Chapter C3
DEAD LOADS, SOIL LOADS, AND HYDROSTATIC PRESSURE

C3.1.2 Weights of Materials and Constructions

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 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, in this commentary, an extended list that will be useful to designer and official alike. However, special cases will unavoidably arise, and authority is therefore granted in the standard for the building official to deal with them.

For ease of computation, most values are given in terms of pounds per square foot (lb/ft^2) (kN/m^2) of given thickness (see Table C3-1). Pounds-per-cubic-foot (lb/ft^3) (kN/m^3) values, consistent with the pounds-per-square foot (kilonewtons per square meter) values, are also presented in some cases (see Table C3-2). 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.

Engineers, architects, and building owners are advised to consider factors that result in differences between actual and calculated loads.

Engineers and architects cannot be responsible for circumstances beyond their control. Experience has shown, however, that conditions are encountered which, if not considered in design, may reduce the future utility of a building or reduce its margin of safety. Among them are

1. Dead Loads. There have been numerous instances in which the actual weights of members and construction materials have exceeded the values used in design. Care is advised in the use of tabular values. Also, allowances should be made for such factors as the influence of formwork and support deflections on the actual thickness of a concrete slab of prescribed nominal thickness.
2. Future Installations. Allowance should be made for the weight of future wearing or protective surfaces where there is a good possibility that such may be applied. Special consideration should be given to the likely types and position of partitions, as insufficient provision for partitioning may reduce the future utility of the building.

Attention is directed also to the possibility of temporary changes in the use of a building, as in the case of clearing a dormitory for a dance or other recreational purpose.

C3.2 SOIL LOADS AND HYDROSTATIC PRESSURE

C3.2.1 Lateral Pressures

Table 3.2-1 includes high earth pressures, 85 pcf ($13.36 kN/m^2$) or more, to show that certain soils are poor backfill material. In addition, when walls are unyielding the earth pressure is increased from active pressure toward earth pressure at rest, resulting in 60 pcf ($9.43 kN/m^2$) for granular soils and 100 pcf ($15.71 kN/m^2$) for silt and clay type soils (Terzaghi and Peck 1967). Examples of light floor systems supported on shallow basement walls mentioned in Table 3.2-1 are floor systems with wood joists and flooring, and cold-formed steel joists without a cast-in-place concrete floor attached.

Expansive soils exist in many regions of the United States and may cause serious damage to basement walls unless special design considerations are provided. Expansive soils should not be used as backfill because they can exert very high pressures against walls. Special soil testing is required to determine the magnitude of these pressures. It is preferable to excavate expansive soil and backfill with non-expansive, freely draining sands or gravels. The excavated back slope adjacent to the wall should be no steeper than 45° from the horizontal to minimize the transmission of swelling pressure from the expansive soil through the new backfill. Other special details are recommended, such as a cap of non-pervious soil on top of the backfill and provision of foundation drains. Refer to current reference books on geotechnical engineering for guidance.

C3.2.2 Uplift on Floors and Foundations

If expansive soils are present under floors or footings, large pressures can be exerted and must be resisted by special design. Alternatively, the expansive soil can be removed and replaced with non-expansive material. A geotechnical engineer should make recommendations in these situations.

REFERENCE

Terzaghi, K., and Peck, R. B. (1967). *Soil mechanics in engineering practice,* 2nd ed. Wiley, New York.

Table C3-1 Minimum Design Dead Loads[a]

Component	Load (psf)
CEILINGS	
Acoustical fiber board	1
Gypsum board (per 1/8-in. thickness)	0.55
Mechanical duct allowance	4
Plaster on tile or concrete	5
Plaster on wood lath	8
Suspended steel channel system	2
Suspended metal lath and cement plaster	15
Suspended metal lath and gypsum plaster	10
Wood furring suspension system	2.5
COVERINGS, ROOF, AND WALL	
Asbestos-cement shingles	4
Asphalt shingles	2
Cement tile	16
Clay tile (for mortar add 10 psf)	
Book tile, 2-in.	12
Book tile, 3-in.	20
Ludowici	10
Roman	12
Spanish	19
Composition:	
Three-ply ready roofing	1
Four-ply felt and gravel	5.5
Five-ply felt and gravel	6
Copper or tin	1
Corrugated asbestos-cement roofing	4
Deck, metal, 20 gage	2.5
Deck, metal, 18 gage	3
Decking, 2-in. wood (Douglas fir)	5
Decking, 3-in. wood (Douglas fir)	8
Fiberboard, 1/2-in.	0.75
Gypsum sheathing, 1/2-in.	2
Insulation, roof boards (per inch thickness)	
Cellular glass	0.7
Fibrous glass	1.1
Fiberboard	1.5
Perlite	0.8
Polystyrene foam	0.2
Urethane foam with skin	0.5
Plywood (per 1/8-in. thickness)	0.4
Rigid insulation, 1/2-in.	0.75
Skylight, metal frame, 3/8-in. wire glass	8
Slate, 3/16-in.	7
Slate, 1/4-in.	10
Waterproofing membranes:	
Bituminous, gravel-covered	5.5
Bituminous, smooth surface	1.5
Liquid applied	1
Single-ply, sheet	0.7
Wood sheathing (per inch thickness)	3
Wood shingles	3
FLOOR FILL	
Cinder concrete, per inch	9

Continued

Table C3-1 (*Continued*)

Component					Load (psf)
Lightweight concrete, per inch					8
Sand, per inch					8
Stone concrete, per inch					12
FLOORS AND FLOOR FINISHES					
Asphalt block (2-in.), 1/2-in. mortar					30
Cement finish (1-in.) on stone–concrete fill					32
Ceramic or quarry tile (3/4-in.) on 1/2-in. mortar bed					16
Ceramic or quarry tile (3/4-in.) on 1-in. mortar bed					23
Concrete fill finish (per inch thickness)					12
Hardwood flooring, 7/7-in.					4
Linoleum or asphalt tile, 1/4-in.					1
Marble and mortar on stone–concrete fill					33
Slate (per mm thickness)					15
Solid flat tile on 1-in. mortar base					23
Subflooring, 3/4-in.					3
Terrazzo (1-1/2-in.) directly on slab					19
Terrazzo (1-in.) on stone–concrete fill					32
Terrazzo (1-in.), 2-in. stone concrete					32
Wood block (3-in.) on mastic, no fill					10
Wood block (3-in.) on 1/2-in. mortar base					16
FLOORS, WOOD-JOIST (NO PLASTER)					
DOUBLE WOOD FLOOR					
Joint sizes (in.)	12-in. spacing (1b/ft^2)	16-in. spacing (1b/ft^2)	24-in. spacing (1b/ft^2)		
2×6	6	5	5		
2×8	6	6	5		
2×10	7	6	6		
2×12	8	7	6		
FRAME PARTITIONS					
Movable steel partitions					4
Wood or steel studs, 1/2-in. gypsum board each side					8
Wood studs, 2×4, unplastered					4
Wood studs, 2×4, plastered one side					12
Wood studs, 2×4, plastered two sides					20
FRAME WALLS					
Exterior stud walls:					
2×4 @ 16-in., 5/8-in. gypsum, insulated, 3/8-in. siding					11
2×6 @ 16-in., 5/8-in. gypsum, insulated, 3/8-in. siding					12
Exterior stud walls with brick veneer					48
Windows, glass, frame, and sash					8
Clay brick wythes:					
4 in.					39
8 in.					79
12 in.					115
16 in.					155
Hollow concrete masonry unit wythes:					
Wythe thickness (in inches)	4	6	8	10	12
Density of unit (105 pcf)					
No grout	22	24	31	37	43
48 in. o.c.		29	38	47	55
40 in. o.c. grout		30	40	49	57
32 in. o.c. spacing		32	42	52	61
24 in. o.c.		34	46	57	67
16 in. o.c.		40	53	66	79
Full grout		55	75	95	115

Table C3-1 (*Continued*)

