Solutions for Structural Analysis 10th Edition by Hibbeler

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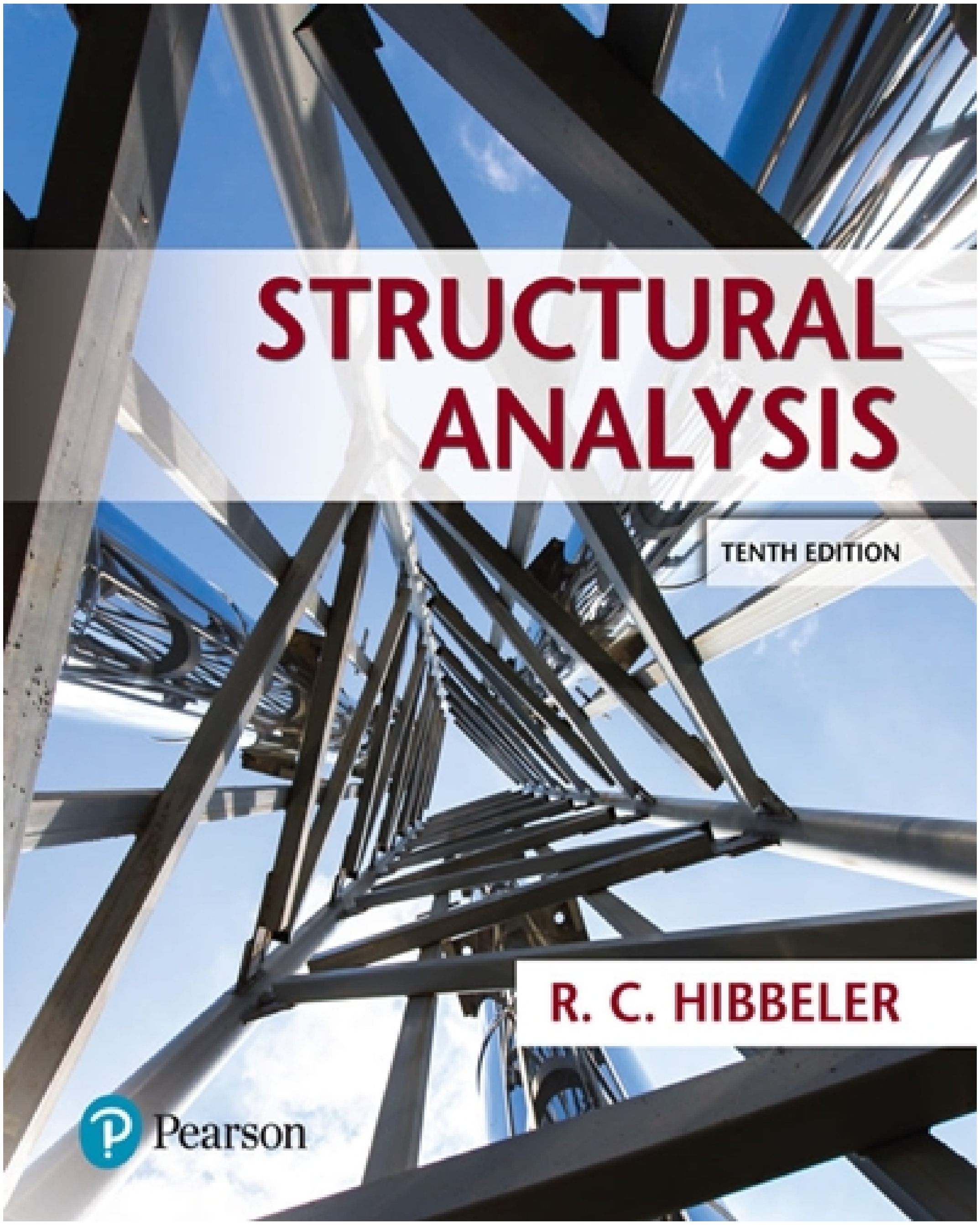


Solutions

1–1. The floor of a heavy storage warehouse building is made of 6-in.-thick stone concrete. If the floor is a slab having a length of 15 ft and width of 10 ft, determine the resultant force caused by the dead load and the live load.

