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,

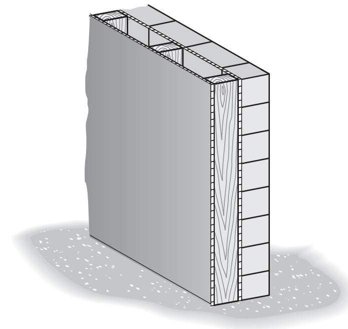
$LL = (250 \text{ lb/ft}^2)(15 \text{ ft})(10 \text{ ft}) = 37{,}500 \text{ lb}$

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,

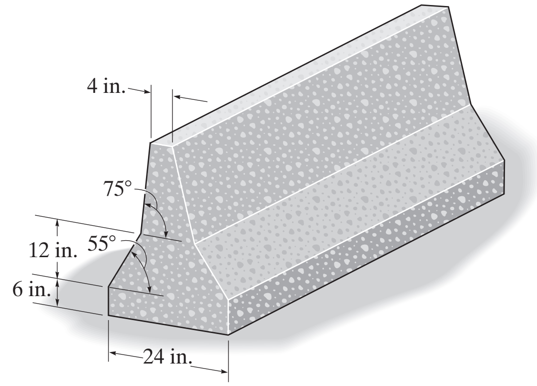
12-in. clay brick: $(115 \text{ lb/ft}^2)(10 \text{ ft}) = 1150 \text{ lb/ft}$

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.



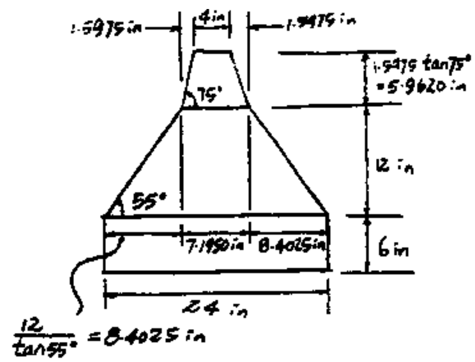
SOLUTION

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

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

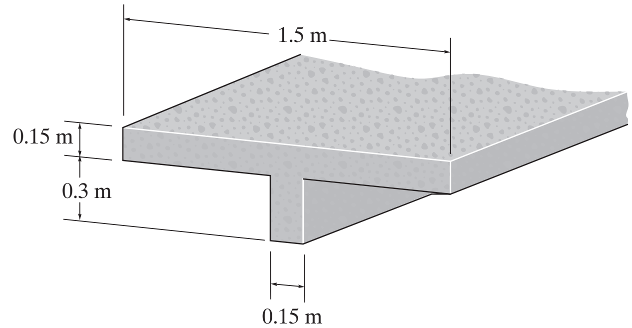
Use Table 1–2.

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



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,

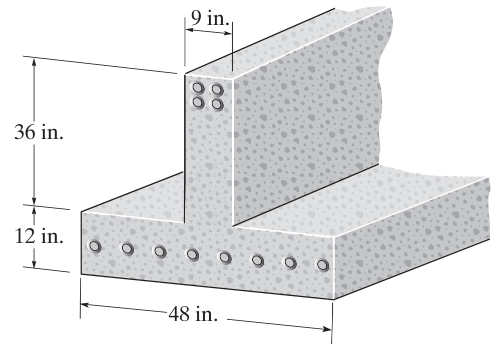
$LL = (6.00 \text{ kN/m}^2)(7 \text{ m})(3 \text{ m}) = 126 \text{ kN}$

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

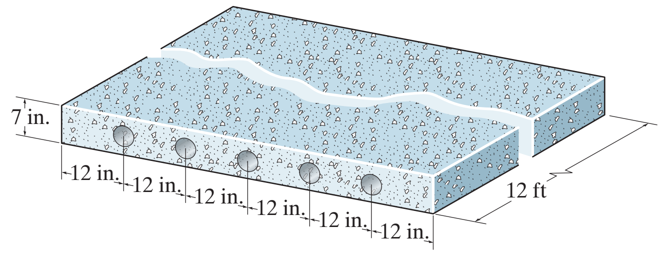
$$= 931.98 \text{ lb/ft}$$

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.

