EXAMPLES

The following three examples illustrate the method used to establish design snow loads for most of the situations discussed in this standard.

Example 1: Determine balanced and unbalanced design snow loads for an apartment complex in a suburb of Boston, Massachusetts. Each unit has an 8-on-12 slope unventilated gable roof. The building length is 100 ft. (30.5 m) and the eave to ridge distance, W, is 30 ft (9.1 m). Composition shingles clad the roofs. Trees will be planted among the buildings.

Flat-roof snow load:

$p_f = 0.7C_eC_tIp_g$
where
$p_g = 30$ lb/ft^2 (1.44 kN/m^2) (from Fig. 7-1)
$C_e = 1.0$ (from Table 7-2 for Terrain Category B and a partially exposed roof)
$C_t = 1.0$ (from Table 7-3); and $I = 1.0$ (from Table 7-4)

Thus:
$p_f = (0.7)(1.0)(1.0)(1.0)(30) = 21$ lb/ft^2 (balanced load)
in SI: $p_f = (0.7)(1.0)(1.0)(1.0)(1.44) = 1.01$ kN/m^2

Since $p_g = 30$ psf (1.44 kN/m^2) and $I = 1.0$, the minimum value of $p_f = 20$ (1.0) = 20 psf (0.96 kN/m^2) and hence does not control, see Section 7.3.

Sloped-roof snow load:

$p_s = C_sp_f$ where $C_s = 0.91$ [from solid line, Fig. 7-2a].
Thus.
$p_s = 0.91\ (21) = 19$ lb/ft^2
in SI: $p_s = 0.91\ (1.01) = 0.92$ kN/m^2

Unbalanced Snow Load:

Since the roof slope is greater than $70/W + 0.5 = 70/30 + 0.5 = 2.38°$, unbalanced loads must be considered. The gable roof length to width (eave to ridge) ratio $L/W = 100/30 = 3.33$ and $\beta = 0.89$ as calculated using Eq. 7-3. For $p_g = 30$ psf (1.44 kN/m^2), the snow density $\gamma = 17.9$ pcf (2.81kN/m^3) as calculated using Eq. 7-4. The roof slope (8 on 12) of 33.6° is between $275\beta p_f / \gamma W = 9.6°$ and 70°, hence from Fig. 7-5 the windward load is $0.3p_s = 6$ psf (0.29 kN/m^2) while the leeward unbalanced load is $1.2(1 + \beta/2)p_s / C_e = 33$ psf (1.6 kN/m^2).

Rain on Snow Surcharge:

A rain-on-snow surcharge load need not be considered, since the slope is greater than 1/2 in./ft (2.38°) (see Section 7.10). See Fig. C7-3 for both loading conditions.

Example 2: Determine the roof snow load for a vaulted theater which can seat 450 people, planned for a suburb of Chicago, Illinois. The building is the tallest structure in a recreation-shopping complex surrounded by a parking lot. Two large deciduous trees are located in an area near the entrance. The building has an 80-foot (24.4-meter) span and 15-foot (4.6-meter) rise circular arc structural concrete roof covered with insulation and aggregate surfaced built-up roofing. The unventilated roofing system has a thermal resistance of 20 ft^2•hr•F°/Btu (3.5 K•m^2/W). It is expected that the structure will be exposed to winds during its useful life.

Flat-roof snow load:

$p_f = 0.7\ C_eC_tIp_g$
where
$p_g = 25$ lb/ft^2 (1.20 kN/m^2) (from Fig. 7-1)
$C_e = 0.9$ (from Table 7-2 for Terrain Category B and a fully exposed roof)
$C_t = 1.0$ (from Table 7-3)
$I = 1.1$ (from Table 7-4)

Thus:
$p_f = (0.7)(0.9)(1.0)(1.1)(25) = 17$ lb/ft^2
In SI: pf = (0.7)(0.9)(1.0)(1.1)(1.19) = 0.83 kN/m^2

Tangent of vertical angle from eaves to crown = 15/40 = 0.375 Angle = 21 degrees

Since the vertical angle exceeds 10 degrees, the minimum allowable values of p_f do not apply. Use $p_f = 17$ lb/ft^2 (0.83 kN/m^2), see Section 7.3.4.

Sloped-roof snow load:

$p_s = C_sp_f$

From Fig. 7-2a, $C_s = 1.0$ until slope exceeds 30 degrees which (by geometry) is 30 feet (9.1 meters) from the centerline. In this area $p_s = 17(1) = 17$ lb/ft^2 (in SI $p_s = 0.83(1) = 0.83$ kN/m^2). At the eaves, where the slope is (by geometry) 41 degrees, $C_s = 0.72$ and $p_s = 17(0.72) = 12$ lb/ft^2 (in SI $p_s = 0.83(0.72) = 0.60$ kN/m^2). Since slope at eaves is 41 degrees, Case II loading applies.

Unbalanced snow load:

Since the vertical angle from the eaves to the crown is greater than 10 degrees and less than 60 degrees, unbalanced snow loads must be considered.

Unbalanced load at crown
$= 0.5\ p_f = 0.5(17) = 9$ lb/ft^2
in SI $= 0.5(0.83) = 0.41$ kN/m^2

Unbalanced load at 30-degree point

$= 2\ p_f C_s/C_e = 2(17)(1.0)/0.9 = 38\ \mathrm{lb/ft^2}$
in SI $= 2(0.83)(1.0)/0.9 = 1.84\ \mathrm{kN/m^2}$

Unbalanced load at eaves
$= 2(17)(0.72)/0.9 = 27\ \mathrm{lb/ft^2}$
in SI: $= 2(0.83)(0.72)/0.9 = 1.33\ \mathrm{kN/m^2}$

Rain on Snow Surcharge:

A rain-on-snow surcharge load need not be considered, since the slope is greater than 1/2 in./ft (2.38°) (see 7.10). See Fig. C7-4 for both loading conditions.