SOLUTION

From Table 1–3,

$DL = [12 \text{ lb/ft}^2 \cdot \text{in.}(6 \text{ in.})](15 \text{ ft})(10 \text{ ft}) = 10{,}800 \text{ lb}$

From Table 1–4,

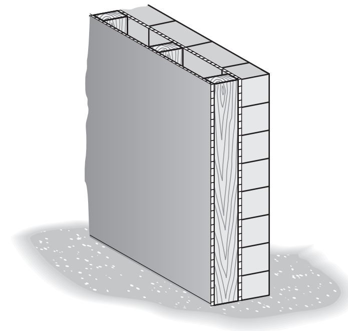
$LL = (250 \text{ lb/ft}^2)(15 \text{ ft})(10 \text{ ft}) = 37{,}500 \text{ lb}$

Total load:

$F = 48{,}300 \text{ lb} = 48.3 \text{ k}$ **Ans.**

Ans.
$F = 48.3 \text{ k}$

1–2. The wall is 15 ft high and consists of 2 × 4 in. studs, plastered on one side. On the other side there is 4-in. clay brick. Determine the average load in lb/ft of length of wall that the wall exerts on the floor.



SOLUTION

Using the data tabulated in Table 1–3,

4-in. clay brick: $(39\ \text{lb/ft}^2)(15\ \text{ft}) = 585\ \text{lb/ft}$

2 × 4-in. studs plastered on one side: $(12\ \text{lb/ft}^2)(15\ \text{ft}) = 180\ \text{lb/ft}$

$w_D = 765\ \text{lb/ft}$ **Ans.**

Ans.
$w_D = 765\ \text{lb/ft}$

1–3. A building wall consists of 12-in. clay brick and $\frac{1}{2}$-in. fiberboard on one side. If the wall is 10 ft high, determine the load in pounds per foot that it exerts on the floor.

SOLUTION

From Table 1–3,

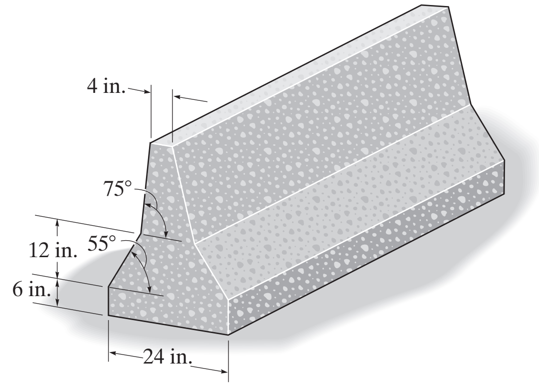
12-in. clay brick: $(115 \text{ lb/ft}^2)(10 \text{ ft}) = 1150 \text{ lb/ft}$

1/2-in. fiberboard: $(0.75 \text{ lb/ft}^2)(10 \text{ ft}) = 7.5 \text{ lb/ft}$

Total: $1157.5 \text{ lb/ft} = 1.16 \text{ k/ft}$ **Ans.**

Ans.
$w = 1.16\text{k/ft}$

***1–4.** The "New Jersey" barrier is commonly used during highway construction. Determine its weight per foot of length if it is made from plain stone concrete.



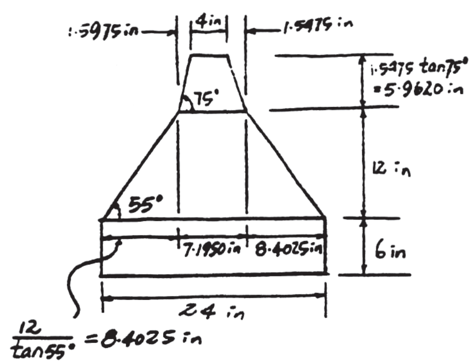
SOLUTION

$$\text{Cross-sectional area} = 6(24) + \left(\frac{1}{2}\right)(24 + 7.1950)(12) + \left(\frac{1}{2}\right)(4 + 7.1950)(5.9620)$$

$$= 364.54\ \text{in}^2$$

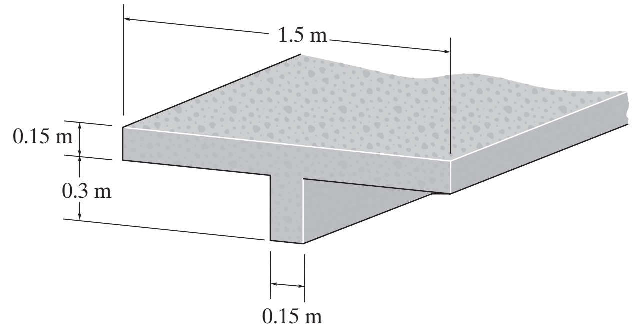
Use Table 1–2.

$$w = 144\ \text{lb/ft}^3(364.54\ \text{in}^2)\left(\frac{1\ \text{ft}^2}{144\ \text{in}^2}\right) = 365\ \text{lb/ft}$$ **Ans.**



Ans.
$w = 365\ \text{lb/ft}$

1–5. The precast floor beam is made from concrete having a specific weight of 23.6 kN/m³. If it is to be used for a floor of an office building, calculate its dead and live loadings per foot length of beam.