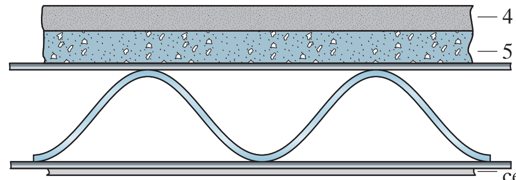
SOLUTION

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,

$L_o = 50$ 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.
$LL = 94.5$ 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.
$p_{0-15} = 14.8 \text{ psf or } 27.8 \text{ psf}$
$p_{20} = 16.1 \text{ psf or } 29.1 \text{ psf}$
$p_{25} = 17.1 \text{ psf or } 30.1 \text{ psf}$
$p_{30} = 18.1 \text{ psf or } 31.1 \text{ psf}$

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,

$q_z = 28.22(0.85) = 23.99$

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

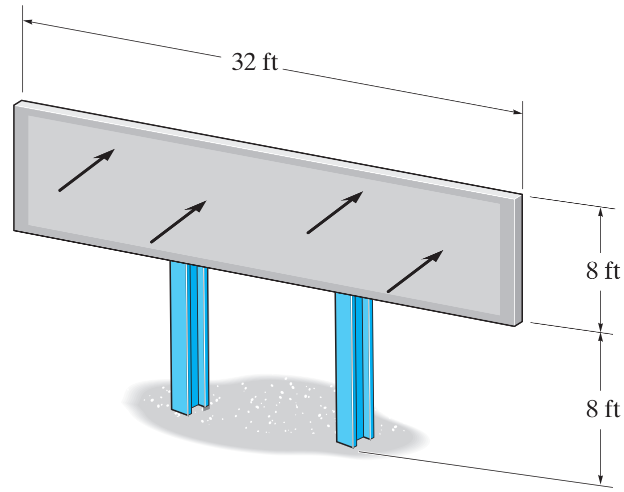
$p = 23.99(0.85)(0.7) - (23.99)(\pm 0.18)$

$p = -9.96$ 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, $C_f = 1.70$.

$$F = q_h G C_f A_s$$

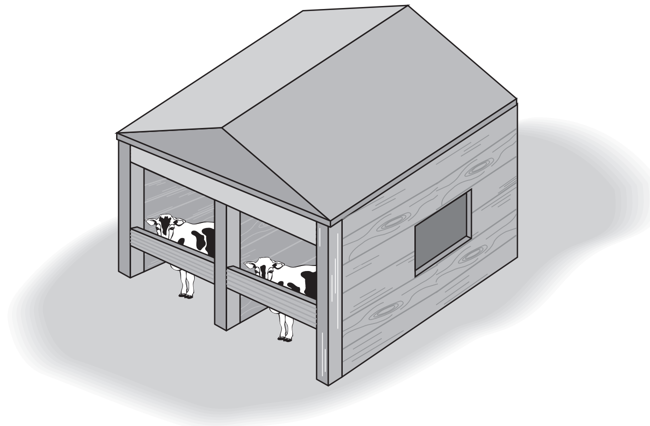
$$= (25.5\ \text{lb/ft}^2)(0.85)(1.70)[(32\ \text{ft})(8\ \text{ft})]$$

$$= 9.433(10^3)\ \text{lb}$$

$$= 9.43\ \text{k}$$ **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/m². Determine the snow load that is required to design the roof of the stall.



