

## 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 ( $\text{lb}/\text{ft}^2$ ) ( $\text{kN}/\text{m}^2$ ) of given thickness (see Table C3-1). Pounds-per-cubic-foot ( $\text{lb}/\text{ft}^3$ ) ( $\text{kN}/\text{m}^3$ ) 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 includes high earth pressures, 85 pcf ( $13.36 \text{ kN}/\text{m}^2$ ) 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 ( $9.43 \text{ kN}/\text{m}^2$ ) for granular soils and 100 pcf ( $15.71 \text{ kN}/\text{m}^2$ ) for silt and clay type soils [Ref. C3-1]. Examples of light floor systems supported on shallow basement walls mentioned in Table 3-2 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  $45^\circ$  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

Ref. C3-1 Terzaghi, K., and Peck, R.B. (1967). *Soil Mechanics in Engineering Practice*. 2nd ed. Wiley, New York.

TABLE C3-1 MINIMUM DESIGN DEAD LOADS\*

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

\*Weights of masonry include mortar but not plaster. For plaster, add 5 lb/ft<sup>2</sup> for each face plastered. Values given represent averages. In some cases there is a considerable range of weight for the same construction.

(continued)

**TABLE C3-1 continued  
MINIMUM DESIGN DEAD LOADS\***

Component	Load (psf)	Component	Load (psf)
<b>FLOORS AND FLOOR FINISHES</b>		Windows, glass, frame, and sash	8
Asphalt block (2-in.), 1/2-in. mortar	30	Clay brick wythes:	
Cement finish (1-in.) on stone-concrete fill	32	4 in.	39
Ceramic or quarry tile (3/4-in.) on 1/2-in. mortar bed	16	8 in.	79
Ceramic or quarry tile (3/4-in.) on 1-in. mortar bed	23	12 in.	115
Concrete fill finish (per inch thickness)	12	16 in.	155
Hardwood flooring, 7/7-in.	4	Hollow concrete masonry unit wythes:	
Linoleum or asphalt tile, 1/4-in.	1	Wythe thickness (in inches)	6
Marble and mortar on stone-concrete fill	33	Density of unit (105 pcf)	4
Slate (per mm thickness)	15	No grout	24
Solid flat tile on 1-in. mortar base	23	48 in. o.c.	29
Subflooring, 3/4-in.	3	40 in. o.c.	30
Terrazzo (1-1/2-in.) directly on slab	19	grout	32
Terrazzo (1-in.) on stone-concrete fill	32	spacing	42
Terrazzo (1-in.), 2-in. stone concrete	32	24 in. o.c.	34
Wood block (3-in.) on mastic, no fill	10	16 in. o.c.	40
Wood block (3-in.) on 1/2-in. mortar base	16	Full grout	55
<b>FLOORS, WOOD-JOIST (NO PLASTER)</b>		Density of unit (125 pcf)	26
<b>DOUBLE WOOD FLOOR</b>		No grout	28
12-in. spacing	16	48 in. o.c.	33
16-in. spacing	16	40 in. o.c.	34
24-in. spacing (1b/ft <sup>2</sup> )	16	32 in. o.c.	36
Joint sizes (in.)		24 in. o.c.	39
2 × 6	6	16 in. o.c.	44
2 × 8	6	Full grout	59
2 × 10	7	Density of unit (135 pcf)	29
2 × 12	8	No grout	30
<b>FRAME PARTITIONS</b>		48 in. o.c.	36
Movable steel partitions	4	40 in. o.c.	37
Wood or steel studs, 1/2-in. gypsum board each side	8	grout	48
Wood studs, 2 × 4, unplastered	4	spacing	59
Wood studs, 2 × 4, plastered one side	12	24 in. o.c.	62
Wood studs, 2 × 4, plastered two sides	20	16 in. o.c.	78
<b>FRAME WALLS</b>		Full grout	90
Exterior stud walls:		Solid concrete masonry unit wythes (incl. concrete brick):	127
2 × 4 @ 16-in., 5/8-in. gypsum, insulated, 3/8-in. siding	11	Wythe thickness (in mm)	
2 × 6 @ 16-in., 5/8-in. gypsum, insulated, 3/8-in. siding	12	4	8
Exterior stud walls with brick veneer	48	Density of unit (105 pcf)	10
		Density of unit (125 pcf)	87
		Density of unit (135 pcf)	110

\*Weights of masonry include mortar but not plaster. For plaster, add 5 lb/ft<sup>2</sup> for each face plastered. Values given represent averages. In some cases there is a considerable range of weight for the same construction.