SOLUTION

The dead load is caused by the self-weight of the beam.

$$w_D = [(1.5\text{ m})(0.15\text{ m}) + (0.15\text{ m})(0.3\text{ m})](23.6\text{ kN/m}^3)$$
$$= 6.372\text{ kN/m} = 6.37\text{ kN/m} \qquad \textbf{Ans.}$$

For the office, the recommended line load for design in Table 1–4 is 2.4 kN/m². Thus,

$$w_L = (2.40\text{ kN/m}^2)(1.5\text{ m}) = 3.60\text{ kN/m} \qquad \textbf{Ans.}$$

Ans.
$w_D = 6.37$ kN/m
$w_L = 3.60$ kN/m

1–6. The floor of a light storage warehouse is made of 150-mm-thick lightweight plain concrete. If the floor is a slab having a length of 7 m and width of 3 m, determine the resultant force caused by the dead load and the live load.

SOLUTION

From Table 1–3,

$DL = [0.015\ \text{kN/m}^2 \cdot \text{mm}\ (150\ \text{mm})](7\ \text{m})(3\ \text{m}) = 47.25\ \text{kN}$

From Table 1–4,

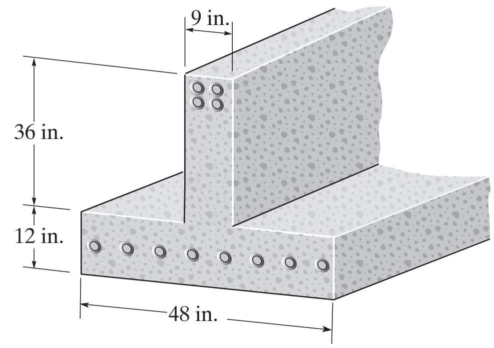
$LL = (6.00\ \text{kN/m}^2)(7\ \text{m})(3\ \text{m}) = 126\ \text{kN}$

Total Load:

$F = 126\ \text{kN} + 47.25\ \text{kN} = 173\ \text{kN}$ **Ans.**

Ans.
$F = 173\ \text{kN}$

1–7. The precast inverted T-beam has the cross section shown. Determine its weight per foot of length if it is made from reinforced stone concrete and twelve $\frac{3}{4}$-in.-diameter cold-formed steel reinforcing rods.



SOLUTION

From Table 1–2, the specific weight of reinforced stone concrete and the cold-formed steel are $\gamma_C = 150\ \text{lb/ft}^3$ and $\gamma_H = 492\ \text{lb/ft}^3$, respectively.

Reinforced stone concrete: $\left[\left(\frac{48}{12}\ \text{ft}\right)\left(\frac{12}{12}\ \text{ft}\right) + \left(\frac{9}{12}\ \text{ft}\right)\left(\frac{36}{12}\ \text{ft}\right) - 12\left(\frac{\pi}{4}\right)\left(\frac{0.75}{12}\ \text{ft}\right)^2\right](150\ \text{lb/ft})$

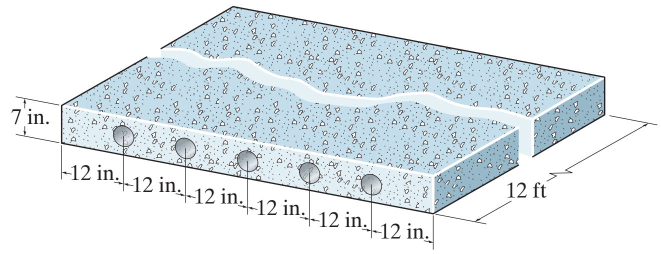
$= 931.98\ \text{lb/ft}$

Cold-formed steel: $\left[12\left(\frac{\pi}{4}\right)\left(\frac{0.75}{12}\ \text{ft}\right)^2\right](492\ \text{lb/ft}^3) = \frac{18.11\ \text{lb/ft}}{950.09\ \text{lb/ft}}$

$$w_D = (950.09\ \text{lb/ft})\left(\frac{1\ \text{k}}{1000\ \text{lb}}\right) = 0.950\ \text{k/ft}$$ **Ans.**

Ans.
$w_D = 0.950\ \text{k/ft}$

***1–8.** The hollow core panel is made from plain stone concrete. Determine the dead weight of the panel. The holes each have a diameter of 4 in.