SOLUTION

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

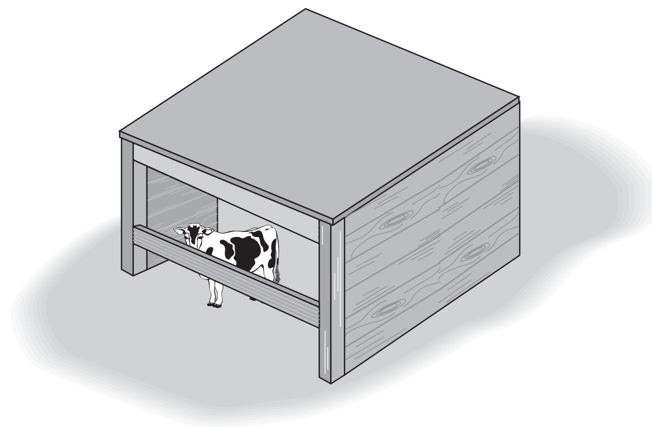
$= 4\% < 5\%$. Then the roof can be considered flat. Since

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/m² 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, $C_e = 1.2$.

$p_f = 0.7C_eC_tI_sp_g$

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

$\quad = 0.968\ \text{kN/m}^2$ **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/m^2. Determine the snow load that is required to design the roof.

SOLUTION

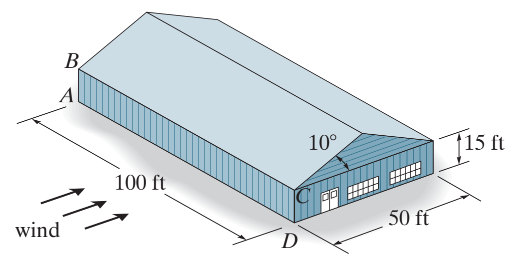
$p_f = 0.7C_eC_tI_sp_g$

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

$= 0.457\text{ kN/m}^2$ **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: $\dfrac{L}{B} = \dfrac{50}{100} = 0.5$

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

External pressure on side walls:

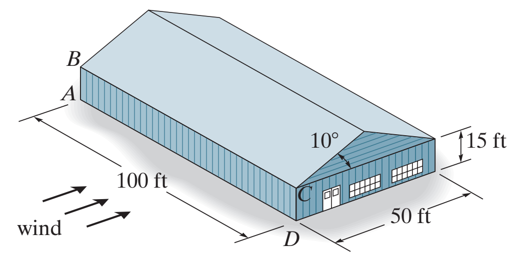
$$p = q_h GC_p = 24.612(0.85)(-0.7) = -14.6 \text{ psf}$$ **Ans.**

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:

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

External pressure on leeward side of roof:

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

Internal pressure:

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

Ans.
External pressure on windward side of roof

$p = -16.2$ psf

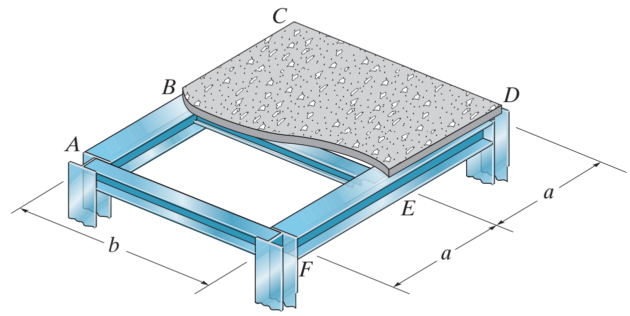
External pressure on leeward side of roof

$p = -7.85$ psf

Internal pressure

$p = \pm 4.43$ psf

2–1. The steel framework is used to support the reinforced stone concrete slab that is used for an office. The slab is 200 mm thick. Sketch the loading that acts along members BE and FED. Take $a = 2$ m, $b = 5$ m. *Hint:* See Tables 1.2 and 1.4.