(continued)

**TABLE C3-1 continued**  
**MINIMUM DESIGN DEAD LOADS\***

Component	Load (kN/m <sup>2</sup> )	Component	Load (kN/m <sup>2</sup> )
<b>CEILING</b>			
Acoustical Fiber Board	0.05	Decking, 51 mm wood (Douglas fir)	0.24
Gypsum board (per mm thickness)	0.008	Decking, 76 mm wood (Douglas fir)	0.38
Mechanical duct allowance	0.19	Fiberboard, 13 mm	0.04
Plaster on tile or concrete	0.24	Gypsum sheathing, 13 mm	0.10
Plaster on wood lath	0.38	Insulation, roof boards (per mm thickness)	
Suspended steel channel system	0.10	Cellular glass	0.0013
Suspended metal lath and cement plaster	0.72	Fibrous glass	0.0021
Suspended metal lath and gypsum plaster	0.48	Fiberboard	0.0028
Wood furring suspension system	0.12	Perlite	0.0015
<b>COVERINGS, ROOF, AND WALL</b>		Polystyrene foam	0.0004
Asbestos-cement shingles		Urethane foam with skin	0.0009
Asphalt shingles	0.19	Plywood (per mm thickness)	0.006
Cement tile	0.10	Rigid insulation, 13 mm	0.04
Clay tile (for mortar add 0.48 kN/m <sup>2</sup> )	0.77	Skylight, metal frame, 10 mm wire glass	0.38
Book tile, 51 mm	0.57	Slate, 5 mm	0.34
Book tile, 76 mm	0.96	Slate, 6 mm	0.48
Ludowici	0.48	Waterproofing membranes:	
Roman	0.57	Bituminous, gravel-covered	0.26
Spanish	0.91	Bituminous, smooth surface	0.07
Composition:		Liquid applied	0.05
Three-ply ready roofing	0.05	Single-ply, sheet	0.03
Four-ply felt and gravel	0.26	Wood sheathing (per mm thickness)	0.0057
Five-ply felt and gravel	0.29	Wood shingles	0.14
Copper or tin	0.05	FLOOR FILL	
Corrugated asbestos-cement roofing	0.19	Cinder concrete, per mm	0.017
Deck, metal, 20 gage	0.12	Lightweight concrete, per mm	0.015
Deck, metal, 18 gage	0.14	Sand, per mm	0.015
		Stone concrete, per mm	0.023

\*Weights of masonry include mortar but not plaster. For plaster, add 5 lb/ft<sup>2</sup> for each face plastered. Values given represent averages. In some cases there is a considerable range of weight for the same construction.

(continued)

**TABLE C3-1 continued  
MINIMUM DESIGN DEAD LOADS\***

Component	Load (kN/m <sup>2</sup> )	Component	Load (kN/m <sup>2</sup> )
<b>FLOORS AND FLOOR FINISHES</b>		Windows, glass, frame, and sash	
Asphalt block (51 mm), 13 mm mortar	1.44	Clay brick wythes:	
Cement finish (25 mm) on stone-concrete fill	1.53	102 mm	1.87
Ceramic or quarry tile (19 mm) on 13 mm mortar bed	0.77	203 mm	3.78
Ceramic or quarry tile (19 mm) on 25 mm mortar bed	1.10	305 mm	5.51
Concrete fill finish (per mm thickness)	0.023	406 mm	7.42
Hardwood flooring, 22 mm	0.19	Hollow concrete masonry unit wythes:	
Linoleum or asphalt tile, 6 mm	0.05	Wythe thickness (in mm)	254
Marble and mortar on stone-concrete fill	1.58	Density of unit (16.49 kN/m <sup>3</sup> )	152
Slate (per mm thickness)	0.028	No grout	1.29
Solid flat tile on 25 mm mortar base	1.10	1219 mm	1.68
Subflooring, 19 mm	0.14	1016 mm	1.92
Terrazzo (38 mm) directly on slab	0.91	grout spacing	2.06
Terrazzo (25 mm) on stone-concrete fill	1.53	813 mm	2.15
Terrazzo (25 mm), 51 mm stone concrete	1.53	610 mm	2.35
Wood block (76 mm) on mastic, no fill	0.48	406 mm	2.68
Wood block (76 mm) on 13 mm mortar base	0.77	Full grout	3.69
<b>FLOORS, WOOD-JOIST (NO PLASTER)</b>		Density of unit (19.64 kN/m <sup>3</sup> )	
<b>DOUBLE WOOD FLOOR</b>		1.25	
Joist sizes (mm):		No grout	1.34
51 × 152	0.29	1219 mm	1.58
51 × 203	0.29	1016 mm	1.63
51 × 254	0.34	813 mm	1.72
51 × 305	0.38	610 mm	1.87
		406 mm	2.11
		Full grout	2.82
<b>FRAME PARTITIONS</b>		Density of unit (21.21 kN/m <sup>3</sup> )	
Movable steel partitions		1.39	
Wood or steel studs, 13 mm gypsum board each side	0.19	No grout	1.68
Wood studs, 51 × 102, unplastered	0.38	1219 mm	1.58
Wood studs, 51 × 102, plastered one side	0.19	1016 mm	1.72
Wood studs, 51 × 102, plastered two sides	0.57	813 mm	1.82
<b>FRAME WALLS</b>		610 mm	1.96
Exterior stud walls:		406 mm	2.25
51 mm × 102 mm @ 406 mm, 16 mm gypsum, insulated, 10 mm siding	0.53	Full grout	3.06
51 mm × 152 mm @ 406 mm, 16 mm gypsum, insulated, 10 mm siding	0.57	Solid concrete masonry unit	
Exterior stud walls with brick veneer	2.30	Wythe thickness (in mm)	203
		Density of unit (16.49 kN/m <sup>3</sup> )	152
		Density of unit (19.64 kN/m <sup>3</sup> )	203
		Density of unit (21.21 kN/m <sup>3</sup> )	254

