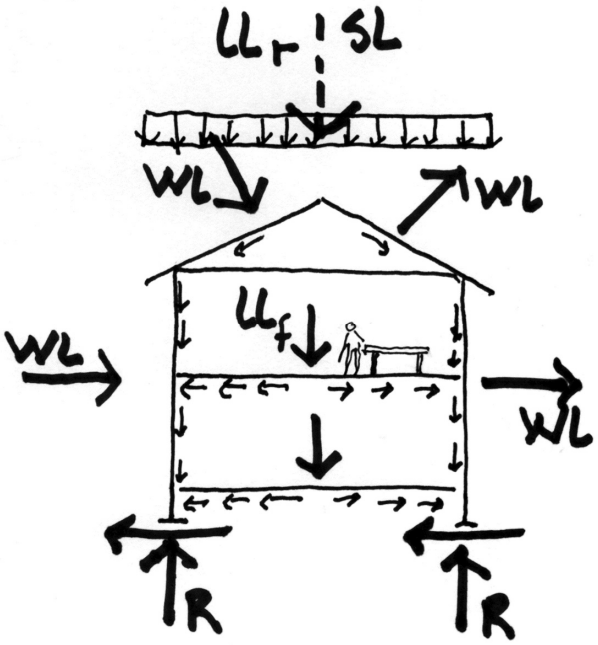
Vertical Loads on Structures

Load Types

- Dead
- Live
- Snow

Load Combinations

- ASD
- LRFD



ASCE - 7

ASCE/SEI 7 Minimum Design Loads For Buildings and Other Structures gives “minimum” loads for:

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Ch. 5 - Flood Loads

Ch. 6 - Tsunami Loads

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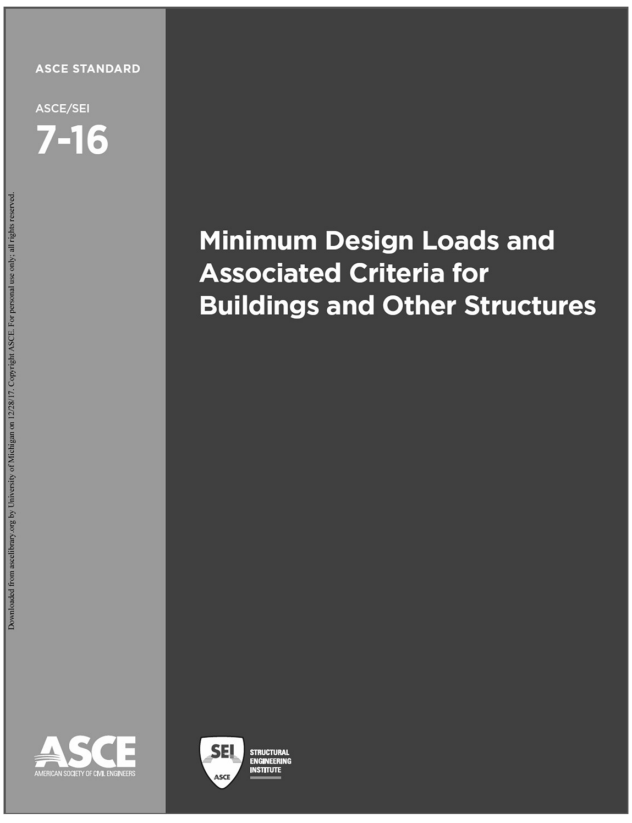


ASCE – 7 Ch. 2 - Load Combinations

Load Types

- Dead Load - D
- Roof Live Load - Lr
- Floor Live Load - L
- Snow Load - S
- Wind Load - W
- Earthquake - E

S.F.

Allowable Stress Design (ASD)

Not factored

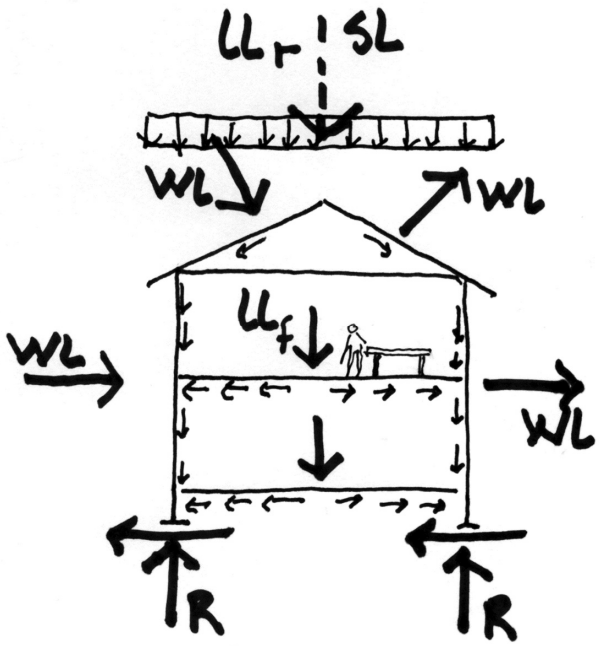
- D
- D + L
- D + (Lr or S)
- D + 0.75 L + 0.75 (Lr or S)
- D + (0.6W)
- D + 0.75L + 0.75(0.6W) + 0.75(Lr or S)
- D + 0.7Ev + 0.7Eh

