Example 1.3.5.14(c)

This example demonstrates the calculation of drift snow loads including unbalanced snow load for multiple gable roof and canopy snow load.

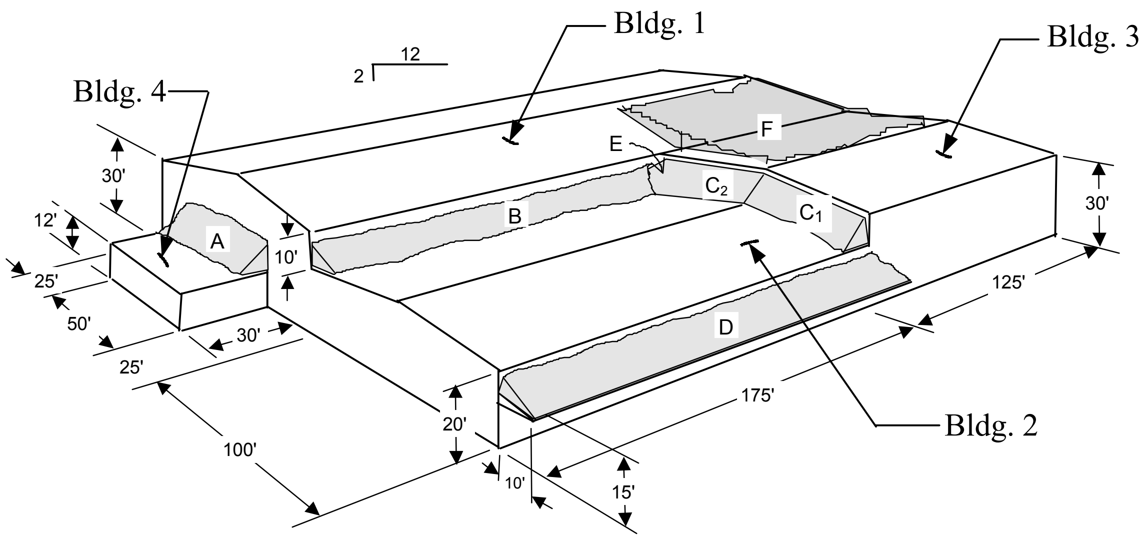


Figure 1.3.5.14(c)-1
Building Geometry and Drift Locations

A. Given:

Building Use: Manufacturing (Standard Building)
Location: Rock County, Minnesota
Building Size: (1) 100′W x 300′L x 30′H
(2) 100′W x 175′L x 20′H
(3) 100′W x 125′L x 30′H
(4) 50′W x 30′L x 12′H (Flat Roof)
Roof Slope: 2:12 (θ = 9.46°) (Buildings 1, 2 and 3)
Frame Type: Clear Span
Roof Type: Sheltered, Heated, Smooth Surface, Unventilated, Roof Insulation (R-19)
Terrain Category: B

B. General:

Ground Snow Load,	p_g = 40 psf	[Figure 7-1, ASCE 7-05]
Importance Factor,	I_s = 1.0	[Table 7-4, ASCE 7-05 or Table 1.3.1(a) in this Manual, Standard Building]
Roof Thermal Factor,	C_t = 1.0	[Table 7-3, ASCE 7-05, Warm Roof]
Roof Slope Factor,	C_s = 1.0	[Figure 7-2(a), ASCE 7-05 or Section 1.3.5.5a(ii) in this Manual] Note that some roof slopes are unobstructed, but some are obstructed because an adjoining

building prevents snow from sliding off of the eave. However, since insulation is R-19, the solid line of Figure 7-2(a) governs for all roof slopes.

Roof Exposure Factor, $C_e = 1.2$ [Table 7-2, ASCE 7-05 for Terrain Category B and sheltered roof]

Snow density $\gamma = 0.13\ (40) + 14 = 19.2$ pcf (Eq. 7-3, ASCE 7-05)

Rain on Snow Surcharge: $p_g > 20$ psf, therefore, rain-on-snow surcharge load need not be considered.

