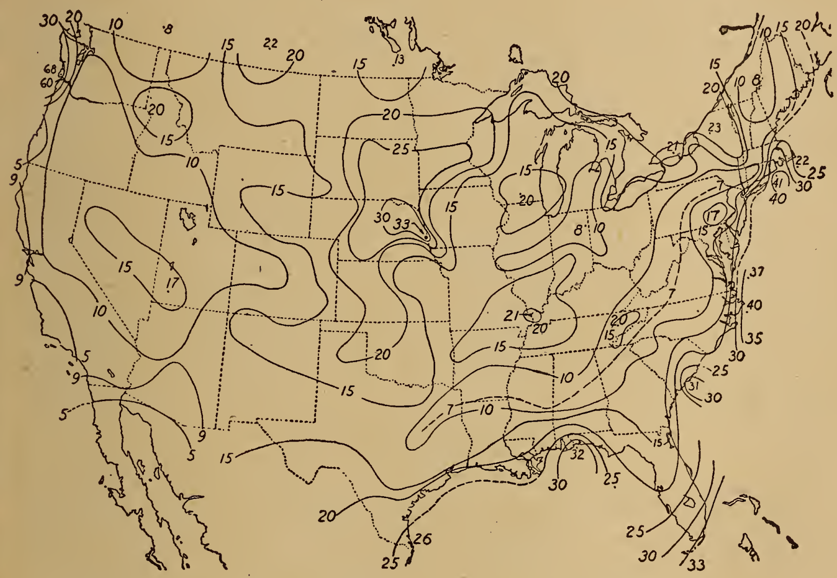

FIGURE 2.—*Velocity pressures (in pounds per square foot).*

In arriving at suitable design pressures, without the use of the map on figure 2, the following must be taken into consideration:

(1) Maximum wind velocities averaged over 5 minutes and corrected for instrumental errors as obtained from records of the Weather Bureau for each of 188 stations;

(2) A seventh-root law for the variation of wind velocity with height above the ground; (A review of information on this subject was made by W. W. Pagon and published in Engineering News-Record, May 23, 1935. This law fits in well with both meteorological and laboratory data.)

(3) A gust factor, which has been taken arbitrarily as 1.5 at 30 feet, 1.3 at 500 feet, 1.23 at 1,000 feet, and 1.2 at 1,500 feet and higher; (There is evidence from many sources that the gustiness decreases with height but that it never completely disappears as known, for example, from airplane flights. The values adopted are conservative. In a paper by W. A. Mattice, "A Comparison Between Wind Velocities as Recorded by the Dines and Robinson Anemometers," Monthly Weather Review, vol. 66, August 1938, p. 238–240, the extreme gust

velocities were 42 percent greater than the fastest single mile, which is itself greater than the 5-minute average. Airplane data show gusts of the order of 40 ft/sec.)

(4) The corresponding velocity pressure which is simply the product of one-half the air density by the square of the resultant design speed, the units being self consistent;

(5) A shape factor or pressure and suction coefficients determined largely from wind-tunnel tests. (The roof data are based on the recommendations in the final report of Subcommittee No. 31, Committee on Steel of the Structural Division, American Society of Civil Engineers, published in the ASCE Proceedings, October 1940, part 2, p. 1713–1739.)

The requirements for general use given in Section 5–1, Minimum Design Pressures, are based on a velocity pressure of 15.4 lb/ft^2, this odd value being selected to give a round number value (20 lb/ft^2) at 30-foot height for ordinary buildings with shape coefficient 1.3. A better value of the velocity pressure for any locality could be obtained by (a) obtaining from the nearest Weather Bureau station the maximum true average velocity V_h for 5 minutes observed during the existence of the station, corrected for instrumental errors; (b) reducing this value to a height of 30 feet by the formula $V_{30}/V_h=(30/h)^{1/7}$, where h is the height of the Weather Bureau anemometer above the ground; (c) increasing V_{30} by 50 percent to allow for gusts, obtaining a design speed for 30-foot height equal to 1.5 V_{30}; and (d) computing the corresponding velocity pressure q_0 at the design speed V from the formula $q_0=0.00256\ V^2$ for V in miles per hour and q_0 in pounds per square foot. In brief,

$$q_0=0.00576\ (30/h)^{2/7}V_h^2.$$

This formula is based on a standard air density of 0.07635 pound per cubic foot. For localities at considerable elevation above sea level, a reduction in proportion to the actual density would be warranted.