Component					Load (psf)
Density of unit (125 pcf)					
No grout	26	28	36	44	50
48 in. o.c.		33	44	54	62
40 in. o.c. grout		34	45	56	65
32 in. o.c. spacing		36	47	58	68
24 in. o.c.		39	51	63	75
16 in. o.c.		44	59	73	87
Full grout		59	81	102	123
Density of unit (135 pcf)					
No grout	29	30	39	47	54
48 in. o.c.		36	47	57	66
40 in. o.c. grout		37	48	59	69
32 in. o.c. spacing		38	50	62	72
24 in. o.c.		41	54	67	78
16 in. o.c.		46	61	76	90
Full grout		62	83	105	127
Solid concrete masonry unit wythes (incl. concrete brick):					
Wythe thickness (in mm)	4	6	8	10	12
Density of unit (105 pcf)	32	51	69	87	105
Density of unit (125 pcf)	38	60	81	102	124
Density of unit (135 pcf)	41	64	87	110	133
CEILINGS					
Acoustical fiber board					0.05
Gypsum board (per mm thickness)					0.008
Mechanical duct allowance					0.19
Plaster on tile or concrete					0.24
Plaster on wood lath					0.38
Suspended steel channel system					0.10
Suspended metal lath and cement plaster					0.72
Suspended metal lath and gypsum plaster					0.48
Wood furring suspension system					0.12
COVERINGS, ROOF, AND WALL					
Asbestos-cement shingles					0.19
Asphalt shingles					0.10
Cement tile					0.77
Clay tile (for mortar add 0.48 kN/m^2)					
Book tile, 51 mm					0.57
Book tile, 76 mm					0.96
Ludowici					0.48
Roman					0.57
Spanish					0.91
Composition:					
Three-ply ready roofing					0.05
Four-ply felt and gravel					0.26
Five-ply felt and gravel					0.29
Copper or tin					0.05
Corrugated asbestos-cement roofing					0.19
Deck, metal, 20 gage					0.12
Deck, metal, 18 gage					0.14
Decking, 51-mm wood (Douglas fir)					0.24
Decking, 76-mm wood (Douglas fir)					0.38
Fiberboard, 13 mm					0.04

Continued

Table C3-1 (*Continued*)

Component				Load (psf)
Gypsum sheathing, 13 mm				0.10
Insulation, roof boards (per mm thickness)				
Cellular glass				0.0013
Fibrous glass				0.0021
Fiberboard				0.0028
Perlite				0.0015
Polystyrene foam				0.0004
Urethane foam with skin				0.0009
Plywood (per mm thickness)				0.006
Rigid insulation, 13 mm				0.04
Skylight, metal frame, 10-mm wire glass				0.38
Slate, 5 mm				0.34
Slate, 6 mm				0.48
Waterproofing membranes:				
Bituminous, gravel-covered				0.26
Bituminous, smooth surface				0.07
Liquid applied				0.05
Single-ply, sheet				0.03
Wood sheathing (per mm thickness)				
Plywood				0.0057
Oriented strand board				0.0062
Wood shingles				0.14
FLOOR FILL				
Cinder concrete, per mm				0.017
Lightweight concrete, per mm				0.015
Sand, per mm				0.015
Stone concrete, per mm				0.023
FLOORS AND FLOOR FINISHES				
Asphalt block (51 mm), 13-mm mortar				1.44
Cement finish (25 mm) on stone–concrete fill				1.53
Ceramic or quarry tile (19 mm) on 13-mm mortar bed				0.77
Ceramic or quarry tile (19 mm) on 25-mm mortar bed				1.10
Concrete fill finish (per mm thickness)				0.023
Hardwood flooring, 22 mm				0.19
Linoleum or asphalt tile, 6 mm				0.05
Marble and mortar on stone–concrete fill				1.58
Slate (per mm thickness)				0.028
Solid flat tile on 25-mm mortar base				1.10
Subflooring, 19 mm				0.14
Terrazzo (38 mm) directly on slab				0.91
Terrazzo (25 mm) on stone–concrete fill				1.53
Terrazzo (25 mm), 51-mm stone concrete				1.53
Wood block (76 mm) on mastic, no fill				0.48
Wood block (76 mm) on 13-mm mortar base				0.77
FLOORS, WOOD-JOIST (NO PLASTER)				
DOUBLE WOOD FLOOR				
Joist sizes (mm):	305-mm spacing (kN/m^2)	406-mm spacing (kN/m^2)	610-mm spacing (kN/m^2)	
51 × 152	0.29	0.24	0.24	
51 × 203	0.29	0.29	0.24	
51 × 254	0.34	0.29	0.29	
51 × 305	0.38	0.34	0.29	
FRAME PARTITIONS				
Movable steel partitions				0.19
Wood or steel studs, 13-mm gypsum board each side				0.38

Table C3-1 (*Continued*)

Component						Load (psf)
Wood studs, 51 × 102, unplastered						0.19
Wood studs, 51 × 102, plastered one side						0.57
Wood studs, 51 × 102, plastered two sides						0.96
FRAME WALLS						
Exterior stud walls:						
51 mm × 102 mm @ 406 mm, 16-mm gypsum, insulated, 10-mm siding						0.53
51 mm × 152 mm @ 406 mm, 16-mm gypsum, insulated, 10-mm siding						0.57
Exterior stud walls with brick veneer						2.30
Windows, glass, frame, and sash						0.38
Clay brick wythes:						
102 mm						1.87
203 mm						3.78
305 mm						5.51
406 mm						7.42
Hollow concrete masonry unit wythes:						
Wythe thickness (in mm)		102	152	203	254	305
Density of unit (16.49 kN/m^3)						
No grout		1.05	1.29	1.68	2.01	2.35
1,219 mm			1.48	1.92	2.35	2.78
1,016 mm	grout		1.58	2.06	2.54	3.02
813 mm	spacing		1.63	2.15	2.68	3.16
610 mm			1.77	2.35	2.92	3.45
406 mm			2.01	2.68	3.35	4.02
Full grout			2.73	3.69	4.69	5.70
Density of unit (19.64 kN/m^3)						
No grout		1.25	1.34	1.72	2.11	2.39
1,219 mm			1.58	2.11	2.59	2.97
1,016 mm	grout		1.63	2.15	2.68	3.11
813 mm	spacing		1.72	2.25	2.78	3.26
610 mm			1.87	2.44	3.02	3.59
406 mm			2.11	2.78	3.50	4.17
Full grout			2.82	3.88	4.88	5.89
Density of unit (21.21 kN/m^3)						
No grout		1.39	1.68	2.15	2.59	3.02
1,219 mm			1.58	2.39	2.92	3.45
1,016 mm	grout		1.72	2.54	3.11	3.69
813 mm	spacing		1.82	2.63	3.26	3.83
610 mm			1.96	2.82	3.50	4.12
406 mm			2.25	3.16	3.93	4.69
Full grout			3.06	4.17	5.27	6.37
Solid concrete masonry unit						
Wythe thickness (in mm)		102	152	203	254	305
Density of unit (16.49 kN/m^3)		1.53	2.35	3.21	4.02	4.88
Density of unit (19.64 kN/m^3)		1.82	2.82	3.78	4.79	5.79
Density of unit (21.21 kN/m^3)		1.96	3.02	4.12	5.17	6.27

[a]Weights of masonry include mortar but not plaster. For plaster, add 0.24 kN/m^2 for each face plastered. Values given represent averages. In some cases there is a considerable range of weight for the same construction.

Table C3-2 Minimum Densities for Design Loads from Materials

Material	Density (lb/ft^3)
Aluminum	170
Bituminous products	
Asphaltum	81
Graphite	135
Paraffin	56
Petroleum, crude	55
Petroleum, refined	50
Petroleum, benzine	46
Petroleum, gasoline	42
Pitch	69
Tar	75
Brass	526
Bronze	552
Cast-stone masonry (cement, stone, sand)	144
Cement, portland, loose	90
Ceramic tile	150
Charcoal	12
Cinder fill	57
Cinders, dry, in bulk	45
Coal	
Anthracite, piled	52
Bituminous, piled	47
Lignite, piled	47
Peat, dry, piled	23
Concrete, plain	
Cinder	108
Expanded-slag aggregate	100
Haydite (burned-clay aggregate)	90
Slag	132
Stone (including gravel)	144
Vermiculite and perlite aggregate, nonload-bearing	25–50
Other light aggregate, load-bearing	70–105
Concrete, reinforced	
Cinder	111
Slag	138
Stone (including gravel)	150
Copper	556
Cork, compressed	14
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
Sand or gravel	60
Sand or gravel and clay	65
Glass	160
Gravel, dry	104
Gypsum, loose	70
Gypsum, wallboard	50
Ice	57
Iron	
Cast	450
Wrought	480
Lead	710
Lime	
Hydrated, loose	32
Hydrated, compacted	45
Masonry, ashlar stone	
Granite	165
Limestone, crystalline	165
Limestone, oolitic	135
Marble	173
Sandstone	144
Masonry, brick	
Hard (low absorption)	130
Medium (medium absorption)	115
Soft (high absorption)	100
Masonry, concrete[a]	
Lightweight units	105
Medium weight units	125
Normal weight units	135
Masonry grout	140
Masonry, rubble stone	
Granite	153
Limestone, crystalline	147
Limestone, oolitic	138
Marble	156
Sandstone	137
Mortar, cement or lime	130
Particleboard	45
Plywood	36
Riprap (not submerged)	
Limestone	83
Sandstone	90
Sand	
Clean and dry	90
River, dry	106
Slag	
Bank	70
Bank screenings	108
Machine	96
Sand	52
Slate	172
Steel, cold-drawn	492
Stone, quarried, piled	
Basalt, granite, gneiss	96
Limestone, marble, quartz	95
Sandstone	82
Shale	92
Greenstone, hornblende	107