SOLUTION

Beam *BE*. Since $\dfrac{b}{a} = \dfrac{5\text{ m}}{2\text{ m}} = 2.5$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this beam is rectangular, as shown in Fig. *a*, and the intensity of the uniform distributed load is

200 mm thick reinforced stone concrete slab:

$$(23.6\text{ kN/m}^3)(0.2\text{ m})(2\text{ m}) = 9.44\text{ kN/m}$$

Live load for office: $(2.40\text{ kN/m}^2)(2\text{ m}) = 480\text{ kN/m}$

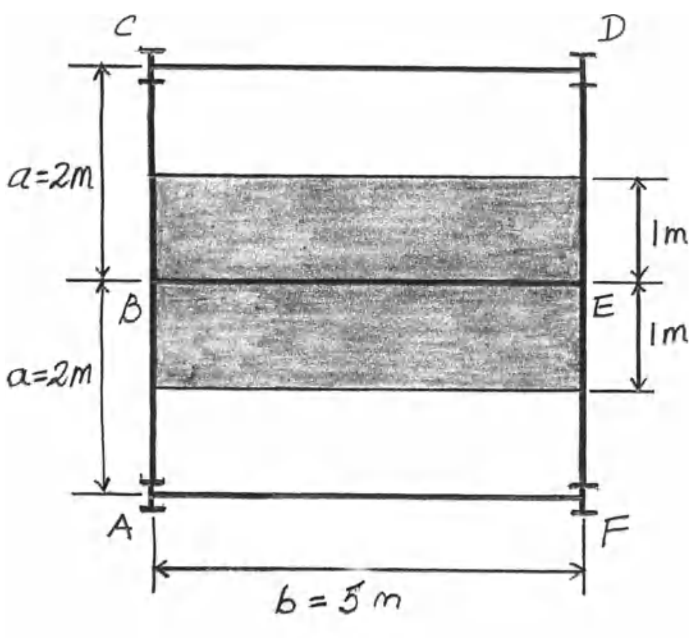
$$14.24\text{ kN/m} \qquad \textbf{Ans.}$$

Due to symmetry, the vertical reactions at B and E are

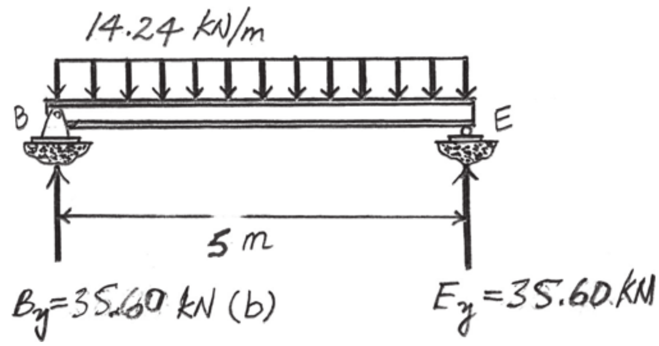
$$B_y = E_y = (14.24\text{ kN/m})(5)/2 = 35.6\text{ kN}$$

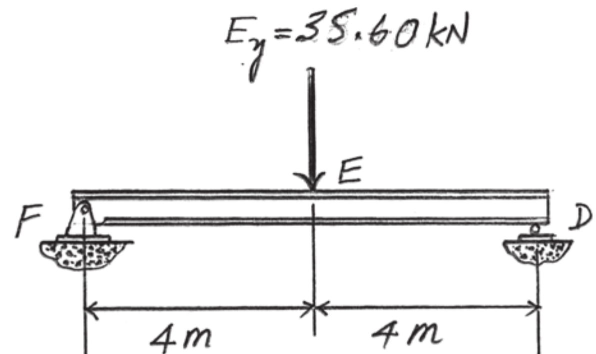
The loading diagram for beam BE is shown in Fig. b.

Beam *FED*. The only load this beam supports is the vertical reaction of beam BE at E, which is $E_y = 35.6$ kN. The loading diagram for this beam is shown in Fig. c.