SOLUTION

From Table 1–2,

$$W = (144\ \text{lb/ft}^3)\left[(12\ \text{ft})(6\ \text{ft})\left(\frac{7}{12}\ \text{ft}\right) - 5(12\ \text{ft})(\pi)\left(\frac{2}{12}\ \text{ft}\right)^2\right] = 5.29\ \text{k} \qquad \textbf{Ans.}$$

Ans.
$W = 5.29$ k

1–9. The floor of a light storage warehouse is made of 6-in.-thick cinder concrete. If the floor is a slab having a length of 10 ft and width of 8 ft, determine the resultant force caused by the dead load and that caused by the live load.

SOLUTION

From Table 1–3,

$DL = (6 \text{ in.})(9 \text{ lb/ft}^2 \cdot \text{in.})(8 \text{ ft})(10 \text{ ft}) = 4.32 \text{ k}$ **Ans.**

From Table 1–4,

$LL = (125 \text{ lb/ft}^2)(8 \text{ ft})(10 \text{ ft}) = 10.0 \text{ k}$ **Ans.**

Ans.
$DL = 4.32 \text{ k}$
$LL = 10.0 \text{ k}$

1–10. The interior wall of a building is made from 2×4 wood studs, plastered on two sides. If the wall is 12 ft high, determine the load in lb/ft of length of wall that it exerts on the floor.

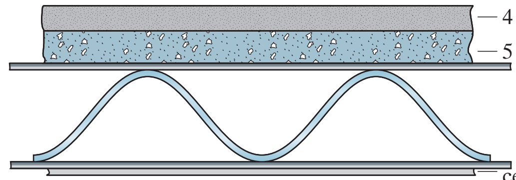
SOLUTION

From Table 1–3,

$w = (20\ \text{lb/ft}^2)(12\ \text{ft}) = 240\ \text{lb/ft}$ **Ans.**

Ans.
$w = 240\ \text{lb/ft}$

1–11. The second floor of a light manufacturing building is constructed from a 5-in.-thick stone concrete slab with an added 4-in. cinder concrete fill as shown. If the suspended ceiling of the first floor consists of metal lath and gypsum plaster, determine the dead load for design in pounds per square foot of floor area.



SOLUTION

From Table 1–3,

5-in. concrete slab	= (12)(5)	= 60.0
4-in. cinder fill	= (9)(4)	= 36.0
metal lath & plaster		= 10.0
Total dead load		= 106.0 lb/ft^2 **Ans.**

Ans.
$DL = 106 \text{ lb/ft}^2$

***1–12.** A two-story hotel has interior columns for the rooms that are spaced 6 m apart in two perpendicular directions. Determine the reduced live load supported by a typical interior column on the first floor under the public rooms.

SOLUTION

Table 1–4:

$L_o = 4.79\ \text{kN/m}^2$

$A_T = (6\ \text{m})(6\ \text{m}) = 36\ \text{m}^2$

$K_{LL} = 4$

$K_{LL}A_T = 4(36) = 144\ \text{m}^2 > 37.2\ \text{m}^2$

From Eq. 1-1,

$$LL = L_o\left(0.25 + \frac{4.57}{\sqrt{K_{LL}A_T}}\right)$$

$$LL = 4.79\left(0.25 + \frac{4.57}{\sqrt{4(36)}}\right)$$

$LL = 3.02\ \text{kN/m}^2$ **Ans.**

$3.02\ \text{kN/m}^2 > 0.4L_o = 1.916\ \text{kN/m}^2$ OK

Ans.
$LL = 3.02\ \text{kN/m}^2$

1–13. A four-story office building has interior columns spaced 30 ft apart in two perpendicular directions. If the flat-roof live loading is estimated to be 30 lb/ft^2, determine the reduced live load supported by a typical interior column located at ground level.