C. Roof Snow Load:

1.) ***Flat Roof Snow Load:***

$p_f = 0.7\ C_e C_t I_s p_g$ [Eq. 7-1, ASCE 7-05]

$p_f = 0.7\ (1.2)(1.0)(1.0)(40) = 33.6$ psf

For $p_g = 40$ psf

$p_{f,min} = I_s\ (20) = 1.0(20) = 20$ psf

$\therefore p_f = 33.6$ psf controls

2.) ***Buildings No. 1, No. 2, and No. 3:***

a.) <u>Sloped Roof Snow Load:</u>

$p_s = C_s\ p_f$ [Eq. 7-2, ASCE 7-05]

$= 1.0(33.6) = 33.6$ psf (balanced load)

b.) <u>Unbalanced Snow Load:</u>

Since the roof slope (9.46°) is greater than the larger of: (70/W + 0.5) = (70/50 + 0.5) = 1.9°, and (1/2 on 12) = <u>2.38°</u>, unbalanced loads must be considered.

$$h_d = 0.43\sqrt[3]{W_w}\ \sqrt[4]{p_g + 10} - 1.5 = 0.43\sqrt[3]{50}\ \sqrt[4]{40 + 10} - 1.5 = 2.71 \text{ ft.}$$

Figure 1.3.5.8(c) is applicable for metal building framing and the unbalanced snow loads are:

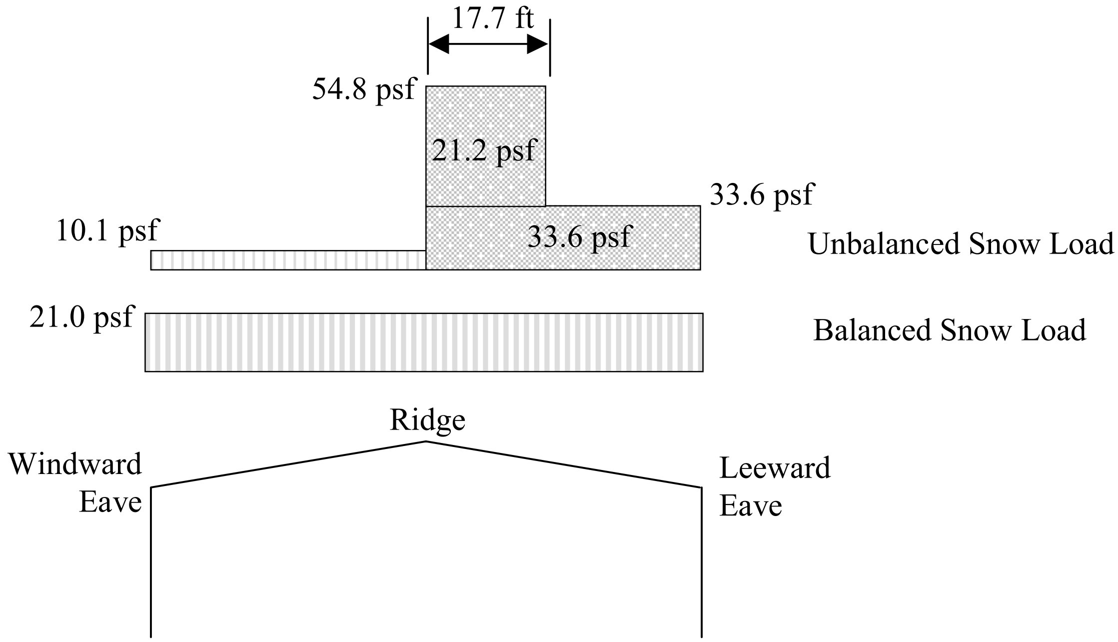
Uniform Windward Load: $0.3p_s = 0.3(33.6) = 10.1$ psf

Uniform Leeward Load: $p_s = 33.6$ psf

Surcharge Leeward Load: $h_d \gamma / \sqrt{S} = (2.71)(19.2)/\sqrt{6} = 21.2$ psf

Surcharge Leeward Length: $(8/3) h_d \sqrt{S} = (8/3)(2.71)\sqrt{6} = 17.7$ ft

The balanced and unbalanced design snow loads are shown in the figure below.



c.) <u>Partial Loading:</u>
Partial loading to be calculated as demonstrated in Examples 1.3.5.14(a) and 1.3.5.14(b).

3.) *Building No. 4 (50x30x12) (Flat roof):*

<u>Flat-roof snow load:</u>
p_f = 33.6 psf

Note: Although slope is less than W/50, still no rain-on-snow required since p_g > 20 psf (ASCE 7-05 Section 7.10).