(a)

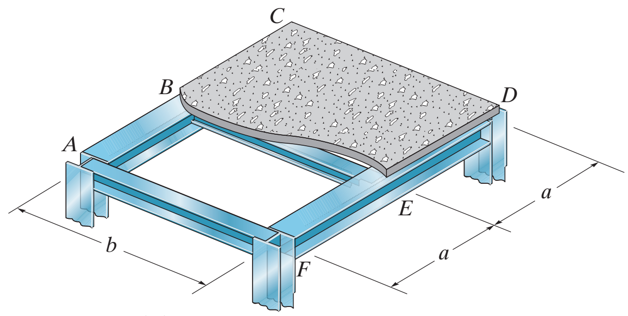




(c)

Ans.
Live load for office: 14.24 kN/m

2–2. Solve Prob. 2–1 with $a = 3$ m, $b = 4$ m.



SOLUTION

Beam *BE*. Since $\frac{b}{a} = \frac{4}{3} < 2$, the concrete slab will behave as a two-way slab. Thus, the tributary area for this beam is the hexagonal area shown in Fig. *a*, and the maximum intensity of the distributed load is:

200-mm-thick reinforced stone concrete slab: $(23.6 \text{ kN/m}^3)(0.2 \text{ m})(3 \text{ m}) = 14.16 \text{ kN/m}$

Live load for office: $[(2.40 \text{ kN/m}^2)(3 \text{ m})] = 7.20 \text{ kN/m}$

21.36 kN/m **Ans.**

Due to symmetry, the vertical reactions at B and E are

$$B_y = E_y = \frac{2\left[\frac{1}{2}(21.36 \text{ kN/m})(1.5 \text{ m})\right] + (21.36 \text{ kN/m})(1 \text{ m})}{2}$$

$$= 26.70 \text{ kN}$$

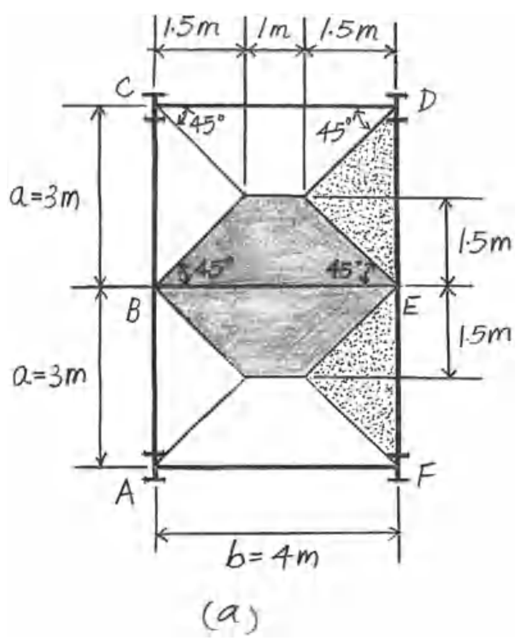
The loading diagram for beam BE is shown in Fig. *b*.

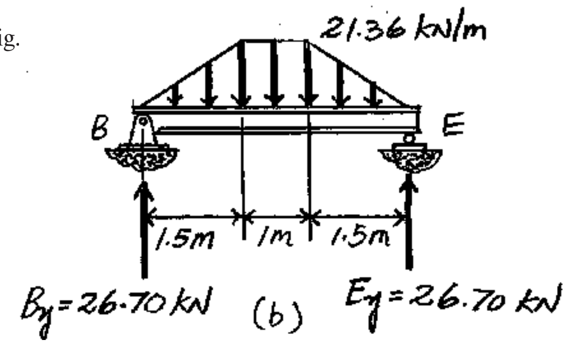
Beam *FED*. The loadings that are supported by this beam are the vertical reaction of beam BE at E, which is $E_y = 26.70$ kN and the triangular distributed load of which its tributary area is the triangular area shown in Fig. *a*. Its maximum intensity is