SOLUTION

From Table 1–4,

$L_o = 50 \text{ psf}$

$A_T = (30)(30) = 900 \text{ ft}^2$

$K_{LL}A_T = 4(900) = 3600 \text{ ft}^2 > 400 \text{ ft}^2$

From Eq. 1-1,

$$L = L_a\left(0.25 - \frac{15}{\sqrt{K_{LL}A_T}}\right)$$

$$L = 50\left(0.25 - \frac{15}{\sqrt{4(900)}}\right) = 25 \text{ psf}$$

$$\% \text{ reduction} = \frac{25}{50} = 50\% > 40\% \text{ (OK)}$$

$F = 3[(25 \text{ psf})(30 \text{ ft})(30 \text{ ft})] + 30 \text{ psf}(30 \text{ ft})(30 \text{ ft}) = 94.5 \text{ k}$ **Ans.**

Ans.
$LL = 94.5 \text{ k}$

1–14. The office building has interior columns spaced 5 m apart in perpendicular directions. Determine the reduced live load supported by a typical interior column located on the first floor under the offices.

SOLUTION

From Table 1–4,

$$L_o = 2.40\ \text{kN/m}^2$$

$$A_T = (5\ \text{m})(5\ \text{m}) = 25\ \text{m}^2$$

$$K_{LL} = 4$$

$$L = L_o\left(0.25 + \frac{4.57}{\sqrt{K_{LL}A_T}}\right)$$

$$L = 2.40\left(0.25 + \frac{4.57}{\sqrt{4(25)}}\right)$$

$$L = 1.70\ \text{kN/m}^2 \qquad \textbf{Ans.}$$

$1.70\ \text{kN/m}^2 > 0.4\,L_o = 0.96\ \text{kN/m}^2$ OK

Ans.
$LL = 1.70\ \text{kN/m}^2$

1–15. A hospital located in Chicago, Illinois, has a flat roof, where the ground snow load is 25 lb/ft². Determine the design snow load on the roof of the hospital.

SOLUTION

$C_e = 1.2$

$C_t = 1.0$

$I = 1.2$

$p_f = 0.7\,C_e C_t I_{pg}$

$p_f = 0.7(1.2)(1.0)(1.2)(25) = 25.2\text{ lb/ft}^2$ **Ans.**

Ans.
$p_f = 25.2\text{ lb/ft}^2$

***1–16.** Wind blows on the side of a fully enclosed 30-ft-high hospital located on open flat terrain in Arizona. Determine the design wind pressure acting over the windward wall of the building at the heights 0–15 ft, 20 ft, and 30 ft. The roof is flat. Take $K_e = 1.0$.

SOLUTION

$V = 120 \text{ mi/h}$

$K_{zt} = 1.0$

$K_d = 1.0$

$K_e = 1.0$

$$q_z = 0.00256\, K_z K_{zt} K_d K_e V^2$$
$$= 0.00256 K_z\,(1.0)(1.0)(1.0)(120)^2$$
$$= 36.86\, K_z$$

From Table 1–5,

z	K_z	q_z
0–15	0.85	31.33
20	0.90	33.18
25	0.94	34.65
30	0.98	36.13

Thus,

$$p = qGC_p - q_h(GC_{pi})$$
$$= q(0.85)(0.8) - 36.13(\pm 0.18)$$
$$= 0.68q \mp 6.503$$

$p_{0-15} = 0.68(31.33) \mp 6.503 = 14.8 \text{ psf or } 27.8 \text{ psf}$ **Ans.**

$p_{20} = 0.68(33.18) \mp 6.503 = 16.1 \text{ psf or } 29.1 \text{ psf}$ **Ans.**

$p_{25} = 0.68(34.65) \mp 6.503 = 17.1 \text{ psf or } 30.1 \text{ psf}$ **Ans.**

$p_{30} = 0.68(36.13) \mp 6.503 = 18.1 \text{ psf or } 31.1 \text{ psf}$ **Ans.**

Ans.
$p_{0-15} = 14.8$ psf or 27.8 psf
$p_{20} = 16.1$ psf or 29.1 psf
$p_{25} = 17.1$ psf or 30.1 psf
$p_{30} = 18.1$ psf or 31.1 psf

1–17. Wind blows on the side of the fully enclosed hospital located on open flat terrain in Arizona. Determine the external pressure acting on the leeward wall, if the length and width of the building are 200 ft and the height is 30 ft.