D. Drift Loads and Sliding Snow Loads

Note: Unbalanced snow loads, drift loads and sliding snow loads are treated as separate load cases and are not to be combined as per Section 1.3.5.12 of this Manual.

1.) *Calculation for Area A:*

a.) <u>Drift Load - Figure 1.3.5.14(c)-2</u>

$$h_r \text{ (Average)} = 30 + \left\{\frac{(25+50)}{2}\left(\frac{2}{12}\right)\right\} - 12 = 24.25 \text{ ft.}$$

$$h_b = \frac{33.6}{19.2} = 1.75 \text{ ft.}; \quad h_c = (h_r - h_b) = 22.5 \text{ ft.}$$

$\frac{h_c}{h_b} = \frac{22.5}{1.75} = 12.86 > 0.2 \quad \therefore$ consider drift loads.

L_L (windward) = 30 ft.

h_d (windward) = $0.75\,[0.43 \times \sqrt[3]{30}\,\sqrt[4]{40+10} - 1.5]$

= 1.55 ft. ≤ h_c = 22.5 ft.

L_u (leeward) = 300 ft.

h_d (leeward) = $[0.43 \times \sqrt[3]{300}\,\sqrt[4]{40+10} - 1.5]$

= 6.15 ft. ≤ h_c = 22.5 ft.

∴ Leeward drift controls with h_d = 6.15 ft. and, $w = 4h_d$ = 24.6 ft.

Drift surcharge load, $p_d = h_d\,\gamma = 6.15 \times 19.2 = 118.1$ psf

$p_t = 33.6 + 118.1 = 151.7$ psf

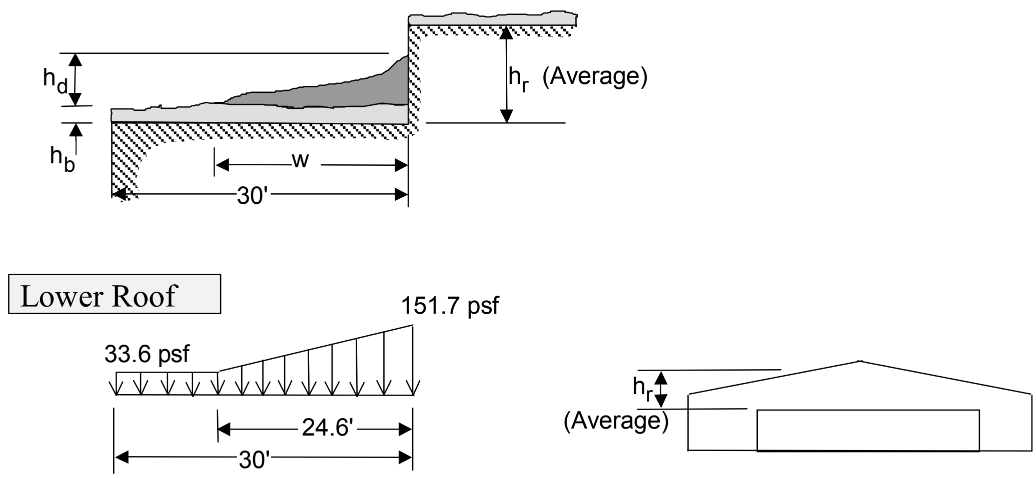


Figure 1.3.5.14(c)-2
Drift Load for Area A

b.) Sliding Snow

No snow will slide off of the roof of Building No. 1 onto the roof of Building No. 4.

2.) *Calculation for Area B:*

a.) Drift Load - Figure 1.3.5.14(c)-3

Sloped-roof snow load, p_s = 33.6 psf (balanced snow load)

h_r = (30-20) = 10 ft.; $h_b = \frac{33.6}{19.2}$ = 1.75 ft.; $h_c = (h_r - h_b)$ = 8.25 ft.

$$\frac{h_c}{h_b} = \frac{8.25}{1.75} = 4.71 > 0.2 \quad \therefore \text{ consider drift loads.}$$

L_L (windward) = L_u (leeward) = 100 ft. ∴ leeward drift controls.

h_d (leeward) = $[0.43 \times \sqrt[3]{100}\ \sqrt[4]{40+10}\ -1.5]$

$= 3.81$ ft. $\leq h_c = 8.25$ ft.

∴ $h_d = 3.81$ ft. and, $w = 4h_d = 15.24$ ft.