Example 3: Determine design snow loads for the upper and lower flat roofs of a building located where $p_g = 40$ psf (1.92 kN/m²). The elevation difference between the roofs is 10 feet (3 meters). The 100-foot by 100-foot (30.5 m by 30.5 m) unventilated high portion is heated and the 170 foot wide (51.8 meter), 100-foot long (30.5 meter) long low portion is an unheated storage area. The building is in an industrial park in flat open country with no trees or other structures offering shelter.

High roof:
$p_f = 0.7\ C_e C_t\ I\ p_g$
where
$p_g = 40\ \mathrm{lb/ft^2}$ (1.92 kN/m²) (given)
$C_e = 0.9$ (from Table 7-2)
$C_t = 1.0$ (from Table 7-3)
$I = 1.0$ (from Table 7-4)
Thus:
$p_f = 0.7\ (0.9)\ (1.0)\ (1.0)\ (40) = 25\ \mathrm{lb/ft^2}$
in SI $p_f = 0.7(0.9)(1.0)(1.0)(1.92) = 1.21\ \mathrm{kN/m^2}$

Since $p_g = 40$ psf (1.92 kN/m²) and $I = 1.0$, the minimum value of $p_f = 20\ (1.0) = 20$ psf (0.96 kN/m²) and hence does not control, see Section 7.3.

Low roof:
$p_f = 0.7\ C_e C_t\ I\ p_g$
where
$p_g = 40\ \mathrm{lb/ft^2}$ (1.92 kN/m²) (given)
$C_e = 1.0$ (from Table 7-2) partially exposed due to presence of high roof;
$C_t = 1.2$ (from Table 7-3)
$I = 0.8$ (from Table 7-4).
Thus:
$p_f = 0.7(1.0)\ (1.2)\ (0.8)\ (40) = 27\ \mathrm{lb/ft^2}$
in SI: $p_f = 0.7(1.0)(1.2)(0.8)(1.92) = 1.29\ \mathrm{kN/m^2}$

Since $p_g = 40$ psf (1.92 kN/m²) and $I = 0.8$, the minimum value of $p_f = 20\ (0.8) = 16$ psf (0.77 kN/m²) and hence does not control, see Section 7.3.

Drift load calculation:
$\gamma = 0.13(40) + 14 = 19\ \mathrm{lb/ft^3}$ (Equation 7-3)
in SI $\gamma = 0.426\ (1.92) + 2.2 = 3.02\ \mathrm{kN/m^3}$
$h_b = p_f/19 = 27/19 = 1.4$ ft
in SI: $h_b = 1.29/3.02 = 0.43$ meters
$h_c = 10 - 1.4 = 8.6$ ft
in SI. $h_c = 3.05 - 0.43 = 2.62$ meters
$h_c/h_b = 8.6/1.4 = 6.1$
in SI $h_c/h_b = 2.62/0.43 = 6.1$

Since $h_c/h_b \geq 0.2$ drift loads must be considered (see Section 7.7.1).

h_d (leeward step) = 3.8 ft (1.16 m) (Fig. 7-9 with $p_g = 40\ \mathrm{lb/ft^2}$ (1.92 kN/m²) and $l_u = 100$ ft (30.5 m))
h_d (windward step) = 3/4 x 4.8 ft (1.5 m) = 3.6 ft (1.1 m) (4.8 ft (1.5 m) from Fig. 7-9 with $p_g = 40\ \mathrm{lb/ft^2}$ (1.92 kN/m²) and l_u = length of lower roof = 170 ft (52 m))
Leeward drift governs, use $h_d = 3.8$ ft (1.16 m)
Since $h_d < h_c$,
$h_d = 3.8$ ft (1.16 m)
$w = 4\ h_d = 15.2$ ft (4.64 m), say 15 ft (4.6 m)
$p_d = h_d\gamma = 3.8(19) = 72\ \mathrm{lb/ft^2}$
in SI. $p_d = 1.16(3.02) = 3.50\ \mathrm{kN/m^2}$)

Rain on Snow Surcharge:

A rain-on-snow surcharge load need not be considered even though the slope is less than 1/2 in./ft (2.38°), since p_g is greater than 20 lb/ft² (0.96 kN/m²). See Fig C7-5 for snow loads on both roofs.

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Table C7-1
Ground Snow Loads at 204 National Weather Service Locations at Which Load Measurements are Made

(Note To convert lb/ft² to kN/m² multiply by 0 0479)