Table C3-2 (*Continued*)

Material	Density (lb/ft^3)	Material	Density (lb/ft^3)
Terra cotta, architectural		Cypress, southern	34
Voids filled	120	Fir, Douglas, coast region	34
Voids unfilled	72	Hem fir	28
Tin	459	Oak, commercial reds and whites	47
Water		Pine, southern yellow	37
Fresh	62	Redwood	28
Sea	64	Spruce, red, white, and Sitka	29
Wood, seasoned		Western hemlock	32
Ash, commercial white	41	Zinc, rolled sheet	449
Aluminum	27	Silt, moist, loose	12.3
Bituminous products		Silt, moist, packed	15.1
Asphaltum	12.7	Silt, flowing	17.0
Graphite	21.2	Sand and gravel, dry, loose	15.7
Paraffin	8.8	Sand and gravel, dry, packed	17.3
Petroleum, crude	8.6	Sand and gravel, wet	18.9
Petroleum, refined	7.9	Earth (submerged)	
Petroleum, benzine	7.2	Clay	12.6
Petroleum, gasoline	6.6	Soil	11.0
Pitch	10.8	River mud	14.1
Tar	11.8	Sand or gravel	9.4
Brass	82.6	Sand or gravel and clay	10.2
Bronze	86.7	Glass	25.1
Cast-stone masonry (cement, stone, sand)	22.6	Gravel, dry	16.3
Cement, portland, loose	14.1	Gypsum, loose	11.0
Ceramic tile	23.6	Gypsum, wallboard	7.9
Charcoal	1.9	Ice	9.0
Cinder fill	9.0	Iron	
Cinders, dry, in bulk	7.1	Cast	70.7
Coal		Wrought	75.4
Anthracite, piled	8.2	Lead	111.5
Bituminous, piled	7.4	Lime	
Lignite, piled	7.4	Hydrated, compacted	5.0
Peat, dry, piled	3.6	Hydrated, loose	7.1
Concrete, plain		Masonry, ashlar stone	
Cinder	17.0	Granite	25.9
Expanded-slag aggregate	15.7	Limestone, crystalline	25.9
Haydite (burned-clay aggregate)	14.1	Limestone, oolitic	21.2
Slag	20.7	Marble	27.2
Stone (including gravel)	22.6	Sandstone	22.6
Vermiculite and perlite aggregate,	3.9–7.9	Masonry, brick	
nonload-bearing		Hard (low absorption)	20.4
Other light aggregate, load-bearing	11.0–16.5	Medium (medium absorption)	18.1
Concrete, reinforced		Soft (high absorption)	15.7
Cinder	17.4	Masonry, concrete[a]	
Slag	21.7	Lightweight units	16.5
Stone (including gravel)	23.6	Medium weight units	19.6
Copper	87.3	Normal weight units	21.2
Cork, compressed	2.2	Masonry grout	22.0
Earth (not submerged)		Masonry, rubble stone	
Clay, dry	9.9	Granite	24.0
Clay, damp	17.3	Limestone, crystalline	23.1
Clay and gravel, dry	15.7	Limestone, oolitic	21.7

Continued

Table C3-2 (*Continued*)

Material	Density (lb/ft^3)	Material	Density (lb/ft^3)
Marble	24.5	Sandstone	12.9
Sandstone	21.5	Shale	14.5
Mortar, cement or lime	20.4	Greenstone, hornblende	16.8
Particleboard	7.1	Terra cotta, architectural	
Plywood	5.7	Voids filled	18.9
Riprap (not submerged)		Voids unfilled	11.3
Limestone	13.0	Tin	72.1
Sandstone	14.1	Water	
Sand		Fresh	9.7
Clean and dry	14.1	Sea	10.1
River, dry	16.7	Wood, seasoned	
Slag		Ash, commercial white	6.4
Bank	11.0	Cypress, southern	5.3
Bank screenings	17.0	Fir, Douglas, coast region	5.3
Machine	15.1	Hem fir	4.4
Sand	8.2	Oak, commercial reds and whites	7.4
Slate	27.0	Pine, southern yellow	5.8
Steel, cold-drawn	77.3	Redwood	4.4
Stone, quarried, piled		Spruce, red, white, and Sitka	4.5
Basalt, granite, gneiss	15.1	Western hemlock	5.0
Limestone, marble, quartz	14.9	Zinc, rolled sheet	70.5

[a]Tabulated values apply to solid masonry and to the solid portion of hollow masonry.

Chapter C4
LIVE LOADS

C4.3 UNIFORMLY DISTRIBUTED LIVE LOADS

C4.3.1 Required Live Loads

A selected list of loads for occupancies and uses more commonly encountered is given in Section 4.3.1, and the authority having jurisdiction should approve on occupancies not mentioned. Tables C4-1 and C4-2 are offered as a guide in the exercise of such authority.

In selecting the occupancy and use for the design of a building or a structure, the building owner should consider the possibility of later changes of occupancy involving loads heavier than originally contemplated. The lighter loading appropriate to the first occupancy should not necessarily be selected. The building owner should ensure that a live load greater than that for which a floor or roof is approved by the authority having jurisdiction is not placed, or caused or permitted to be placed, on any floor or roof of a building or other structure.

To solicit specific informed opinion regarding the design loads in Table 4-1, a panel of 25 distinguished structural engineers was selected. A Delphi (Corotis et al. 1981) was conducted with this panel in which design values and supporting reasons were requested for each occupancy type. The information was summarized and recirculated back to the panel members for a second round of responses. Those occupancies for which previous design loads were reaffirmed, as well as those for which there was consensus for change, were included.

It is well known that the floor loads measured in a live-load survey usually are well below present design values (Peir and Cornell 1973, McGuire and Cornell 1974, Sentler 1975, and Ellingwood and Culver 1977). However, buildings must be designed to resist the maximum loads they are likely to be subjected to during some reference period T, frequently taken as 50 years. Table C4-2 briefly summarizes how load survey data are combined with a theoretical analysis of the load process for some common occupancy types and illustrates how a design load might be selected for an occupancy not specified in Table 4-1 (Chalk and Corotis 1980). The floor load normally present for the intended functions of a given occupancy is referred to as the sustained load. This load is modeled as constant until a change in tenant or occupancy type occurs. A live-load survey provides the statistics of the sustained load. Table C4-2 gives the mean, m_s, and standard deviation, σ_x, for particular reference areas. In addition to the sustained load, a building is likely to be subjected to a number of relatively short-duration, high-intensity, extraordinary, or transient loading events (due to crowding in special or emergency circumstances, concentrations during remodeling, and the like). Limited survey information and theoretical considerations lead to the means, m_t, and standard deviations, σ_t, of single transient loads shown in Table C4-2.

Combination of the sustained load and transient load processes, with due regard for the probabilities of occurrence, leads to statistics of the maximum total load during a specified reference period T. The statistics of the maximum total load depend on the average duration of an individual tenancy, τ, the mean rate of occurrence of the transient load, ν_e, and the reference period, T. Mean values are given in Table C4-2. The mean of the maximum load is similar, in most cases, to the Table 4-1 values of minimum uniformly distributed live loads and, in general, is a suitable design value.

For library stack rooms, the 150 psf (7.18 kN/m) uniform live load specified in Table 4-1 is intended to cover the range of ordinary library shelving. The most important variables that affect the floor loading are the book stack unit height and the ratio of the shelf depth to the aisle width. Common book stack units have a nominal height of 90 in. (2,290 mm) or less, with shelf depths in the range of 8 in. (203 mm) to 12 in. (305 mm). Book weights vary, depending on their size and paper density, but there are practical limits to what can be stored in any given space. Book stack weights also vary, but not by enough to significantly affect the overall loading. Considering the practical combinations of the relevant dimensions, weights, and other parameters, if parallel rows of ordinary double-faced book stacks are separated by aisles that are at least 36 in. (914 mm) wide, then the average floor loading is unlikely to exceed the specified 150 psf (7.18 kN/m^2), even after allowing for a nominal aisle floor loading of 20 to 40 psf (0.96 to 1.92 kN/m^2).