LOAD + RESIST.

Strength Design (LRFD)

With gamma (γ) safety factors 2022

- 1.4 D
- 1.2 D + 1.6 L + (0.5Lr or 0.3S or 0.5R)
- 1.2 D + (1.6Lr or S or 1.6R) + (L or 0.5W)
- 1.2 D + 1.0W + L + (0.5Lr or 0.3S or 0.5R)
- 0.9D + 1.0W
- 1.2D + Ev + Eh + L + 1.5S
- 0.9D - Ev + Eh



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CHAPTER 3
DEAD LOADS, SOIL LOADS, AND HYDROSTATIC PRESSURE

3.1 DEAD LOADS

3.1.1 Definition. Dead loads consist of the weight of all materials of construction incorporated into the building including, but not limited to, walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items and fixed service equipment, including the weight of cranes and material handling systems.

3.1.2 Weights of Materials and Constructions. In determining 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 approved by the Authority Having Jurisdiction shall be used.

3.1.3 Weight of Fixed Service Equipment. In determining dead loads for purposes of design, the weight of fixed service equipment, including the maximum weight of the contents of fixed service equipment, shall be included. The components of fixed service equipment that are variable, such as liquid contents and movable trays, shall not be used to counteract forces causing overturning, sliding, and uplift conditions in accordance with Section 1.3.6.

EXCEPTIONS:

1. Where force effects are the result of the presence of the variable components, the components are permitted to be used to counter those load effects. In such cases, the structure shall be designed for force effects with the variable components present and with them absent.
2. For the calculation of seismic force effects, the components of fixed service equipment that are variable, such as liquid contents and movable trays, need not exceed those expected during normal operation.

3.1.4 Vegetative and Landscaped Roofs. The weight of all landscaping and hardscaping materials shall be considered as dead load. The weight shall be computed considering both fully saturated soil and drainage layer materials and fully dry soil and drainage layer materials to determine the most severe load effects on the structure.

Table 3.2-1 Design Lateral Soil Load

Description of Backfill Material	Unified Soil Classification	Design Lateral Soil Load[a] psf per foot of depth (kN/m² per meter of depth)
Well-graded, clean gravels, gravel–sand mixes	GW	35 (5.50)[b]
Poorly graded, clean gravels, gravel–sand mixes	GP	35 (5.50)[b]
Silty gravels, poorly graded gravel–sand mixes	GM	35 (5.50)[b]
Clayey gravels, poorly graded gravel-and-clay mixes	GC	45 (7.07)[b]
Well-graded, clean sands; gravel–sand mixes	SW	35 (5.50)[b]
Poorly graded, clean sands, sand–gravel mixes	SP	35 (5.50)[b]
Silty sands, poorly graded sand–silt mixes	SM	45 (7.07)[b]
Sand–silt clay mix with plastic fines	SM–SC	85 (13.35)[c]
Clayey sands, poorly graded sand–clay mixes	SC	85 (13.35)[c]
Inorganic silts and clayey silts	ML	85 (13.35)[c]
Mixture of inorganic silt and clay	ML–CL	85 (13.35)[c]
Inorganic clays of low to medium plasticity	CL	100 (15.71)
Organic silts and silt–clays, low plasticity	OL	[d]
Inorganic clayey silts, elastic silts	MH	[d]
Inorganic clays of high plasticity	CH	[d]
Organic clays and silty clays	OH	[d]

[a]Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.
[b]For relatively rigid walls, as when braced by floors, the design lateral soil load shall be increased for sand and gravel type soils to 60 psf (9.43 kN/m²) per foot (meter) of depth. Basement walls extending not more than 8 ft (2.44 m) below grade and supporting light floor systems are not considered as being relatively rigid walls.
[c]For relatively rigid walls, as when braced by floors, the design lateral load shall be increased for silt and clay type soils to 100 psf (15.71 kN/m²) per foot (meter) of depth. Basement walls extending not more than 8 ft (2.44 m) below grade and supporting light floor systems are not considered as being relatively rigid walls.
[d]Unsuitable as backfill material.