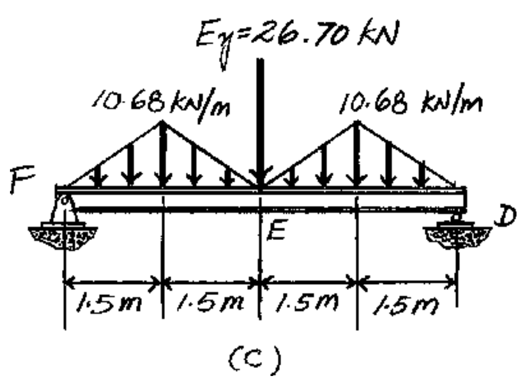
200-mm-thick reinforced stone concrete slab: $(23.6 \text{ kN/m}^3)(0.2 \text{ m})(1.5 \text{ m}) = 7.08 \text{ kN/m}$

Live load for office: $(2.40 \text{ kN/m}^2)(1.5 \text{ m}) = \frac{3.60 \text{ kN/m}}{10.68 \text{ kN/m}}$ **Ans.**

The loading diagram for beam FED is shown in Fig.



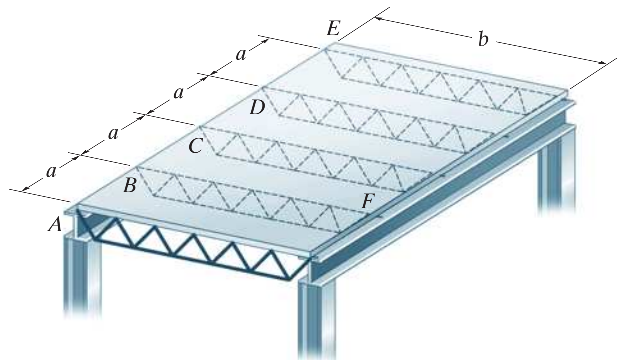




Ans.
Live load for office:
21.36 kN/m

Live load for office:
$\frac{3.60 \text{ kN/m}}{10.68 \text{ kN/m}}$

2–3. The floor system used in a school classroom consists of a 4-in. reinforced stone concrete slab. Sketch the loading that acts along the joist BF and side girder $ABCDE$. Set $a = 10$ ft, $b = 30$ ft. *Hint:* See Tables 1.2 and 1.4.



SOLUTION

Joist *BF*. Since $\dfrac{b}{a} = \dfrac{30\text{ ft}}{10\text{ ft}} = 3$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this joist is the rectangular area shown in Fig. *a*, and the intensity of the uniform distributed load is

$$\text{4-in.-thick reinforced stone concrete slab: } (0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(10\text{ ft}) = 0.5\text{ k/ft}$$

$$\text{Live load for classroom: } (0.04\text{ k/ft}^2)(10\text{ ft}) = 0.4\text{ k/ft}$$

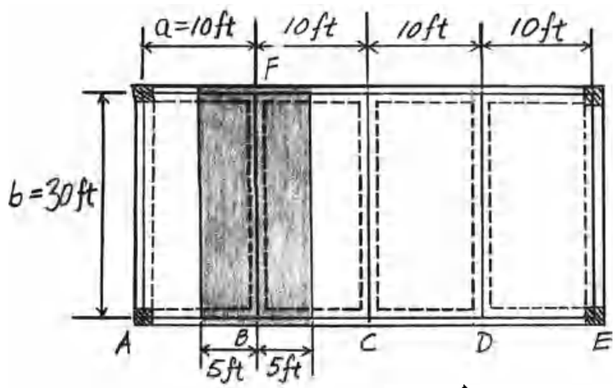
$$0.9\text{ k/ft} \qquad \textbf{Ans.}$$

Due to symmetry, the vertical reactions at B and F are

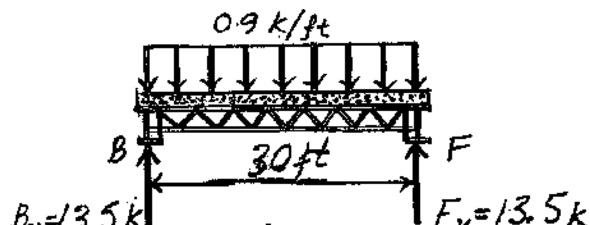
$$B_y = F_y = (0.9\text{ k/ft})(30\text{ ft})/2 = 13.5\text{ k} \qquad \textbf{Ans.}$$

The loading diagram for joist BF is shown in Fig. *b*.