The 150 psf floor loading is also applicable to typical file cabinet installations, provided that the 36-in. minimum aisle width is maintained. Five-drawer lateral or conventional file cabinets, even with two levels of book shelves stacked above them, are unlikely to exceed the 150 psf average floor loading unless all drawers and shelves are filled to capacity with maximum density paper. Such a condition is essentially an upper bound for which the normal load factors and safety factors applied to the 150 psf criterion should still provide a safe design.

If a library shelving installation does not fall within the parameter limits that are specified in footnote *c* of Table 4-1, then the design should account for the actual conditions. For example, the floor loading for storage of medical X-ray film may easily exceed 200 psf (9.58 kN/m^2), mainly because of the increased depth of the shelves. Mobile library shelving that rolls on rails should also be designed to meet the actual requirements of the specific installation, which may easily exceed 300 psf (14.4 kN/m^2). The rail support locations and deflection limits should be considered in the design, and the engineer should work closely with the system manufacturer to provide a serviceable structure.

The lateral loads of Table 4-1, footnote *k*, applies to "stadiums and arenas" and to "reviewing stands, grandstands, and bleachers." However, it does not apply to "gymnasiums—main floors and balconies." Consideration should be given to treating gymnasium balconies that have stepped floors for seating as arenas, and requiring the appropriate swaying forces.

For the 2010 version of the standard, the provision in the live load table for "Marquees" with its distributed load requirement of 75 psf has been removed, along with "Roofs used for promenade purposes" and its 60 psf loading. Both "marquee" and "promenade" are considered archaic terms that are not used elsewhere in the standard or in building codes, with the exception of the listings in the live load tables. "Promenade purposes" is essentially an assembly use and is more clearly identified as such.

"Marquee" has not been defined in ASCE 7 but has been defined in building codes as a roofed structure that projects into a public right-of-way. However, the relationship between a structure and a right-of-way does not control loads that are applied to a structure. The marquee should therefore be designed with all of the loads appropriate for a roofed structure. If the arrangement of the structure is such that it invites additional occupant loading (e.g., there is window access that might invite loading for spectators of a parade), balcony loading should be considered for the design.

Balconies and decks are recognized as often having distinctly different loading patterns than most interior rooms. They are often subjected to concentrated line loads from people congregating along the edge of the structure (e.g., for viewing vantage points). This loading condition is acknowledged in Table 4-1 as an increase of the live load for the area served, up to the point of satisfying the loading requirement for most assembly occupancies. As always, the designer should be aware of potential unusual loading patterns in their structure that are not covered by these minimum standards.

C4.3.2 Provision for Partitions

The 2005 version of the standard provides the minimum partition load for the first time, although the requirement for the load has been included for many years. Historically a value of 20 psf has been required by building codes. This load, however, has sometimes been treated as a dead load.

If we assume that a normal partition would be a stud wall with ½-in. gypsum board on each side (8 psf per Table C3-1), 10 ft high, we end up with a wall load on the floor of 80 lb/ft. If the partitions are spaced throughout the floor area creating rooms on a grid 10 ft on center, which would be an extremely dense spacing over a whole bay, the average distributed load would be 16 psf. A design value of 15 psf is judged to be reasonable in that the partitions are not likely to be spaced this closely over large areas. Designers should consider a larger design load for partitions if a high density of partitions is anticipated.

C4.3.3 Partial Loading

It is intended that the full intensity of the appropriately reduced live load over portions of the structure or member be considered, as well as a live load of the same intensity over the full length of the structure or member.

Partial-length loads on a simple beam or truss will produce higher shear on a portion of the span than a full-length load. "Checkerboard" loadings on multistoried, multipanel bents will produce higher positive moments than full loads, while loads on either side of a support will produce greater negative moments. Loads on the half span of arches and domes or on the two central quarters can be critical.

For roofs, all probable load patterns should be considered uniform for roof live loads that are reduced to less than 20 lb/ft^2 (0.96 kN/m^2) using Section 4.8. Where the full value of the roof live load (L_r) is used without reduction, it is considered that there is a low probability that the live load created by maintenance workers, equipment, and material could occur in a patterned arrangement. Where a uniform roof live load is caused by an occupancy, partial or pattern loading should be considered regardless of the magnitude of the uniform load. Cantilevers must not rely on a possible live load on the anchor span for equilibrium.

C4.4 CONCENTRATED LIVE LOADS

The provision in Table 4-1 regarding concentrated loads supported by roof trusses or other primary roof members is intended to provide for a common situation for which specific requirements are generally lacking.

Primary roof members are main structural members such as roof trusses, girders, and frames, which are exposed to a work floor below, where the failure of such a primary member resulting from their use as attachment points for lifting or hoisting loads could lead to the collapse of the roof. Single roof purlins or rafters (where there are multiple such members placed side by side at some reasonably small center-to-center spacing, and where the failure of a single such member would not lead to the collapse of the roof) are not considered to be primary roof members.

Helipads. These provisions are added to the standard in 2010. For the standard, the term "helipads" is used to refer specifically to the structural surface. In building codes and other references, different terminology may be used when describing helipads, e.g., heliports, helistops, but the distinctions between these are not relevant to the structural loading issue addressed in ASCE 7.

Although these structures are intended to be specifically kept clear of non-helicopter occupant loads on the landing and taxi areas, the uniform load requirement is a minimum to ensure a degree of substantial construction and the potential to resist the effects of unusual events.

Concentrated loads applied separately from the distributed loads are intended to cover the primary helicopter loads. The designer should always consider the geometry of the design basis helicopter for applying the design loads. A factor of 1.5 is used to address impact loads (two single concentrated loads of 0.75 times the maximum take-off weight), to account for a hard landing with many kinds of landing gear. The designer should be aware that some helicopter configurations, particularly those with rigid landing gear, could result in substantially higher impact factors that should be considered.

The 3000-lb (13.35-kN) concentrated load is intended to cover maintenance activities, similar to the jack load for a parking garage.

Additional information on helipad design can be found in International Civil Aviation Organization (1995). Note that the Federal Aviation Administration provides standards for helicopter landing pads, including labeling for weight limitations (U.S. Department of Transportation 2004).

C4.5 LOADS ON HANDRAIL, GUARDRAIL, GRAB BAR, AND VEHICLE BARRIER SYSTEMS, AND FIXED LADDERS

C4.5.1 Loads on Handrail and Guardrail Systems

Loads that can be expected to occur on handrail and guardrail systems are highly dependent on the use and occupancy of the protected area. For cases in which extreme loads can be anticipated, such as long straight runs of guardrail systems against which crowds can surge, appropriate increases in loading shall be considered.

C4.5.2 Loads on Grab Bar Systems

When grab bars are provided for use by persons with physical disabilities, the design is governed by CABO A117.1 *Accessible and Usable Buildings and Facilities*.

C4.5.3 Loads on Vehicle Barrier Systems

Vehicle barrier systems may be subjected to horizontal loads from moving vehicles. These horizontal loads may be applied normal to the plane of the barrier system, parallel to the plane of the barrier system, or at any intermediate angle. Loads in garages accommodating trucks and buses may be obtained from the provisions contained in AASHTO (1989).

C4.5.4 Loads on Fixed Ladders

This provision was introduced to the standard in 1998 and is consistent with the provisions for stairs.

Side rail extensions of fixed ladders are often flexible and weak in the lateral direction. OSHA (CFR 1910) requires side rail extensions, with specific geometric requirements only. The load provided was introduced to the standard in 1998 and has been determined on the basis of a 250-lb person standing on a rung of the ladder, and accounting for reasonable angles of pull on the rail extension.

C4.6 IMPACT LOADS

Grandstands, stadiums, and similar assembly structures may be subjected to loads caused by crowds swaying in unison, jumping to their feet, or stomping. Designers are cautioned that the possibility of such loads should be considered.

Elevator loads are changed in the standard from a direct 100% impact factor to a reference to ASME A17.1. The provisions in ASME A17.1 include the 100% impact factor, along with deflection limits on the applicable elements.