Drift surcharge load, $p_d = h_d\,\gamma = 3.81 \times 19.2 = 73.2$ psf

$p_t = 33.6 + 73.2 = 106.8$ psf

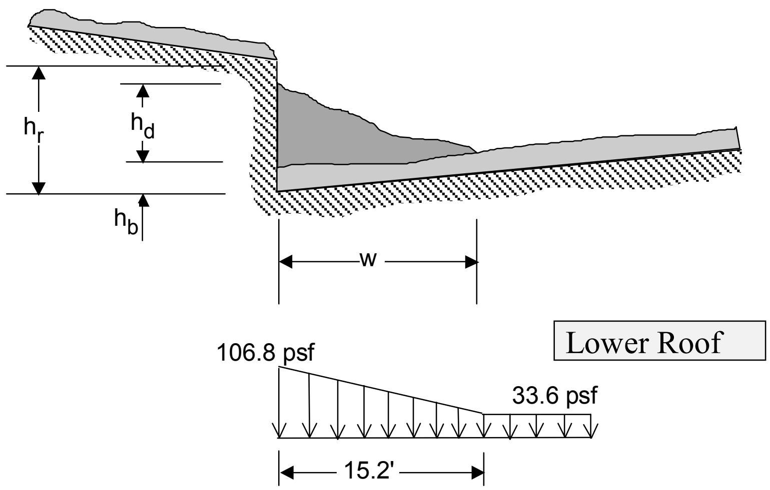


Figure 1.3.5.14(c)-3
Drift Load for Area B

b.) <u>Sliding Snow - Figure 1.3.5.14(c)-4</u>

$h_c = h_r - h_b = (10.0\text{-}1.75) = 8.25$ ft. ; $L_u = 50.0$ ft. ; slope = 2:12

Since 2:12 > ¼:12, sliding snow must be checked

Total sliding load/ft of eave = $0.4p_fW = 0.4(33.6)(50) = 672$ lb/ft

Sliding snow shall be distributed over 15 ft.

$$\frac{672}{15} = 44.8 \text{ psf}$$

Since $\frac{44.8}{19.2} = 2.3$ ft < 8.25 ft, no reduction is allowed

$p_t = (33.6 + 44.8) = 78.4$ psf

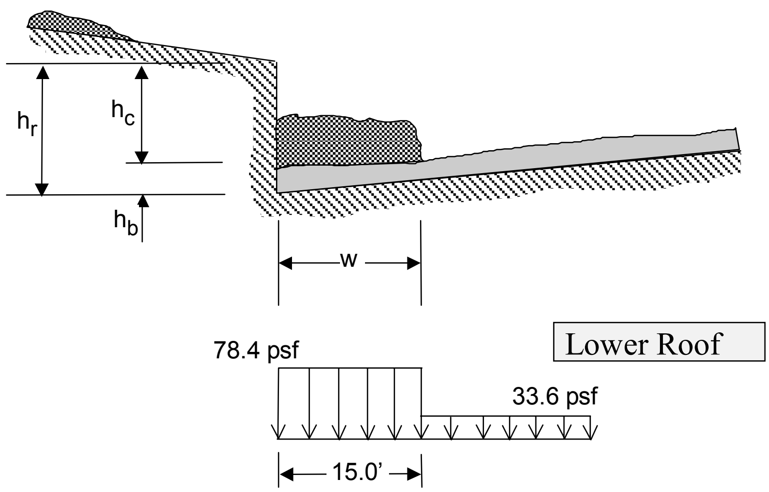


Figure 1.3.5.14(c)-4
Sliding Snow for Area B

3.) ***Calculation for Areas C_1 and C_2:***

a.) Drift Load - Figure 1.3.5.14(c)-5

Sloped-roof snow load, p_s = 33.6 psf (balanced snow load)

Note: C_1 is on unobstructed side and C_2 is on obstructed side where snow is prevented from sliding off eave. However, as previously indicated, C_S is equal to 1.0 for both sides for the roof insulation of R-19.

$h_r = (30\text{-}20) = 10$ ft. ; $h_b = \dfrac{33.6}{19.2} = 1.75$ ft.; $h_c = (h_r - h_b) = 8.25$ ft.

$\dfrac{h_c}{h_b} = \dfrac{8.25}{1.75} = 4.71 > 0.2$ $\therefore$ consider drift loads.