\*Weights of masonry include mortar but not plaster. For plaster, add 0.24 kN/m<sup>2</sup> 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 <sup>3</sup> )	Material	Density (lb/ft <sup>3</sup> )
Aluminum	170	Lime	
Bituminous products		Hydrated, loose	32
Asphaltum	81	Hydrated, compacted	45
Graphite	135	Masonry, ashlar stone	
Paraffin	56	Granite	165
Petroleum, crude	55	Limestone, crystalline	165
Petroleum, refined	50	Limestone, oolitic	135
Petroleum, benzine	46	Marble	173
Petroleum, gasoline	42	Sandstone	144
Pitch	69	Masonry, brick	
Tar	75	Hard (low absorption)	130
Brass	526	Medium (medium absorption)	115
Bronze	552	Soft (high absorption)	100
Cast-stone masonry (cement, stone, sand)	144	Masonry, concrete*	
Cement, portland, loose	90	Lightweight units	105
Ceramic tile	150	Medium weight units	125
Charcoal	12	Normal weight units	135
Cinder fill	57	Masonry grout	140
Cinders, dry, in bulk	45	Masonry, rubble stone	
Coal		Granite	153
Anthracite, piled	52	Limestone, crystalline	147
Bituminous, piled	47	Limestone, oolitic	138
Lignite, piled	47	Marble	156
Peat, dry, piled	23	Sandstone	137
Concrete, plain		Mortar, cement or lime	130
Cinder	108	Particleboard	45
Expanded-slag aggregate	100	Plywood	36
Haydite (burned-clay aggregate)	90	Riprap (not submerged)	
Slag	132	Limestone	83
Stone (including gravel)	144	Sandstone	90
Vermiculite and perlite aggregate, nonload-bearing	25–50	Sand	
Other light aggregate, load-bearing	70–105	Clean and dry	90
Concrete, reinforced		River, dry	106
Cinder	111	Slag	
Slag	138	Bank	70
Stone (including gravel)	150	Bank screenings	108
Copper	556	Machine	96
Cork, compressed	14	Sand	52
Earth (not submerged)		Slate	172
Clay, dry	63	Steel, cold-drawn	492
Clay, damp	110	Stone, quarried, piled	
Clay and gravel, dry	100	Basalt, granite, gneiss	96
Silt, moist, loose	78	Limestone, marble, quartz	95
Silt, moist, packed	96	Sandstone	82
Silt, flowing	108	Shale	92
Sand and gravel, dry, loose	100	Greenstone, hornblende	107
Sand and gravel, dry, packed	110	Terra Cotta, architectural	
Sand and gravel, wet	120	Voids filled	120
Earth (submerged)		Voids unfilled	72
Clay	80	Tin	459
Soil	70	Water	
River mud	90	Fresh	62
Sand or gravel	60	Sea	64
Sand or gravel and clay	65	Wood, seasoned	
Glass	160	Ash, commercial white	41
Gravel, dry	104	Cypress, southern	34
Gypsum, loose	70	Fir, Douglas, coast region	34
Gypsum, wallboard	50	Hem fir	28
Ice	57	Oak, commercial reds and whites	47
Iron		Pine, southern yellow	37
Cast	450	Redwood	28
Wrought	480	Spruce, red, white, and Stika	29
Lead	710	Western hemlock	32
		Zinc, rolled sheet	449

\*Tabulated values apply to solid masonry and to the solid portion of hollow masonry.