C4.7 REDUCTION IN LIVE LOADS

C4.7.1 General

The concept of, and methods for, determining member live load reductions as a function of a loaded member's influence area, A_I, was first introduced into this standard in 1982 and was the first such change since the concept of live load reduction was introduced over 40 years ago. The revised formula is a result of more extensive survey data and theoretical analysis (Harris et al. 1981). The change in format to a reduction multiplier results in a formula that is simple and more convenient to use. The use of influence area, now defined as a function of the tributary area, A_T, in a single equation has been shown to give more consistent reliability for the various structural effects. The influence area is defined as that floor area over which the influence surface for structural effects is significantly different from zero.

The factor K_{LL} is the ratio of the influence area (A_I) of a member to its tributary area (A_T), that is, $K_{LL} = A_I/A_T$, and is used to better define the influence area of a member as a function of its tributary area. Figure C4-1 illustrates typical influence areas and tributary areas for a structure with regular bay spacings. Table 4-2 has established K_{LL} values (derived from calculated K_{LL} values) to be used in Eq. 4-1 for a variety of structural members and configurations. Calculated K_{LL} values vary for column and beam members having adjacent cantilever construction, as is shown in Fig. C4-1, and the Table 4-2 values have been set for these cases to result in live load reductions that are slightly conservative. For unusual shapes, the concept of significant influence effect should be applied.

An example of a member without provisions for continuous shear transfer normal to its span would be a precast T-beam or double-T beam that may have an expansion joint along one or both flanges, or that may have only intermittent weld tabs along the edges of the flanges. Such members do not have the ability to share loads located within their tributary areas with adjacent members, thus resulting in $K_{LL} = 1$ for these types of members. Reductions are permissible for two-way slabs and for beams, but care should be taken in defining the appropriate influence area. For multiple floors, areas for members supporting more than one floor are summed.

The formula provides a continuous transition from unreduced to reduced loads. The smallest allowed value of the reduction multiplier is 0.4 (providing a maximum 60 percent reduction), but there is a minimum of 0.5 (providing a 50 percent reduction) for members with a contributory load from just one floor.

C4.7.3 Heavy Live Loads

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 not be reduced for the floor-and-beam design, but that it could be reduced a flat 20 percent for the design of members supporting more than one floor. Accordingly, this principle has been incorporated in the recommended requirement.

C4.7.4 Passenger Vehicle Garages

Unlike live loads in office and residential buildings, which are generally spatially random, parking garage loads are due to vehicles parked in regular patterns, and the garages are often full. The rationale behind the reduction according to area for other live loads, therefore, does not apply. A load survey of vehicle weights was conducted at nine commercial parking garages in four cities of different sizes (Wen and Yeo 2001). Statistical analyses of the maximum load effects on beams and columns due to vehicle loads over the garage's life were carried out using the survey results. Dynamic effects on the deck due to vehicle motions and on the ramp due to impact were investigated. The equivalent uniformly distributed loads (EUDL) that would produce the lifetime maximum column axial force and midspan beam bending moment are conservatively estimated at 34.8 psf. The EUDL is not sensitive to bay-size variation. In view of the possible impact of very heavy vehicles in the future such as sport-utility vehicles, however, a design load of 40 psf is recommended with no allowance for reduction according to bay area.

Compared with the design live load of 50 psf given in previous editions of the standard, the design load contained herein represents a 20 percent reduction, but it is still 33 percent higher than the 30 psf one would obtain were an area-based reduction to be applied to the 50 psf value for large bays as allowed in most standards. Also the variability of the maximum parking garage load effect is found to be small with a coefficient of variation less than 5 percent in comparison with 20 percent to 30 percent for most other live loads. The implication is that when a live load factor of 1.6 is used in design, additional conservatism is built into it such that the recommended value would also be sufficiently conservative for special purpose parking (e.g., valet parking) where vehicles may be more densely parked causing a higher load effect. Therefore, the 50 psf design value was felt to be overly conservative, and it can be reduced to 40 psf without sacrificing structural integrity.

In view of the large load effect produced by a single heavy vehicle (up to 10,000 lb), the current concentrated load of 2,000 lb should be increased to 3,000 lb acting on an area of 4.5 in. × 4.5 in., which represents the load caused by a jack in changing tires.

C4.7.6 Limitations on One-Way Slabs

One-way slabs behave in a manner similar to two-way slabs but do not benefit from having a higher redundancy that results from two-way action. For this reason, it is appropriate to allow a live load reduction for one-way slabs but restrict the tributary area, A_T, to an area that is the product of the slab span times a width normal to the span not greater than 1.5 times the span (thus resulting in an area with an aspect ratio of 1.5). For one-way slabs with aspect ratios greater than 1.5, the effect will be to give a somewhat higher live load (where a reduction has been allowed) than for two-way slabs with the same ratio.

Members, such as hollow-core slabs, that have grouted continuous shear keys along their edges and span in one direction only, are considered as one-way slabs for live load reduction even though they may have continuous shear transfer normal to their span.

C4.8 REDUCTION IN ROOF LIVE LOADS

C4.8.2 Flat, Pitched, and Curved Roofs

The values specified in Eq. 4-2 that act vertically upon the projected area have been selected as minimum roof live loads, even in localities where little or no snowfall occurs. This is because it is considered necessary to provide for occasional loading due to the presence of workers and materials during repair operations.

C4.8.3 Special Purpose Roofs

Designers should consider any additional dead loads that may be imposed by saturated landscaping materials in addition to the live load required in Table 4-1. Occupancy related loads on roofs are live loads (L) normally associated with the design of floors rather than roof live loads (L_r), and are permitted to be reduced in accordance with the provisions for live loads in Section 4.7 rather than Section 4.8.

C4.9 CRANE LOADS

All support components of moving bridge cranes and monorail cranes, including runway beams, brackets, bracing, and connections, shall be designed to support the maximum wheel load of the crane and the vertical impact, lateral, and longitudinal forces induced by the moving crane. Also, the runway beams shall be designed for crane stop forces. The methods for determining these loads vary depending on the type of crane system and support. MHI (2003, 2004a, 2004b) and MBMA (2006) describe types of bridge cranes and monorail cranes. Cranes described in these references include top running bridge cranes with top running trolley, underhung bridge cranes, and underhung monorail cranes. AISE (2003) gives more stringent requirements for crane runway designs that are more appropriate for higher capacity or higher speed crane systems.

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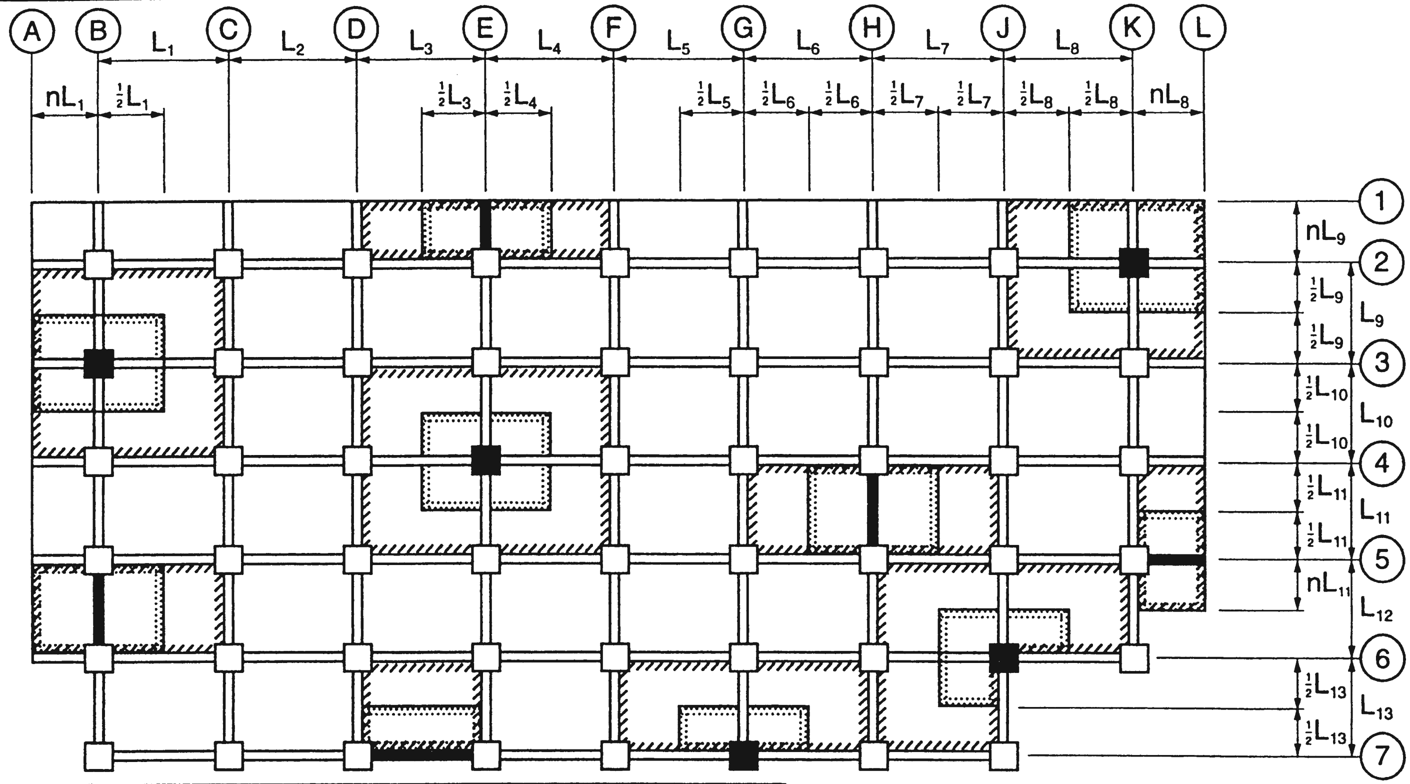