Location	Ground Snow Load (lb/ft²) Years of Record	 Maximum observed	 2% Annual probability *
ALABAMA			
Birmingham	40	4	3
Huntsville	33	7	5
Mobile	40	1	1
ARIZONA			
Flagstaff	38	88	48
Tucson	40	3	3
Winslow	39	12	7
ARKANSAS			
Fort Smith	37	6	5
Little Rock	24	6	6
CALIFORNIA			
Bishop	31	6	8
Blue Canyon	26	213	242
Mt. Shasta	32	62	62
Red Bluff	34	3	3
COLORADO			
Alamosa	40	14	14
Colorado Springs	39	16	14
Denver	40	22	18
Grand Junction	40	18	16
Pueblo	33	7	7
CONNECTICUT			
Bridgeport	39	21	24
Hartford	40	23	33
New Haven	17	11	15
DELAWARE			
Wilmington	39	12	15
GEORGIA			
Athens	40	6	5
Atlanta	39	4	3
Augusta	40	8	7
Columbus	39	1	1
Macon	40	8	7
Rome	28	3	2
IDAHO			
Boise	38	8	9
Lewiston	37	6	9
Pocatello	40	12	10
ILLINOIS			
Chicago-O'Hare	32	25	17
Chicago	26	37	22
Moline	39	21	19
Peoria	39	27	15
Rockford	26	31	19
Springfield	40	20	21
INDIANA			
Evansville	40	12	17
Fort Wayne	40	23	20
Indianapolis	40	19	22
South Bend	39	58	41
IOWA			
Burlington	11	15	17
Des Moines	40	22	22
Dubuque	39	34	32
Sioux City	38	28	28
Waterloo	33	25	32
KANSAS			
Concordia	30	17	17
Dodge City	40	10	14
Goodland	39	12	15
Topeka	40	18	17
Wichita	40	10	14
KENTUCKY			
Covington	40	22	13
Jackson	11	12	18
Lexington	40	15	13
Louisville	39	11	12
LOUISIANA			
Alexandria	17	2	2
Shreveport	40	4	3
MAINE			
Caribou	34	68	95
Portland	39	51	60
MARYLAND			
Baltimore	40	20	22
MASSACHUSETTS			
Boston	39	25	34
Nantucket	16	14	24
Worcester	33	29	44
MICHIGAN			
Alpena	31	34	48
Detroit City	14	6	10
Detroit Airport	34	27	18
Detroit-Willow	12	11	22
Flint	37	20	24
Grand Rapids	40	32	36
Houghton Lake	28	33	48
Lansing	35	34	36
Marquette	16	44	53
Muskegon	40	40	51
Sault Ste Marie	40	68	77
MINNESOTA			
Duluth	40	55	63
International Falls	40	43	44
Minneapolis-St Paul	40	34	51
Rochester	40	30	47
St. Cloud	40	40	53
MISSISSIPPI			
Jackson	40	3	3
Meridian	39	2	2
MISSOURI			
Columbia	39	19	20
Kansas City	40	18	18
St Louis	37	28	21
Springfield	39	14	14
MONTANA			
Billings	40	21	15
Glasgow	40	18	19
Great Falls	40	22	15
Havre	26	22	24
Helena	40	15	17
Kalispell	29	27	45
Missoula	40	24	22
NEBRASKA			
Grand Island	40	24	23
Lincoln	20	15	22
Norfolk	40	28	25
North Platte	39	16	13
Omaha	25	23	20
Scottsbluff	40	10	12
Valentine	26	26	22
NEVADA			
Elko	12	12	20
Ely	40	10	9
Las Vegas	39	3	3

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* It is not appropriate to use only the site specific information in this table for design purposes. Reasons are given in Commentary Section 7 2

Location	Ground Snow Load (lb/ft^2)		
	Years of Record	Maximum observed	2% Annual probability *
Reno	39	12	11
Winnemucca	39	7	7
NEW HAMPSHIRE			
Concord	40	43	63
NEW JERSEY			
Atlantic City	35	12	15
Newark	39	18	15
NEW MEXICO			
Albuquerque	40	6	4
Clayton	34	8	10
Roswell	22	6	8
NEW YORK			
Albany	40	26	27
Binghamton	40	30	35
Buffalo	40	41	39
NYC - Kennedy	18	8	15
NYC - LaGuardia	40	23	16
Rochester	40	33	38
Syracuse	40	32	32
NORTH CAROLINA			
Asheville	28	7	14
Cape Hatteras	34	5	5
Charlotte	40	8	11
Greensboro	40	14	11
Raleigh-Durham	36	13	14
Wilmington	39	14	7
Winston-Salem	12	14	20
NORTH DAKOTA			
Bismark	40	27	27
Fargo	39	27	41
Williston	40	28	27
OHIO			
Akron-Canton	40	16	14
Cleveland	40	27	19
Columbus	40	11	11
Dayton	40	18	11
Mansfield	30	31	17
Toledo Express	36	10	10
Youngstown	40	14	10
OKLAHOMA			
Oklahoma City	40	10	8
Tulsa	40	5	8
OREGON			
Astoria	26	2	3
Burns City	39	21	23
Eugene	37	22	10
Medford	40	6	6
Pendleton	40	9	13
Portland	39	10	8
Salem	39	5	7
Sexton Summit	14	48	64
PENNSYLVANIA			
Allentown	40	16	23
Erie	32	20	18
Harrisburg	19	21	23
Philadelphia	39	13	14
Pittsburgh	40	27	20
Scranton	37	13	18
Williamsport	40	18	21
RHODE ISLAND			
Providence	39	22	23
SOUTH CAROLINA			
Charleston	39	2	2
Columbia	38	9	8
Florence	23	3	3
Greenville-Spartanburg	24	6	7
SOUTH DAKOTA			
Aberdeen	27	23	43
Huron	40	41	46
Rapid City	40	14	15
Sioux Falls	39	40	40
TENNESSEE			
Bristol	40	7	9
Chattanooga	40	6	6
Knoxville	40	10	9
Memphis	40	7	6
Nashville	40	6	9
TEXAS			
Abilene	40	6	6
Amarillo	39	15	10
Austin	39	2	2
Dallas	23	3	3
El Paso	38	8	8
Fort Worth	39	5	4
Lubbock	40	9	11
Midland	38	4	4
San Angelo	40	3	3
San Antonio	40	9	4
Waco	40	3	2
Wichita Falls	40	4	5
UTAH			
Milford	23	23	14
Salt Lake City	40	11	11
Wendover	13	2	3
VERMONT			
Burlington	40	43	36
VIRGINIA			
Dulles Airport	29	15	23
Lynchburg	40	13	18
National Airport	40	16	22
Norfolk	38	9	10
Richmond	40	11	16
Roanoke	40	14	20
WASHINGTON			
Olympia	40	23	22
Quillayute	25	21	15
Seattle-Tacoma	40	15	18
Spokane	40	36	42
Stampede Pass	36	483	516
Yakima	39	19	30
WEST VIRGINIA			
Beckley	20	20	30
Charleston	38	21	18
Elkins	32	22	18
Huntington	30	15	19
WISCONSIN			
Green Bay	40	37	36
La Crosse	16	23	32
Madison	40	32	35
Milwaukee	40	34	29
WYOMING			
Casper	40	9	10
Cheyenne	40	18	18
Lander	39	26	24
Sheridan	40	20	23

* It is not appropriate to use only the site specific information in this table for design purposes Reasons are given in Commentary Section 7.2