SOLUTION

$V = 120 \text{ mi/h}$

$K_{zt} = 1.0$

$K_d = 1.0$

$K_e = 1.0$

$$q_h = 0.00256 K_z K_{zt} K_d K_e V^2$$
$$= 0.00256 K_z (1.0)(1.0)(1.0)(120)^2$$
$$= 36.864 K_z$$

From Table 1–5, for $z = h = 30$ ft, $K_z = 0.98$

$$q_h = 36.864(0.98) = 36.13$$

From the text,

$$\frac{L}{B} = \frac{200}{200} = 1 \text{ so that } C_p = -0.5$$

$$p = qGC_p - q_h(GC_{pi})$$

$$p = 36.13(0.85)(-0.5) - 36.13(\mp 0.18)$$

$$p = -21.9 \text{ psf or } -8.85 \text{ psf}$$ **Ans.**

Ans.
$p = -21.9$ psf or -8.85 psf

1–18. The light metal storage building is on open flat terrain in central Oklahoma. If the side wall of the building is 14 ft high, what are the two values of the design wind pressure acting on this wall when the wind blows on the back of the building? The roof is essentially flat and the building is fully enclosed.

SOLUTION

$V = 105 \text{ mi/h}$

$K_{zt} = 1.0$

$K_d = 1.0$

$K_e = 1.0$

$q_z = 0.00256 K_z K_{zt} K_d K_e V^2$

$= 0.00256 K_z (1.0)(1.0)(1.0)(105)^2$

$= 28.22 K_z$

From Table 1–5,

For $0 \leq z \leq 15$ ft, $K_z = 0.85$

Thus,

$q_z = 28.22(0.85) = 23.99$

$p = qGC_p - q_h(GC_{pi})$

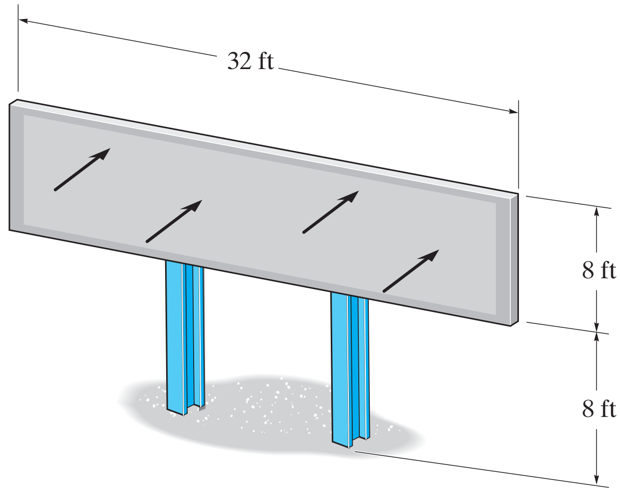
$p = 23.99(0.85)(0.7) - (23.99)(\pm 0.18)$

$p = -9.96$ psf or $p = -18.6$ psf **Ans.**

Ans.

$p = -9.96$ psf or -18.6 psf

1–19. Determine the resultant force acting on the face of the sign if $q_h = 25.5\ \text{lb/ft}^2$. The sign has a width of 32 ft and a height of 8 ft as indicated.



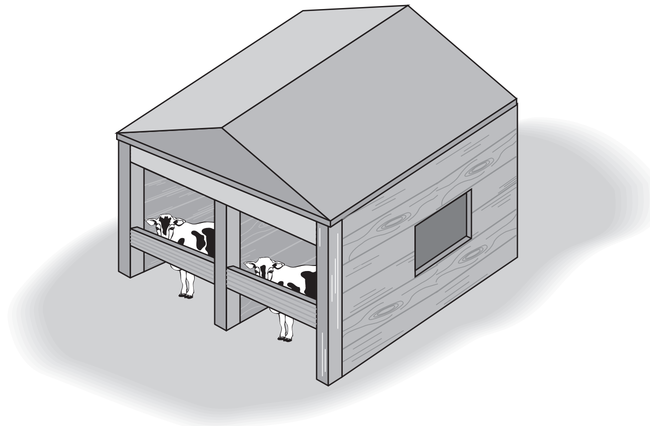
SOLUTION

Here, $G = 0.85$ since the structure that supports the sign can be considered rigid. Since $B/s = 32\ \text{ft}/8\ \text{ft} = 4$, Table 1–6 can be used to obtain C_f. Here, $s/h = 8\ \text{ft}/(8\ \text{ft} + 8\ \text{ft}) = 0.5$. Then, $C_f = 1.70$.

$$F = q_h G C_f A_s$$
$$= (25.5\ \text{lb/ft}^2)(0.85)(1.70)[(32\ \text{ft})(8\ \text{ft})]$$
$$= 9.433(10^3)\ \text{lb}$$
$$= 9.43\ \text{k}$$ **Ans.**

Ans.
$F = 9.43\ \text{k}$

***1–20.** The barn has a roof with a slope of 40 mm/m. It is located in an open field where the ground snow load is 1.50 kN/m^2. Determine the snow load that is required to design the roof of the stall.