The shape coefficient depends somewhat on the ratio of height to width, but for ordinary buildings the observed values lie between 1.3 and 1.5. The variation with height is a stepwise approximation to the formula given. In the design of the main frame, the wind pressure is assumed to act on the area of the windward wall. It is not ordinarily necessary to distribute the load between windward and leeward walls.

By the use of the map shown in figure 2 some of the operations described above may be dispensed with, since the values shown on the map incorporate most of the steps taken.

After ascertaining from the map, interpolating between isopleths if necessary, the velocity pressure for a given place, this should be multiplied by the following factors to provide for increase in wind velocity with height:

Height	Factor
Feet	
Less than 50	1
50 to 99	1. 2
100 to 199	1. 4
200 to 299	1. 5
300 to 399	1. 6
400 to 499	1. 65
500 to 599	1. 7
600 to 799	1. 75
800 to 999	1. 8
1,000 to 1,199	1. 85
1,200 to 1,399	1. 9
1,400 to 1,599	1. 95
1,600 and over	2. 00

The remaining step is to multiply the velocity pressures thus obtained by the shape factor of 1.3, which completes the table for insertion in Section 5–1, Minimum Design Pressures, in place of the one presented for general conditions.

For ordinary buildings and for other buildings whose ratio of height to least width is less than 2½ to 1 in which the walls, floors, and partitions contribute materially to the lateral rigidity, no design computations or test data need ordinarily be submitted. The building official may, however, require evidence of the safety of the structure. For new types of construction, such as those consisting of prefabricated panels or of unusually light supporting members, the official will in many cases need adequate evidence that the construction is capable of resisting the pressures to which it may be subjected.

5–2. Exterior Walls.—By failure of windows, or otherwise, the interior may be subjected to either the full pressure or suction acting on the building. Hence, any exterior wall should be able to withstand the full wind load acting either inward or outward.

5–3. Roofs.—In case it is desired to make allowance for combined loadings inward and outward on roofs, the following requirements are suggested:

Roofs or sections of roofs shall be capable of withstanding the following loads acting simultaneously on the windward and leeward slopes:

Slope	Exterior load coefficients [a] (factors to be applied to loads specified in sec. 5–1)	
	Windward slope	Leeward slope
20° or less	−0. 60	−0. 45
Between 20° and 30°	0. 06A −1. 8	−0. 45
Between 30° and 60°	0. 015A−0. 45	−0. 45
Between 60° and 90°	0. 45	−0. 45

[a] Positive values indicate an inward load; negative values an outward load. A is the roof slope in degrees.

The maximum outward force on a gable roof occurs when the wind blows parallel to the ridge. The suction coefficient is about −0.6. The interior may, however, be subject to full velocity pressure through broken windows or other openings, and hence the force coefficient is 1.6. In view of the recommendations of various insurance groups, somewhat higher values have been adopted, namely one and one-fourth those in Section 5–1, Minimum Design Pressures.

The highest inward loads on gable roofs occur when the interior is subjected to full suction. The force on the lee slope is then zero, and the total inward force on the windward slope has been taken equal to the values in Section 5–1, Minimum Design Pressures, for angles greater than 30°. No inward loads need to be considered for angles less than 30°.

The combined loadings are based on the recommendations given in the final report of Subcommittee No. 31, Committee on Steel of the Structural Division, American Society of Civil Engineers, published in the ASCE Proceedings, October 1940, part 2, p. 1713–1739. The subcommittee also gives recommendations for rounded roofs. It is believed that these combined loadings are critical only for certain types of roof trusses.

5–4. Chimneys.—The value for round chimneys corresponds to a shape coefficient of 0.84, which is in good agreement with the wind-tunnel value 0.8. Hence, the familiar value is retained.

5–5. Signs.—Signs or signboards on the roofs of buildings are exposed to local wind velocities considerably higher than those of the wind itself. The increase is produced by the presence of the building. The reduced value for solid signs on the ground is made in recognition of the decreased velocity pressure to be expected at the limited height within which such signs are generally erected, and the decreased risk of signs located at such height. The recommendations for open signs are based on the work of O. Flachsbart and H. Winter, published in Der Stahlbau, 1934, Nos. 9 and 10, and 1935, Nos. 8, 9, and 10. They take into account the increased load to be expected on the exposed parts of such signs because of the shape factor of these parts.