Table C7-2 Comparison of Some Site-Specific Values and Zoned Values in Fig. 7-1

State	Location	Elevation, ft (m)	Zoned value lb/ft^2 (kN/m^2)	Case Study Value * psf (kN/m^2)
California	Mount Hamilton	4210 (1283)	0 to 2400' (732m)	30 (1.44)
Arizona	Palisade Ranger Station	7950 (2423)	0 to 3500' (1067m) 5 to 4600' (0.24 to 1402m) 10 to 5000' (0.48 to 1524m)	120 (5.75)
Tennessee	Monteagle	1940 (591)	10 to 1800' (0.48 to 549m)	15 (0.72)
Maine	Sunday River Ski Area	900 (274)	90 to 700' (4.31 to 213m)	100 (4.79)

* Based on a detailed study of information in the vicinity of each location

Table C7-3 Factors for Converting from Other Annual Probabilities of Being Exceeded and Other Mean Recurrence Intervals, to that used in this Standard

Annual probability of being exceeded (%)	Mean recurrence interval (years)	Multiplication factor
10	10	1.82
4	25	1.20
3.3	30	1.15
1	100	0.82

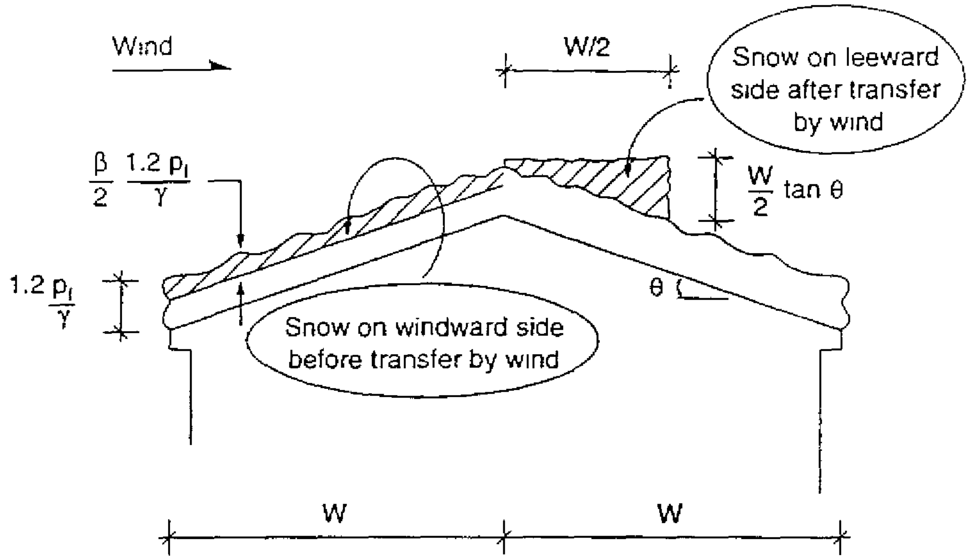


Figure C7-1. Formation of a Unbalanced Load on a Gable Roof

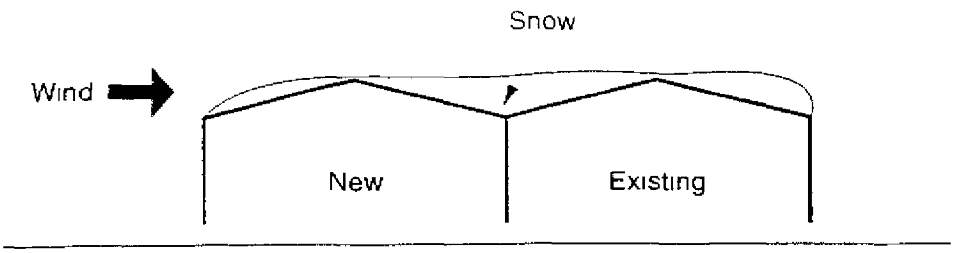
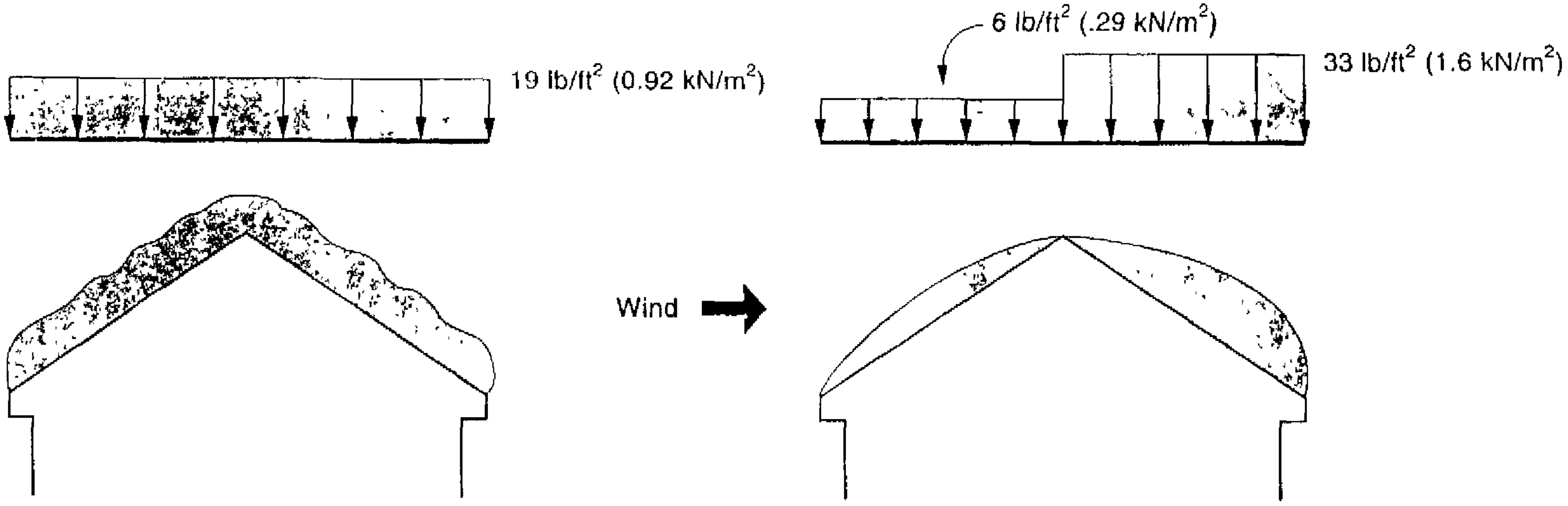