SOLUTION

Here, the slope of the roof $= \left(\dfrac{40\text{ mm}}{1000\text{ mm}}\right) \times 100\%$

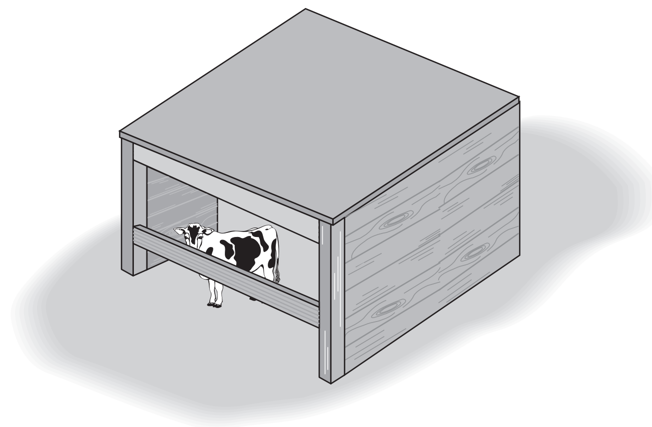
$= 4\% < 5\%$. Then the roof can be considered flat. Since

the barn is located in an open terrain, is unheated and is an agricultural building, $C_e = 0.8$, $C_t = 1.2$, and $I_s = 0.80$, respectively. Here, $p_g = 1.50\text{ kN/m}^2$.

$$p_f = 0.7\, C_e C_t I_s p_g$$
$$= 0.7(0.8)(1.2)(0.8)(1.50\text{ kN/m}^2)$$
$$= 0.8064\text{ kN/m}^2 = 0.806\text{ kN/m}^2 \qquad \textbf{Ans.}$$

Ans.
$p_f = 0.806\text{ kN/m}^2$

1–21. The stall has a flat roof with a slope of 40 mm/m. It is located in an open field where the ground snow load is 0.84 kN/m². Determine the snow load that is required to design the roof of the stall.



SOLUTION

Here, the slope of the roof $= \left(\dfrac{40\text{ mm}}{1000\text{ mm}}\right) \times 10\%$

$= 4\% < 5\%$. Then the roof can be considered flat. Since the barn is located in an open terrain, is unheated and is an agricultural building, $C_e = 0.8$, $C_t = 1.2$ and $I_s = 0.8$, respectively. Here, $p_g = 0.84\text{ kN/m}^2$.

$$p_f = 0.7C_eC_tI_sp_g$$
$$= 0.7(0.8)(1.2)(0.8)(0.84\text{ kN/m}^2)$$
$$= 0.4516\text{ kN/m}^2 = 0.452\text{ kN/m}^2 \qquad \textbf{Ans.}$$

Ans.
$p_f = 0.452\text{ kN/m}^2$

1–22. An urban hospital located in central Illinois has a flat roof. Determine the snow load in kN/m^2 that is required to design the roof.

SOLUTION

In central Illinois, $p_g = 0.96\ \text{kN/m}^2$. Because the hospital is in an urban area, $C_e = 1.2$.

$p_f = 0.7C_eC_tI_sp_g$

$p_f = 0.7(1.2)(1.0)(1.20)(0.96)$

$= 0.968\ \text{kN/m}^2$ **Ans.**

Ans.
$p_f = 0.968\ \text{kN/m}^2$

1–23. The school building has a flat roof. It is located in an open area where the ground snow load is 0.68 kN/m². Determine the snow load that is required to design the roof.

SOLUTION

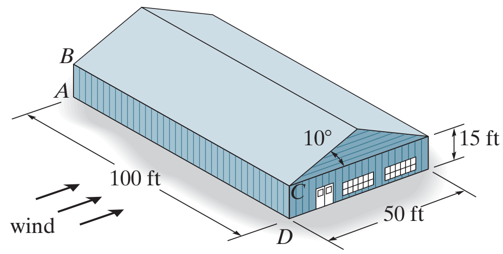
$p_f = 0.7C_eC_tI_sp_g$

$p_f = 0.7(0.8)(1.0)(1.20)(0.68)$

$= 0.457\ \text{kN/m}^2$ **Ans.**

Ans.
$p_f = 0.457\ \text{kN/m}^2$

***1–24.** Wind blows on the side of the fully enclosed agriculture building located on open flat terrain in Oklahoma. Determine the external pressure acting over the windward wall, the leeward wall, and the side walls. Also, what is the internal pressure in the building which acts on the walls? Use linear interpolation to determine q_h.