**TABLE C3-2 Minimum Densities for Design Loads from Materials**

Material	Density (kN/m <sup>3</sup> )	Material	Density (kN/m <sup>3</sup> )
Aluminum	170	Lime	
Bituminous products		Hydrated, loose	5.0
Asphaltum	12.7	Hydrated, compacted	7.1
Graphite	21.2	Masonry, ashlar stone	
Paraffin	8.8	Granite	25.9
Petroleum, crude	8.6	Limestone, crystalline	25.9
Petroleum, refined	7.9	Limestone, oolitic	21.2
Petroleum, benzine	7.2	Marble	27.2
Petroleum, gasoline	6.6	Sandstone	22.6
Pitch	10.8	Masonry, brick	
Tar	11.8	Hard (low absorption)	20.4
Brass	82.6	Medium (medium absorption)	18.1
Bronze	86.7	Soft (high absorption)	15.7
Cast-stone masonry (cement, stone, sand)	22.6	Masonry, concrete*	
Cement, portland, loose	14.1	Lightweight units	16.5
Ceramic tile	23.6	Medium weight units	19.6
Charcoal	1.9	Normal weight units	21.2
Cinder fill	9.0	Masonry grout	22.0
Cinders, dry, in bulk	7.1	Masonry, rubble stone	
Coal		Granite	24.0
Anthracite, piled	8.2	Limestone, crystalline	23.1
Bituminous, piled	7.4	Limestone, oolitic	21.7
Lignite, piled	7.4	Marble	24.5
Peat, dry, piled	3.6	Sandstone	21.5
Concrete, plain		Mortar, cement or lime	20.4
Cinder	17.0	Particleboard	7.1
Expanded-slag aggregate	15.7	Plywood	5.7
Haydite (burned-clay aggregate)	14.1	Riprap (not submerged)	
Slag	20.7	Limestone	13.0
Stone (including gravel)	22.6	Sandstone	14.1
Vermiculite and perlite aggregate, nonload-bearing	3.9–7.9	Sand	
Other light aggregate, load-bearing	11.0–16.5	Clean and dry	14.1
Concrete, reinforced		River, dry	16.7
Cinder	17.4	Slag	
Slag	21.7	Bank	11.0
Stone (including gravel)	23.6	Bank screenings	17.0
Copper	87.3	Machine	15.1
Cork, compressed	2.2	Sand	8.2
Earth (not submerged)		Slate	27.0
Clay, dry	9.9	Steel, cold-drawn	77.3
Clay, damp	17.3	Stone, quarried, piled	
Clay and gravel, dry	15.7	Basalt, granite, gneiss	15.1
Silt, moist, loose	12.3	Limestone, marble, quartz	14.9
Silt, moist, packed	15.1	Sandstone	12.9
Silt, flowing	17.0	Shale	14.5
Sand and gravel, dry, loose	15.7	Greenstone, hornblende	16.8
Sand and gravel, dry, packed	17.3	Terra Cotta, architectural	
Sand and gravel, wet	18.9	Voids filled	18.9
Earth (submerged)		Voids unfilled	11.3
Clay	12.6	Tin	72.1
Soil	11.0	Water	
River mud	14.1	Fresh	9.7
Sand or gravel	9.4	Sea	10.1
Sand or gravel and clay	10.2	Wood, Seasoned	
Glass	25.1	Ash, commercial white	6.4
Gravel, dry	16.3	Cypress, southern	5.3
Gypsum, loose	11.0	Fir, Douglas, coast region	5.3
Gypsum, wallboard	7.9	Hem fir	4.4
Ice	9.0	Oak, commercial reds and whites	7.4
Iron		Pine, southern yellow	5.8
Cast	70.7	Redwood	4.4
Wrought	75.4	Spruce, red, white, and Stika	4.5
Lead	111.5	Western hemlock	5.0
		Zinc, rolled sheet	70.5

\*Tabulated values apply to solid masonry and to the solid portion of hollow masonry.