Dead Load

The weight of material

by density:

MATERIAL	WEIGHT	CATEGORY
Aluminum	170 PCF	Metals/Alloys
Copper (cast)	556 PCF	Metals/Alloys
Iron (wrought)	485 PCF	Metals/Alloys
Lead	710 PCF	Metals/Alloys
Glass (plate)	161 PCF	Mineral
Sand	96 PCF	Mineral
Concrete (reinf.)	150 PCF	Mineral
Brick (common)	120 PCF	Mineral
Douglas Spruce Fir	32 PCF	Timber
White Oak	46 PCF	Timber
White Pine	26 PCF	Timber
Oil	57 PCF	Liquid
Water (39.2° F)	62.428 PCF	Liquid
Snow (fresh fallen)	8 PCF	Powder
Air	0.807	Gas

by area:

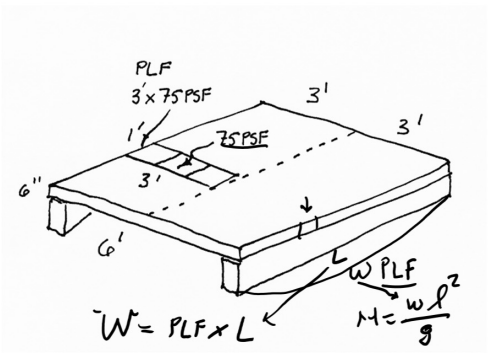
MATERIAL	WEIGHT	CATEGORY
Lightweight Concrete	6 - 10 PSF	Floors
1/4" Linoleum Finish	1 PSF	Floors
7/8" Hardwood Finish	4 PSF	Floors
Copper or Tin	1 PSF	Roofing
5-Ply felt and Gravel	6 PSF	Roofing
Asphalt Shingles	3 PSF	Roofing
Clay Tile Shingles	9 - 14 PSF	Roofing
3/4" Plywood Sheathing	3 PSF	Roofing
Wood studs 2 x 4	2 PSF	Partitions
1" Gypsum	5 PSF	Partitions
4" Brick	40 PSF	Walls
6" Hollow Conc. Block	43 PSF	Walls
8" Hollow Conc. Block	55 PSF	Walls
4" Glass Block	18 PSF	Walls
Windows, Glass	8 PSF	Walls

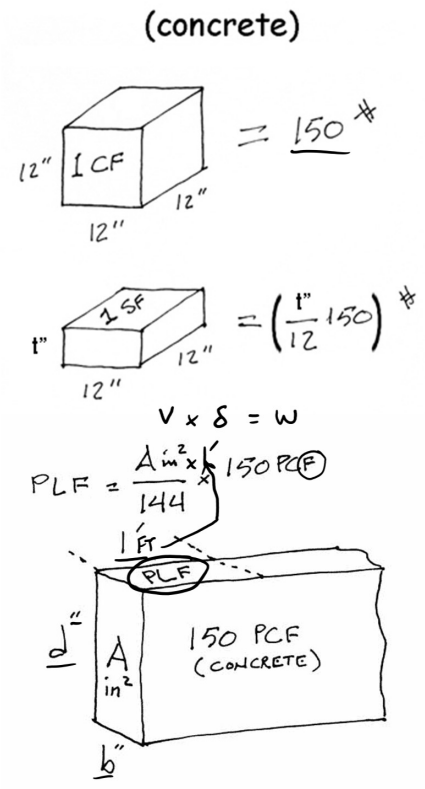
Dead Load

Weight of material

- weight of structure
- weight of permanent fixtures

Because it is known more precisely the LRFD safety factor is less: $\gamma = 1.2$





Dead Load

Floor framing

- Joist selfweight

$$PLF = \frac{\text{AREA}\,(in^2) \times 1'}{144} \times \text{DENSITY}\,(PCF)$$

- Joist weight on floor

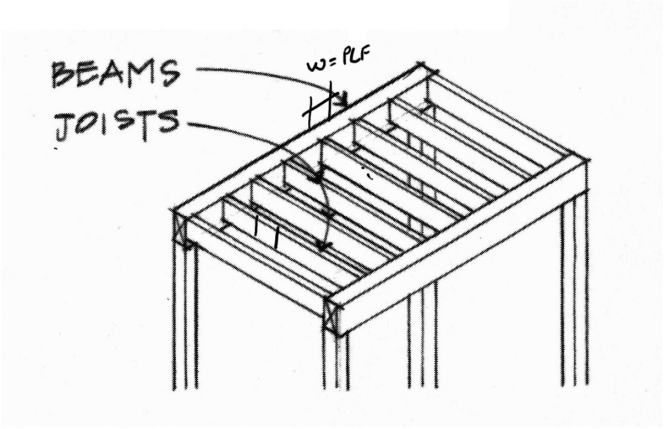
  on center space in inches (o.c.)