6 and 7. Earthquake Loads.—It is hoped that the very moderate coefficients of lateral load which have been recommended in Section 6, Earthquake Loads—General, together with the fact that they are measured in terms of the dead load only of buildings, and are to be used with stresses 50 percent greater than the ordinary working stresses for dead and live load, will make this section suitable for general use. The recommended provisions will give increased stability of construction with very small increase in cost over that required for poor or even mediocre construction.

From experience it has been found that certain structural features will, if incorporated in the construction, give practical and effective resistance, not only to earthquakes, but to the lateral force of high winds. Among such structural features are the adequate anchorage of floors to masonry walls, reinforced-concrete bond beams placed in the masonry walls just below the floors, and corresponding reinforced-concrete bond columns placed in the corners of the walls. These special structural features are particularly important in the more common type of building, represented by the one-story commercial buildings with brick walls and timber floors and partitions. Schools and churches are examples of buildings of similar construction which often lack lateral stability and are hazardous in earthquakes or wind storms. Buildings of this type are often, if not usually, designed and constructed without the services of a structural engineer. Tall office buildings, on the contrary, are usually designed, insofar as their structural features are concerned, by structural engineers.

Methods of structural design for resistance to earthquakes are much more complex and consequently more controversial in the case of tall multistoried buildings than for low commercial buildings. For the multistoried buildings it seems best that some flexibility in design should be allowed, with the provision that the design for earthquake resistance be required to conform to reasonable and logical analysis and be subject to the approval of the building official. Some experiments made on models of tall buildings indicate that the horizontal shear factors increase with the number of stories. However, the committee feels that the range of experiments has not been sufficiently broad to justify definite recommendations on the subject. For this reason it has been thought best to recommend a constant coefficient for the earthquake factor, as has been done in Section 7–1, Minimum Lateral Load, of the requirements. Again, due to the probability that in the majority of buildings the assumed live load is often not realized, it has been thought best to base the earthquake factor on the dead load of the building, except in the case of buildings used for storage purposes, where it is recommended that one-half the live load be counted as dead load.

With reference to the Rossi-Forel and other scales measuring the intensity of earthquakes, and to the history of earthquakes in America and their distribution, attention is invited to the earthquake bulletins of the Seismological Society of America, and to the earthquake catalogs of the United States Coast and Geodetic Survey and of the Seismological Society of America.

The following information provided by the U. S. Coast and Geodetic Survey is presented for the information of local code committees:

EARTHQUAKES IN THE UNITED STATES

The United States lies partly within the great seismic belt which circumscribes the Pacific Ocean. Practically all parts of the country, however, are subject to earthquakes, as will be seen in figure 3, which shows the distribution and magnitude of destructive earthquakes within historic time. While the great majority of strong shocks are restricted to rather broadly defined belts, even great earthquakes, such as that at Charleston, S. C., in 1886, may occur in regions generally considered immune on the basis of the historical record.

Earthquake map.—Four grades of intensity are indicated on figure 3. The smallest dots represent either shocks which were strong enough to overthrow chimneys or shocks perceptible over more than 25,000 square miles. They may be either VII or VIII according to the Rossi-Forel scale of earthquake intensity. (VII indicates the fall of some chimneys, and VIII, IX, and X increasing degrees of destruction up to and including total destruction.) The larger solid dots may be associated with damage ranging from several thousand dollars to a hundred thousand, or to shocks usually perceptible over more than 150,000 square miles. The intensity range is from VIII to IX. The smaller encircled dots represent damage ranging approximately from a hundred thousand to a million dollars, or an affected area greater than 500,000 square miles. The intensity range is IX to X. The larger encircled dots indicate damage of a million dollars or more, or an affected area usually greater than 1,000,000 square miles. An intensity of X is indicated. The numeral after a dot indicates the number of shocks that have occurred at or near the location shown. Earthquakes in the border areas of Canada are included as they sometimes result in damage in the United States.

FIGURE 3.—*Earthquakes of destructive intensity.*
[See text for explanation of size of dots.]

Quite a few have been felt over very large areas in both countries. This is also true for Mexico. The points of origin of many of the earlier shocks are uncertain.