L_L (windward) = 175 ft.

h_d (windward) $= 0.75\ [0.43 \times \sqrt[3]{175}\ \sqrt[4]{40+10}\ \text{-}1.5]$

$= 3.68$ ft. $\leq h_c = 8.25$ ft.

L_u (leeward) = 125 ft.

h_d (leeward) $= [0.43 \times \sqrt[3]{125}\ \sqrt[4]{40+10}\ \text{-}1.5]$

$= 4.22$ ft. $\leq h_c = 8.25$ ft.

$\therefore$ Leeward drift controls with $h_d = 4.22$ ft. and, $w = 4h_d = 16.88$ ft.

Drift surcharge load, $p_d = h_d\,\gamma = 4.22 \times 19.2 = 81.0$ psf

$p_t = 33.6 + 81.0 = 114.6$ psf

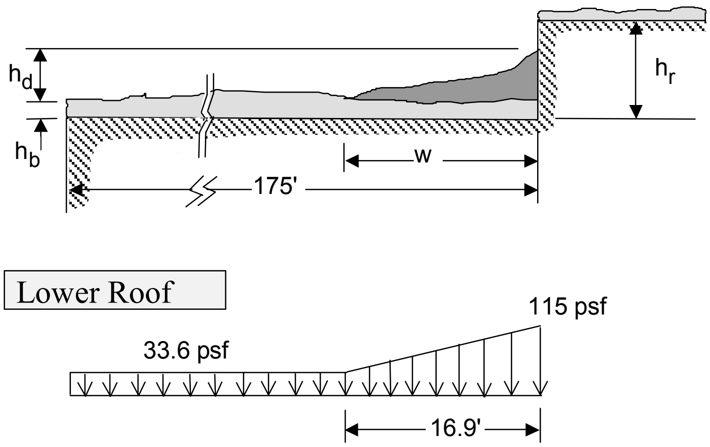


Figure 1.3.5.14(c)-5
Drift Load for Areas C_1 and C_2

b.) <u>Sliding Snow</u>

No snow will slide off of the roof of Building No. 3 onto the roof of Building No. 2.

4.) ***Calculation for Area D:***

a.) <u>Drift Load - Figure 1.3.5.14(c)-6</u>

Unheated structure due to canopy condition.
Flat-roof snow load, $p_f = 0.7\, C_e\, C_t\, I_s\, p_g$
where,
$p_g = 40$ psf
$C_e = 1.2$ [Table 7-2, ASCE 7-05 for Terrain Category B and sheltered roof]
$C_t = 1.2$ [Table 7-3, ASCE 7-05, Unheated Structure];
$\therefore p_f = 0.7\,(1.2)(1.2)(1.0)(40) = 40.3$ psf

$h_r = (20\text{-}15) = 5$ ft. ; $h_b = \dfrac{40.3}{19.2} = 2.10$ ft.; $h_c = (h_r - h_b) = 2.90$ ft.

$\dfrac{h_c}{h_b} = \dfrac{2.90}{2.10} = 1.38 > 0.2$ $\therefore$ consider drift loads.

L_L (windward) = 10 ft. $\leq$ 25 ft. $\therefore$ use L_L (windward) = 25 ft.

h_d (windward) $= 0.75\,[0.43 \times \sqrt[3]{25}\,\sqrt[4]{40+10} - 1.5]$
$= 1.38$ ft. $\leq h_c = 2.90$ ft.

L_u (leeward) = 100 ft.

h_d (leeward) $= [0.43 \times \sqrt[3]{100}\,\sqrt[4]{40+10} - 1.5]$
$= 3.81$ ft. $> h_c = 2.90$ ft.

$\therefore$ Leeward drift controls with drift height $= h_c = 2.90$ ft. and, $w = 4h_d^{\,2} / h_c$

$$w = \frac{4(3.81)^2}{2.90} = 20.0 \text{ ft.}$$

Maximum drift width, $w = 8h_c = 8 \times 2.90 = 23.2$ ft. > 20.0 ft.

$\therefore$ w = 20.0 ft.