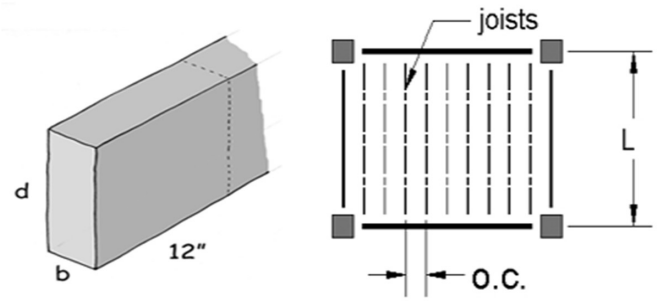
$$\text{FLOOR } PSF = \frac{12}{\text{O.C.}\,(IN)} \times PLF_{JOIST}$$

Wood density by species:

ca. 25 – 50 PCF

$$PLF = LBS/FT$$
$$PSF = LBS/FT^2$$
$$PCF = LBS/FT^3$$





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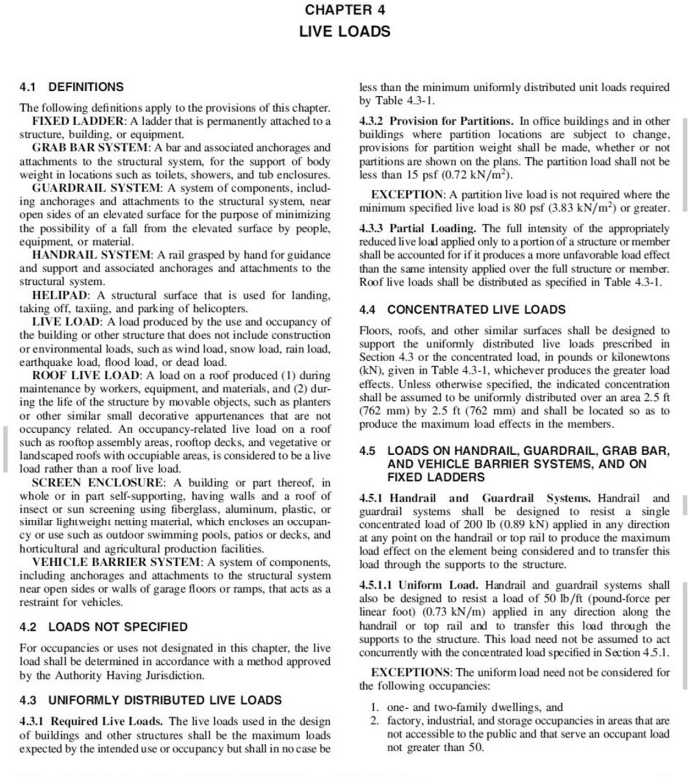


CHAPTER 4
LIVE LOADS

4.1 DEFINITIONS

The following definitions apply to the provisions of this chapter.

FIXED LADDER: A ladder that is permanently attached to a structure, building, or equipment.

GRAB BAR SYSTEM: A bar and associated anchorages and attachments to the structural system, for the support of body weight in locations such as toilets, showers, and tub enclosures.

GUARDRAIL SYSTEM: A system of components, including anchorages and attachments to the structural system, near open sides of an elevated surface for the purpose of minimizing the possibility of a fall from the elevated surface by people, equipment, or material.

HANDRAIL SYSTEM: A rail grasped by hand for guidance and support and associated anchorages and attachments to the structural system.

HELIPAD: A structural surface that is used for landing, taking off, taxiing, and parking of helicopters.

LIVE LOAD: A load produced by the use and occupancy of the building or other structure that does not include construction or environmental loads, such as wind load, snow load, rain load, earthquake load, flood load, or dead load.

ROOF LIVE LOAD: A load on a roof produced (1) during maintenance by workers, equipment, and materials, and (2) during the life of the structure by movable objects, such as planters or other similar small decorative appurtenances that are not occupancy related. An occupancy-related live load on a roof such as rooftop assembly areas, rooftop decks, and vegetative or landscaped roofs with occupiable areas, is considered to be a live load rather than a roof live load.