Element	Actual K_{LL} Members w/o Cantilevers	Actual K_{LL} Members w/ Cantilevers			K_{LL} (Table 4-2)	Example Member (Fig. C-4)
		n = 0	n = 0.5	n = 1.0		
Interior Columns	4	-	-	-	4	E4
Exterior Columns w/o cantilevers	4	-	-	-	4	G7, J6
Edge Columns w/ cantilevers	-	4	3	2.67	3	B3
Corner Columns w/ cantilevers	-	4	2.25	1.78	2	K2
Edge Beams w/o cantilever slabs	2	-	-	-	2	D7 - E7
Interior Beams	2	-	-	-	2	H4 - H5
Edge Beams w/ cantilever slabs	-	2	1.5	1.33	1	B5 - B6
Cantilever Beams w/o cantilever slabs	2	-	-	-	1	E1 - E2
Cantilever Beams w/ cantilever slabs	-	2*	1.5*	1.33*	1	K5 - L5

* The value of n for member K5-L5 is used to calculate the distance nL_{11}

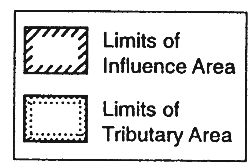


FIGURE C4-1 Typical Tributary and Influence Areas.

Table C4-1 Minimum Uniformly Distributed Live Loads

Occupancy or Use	Live Load lb/ft^2 (kN/m^2)	Occupancy or use	Live Load lb/ft^2 (kN/m^2)
Air conditioning (machine space)	200[a] (9.58)	Kitchens, other than domestic	150[a] (7.18)
Amusement park structure	100[a] (4.79)	Laboratories, scientific	100 (4.79)
Attic, nonresidential		Laundries	150[a] (7.18)
Nonstorage	25 (1.20)	Manufacturing, ice	300 (14.36)
Storage	80[a] (3.83)	Morgue	125 (6.00)
Bakery	150 (7.18)	Printing plants	
Boathouse, floors	100[a] (4.79)	Composing rooms	100 (4.79)
Boiler room, framed	300[a] (14.36)	Linotype rooms	100 (4.79)
Broadcasting studio	100 (4.79)	Paper storage	[d]
Ceiling, accessible furred	10[f] (0.48)	Press rooms	150[a] (7.18)
Cold storage		Railroad tracks	[e]
No overhead system	250[b] (11.97)	Ramps	
Overhead system		Seaplane (see hangars)	
Floor	150 (7.18)	Rest rooms	60 (2.87)
Roof	250 (11.97)	Rinks	
Computer equipment	150[a] (7.18)	Ice skating	250 (11.97)
Courtrooms	50–100 (2.40–4.79)	Roller skating	100 (4.79)
Dormitories		Storage, hay or grain	300[a] (14.36)
Nonpartitioned	80 (3.83)	Theaters	
Partitioned	40 (1.92)	Dressing rooms	40 (1.92)
Elevator machine room	150[a] (7.18)	Gridiron floor or fly gallery:	
Fan room	150[a] (7.18)	Grating	60 (2.87)
Foundries	600[a] (28.73)	Well beams	250 lb/ft per pair
Fuel rooms, framed	400 (19.15)	Header beams	1,000 lb/ft
Greenhouses	150 (7.18)	Pin rail	250 lb/ft
Hangars	150[c] (7.18)	Projection room	100 (4.79)
Incinerator charging floor	100 (4.79)	Toilet rooms	60 (2.87)
		Transformer rooms	200[a] (9.58)
		Vaults, in offices	250[a] (11.97)

[a]Use weight of actual equipment or stored material when greater. Note that fixed service equipment is treated as a Dead Load instead of Live Load.
[b]Plus 150 lb/ft^2 (7.18 kN/m^2) for trucks.
[c]Use American Association of State Highway and Transportation Officials lane loads. Also subject to not less than 100% maximum axle load.
[d]Paper storage 50 lb/ft^2 per foot of clear story height.
[e]As required by railroad company.
[f]Accessible ceilings normally are not designed to support persons. The value in this table is intended to account for occasional light storage or suspension of items. If it may be necessary to support the weight of maintenance personnel, this shall be provided for.

Table C4-2 Typical Live Load Statistics

	Survey Load		Transient Load		Temporal Constants			Mean Maximum Load[a]
	m_s	σ_s[a]	m_t[a]	σ_t[a]	τ_s[b]	v_e[c]	T[d]	
Occupancy or Use	lb/ft^2 (kN/m^2)	lb/ft^2 (kN/m^2)	lb/ft^2 (kN/m^2)	lb/ft^2 (kN/m^2)	(years)	(per year)	(years)	lb/ft^2 (kN/m^2)
Office buildings: offices	10.9 (0.52)	5.9 (0.28)	8.0 (0.38)	8.2 (0.39)	8	1	50	55 (2.63)
Residential								
renter occupied	6.0 (0.29)	2.6 (0.12)	6.0 (0.29)	6.6 (0.32)	2	1	50	36 (1.72)
owner occupied	6.0 (0.29)	2.6 (0.12)	6.0 (0.29)	6.6 (0.32)	10	1	50	38 (1.82)
Hotels: guest rooms	4.5 (0.22)	1.2 (0.06)	6.0 (0.29)	5.8 (0.28)	5	20	50	46 (2.2)
Schools: classrooms	12.0 (0.57)	2.7 (0.13)	6.9 (0.33)	3.4 (0.16)	1	1	100	34 (1.63)

[a]For 200 ft^2 (18.58 m^2) area, except 1,000 ft^2 (92.9 m^2) for schools.
[b]Duration of average sustained load occupancy.
[c]Mean rate of occurrence of transient load.
[d]Reference period.

TABLE 1

ALLOWABLE SHEAR (POUNDS PER FOOT) FOR APA PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS-FIR, LARCH, OR SOUTHERN PINE[a] FOR WIND OR SEISMIC LOADING [b,h,i,j,k] (See also IBC Table 2306.4.1)

Panel Grade	Minimum Nominal Panel Thickness (in.)	Minimum Nail Penetration in Framing (in.)	Panels Applied Direct to Framing: Nail Size (common or galvanized box)[k]	Panels Applied Direct to Framing: Nail Spacing at Panel Edges (in.) 6	4	3	2[e]	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Size (common or galvanized box)	Panels Applied Over 1/2" or 5/8" Gypsum Sheathing: Nail Spacing at Panel Edges (in.) 6	4	3	2[e]
APA STRUCTURAL I grades	5/16	1-1/4	6d (0.113" dia.)	200	300	390	510	8d (0.131" dia.)	200	300	390	510
	3/8	1-3/8	8d (0.131" dia.)	230[d]	360[d]	460[d]	610[d]	10d (0.148" dia.)	280	430	550[f]	730
	7/16			255[d]	395[d]	505[d]	670[d]					
	15/32			280	430	550	730					
	15/32	1-1/2	10d (0.148" dia.)	340	510	665[f]	870		—	—	—	—
APA RATED SHEATHING; APA RATED SIDING[g] and other APA grades except Species Group 5	5/16 or 1/4[c]	1-1/4	6d (0.113" dia.)	180	270	350	450	8d (0.131 dia.)	180	270	350	450
	3/8			200	300	390	510		200	300	390	510
	3/8	1-3/8	8d (0.131" dia.)	220[d]	320[d]	410[d]	530[d]	10d (0.148" dia.)	260	380	490[f]	640
	7/16			240[d]	350[d]	450[d]	585[d]					
	15/32			260	380	490	640					
	15/32	1-1/2	10d (0.148" dia.)	310	460	600[f]	770	—	—	—	—	—
	19/32			340	510	665[f]	870	—	—	—	—	—
APA RATED SIDING[g] and other APA grades except Species Group 5			Nail Size (galvanized casing)					Nail Size (galvanized casing)				
	5/16[c]	1-1/4	6d (0.113" dia.)	140	210	275	360	8d (0.131" dia.)	140	210	275	360
	3/8	1-3/8	8d (0.131" dia.)	160	240	310	410	10d (0.148" dia.)	160	240	310[f]	410