SOLUTION

$$q_z = 0.00256 K_z K_{zt} K_d K_e V^2$$

$$q_z = 0.00256 K_z (1)(1)(1)(105)^2$$

$$q_{15} = 0.00256(0.85)(1)(1)(1)(105)^2 = 23.9904 \text{ psf}$$

$$q_{20} = 0.00256(0.90)(1)(1)(1)(105)^2 = 25.4016 \text{ psf}$$

$$h = 15 + \frac{1}{2}(25 \tan 10°) = 17.204 \text{ ft}$$

$$\frac{q_h - 23.9904}{17.204 - 15} = \frac{25.4016 - 23.9904}{20 - 15}$$

$$q_h = 24.612 \text{ psf}$$

External pressure on windward wall:

$$p_{max} = q_z GC_p = 23.9904(0.85)(0.8) = 16.3 \text{ psf}$$ **Ans.**

External pressure on leeward wall: $\frac{L}{B} = \frac{50}{100} = 0.5$

$$p = q_h GC_p = 24.612(0.85)(-0.5) = -10.5 \text{ psf}$$ **Ans.**

External pressure on side walls:

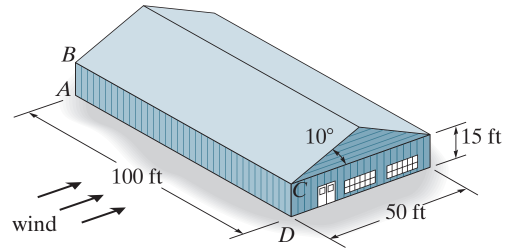
$$p = q_h GC_p = 24.612(0.85)(-0.7) = -14.6 \text{ psf}$$ **Ans.**

Internal pressure:

$$p = -q_h(GC_{pi}) = -24.612(0.18) = \pm 4.43 \text{ psf}$$ **Ans.**

Ans.
External pressure on windward wall
$p_{max} = 16.3$ psf
External pressure on leeward wall
$p = -10.5$ psf
External pressure on side walls
$p = -14.6$ psf
Internal pressure
$p = \pm 4.43$ psf

1–25. Wind blows on the side of the fully enclosed agriculture building located on open flat terrain in Oklahoma. Determine the external pressure acting on the roof. Also, what is the internal pressure in the building which acts on the roof? Use linear interpolation to determine q_h and C_p in Fig. 1–13.



SOLUTION

$$q_z = 0.00256 K_z K_{zt} K_d K_e V^2$$
$$= 0.00256 K_z (1)(1)(1)(105)^2$$
$$q_{15} = 0.00256(0.85)(1)(1)(1)(105)^2 = 23.9904 \text{ psf}$$
$$q_{20} = 0.00256(0.90)(1)(1)(1)(105)^2 = 25.4016 \text{ psf}$$
$$h = 15 + \frac{1}{2}(25 \tan 10°) = 17.204 \text{ ft}$$
$$\frac{q_h - 23.9904}{17.204 - 15} = \frac{25.4016 - 23.9904}{20 - 15}$$
$$q_h = 24.612 \text{ psf}$$

External pressure on windward side of roof:

$$p = q_h GC_p$$
$$\frac{h}{L} = \frac{17.204}{50} = 0.3441$$
$$\frac{[-0.9 - (-0.7)]}{(0.5 - 0.25)} = \frac{(-0.9 - C_p)}{(0.5 - 0.3441)}$$
$$C_p = -0.7753$$
$$p = 24.612(0.85)(-0.7753) = -16.2 \text{ psf}$$ **Ans.**

External pressure on leeward side of roof:

$$\frac{[-0.5 - (-0.3)]}{(0.5 - 0.25)} = \frac{(-0.5 - C_p)}{(0.5 - 0.3441)}$$
$$C_p = -0.3753$$
$$p = q_h GC_p$$
$$= 24.612(0.85)(-0.3753) = -7.85 \text{ psf}$$ **Ans.**

Internal pressure:

$$p = -q_h(GC_{pi}) = -24.612(\pm 0.18) = \pm 4.43 \text{ psf}$$ **Ans.**

Ans.
External pressure on windward side of roof

$p = -16.2$ psf

External pressure on leeward side of roof

$p = -7.85$ psf

Internal pressure

$p = \pm 4.43$ psf