SCREEN ENCLOSURE: A building or part thereof, in whole or in part self-supporting, having walls and a roof of insect or sun screening using fiberglass, aluminum, plastic, or similar lightweight netting material, which encloses an occupancy or use such as outdoor swimming pools, patios or decks, and horticultural and agricultural production facilities.

VEHICLE BARRIER SYSTEM: A system of components, including anchorages and attachments to the structural system near open sides or walls of garage floors or ramps, that acts as a restraint for vehicles.

4.2 LOADS NOT SPECIFIED

For occupancies or uses not designated in this chapter, the live load shall be determined in accordance with a method approved by the Authority Having Jurisdiction.

4.3 UNIFORMLY DISTRIBUTED LIVE LOADS

4.3.1 Required Live Loads. The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall in no case be less than the minimum uniformly distributed unit loads required by Table 4.3-1.

4.3.2 Provision for Partitions. In office buildings and in other buildings where partition locations are subject to change, provisions for partition weight shall be made, whether or not partitions are shown on the plans. The partition load shall not be less than 15 psf (0.72 kN/m^2).

EXCEPTION: A partition live load is not required where the minimum specified live load is 80 psf (3.83 kN/m^2) or greater.

4.3.3 Partial Loading. The full intensity of the appropriately reduced live load applied only to a portion of a structure or member shall be accounted for if it produces a more unfavorable load effect than the same intensity applied over the full structure or member. Roof live loads shall be distributed as specified in Table 4.3-1.

4.4 CONCENTRATED LIVE LOADS

Floors, roofs, and other similar surfaces shall be designed to support the uniformly distributed live loads prescribed in Section 4.3 or the concentrated load, in pounds or kilonewtons (kN), given in Table 4.3-1, whichever produces the greater load effects. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area 2.5 ft (762 mm) by 2.5 ft (762 mm) and shall be located so as to produce the maximum load effects in the members.

4.5 LOADS ON HANDRAIL, GUARDRAIL, GRAB BAR, AND VEHICLE BARRIER SYSTEMS, AND ON FIXED LADDERS

4.5.1 Handrail and Guardrail Systems. Handrail and guardrail systems shall be designed to resist a single concentrated load of 200 lb (0.89 kN) applied in any direction at any point on the handrail or top rail to produce the maximum load effect on the element being considered and to transfer this load through the supports to the structure.

4.5.1.1 Uniform Load. Handrail and guardrail systems shall also be designed to resist a load of 50 lb/ft (pound-force per linear foot) (0.73 kN/m) applied in any direction along the handrail or top rail and to transfer this load through the supports to the structure. This load need not be assumed to act concurrently with the concentrated load specified in Section 4.5.1.

EXCEPTIONS: The uniform load need not be considered for the following occupancies:

1. one- and two-family dwellings, and
2. factory, industrial, and storage occupancies in areas that are not accessible to the public and that serve an occupant load not greater than 50.

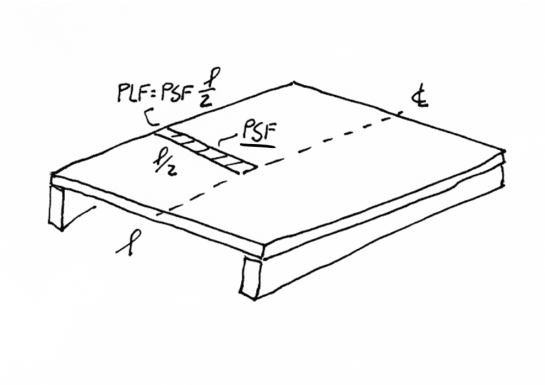
Minimum Design Loads and Associated Criteria for Buildings and Other Structures 13

Live Load

Live Load (on projected area)

Floor live load

- by occupancy
- 40 PSF to ~250 PSF



Roof live load

- construction or maintenance
- 12 PSF to 20 PSF (depending on area and slope)
- LRFD safety factor γ = 1.6 (depending on load combination)