(a) For framing of other species: Find specific gravity for species of lumber in the AF&PA National Design Specification (NDS). Find shear value from table above for nail size for actual grade and multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = Specific Gravity of the framing lumber. This adjustment shall not be greater than 1.

(b) Panel edges backed with 2 inch nominal or wider framing. Install panels either horizontally or vertically. Space fasteners maximum 6 inches on center along intermediate framing members for 3/8 inch and 7/16 inch panels installed on studs spaced 24 inches on center. For other conditions and panel thicknesses, space nails maximum 12 inches on center on intermediate supports.

(c) 3/8 inch panel thickness or siding with a span rating of 16 inches on center is the minimum recommended where applied direct to framing as exterior siding.

(d) Allowable shear values are permitted to be increased to values shown for 15/32 inch sheathing with same nailing provided (1) studs are spaced a maximum of 16 inch on center, or (2) panels are applied with long dimension across studs.

(e) Framing at adjoining panel edges shall be 3 inch nominal or wider, and nails shall be staggered where nails are spaced 2 inch on center.

(f) Framing at adjoining panel edges shall be 3 inch nominal or wider, and nails shall be staggered where both the following conditions are met: (1) 10d (3 inch x 0.148 inch) nails having penetration into framing of more than 1-1/2 inch and (2) nails are spaced 3 inch on center.

(g) Values apply to all-veneer plywood. Thickness at point of fastening on panel edges governs shear values.

(h) Where panels applied on both faces of a wall and nail spacing is less than 6 inches o.c. on either side, panel joints shall be offset to fall on different framing members, or framing shall be 3 inch nominal or thicker at adjoining panel edges and nails on each side shall be staggered.

(i) In Seismic Design Category D, E or F, where shear design values exceed 350 pounds per lineal foot, all framing members receiving edge nailing from abutting panels shall not be less than a single 3 inch nominal member, or two 2 inch nominal members fastened together in accordance with IBC Section 2306.1 to transfer the design shear value between framing members. Wood structural panel joint and sill plate nailing shall be staggered in all cases. See IBC Section 2305.3.11 for sill plate size and anchorage requirements.

(j) Galvanized nails shall be hot dipped or tumbled.

(k) For shear loads of normal or permanent load duration as defined by the AF&PA NDS, the values in the table above shall be multiplied by 0.63 or 0.56, respectively.

Typical Layout for Shear Walls

TABLE 2

ALLOWABLE SHEAR (POUNDS PER FOOT) FOR HORIZONTAL APA PANEL DIAPHRAGMS WITH FRAMING OF DOUGLAS-FIR, LARCH OR SOUTHERN PINE (a) FOR WIND OR SEISMIC LOADING (g) (See also IBC Table 2306.3.1)

					Blocked Diaphragms				Unblocked Diaphragms	
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)(b)				Nails Spaced 6" max. at Supported Edges (b)	
					6	4	2-1/2 (c)	2 (c)		
					Nail Spacing (in.) at other panel edges (Cases 1, 2, 3 & 4)(b)					
Panel Grade	Common Nail Size (f)	Minimum Nail Penetration in Framing (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Framing Member at Adjoining Panel Edges and Boundaries (in.)	6	6	4	3	Case 1 (No unblocked edges or continuous joints parallel to load)	All other configurations (Cases 2, 3, 4, 5 & 6)
APA STRUCTURAL I grades	6d (e) (0.113" dia.)	1-1/4	5/16	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d (0.131" dia.)	1-3/8	3/8	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d (d) (0.148" dia.)	1-1/2	15/32	2	320	425	640	730	285	215
				3	360	480	720	820	320	240
APA RATED SHEATHING; APA RATED STURD-I-FLOOR and other APA grades except Species Group 5	6d (e) (0.113" dia.)	1-1/4	5/16	2	170	225	335	380	150	110
				3	190	250	380	430	170	125
			3/8	2	185	250	375	420	165	125
				3	210	280	420	475	185	140
	8d (0.131" dia.)	1-3/8	3/8	2	240	320	480	545	215	160
				3	270	360	540	610	240	180
			7/16	2	255	340	505	575	230	170
				3	285	380	570	645	255	190
			15/32	2	270	360	530	600	240	180
				3	300	400	600	675	265	200
	10d (d) (0.148" dia.)	1-1/2	15/32	2	290	385	575	655	255	190
				3	325	430	650	735	290	215
			19/32	2	320	425	640	730	285	215
				3	360	480	720	820	320	240

(a) For framing of other species: Find specific gravity for species of lumber in the AF&PA NDS. Find shear value from table above for nail size for actual grade and multiply value by the following adjustment factor: Specific Gravity Adjustment Factor = [1 – (0.5 – SG)], where SG = Specific Gravity of the framing lumber. This adjustment shall not be greater than 1.

(b) Space fasteners maximum 12 inches o.c. along intermediate framing members (6 inches o.c. when supports are spaced 48 inches o.c. or greater).

(c) Framing at adjoining panel edges shall be 3 inch nominal or wider, and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.

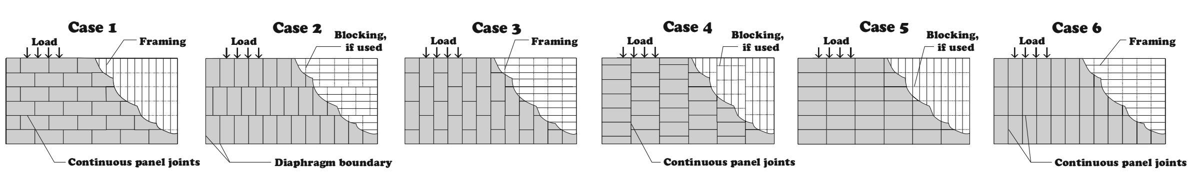
(d) Framing at adjoining panel edges shall be 3 inch nominal or wider, and nails shall be staggered where both of the following conditions are met: (1) 10d nails having penetration into framing of more than 1-1/2 inches and (2) nails are spaced 3 inches o.c. or less.

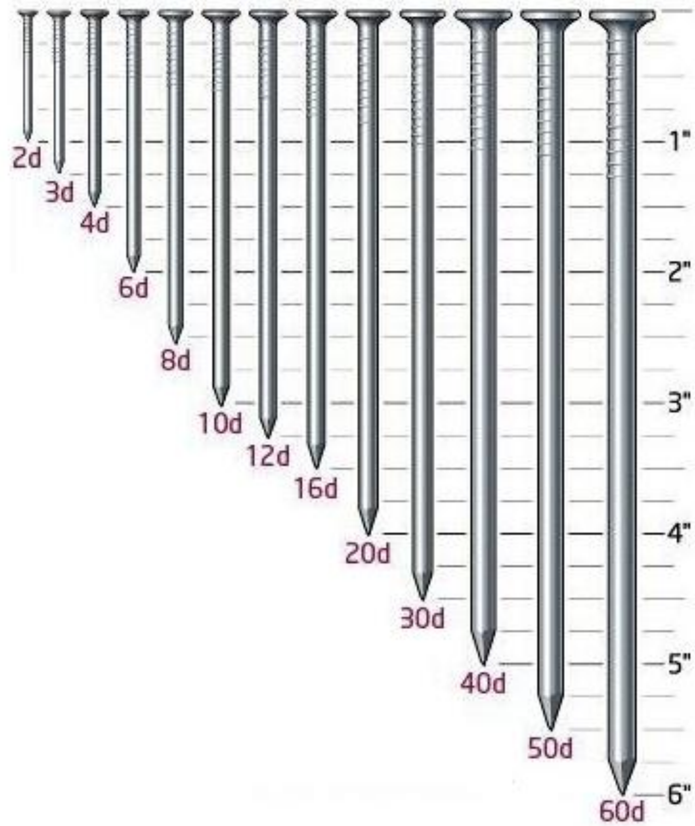
(e) 8d is recommended minimum for roofs due to negative pressures of high winds.