Drift surcharge load, $p_d = h_c\, \gamma = 2.90 \times 19.2 = 55.7$ psf

$p_t = 40.3 + 55.7 = 96.0$ psf

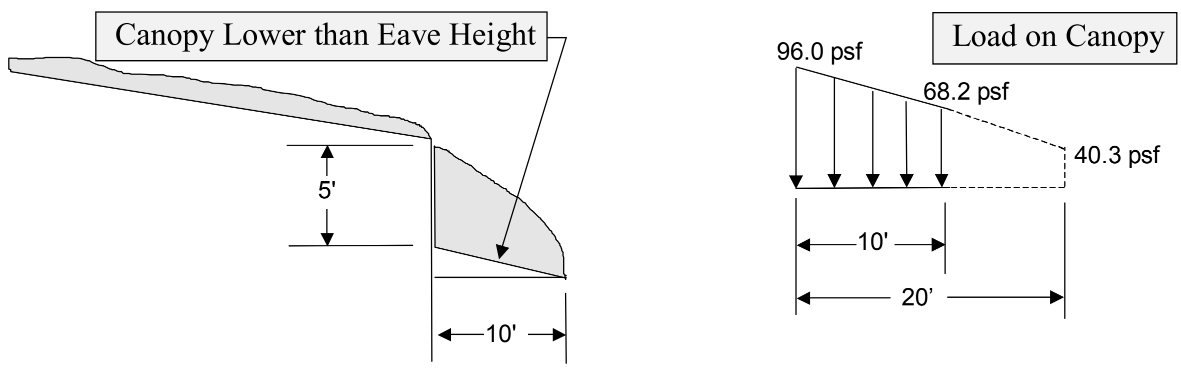


Figure 1.3.5.14(c)-6
Drift Load for Area D

<u>Note</u>: For the below eave canopy, the minimum design load per Section 7.4.5 of ASCE 7-05 is $2p_f = 2(40.3) = 80.6$ psf.

b.) <u>Sliding Snow - Figure 1.3.5.14(c)-7)</u>

$h_c = h_r - h_b = (5.0 - 2.10) = 2.90$ ft. ; $L_u = 50.0$ ft. ; slope = 2:12

Since 2:12 > ¼:12, sliding snow must be checked

Total sliding load/ft of eave = $0.4p_fW = 0.4(33.6)(50) = 672$ lb/ft

Sliding snow shall be distributed over 15 ft (Even though canopy width is 10 ft.).

$$\frac{672}{15} = 44.8 \text{ psf}$$

Since $\frac{44.8}{19.2} = 2.3$ ft < 2.9 ft, no reduction is allowed

$p_t = (40.3 + 44.8) = 85.1$ psf

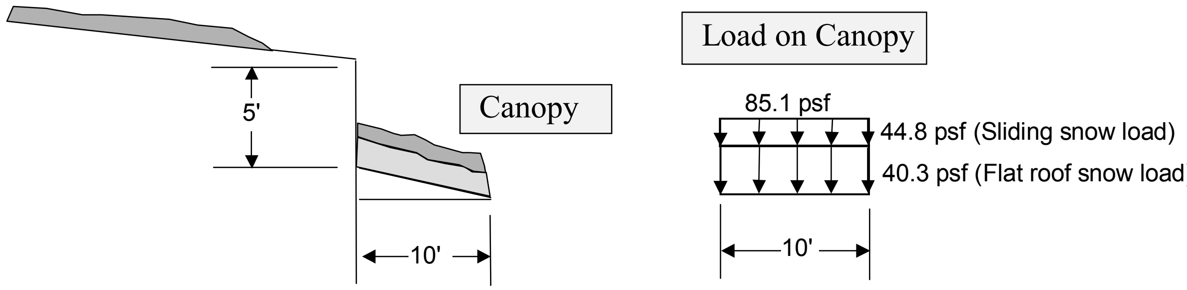


Figure 1.3.5.14(c)-7
Sliding Snow for Area D

5.) ***Calculation for Area E and Figure 1.3.5.14(c)-8:***

For the intersection of drifts B and C_2 at E, the design load should be as shown in Figure 1.5.14(c)-8