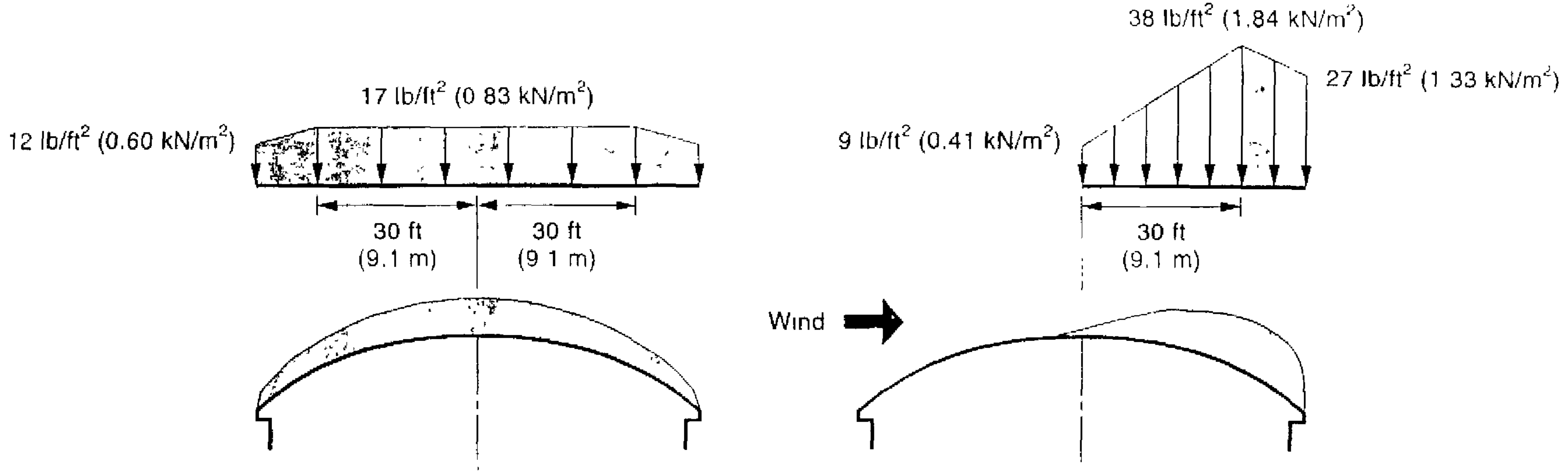
Figure C7-2. Valley in Which Snow Will Drift is Created When New Gable Roof is Added Alongside Existing Gable Roof