Live Load

Floor Loads

OCCUPANCY OR USE	WEIGHT	CATEGORY
Fixed seats (fastened to flr)	60 PSF	Assembly areas & theaters
Lobbies	100 PSF	Assembly areas & theaters
Movable seats	100 PSF	Assembly areas & theaters
Stage floors	150 PSF	Assembly areas & theaters
Balconies (exterior)	100 PSF	
Bowling and poolrooms	75 PSF	Recreational areas
Dance halls & ballrooms	100 PSF	
Dining room & restaurants	100 PSF	
Gyms, main flrs & balconies	100 PSF	
Private rooms and corridors	40 PSF	Hotels and multifamily houses
Public rooms and corridors	100 PSF	Hotels and multifamily houses
Classrooms	40 PSF	Schools
Corridors above first floor	80 PSF	Schools
First floor corridor	100 PSF	Schools
Bleachers	100 PSF	Stadiums/arenas
Fixed seats (fastened to flr)	60 PSF	Stadiums/arenas
Light manufacturing	125 PSF	Manufacturing
Heavy manufacturing	250 PSF	Manufacturing
Habitable sleeping areas	30 PSF	Residential
All other areas (except stairs)	40 PSF	Residential

Roof Live Load

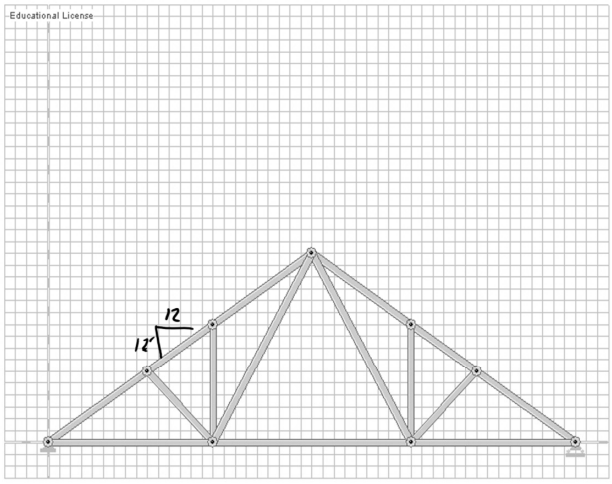
- Minimum L_r between 12 PSF and 20 PSF
- $L_r = 20\ R_1\ R_2$

BASIC

Area Reduction:

$$R_1 = \begin{cases} 1 & \text{for } A_t \le 200 \text{ ft}^2 (18.58 \text{ m}^2) \\ 1.2 - 0.001A_t & \text{for } 200 \text{ ft}^2 < A_t < 600 \text{ ft}^2 \\ 0.6 & \text{for } A_t \ge 600 \text{ ft}^2 (55.74 \text{ m}^2) \end{cases}$$

where A_t = tributary area in ft^2 (m^2) supported by any structural member



Slope Reduction:

$$R_2 = \begin{cases} 1 & \text{for } F \le 4 \\ 1.2 - 0.05F & \text{for } 4 < F < 12 \\ 0.6 & \text{for } F \ge 12 \end{cases}$$

pitched roof: F = number of inches of rise per ft.
arch or dome: F = rise-to span ratio multiplied by 32.

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CHAPTER 7
SNOW LOADS

7.1 DEFINITIONS AND SYMBOLS

7.1.1 Definitions

DRIFT: The accumulation of wind-driven snow that results in a local surcharge load on the roof structure at locations such as a parapet or roof step.

FLAT ROOF SNOW LOAD: Uniform load for flat roofs.

FREEZER BUILDINGS: Buildings in which the inside temperature is kept at or below freezing. Buildings with an air space between the roof insulation layer above and a ceiling of the freezer area below are not considered freezer buildings.

GROUND SNOW LOAD: The site-specific weight of the accumulated snow at the ground level used to develop roof snow loads on the structure. It generally has a 50-year mean recurrence interval.

MINIMUM SNOW LOAD: Snow load on low sloped roofs, including the roof snow load immediately after a single snow storm without wind.

PONDING: Refer to definitions in Chapter 8, Rain Loads

PONDING INSTABILITY: Refer to definitions in Chapter 8, Rain Loads.

R-VALUE: A measure of the resistance to heat flow through a roof component or assembly per unit area.

SLIPPERY SURFACE: Membranes with a smooth surface, e.g., glass, metal, or rubber. Membranes with an embedded aggregate or mineral granule surface are not considered a slippery surface.

SLOPED ROOF SNOW LOAD: Uniform load on horizontal projection of a sloped roof, also known as the balanced load.

VENTILATED ROOF: Roof that allows exterior air to naturally circulate between the roof surface above and the insulation layer below. The exterior air commonly flows from the eave to the ridge.