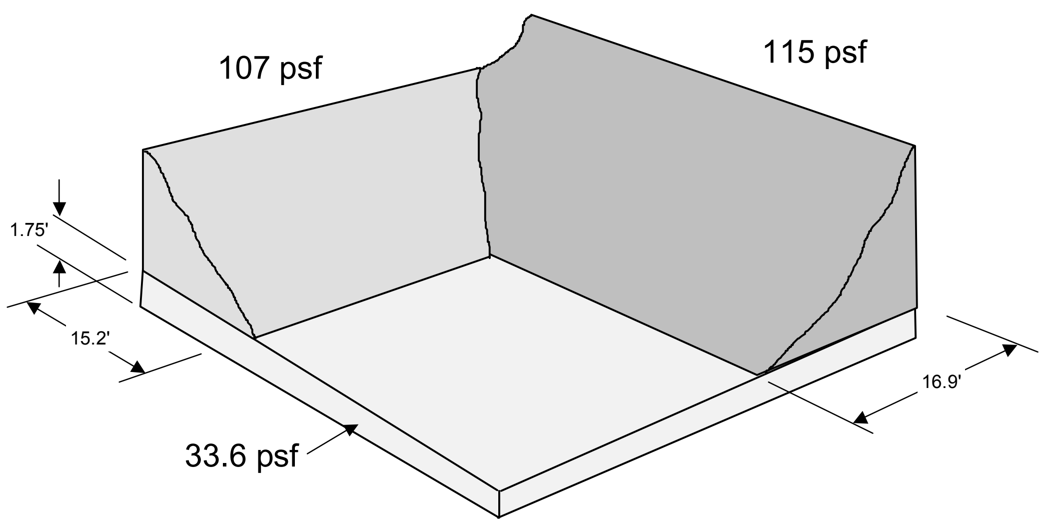


Figure 1.3.5.14(c)-8
Intersecting Snow Drifts for Area E

6.) ***Calculation for Area F:***

a.) <u>Valley Drift Load - Figure 1.3.5.14(c)-9</u>

For buildings 1 & 3, p_f = 33.6 psf

$h_b = \dfrac{p_f}{\gamma} = \dfrac{33.6}{19.2} = 1.75$ ft.

$C_e = 1.2$ (Table 7-2 for Terrain Category B and sheltered roof)

The unbalanced snow load (See ASCE 7-05, Section 7.6.3):

At Ridge $= 0.5\ p_f = 0.5 \times 33.6 = 16.8$ psf

At Valley $= 2\ p_f / C_e = (2 \times 33.6)/1.2 = 56.0$ psf

Check if calculated snow depth in valley extends above snow level at ridge:

Snow depth at valley, $h_{dv} = \dfrac{56.0}{19.2} = 2.92$ ft.

Snow level at ridge relative to valley $= \dfrac{50(2)}{12} + \dfrac{1.75}{2} = 9.20 > 2.92$ ft

$\therefore$ The valley snow depth does not extend above ridges

Windward slope snow load $= 0.3\ p_f = 0.3 \times 33.6 = 10.1$ psf
Leeward slope snow load $= p_f = 33.6$ psf

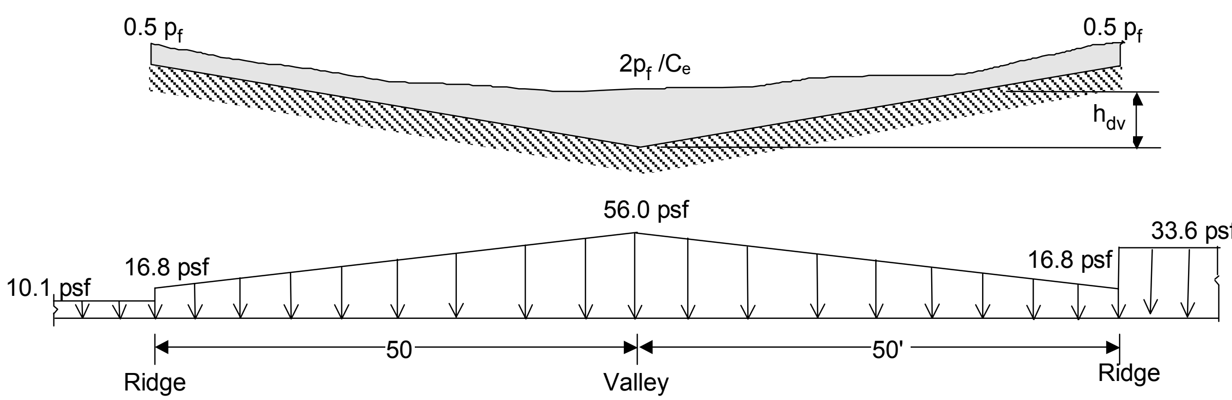


Figure 1.3.5.14(c)-9
Valley Snow Drift for Area F