a. Balanced Condition

b. Unbalanced Condition

Figure C7-3. Design Snow Loads for Example 1



a. Balanced Condition

b. Unbalanced Condition

Figure C7-4. Design Snow Loads for Example 2

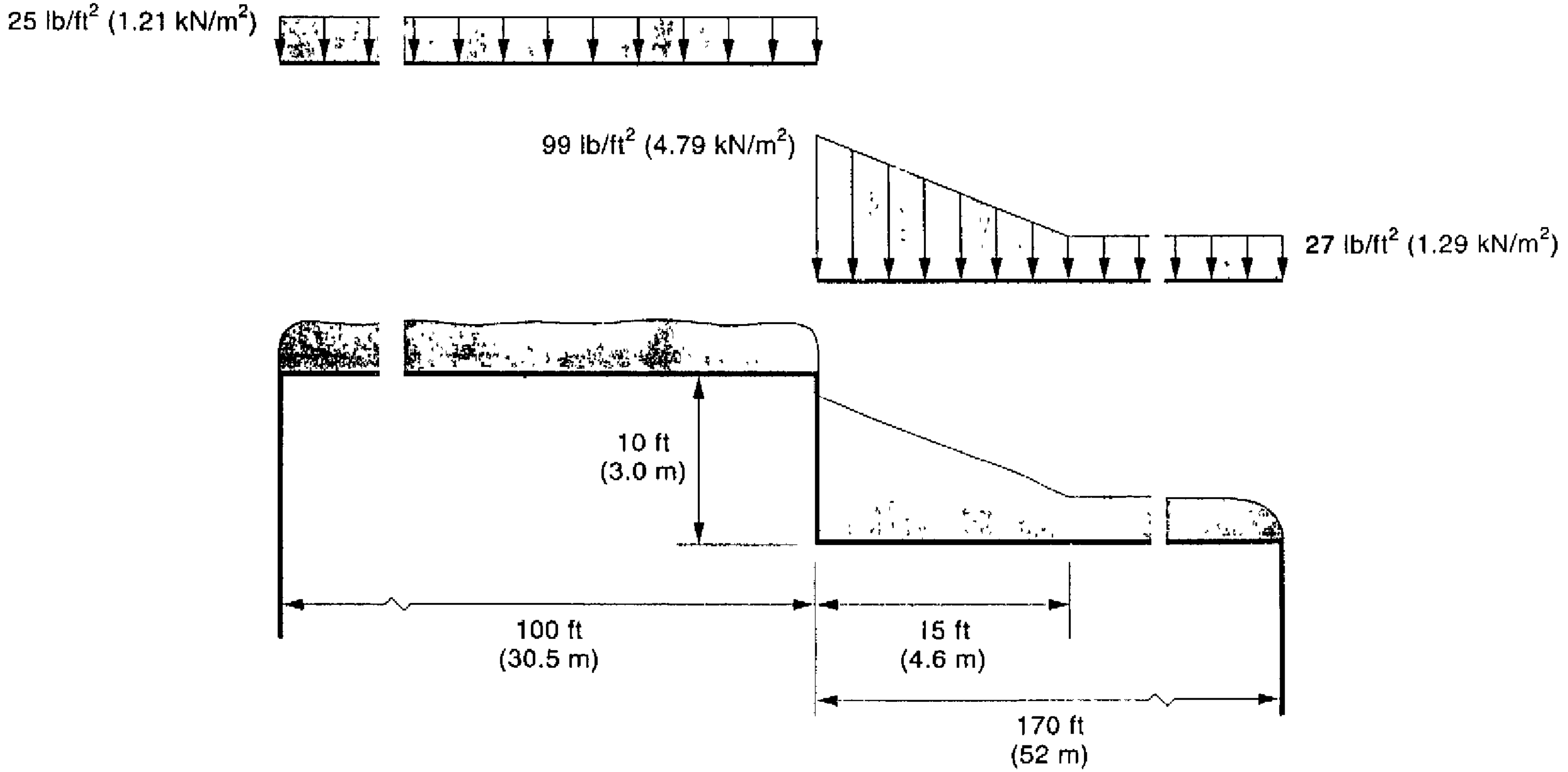


Figure C7-5. Design Snow Loads for Example 3

C8. Rain Loads

C8.1 Symbols and Notation.

A = roof area serviced by a single drainage system, in square feet (square meters).

i = design rainfall intensity as specified by the code having jurisdiction, in inches per hour (millimeters per hour).

Q = flow rate out of a single drainage system, in gallons per minute (cubic meters per second)

C8.2 Roof Drainage. Roof drainage systems are designed to handle all the flow associated with intense. short-duration rainfall events. (For example, the 1993 BOCA National Plumbing Code [1], and Factory Mutual Loss Prevention Data 1-54, "Roof Loads for New Construction" [2] use a one-hour duration event with a 100-year return period, the 1994 Standard Plumbing Code [3] uses one-hour and 15-minute duration events with 100-year return periods for the primary and secondary drainage systems. respectively and the 1990 National Building Code [4] of Canada uses a 15-minute event with a 10-year return period. A very severe local storm or thunderstorm may produce a deluge of such intensity and duration that properly designed primary drainage systems are temporarily overloaded Such temporary loads are adequately covered in design when blocked drains (see 8.3) and ponding instability (see 8 4) are considered.

Roof drainage is a structural, architectural and mechanical (plumbing) issue. The type and location of secondary drains and the hydraulic head above their inlets at the design flow must be known in order to determine rain loads. Design team coordination is particularly important when establishing rain loads

C8.3 Design Rain Loads. The amount of water that could accumulate on a roof from blockage of the primary drainage system is determined and the roof is designed to withstand the load created by that water plus the uniform load caused by water that rises above the inlet of the secondary drainage systems at its design flow. If parapet walls, cant strips, expansion joints, and other features create the potential for deep water in an area, it may be advisable to install in that area secondary (overflow) drains with separate drain lines rather than overflow scuppers to reduce the magnitude of the design rain load Where geometry permits, free discharge is the preferred form of emergency drainage.

When determining these water loads, it is assumed that the roof does not deflect. This eliminates complexities associated with determining the distribution of water loads within deflection depressions. However, it is quite important to consider this water when assessing ponding instability in Section 8.4.

The depth of water, d_h, above the inlet of the secondary drainage system (i e , the hydraulic head) is a function of the rainfall intensity at the site, the area of roof serviced by that drainage system and the size of the drainage system.

The flow rate through a single drainage system is as follows:

$$Q = 0.0104\,Ai \quad (\text{In SI } Q = 0.278\text{x}10^{-6} Ai) \qquad (\text{Eq C8-1})$$

The hydraulic head, d_h, is related to flow rate, Q, for various drainage systems in Table C8-1. That table indicates that d_h can vary considerably depending on the type and size of each drainage system and the flow rate it must handle For this reason the single value of 1 inch (25 mm) (i e . 5 lb/ft^2 (0.24 kN/m^2)) used in ASCE 7-93 has been eliminated

The hydraulic head, d_h, is zero when the secondary drainage system is simply overflow all along a roof edge.

C8.4 Ponding Instability. Water may accumulate as ponds on relatively flat roofs. As additional water flows to such areas, the roof tends to deflect more, allowing a deeper pond to form there If the structure does not possess enough stiffness to resist this progression, failure by localized overloading may result. References [1] through [16] contain information on ponding and its importance in the design of flexible roofs. Rational design methods to preclude instability from ponding are presented in references [5] and [6]

By providing roofs with a slope of 1/4 in./ft (1 19°) or more, ponding instability can be avoided. If the slope is less than 1/4 in./ft, (1 19°) the roof structure must be checked for ponding instability because construction tolerances and long-term deflections under dead load can result in flat portions susceptible to ponding.

C8.5 Controlled Drainage. In some areas of the country, ordinances are in effect that limit the rate of rainwater flow from roofs into storm drains. Controlled-flow drains are often used on such roofs. Those roofs must be capable of sustaining the storm water temporarily stored on them Many roofs designed with controlled-flow drains have a design rain load of 30 lb/ft^2 (1.44 kN/m^2) and are equipped with a secondary drainage system (for example, scuppers) that prevents water depths ($d_s + d_h$) greater than 5-3/4 (145 mm) inches on the roof.

Examples

The following two examples illustrate the method used to establish design rain loads based on Section 8 of this standard.

Example 1: Determine the design rain load, R, at the secondary drainage for the roof plan shown in Fig. C8-1, located at a site in Birmingham, AL. The design rainfall intensity, i, specified by the plumbing code for a 100-yr., 1-hour rainfall is 3 75 in./hr. (95 mm/hr.). The inlet of the 4 in. diameter (102 mm) secondary roof drains are set 2 in. (51 mm) above the roof surface.