(f) The minimum nominal width of frraming members not located at boundaries or adjoining panel edges shall be 2 inches

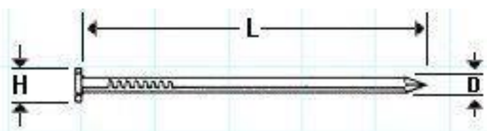
(g) For shear loads of normal or permanent load duration as defined by AF&PA NDS, the values in the table above shall be multiplied by 0.63 and 0.56, respectively.

Note: Design for diaphragm stresses depends on direction of continuous panel joints with reference to load, not on direction of long dimension or strength axis of sheet. Continuous framing may be in either direction for blocked diaphragms.





Common Nails
Smooth Shank



Nail Size		D	L	H	Nail Count		
		Shank Diameter	Shank Length	Head Diameter	per lb (aprox.)		
Penny	Gauge	Nominal	Nominal	Aprx.	Alum.	Cop.	SS.
2D	15	0.072	1"	3/16"	2225	689	760
	14	0.083	1"	13/64"		573	586
3D	14	0.083	1-¼"	13/64"	1375	421	477
4D	12	0.109	1-½"	1/4"	800	204	229
5D	12	0.109	1-¾"	1/4"		162	182
6D	11	0.120	2"	17/64"	425	130	147
8D	10	0.134	2-½"	9/32"	230	83	94
10D	9	0.148	3"	5/16"	165	55	63
12D	9	0.148	3-¼"	5/16"		52	59
16D	8	0.165	3-½"	11/32"	120	40	44
20D	6	0.203	4"	13/32"	78	23	25
30D	5	0.220	4-½"	7/16"		18	18
40D	4	0.238	5"	15/32"		14	14
60D	4	0.238	6"	17/32"			13
	2	0.284	6"	17/32"		8	

SHEAR WALL SCHEDULE

MARK	PLYWOOD AND NAILING	FLOOR PLATE NAILING	FRAMING ANCHORS @FLOOR & ROOF	VERTICAL HOLDDOWNS @ FLOOR OR @ CONC. LEVEL	CAPACITY	ANCHOR BOLTS
A	15/32 w/ 10d @ 6" EDGE 12" FIELD	3/8" Ø x 8" @ 24"	LTP5 OR A35 @ 24" O.C.	HDU2 w/ 4x4 MIN.	280 LBS. PER FT.	5/8" Ø x 12" @ 48" O.C.
B	15/32 w/ 10d @ 4" EDGE 12" FIELD	3/8" Ø x 8" @ 16"	LTP5 OR A35 @ 16" O.C.	HDU4 w/ 4x4 MIN.	430 LBS. PER FT.	5/8" Ø x 12" @ 32" O.C.
C	15/32 w/ 10d @ 3" EDGE 12" FIELD	3/8" Ø x 8" @ 12"	LTP5 OR A35 @ 16" O.C.	HDU5 w/ 4x4 MIN.	550 LBS. PER FT.	5/8" Ø x 12" @ 24" O.C.
D	15/32 w/ 10d @ 2" EDGE 12" FIELD	3/8" Ø x 8" @ 8" 3x BLK'G.	LTP5 OR A35 @ 12" O.C.	HDU8 w/ 4x8 MIN.	730 LBS. PER FT.	5/8" Ø x 12" @ 16" O.C.
E	15/32 E. F. w/ 10d @ 4" EDGE 12" FIELD	3/8" Ø x 8" @ 6" 3x BLK'G.	LTP5 OR A35 @ 10" O.C.	HDU8 w/ 4x8 MIN.	860 LBS. PER FT.	5/8" Ø x 12" @ 16" O.C.
F	15/32 E. F. w/ 10d @ 3" EDGE 12" FIELD	3/8" Ø x 8" @ 4" 3x BLK'G.	LTP5 OR A35 @ 8" O.C.	HDU11 w/ 4x8 MIN.	1100 LBS. PER FT.	3/4" Ø x 12" @ 16" O.C.
G	15/32 E. F. w/ 10d @ 2" EDGE 12" FIELD	3/8" Ø x 8" @ 3" 3x BLK'G.	LTP5 OR A35 @ 6" O.C.	HDU14 w/ 6x6 MIN.	1460 LBS. PER FT.	3/4" Ø x 12" @ 12" O.C.
	COMMON NAILS	LAG BOLTS				

1806.2 Presumptive load-bearing values

The load-bearing values used in design for supporting soils near the surface shall not exceed the values specified in Table 1806.2 unless data to substantiate the use of higher values are submitted and approved. Where the building official has reason to doubt the classification, strength or compressibility of the soil, the requirements of Section 1803.5.2 shall be satisfied.

Presumptive load-bearing values shall apply to materials with similar physical characteristics and dispositions. Mud, organic silt, organic clays, peat or unprepared fill shall not be assumed to have a presumptive load-bearing capacity unless data to substantiate the use of such a value are submitted.

> **Exception:** A presumptive load-bearing capacity shall be permitted to be used where the building official deems the load-bearing capacity of mud, organic silt or unprepared fill is adequate for the support of lightweight or temporary structures.

TABLE 1806.2

PRESUMPTIVE LOAD-BEARING VALUES

CLASS OF MATERIALS	VERTICAL FOUNDATION PRESSURE (psf)	LATERAL BEARING PRESSURE (psf/ft below natural grade)	LATERAL SLIDING RESISTANCE	
			Coefficient of friction[a]	Cohesion (psf)[b]
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500	100	—	130

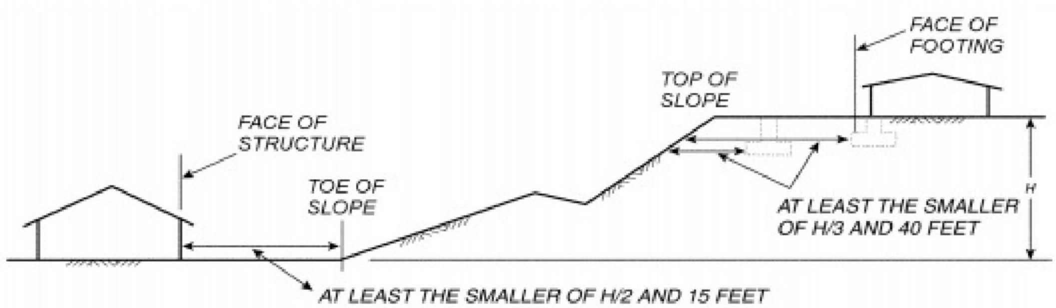
For SI: 1 pound per square foot = 0.0479kPa, 1 pound per square foot per foot = 0.157 kPa/m.

a. Coefficient to be multiplied by the dead load.

b. Cohesion value to be multiplied by the contact area, as limited by Section 1806.3.2.

1808.7.1 Building clearance from ascending slopes

In general, buildings below slopes shall be set a sufficient distance from the slope to provide protection from slope drainage, erosion and shallow failures. Except as provided in Section 1808.7.5 and Figure 1808.7.1, the following criteria will be assumed to provide this protection. Where the existing slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the toe of the slope shall be assumed to be at the intersection of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees (0.79 rad) to the horizontal. Where a retaining wall is constructed at the toe of the slope, the height of the slope shall be measured from the top of the wall to the top of the slope.



For SI: 1 foot = 304.8 mm.

FIGURE 1808.7.1

FOUNDATION CLEARANCES FROM SLOPES

1808.7.2 Foundation setback from descending slope surface

Foundations on or adjacent to slope surfaces shall be founded in firm material with an embedment and set back from the slope surface sufficient to provide vertical and lateral support for the foundation without detrimental settlement. Except as provided for in Section 1808.7.5 and Figure 1808.7.1, the following setback is deemed adequate to meet the criteria. Where the slope is steeper than 1 unit vertical in 1 unit horizontal (100-percent slope), the required setback shall be measured from an imaginary plane 45 degrees (0.79 rad) to the horizontal, projected upward from the toe of the slope.