Relation between destructive and potentially destructive shocks.—Relatively weak shocks may cause great damage in congested areas while shocks of heavy energy occurring in uninhabited areas will cause practically no damage. The map must therefore be viewed as having value in showing in a broad way the potential earthquake risk in various areas as based on the historical record. Earthquakes of the Pacific Coast and western mountain region are considered shallower than those in other parts of the country as the ground motions are generally of more destructive character in comparison with those of equal areal extent elsewhere.

In the greatest earthquakes, those of the type indicated by encircled dots on the map, damage was great in 10 percent, heavy in 15 percent, considerable in 30 percent, and minor or negligible in 45 percent of the total number. In very strong shocks, indicated by the large dots, damage was great in 10 percent, heavy in 20 percent, considerable in 27 percent, and minor or negligible in 43 percent. In strong shocks, those in the small dot category, damage was heavy in 1 percent, considerable in 9 percent, and minor or negligible in 90 percent. In this appraisal, damage over a million dollars is considered great; a hundred thousand dollars or over, heavy; over ten thousand dollars, considerable; and anything less, minor. More than half of the shocks of destructive intensity in the country have occurred in the Pacific Coast and western Nevada area.

References.—This summary is based on reports and records of the United States Coast and Geodetic Survey, principally Serial 609, Earthquake History of the United States, Part I—Continental United States (Exclusive of California and Western Nevada) and Alaska; Part II—Stronger Earthquakes of California and Western Nevada. More detailed information will be found in those reports and in the annual Seismological reports of the Survey. Special reference is made to the January 1939 number of the Bulletin of the Seismological Society of America containing a "Descriptive Catalog of Earthquakes of the Pacific Coast of the United States, 1769 to 1928," by S. D. Townley and M. W. Allen. A comprehensive review and discussion of the earthquake problem in the United States from the insurance and engineering viewpoints is "Earthquake Damage and Earthquake Insurance" by J. R. Freeman (McGraw-Hill Book Co., Inc., New York and London, 1932).

General.—While only about 275 shocks are indicated in figure 3, the actual number of shocks of all types, felt and unfelt, runs into the thousands annually. As many as a million have been suggested for the earth as a whole. Neither their ultimate nor immediate cause is known although plausible hypotheses have been advanced, especially in regard to their immediate cause. They cannot be predicted with respect to time and place. Analyses of available statistics have not revealed any periodicity factors of practical value in predicting.

Since 1933 the Coast and Geodetic Survey has made instrumental observations of destructive ground motions. Although the application of this information to the design of structures is handicapped by the need for further laboratory research and more satisfactory analytical methods, progress is being made through the active participation of several engineering research organizations in this specialized field. There is indication that the complex stresses set up in structures during destructive earthquake motions can be expressed in terms of equivalent static forces. Pending the successful completion of this research and the accumulation of sufficient instrumental records of destructive ground motions, the engineer must depend largely on empirical formulas such as recommended in Sections 6 and 7.

Important earthquakes of the United States and adjoining regions

Year	Date	Place	R-F intensity	Remarks
1638	June 1	Mass., Plymouth	VIII	Many stone chimneys down. Chimneys down in shocks in 1662 and probably other years.
1663	Feb. 5	Canada, Three Rivers, Lower St. Lawrence River.	X	Chimneys broken in Mass. Bay area.
1732	Sept. 15	Canada, Ontario	IX?	7 killed at Montreal.
1755	Nov. 18	Mass., near Cambridge	IX	Many chimneys down, brick buildings damaged, stone fences generally wrecked. Sand emitted from ground cracks. Felt from Chesapeake Bay to Annapolis, Nova Scotia.
1769	July 28	Calif., San Pedro Channel area.	X	Major disturbance with many aftershocks.
1790	(?)	Calif., Owens Valley	X	Major shock with appearance of fault scarps.
1811	Dec. 16	Mo., New Madrid	X	Greatest United States earthquake in historic time. Town destroyed, great changes in configuration of ground and rivers including the Mississippi River. Chimneys down in Cincinnati. Felt in Boston. Several killed.
1812	Dec. 8	Calif., San Juan Capistrano.	IX	Church collapsed killing 40.
1812	Dec. 21	Calif., near Lompoc	X	Churches and other buildings wrecked in several towns including Santa Barbara.
1839	(?)	Calif., Redwood City	IX?	Possibly thousands of redwoods broken off.
1857	Jan. 9	Calif., Fort Tejon	X	Probably greatest of Pacific Coast shocks. Originated in NW corner of Los Angeles Co. Buildings and large trees thrown down.
1868	Oct. 21	Calif., Hayward	X	Many buildings wrecked, nearly all damaged. Severe damage at San Leandro and San Francisco. 30 killed.
1870	Oct. 20	Canada, Montreal to Quebec.	IX	Widespread. Minor damage on coast of Maine.
1872	Mar. 26	Calif., Owens Valley	X	One of 3 greatest earthquakes in Pacific Coast area. 23-foot fault scarp formed. 27 killed at Lone Pine out of 300 population; all adobe houses wrecked.
1886	Aug. 31	S. C., Charleston	X	Greatest earthquake in eastern part of country. 102 buildings destroyed; 90 percent damaged; nearly all chimneys down. $5,500,000 damage. About 100 killed. Felt at Boston, Chicago and St. Louis.