Flow rate, Q, for the secondary drainage 4 in diameter (102 mm) roof drain:

$Q = 0.0104A_i$ Eq. C8-1

$Q = 0\ 0104\ (2500)(3.75) = 97.5$ gal./min. ($0.0062\ m^3$/sec.)

Hydraulic head, d_h:

Using Table C8-1, for a 4 in. diameter (102 mm) roof drain with a flow rate of 97 5 gal./min. ($0.0062\ m^3$/sec.) interpolate between a hydraulic head of 1 and 2 in (25 and 51 mm) as follows.

$d_h = 1 + [(97\ 5 - 80) - (170-80)] = 1.19$ in. 30.2 mm)

Static head $d_s = 2$ in. (51 mm); the water depth from drain inlet to the roof surface.

Design rain load, R, adjacent to the drains:

$R = 5\ 2\ (d_s + d_h)$ Eq 8-1

$R = 5.2\ (2 + 1\ 19) = 16.6$ psf ($0.80\ kN/m^2$)

Example 2: Determine the design rain load, R, at the secondary drainage for the roof plan shown in Fig. C8-2, located at a site in Los Angeles, CA. The design rainfall intensity, i, specified by the plumbing code for a 100-yr., 1-hour rainfall is 1.5 in./hr. (38 mm/hr). The inlet of the 12 in. (305 mm) secondary roof scuppers are set 2 in. (51 mm) above the roof surface.

Flow rate Q, for the secondary drainage, 12 in. (305 mm) wide channel scupper:

$Q = 0.0104\ A_i$ Eq. C8-1

$Q = 0.0104\ (11{,}500)(1\ 5) = 179$ gal./min. ($0.0113\ m^3$/sec)

Hydraulic head, d_h:

Using Table C8-1, by interpolation, the flow rate for a 12 in (305 mm) wide channel scupper is twice that of a 6 in. (152 mm) wide channel scupper. Using Table C8-1, the hydraulic head, d_h, for one-half the flow rate, Q, or 90 gal./min. ($0.0057\ m^3$/sec.), through a 6 in (152 mm) wide channel scupper is 3 in. (76 mm).

$d_h = 3$ in. (76 mm) for a 12 in. wide (305 mm) channel scupper with a flow rate, Q, of 179 gal./min (0 0113 m^3/sec)

Static head, $d_s = 2$ in. (51 mm); depth of water from the scupper inlet to the roof surface

Design rain load, R, adjacent to the scuppers:

$R = 5.2(d_h + d_s)$ Eq. 8-1

$R = 5.2\ (2 + 3) = 26$ psf ($1.2\ kN/m^2$)

References

[1] Building Officials and Code Administrators International. The BOCA National Plumbing Code/1993 Country Club Hills, Illinois, BOCA Inc , Jan 1993.

[2] Factory Mutual Engineering Corp Loss Prevention Data 1-54. Roof Loads for New Construction, Norwood, Mass FM Aug. 1991.

[3] Southern Building Code Congress International Standard Plumbing Code, 1991 Edition. Birmingham, Alabama, SBCCI Inc., 1991

[4] Associate Committee on the National Building Code. National Building Code of Canada 1990, Ottawa, Ontario, National Research Council of Canada, Jan. 1990.

[5] American Institute of Steel Construction Specification for structural steel for buildings, allowable stress design and plastic design. New York AISC. June 1989

[6] American Institute of Steel Construction. Load and resistance factor design specification for structural steel buildings. New York. AISC, Sept. 1986.

[7] American Institute of Timber Construction Roof slope and drainage for flat or nearly flat roofs. Englewood, Colo.: AITC. Tech Note No 5. Dec. 1978

[8] Burgett, L.B Fast check for ponding *Eng. J Am. Inst. Steel Construction* 10(1). 26-28. first quarter, 1973.

[9] Chinn, J., Mansouri, A.H., and Adams, S.F. Ponding of liquids on flat roofs. *J Struct Div.*. ASCE, 95(ST5), 797-808, May 1969.

[10] Chinn, J. Failure of simply-supported flat roofs by ponding of rain. *Eng. J Am Inst. Steel Construction* 3(2): 38-41, April 1965.

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[14] Salama, A E , and Moody, M L. Analysis of beams and plates for ponding loads. *J Struct Div.*, ASCE. 93(ST1): 109-126, Feb 1967

[15] Sawyer, D.A Ponding of rainwater on flexible roof systems *J Struct. Div.*, ASCE. 93(ST1): 127-148, Feb 1967

[16] Sawyer. D A Roof-structural roof-drainage interactions. *J. Struct Div.*, ASCE 94(ST1), 175-198, Jan. 1969

Table C8-1

Flow rate, Q, in gallons per minute of various drainage systems at various hydraulic heads, d_h in inches [2]

	Hydraulic Head d_h, inches									
Drainage System	1	2	2.5	3	3.5	4	4.5	5	7	8
4 in diameter drain	80	170	180							
6 in diameter drain	100	190	270	380	540					
8 in diameter drain	125	230	340	560	850	1100	1170			
6 in wide, channel scupper**	18	50	*	90	*	140	*	194	321	393
24 in wide, channel scupper	72	200	*	360	*	560	*	776	1284	1572
6 in. wide, 4 in high, closed scupper**	18	50	*	90	*	140	*	177	231	253
24 in. wide, 4 in high, closed scupper	72	200	*	360	*	560	*	708	924	1012
6 in wide, 6 in high, closed scupper	18	50	*	90	*	140	*	194	303	343
24 in. wide, 6 in high, closed scupper	72	200	*	360	*	560	*	776	1212	1372

* Interpolation is appropriate, including between widths of each scupper

** Channel scuppers are open-topped (i.e., 3-sided). Closed scuppers are 4-sided

In SI, Flow rate, Q, in cubic meters per second of various drainage systems at various hydraulic heads, d_h in millimeters [2]