7.1.2 Symbols

C_e = exposure factor as determined from Table 7.3-1.
C_s = slope factor as determined from Fig. 7.4-1.
C_t = thermal factor as determined from Table 7.3-2.
h = vertical separation distance in feet (m) between the edge of a higher roof including any parapet and the edge of a lower adjacent roof excluding any parapet.
h_b = height of balanced snow load determined by dividing p_f by γ, in ft (m).
h_c = clear height from top of balanced snow load to (1) closest point on adjacent upper roof, (2) top of parapet, or (3) top of a projection on the roof, in ft (m).
h_d = height of snow drift, in ft (m).
h_{d1} or h_{d2} = heights of snow drifts, in ft (m), where two intersecting snow drifts can form.
h_o = height of obstruction above the surface of the roof, in ft (m).
I_s = importance factor as prescribed in Section 7.3.3.
l_u = length of the roof upwind of the drift, in ft (m).
p_d = maximum intensity of drift surcharge load, in lb/ft^2 (kN/m^2).
p_f = snow load on flat roofs ("flat" = roof *slope* $\le 5°$), in lb/ft^2 (kN/m^2).
p_g = ground snow load as determined from Fig. 7.2-1 and Table 7.2-1; or a site-specific analysis, in lb/ft^2 (kN/m^2).
p_m = minimum snow load for low-slope roofs, in lb/ft^2 (kN/m^2).
p_s = sloped roof (balanced) snow load, in lb/ft^2 (kN/m^2).
s = horizontal separation distance in ft (m) between the edges of two adjacent buildings.
S = roof slope run for a rise of one.
w = width of snow drift, in ft (m).
w_1 or w_2 = widths of snow drifts, in ft (m), where two intersecting snow drifts can form.
W = horizontal distance from eave to ridge, in ft (m).
γ = snow density, in lb/ft^3 (kN/m^3), as determined from Eq. (7.7-1).
θ = roof slope on the leeward side, in degrees.

7.2 GROUND SNOW LOADS, p_g

Ground snow loads, p_g, to be used in the determination of design snow loads for roofs shall be as set forth in Fig. 7.2-1 for the contiguous United States and Table 7.2-1 for Alaska. Site-specific case studies shall be made to determine ground snow loads in areas designated CS in Fig. 7.2-1 (see also Tables 7.2-2 through 7.2-8). Ground snow loads for sites at elevations above the limits indicated in Fig. 7.2-1 and for all sites within the CS areas shall be approved by the Authority Having Jurisdiction. Ground snow load determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2% annual probability of being exceeded (50-year mean recurrence interval).

Snow loads are zero for Hawaii, except in mountainous regions as determined by the Authority Having Jurisdiction.

The importance factor times the ground snow load, $I_s p_g$, shall be used as the balanced snow load for snow accumulation surfaces, such as decks, balconies, and other near-ground level surfaces or roofs of subterranean spaces, whose height above the ground surface is less than the depth of the ground snow, h_g ($h_g = p_g/\gamma$).

7.3 FLAT ROOF SNOW LOADS, p_f

The flat roof snow load, p_f, shall be calculated in lb/ft^2 (kN/m^2) using the following formula:

$$p_f = 0.7 C_e C_t I_s p_g \qquad (7.3\text{-}1)$$

Snow Load

Snow Load (on projected length)

Ground Snow

- p_g by region (see map)
- Ann Arbor 25 psf

Flat Roof

- p_f = 70% p_g x condition factors (exposure, thermal, importance)

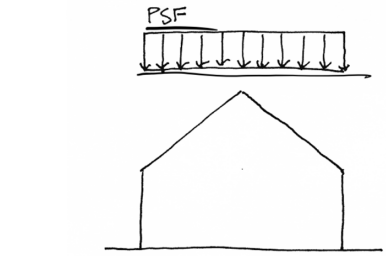
C_e C_t

Sloped Roof

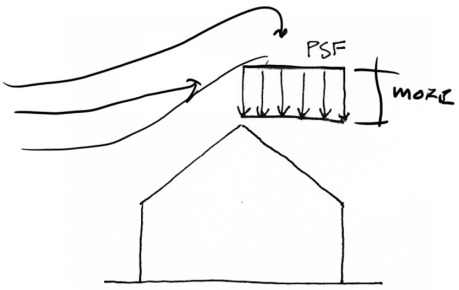
- p_s = p_f x slope factors
- Balanced (full roof)
- Un-balanced

Safety Factor

- γ = 1.6



balanced



un-balanced

Snow Load

Ground Snow

- p_g by region
- Ann Arbor 25 psf

Flat Roof

- p_f = 70% p_g x condition factors (exposure, thermal, importance)