Important earthquakes of the United States and adjoining regions—Continued

Year	Date	Place	R–F intensity	Remarks
1887	May 3	Mexico, Sonora	X	Widespread in border states. Chimneys down in several towns including El Paso and Albuquerque.
1895	Oct. 31	Mo., near Charleston	IX	Felt in Canada, Virginia, Louisiana and South Dakota. Acres of ground sank and lake formed. Many chimneys demolished.
1899	Dec. 25	Calif., San Jacinto	X	Nearly all brick buildings badly damaged in San Jacinto and Hemet. Chimneys down in Riverside. 6 killed. Another severe shock in 1918.
1906	Apr. 18	Calif., San Francisco	X	Great earthquake and fire. About 95 percent of estimated $400,000,000 damage due to fire. 700 killed. Greatest destruction in San Francisco, Santa Rosa, and other towns near San Andreas fault. Horizontal slipping along fault, 21 feet. Greatest damage on made land.
1909	May 26	Ill., Aurora	VIII	Many chimneys down. Felt over wide area.
1915	June 22	Calif., Imperial Valley	IX	Nearly $1,000,000 damage. 6 killed. Well-constructed buildings were cracked.
1915	Oct. 2	Nev., Pleasant Valley	X	Widespread. Adobe houses and water tank towers wrecked.
1925	Feb. 28	Canada, Murray Bay	IX	Felt in many eastern and central states. Damage less than $100,000.
1925	June 27	Montana, Manhattan	IX	Landslide blocked entrance to railroad tunnel. Some buildings wrecked and many chimneys fell. $300,000 damage.
1925	June 29	Calif., Santa Barbara	X	$6,000,000 damage. 13 killed. 70 buildings condemned.
1929	Aug. 12	N. Y., Attica	IX	250 chimneys toppled.
1929	Nov. 18	Grand Banks, off Newfoundland.	X	Submarine shock broke 12 transatlantic cables; some breaks 150 miles apart. Some deaths by seismic sea wave along Burin Peninsula. Some chimneys in Canada toppled.
1931	Apr. 20	N. Y., Lake George	VIII	Chimneys fell.
1931	Aug. 16	Texas, near Valentine	IX	All buildings damaged; many chimneys fell.
1932	Dec. 20	Nev., Cedar Mountain	X	In sparsely settled region. Widespread.
1933	Mar. 10	Calif., Long Beach	IX	$41,000,000 damage; 120 killed. Fire damage insignificant. Greatest strictly earthquake damage in country.

Important earthquakes of the United States and adjoining regions—Continued

Year	Date	Place	R-F intensity	Remarks
1934	Mar. 12	Utah, Kosmo	IX	Marked changes in terrain north of Great Salt Lake. 2 killed.
1935	Nov. 1	Canada, Timiskaming	IX	Widespread. Landslide near origin.
1935	Oct. 18	Montana, Helena	IX	$3,500,000 damage. 4 killed; less than 50 injured. More than half of buildings damaged from 2.5 to 100 percent.
1941	June 30	Calif., Santa Barbara	IX	$100,000 damage.
1941	Nov. 14	Calif., Torrance-Gardena area.	VIII	About $1,000,000 damage. 50 buildings severely damaged.
1944	Sept. 5	Canada-New York, Cornwall and Massena.	IX	On St. Lawrence River. $1,500,000 damage reported. 90 percent of chimneys in Massena destroyed or damaged.

WASHINGTON, April 26, 1945.

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