	Hydraulic Head d_h, mm									
Drainage System	25	51	64	76	89	102	114	127	178	203
102 mm diameter drain	.0051	.0107	.0114							
152 mm diameter drain	.0063	.0120	.0170	.0240	.0341					
203 mm diameter drain	.0079	.0145	.0214	.0353	.0536	.0694	.0738			
152 mm wide, channel scupper**	.0011	.0032	*	.0057	*	.0088	*	.0122	.0202	.0248
610 mm wide, channel scupper	.0045	.0126	*	.0227	*	.0353	*	.0490	.0810	.0992
152 mm wide, 102 mm high, closed scupper**	.0011	.0032	*	.0057	*	.0088	*	.0112	.0146	.0160
610 mm wide, 102 mm high, closed scupper	.0045	.0126	*	.0227	*	.0353	*	.0447	.0583	.0638
152 mm wide, 152 mm high, closed scupper	.0011	.0032	*	.0057	*	.0088	*	.0122	.0191	.0216
610 mm wide, 152 mm high, closed scupper	.0045	.0126	*	.0227	*	.0353	*	.0490	.0765	.0866

* Interpolation is appropriate, including between widths of each scupper

** Channel scuppers are open-topped (i.e., 3-sided). Closed scuppers are 4-sided

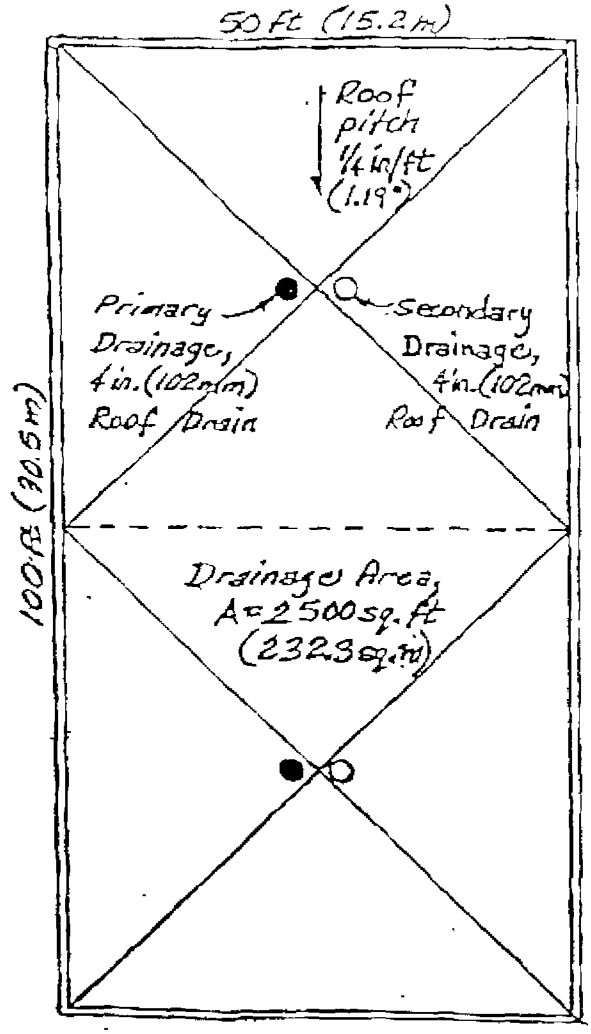

Fig. C8-1

Example 1 Roof Plan

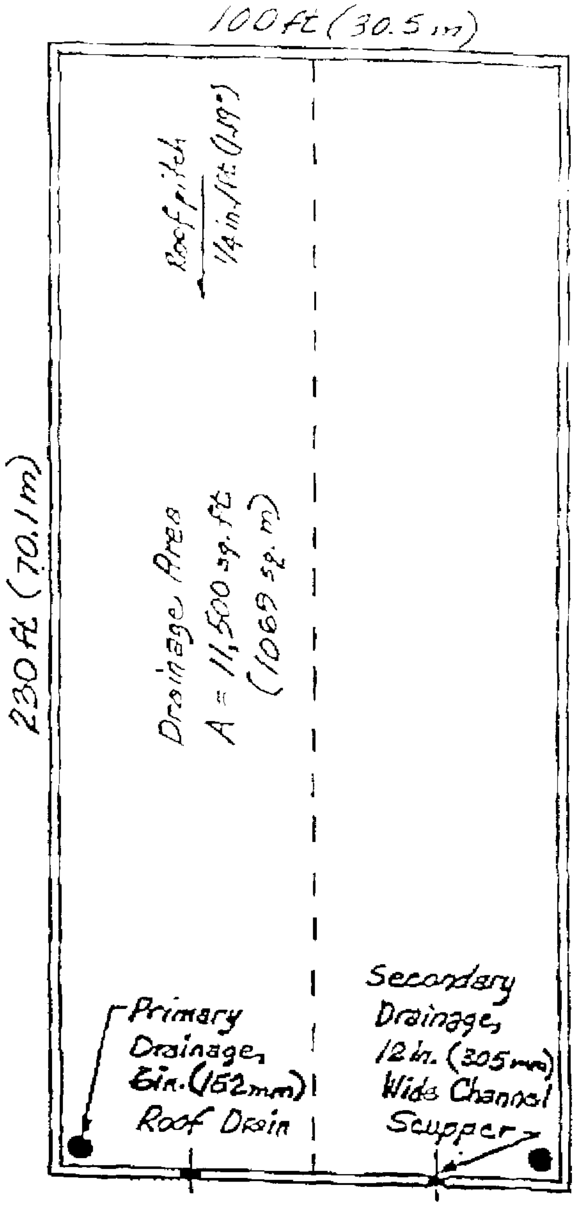

Fig. C8-2

Example 2 Roof Plan

Dashed lines in Figs. C8-1 and C8-2 indicate the boundary between separate drainage areas.