Sloped Roof

- p_s = p_f x slope factors
- Balanced (full roof)
- Un-balanced

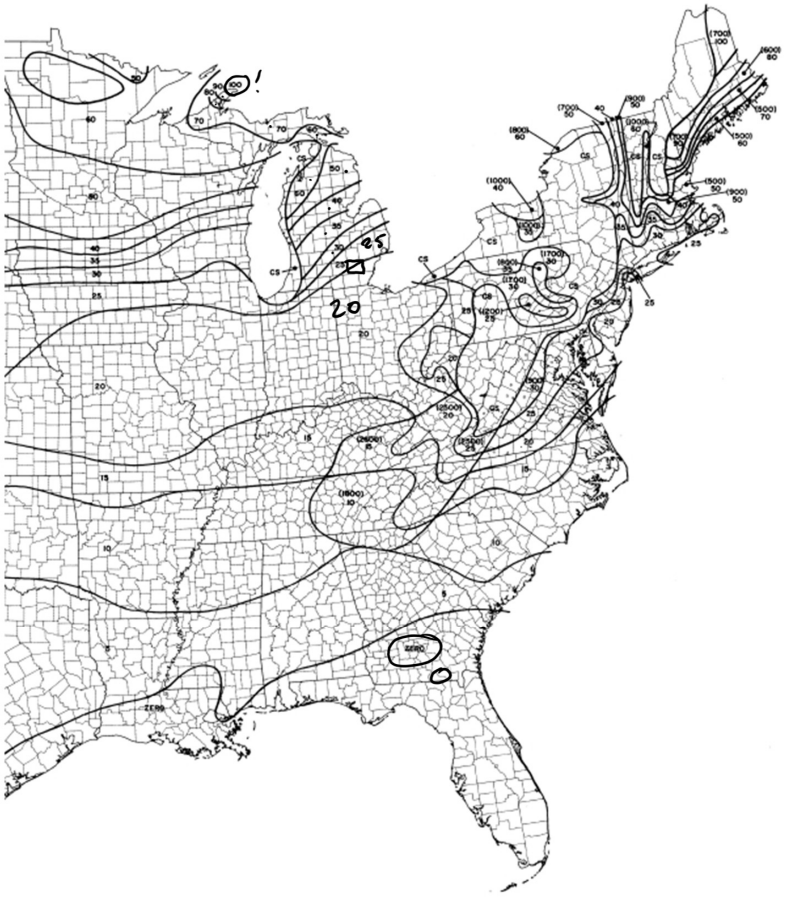
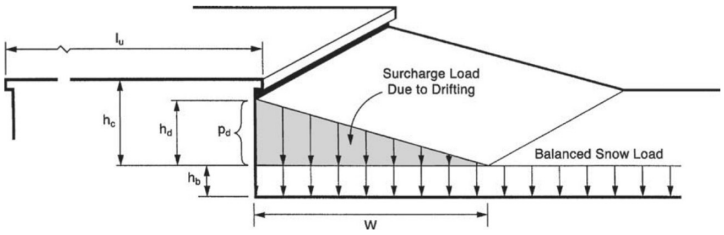


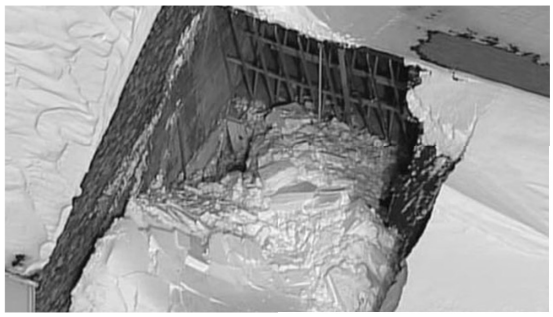
FIGURE 7-1 — continued
GROUND SNOW LOADS, p_g FOR THE UNITED STATES (lB/SQ FT)

Snow Load



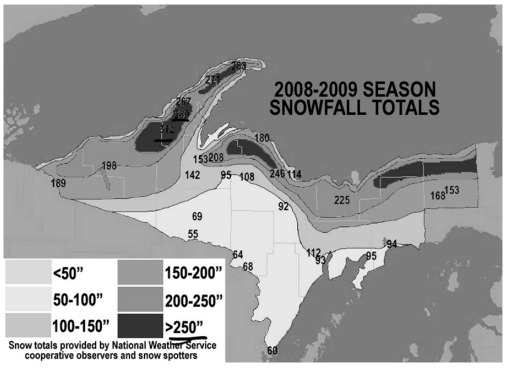
Drift Loading

- Windward
- Leeward
- Sawtooth



Ann Arbor

Houghton, Michigan



Snow Load

Pontiac Silverdome

Snow Load

Metrodome, Minneapolis

Dec. 11, 2010