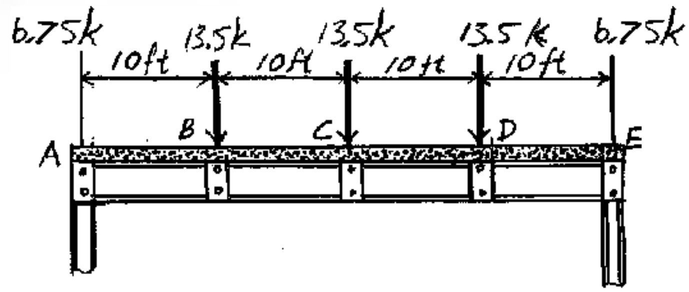
Girder *ABCDE*. The loads that act on this girder are the vertical reactions of the joists at B, C, and D, which are $B_y = C_y = D_y = 13.5$ k, and 6.75-k end loads from the joists at A and E. The loading diagram for this girder is shown in Fig. *c*.



(a)



(b)

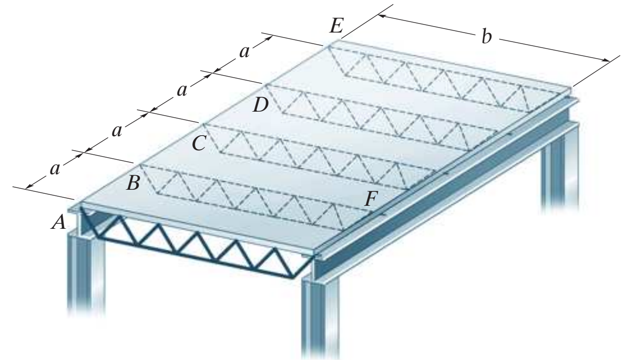


(c)

Ans.
Live load for classroom: 0.9 k/ft

$B_y = 13.5$ k

***2–4.** Solve Prob. 2–3 with $a = 10$ ft, $b = 15$ ft.



SOLUTION

Joist *BF*. Since $\dfrac{b}{a} = \dfrac{15\text{ ft}}{10\text{ ft}} = 1.5 < 2$, the concrete slab will behave as a two-way slab. Thus, the tributary area for the joist is the hexagonal area, as shown in Fig. *a*, and the maximum intensity of the distributed load is:

$$\text{4- in.-thick reinforced stone concrete slab: } (0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(10\text{ ft}) = 0.5\text{ k/ft}$$

$$\text{Live load for classroom: } (0.04\text{ k/ft}^2)(10\text{ ft}) = 0.4\text{ k/ft}$$

$$0.9\text{ k/ft} \quad \textbf{Ans.}$$

Due to symmetry, the vertical reactions at B and G are

$$B_y = F_y = \frac{2\left[\frac{1}{2}(0.9\text{ k/ft})(5\text{ ft})\right] + (0.9\text{ k/ft})(5\text{ ft})}{2} = 4.50\text{ k} \qquad \textbf{Ans.}$$

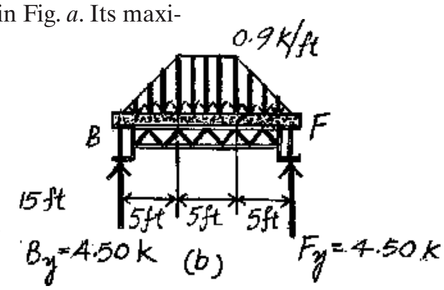
The loading diagram for beam BF is shown in Fig. *b*.

Girder *ABCDE*. The loadings that are supported by this girder are the vertical reactions of the joist at B, C and D, which are $B_y = C_y = D_y = 4.50$ k, the 2.25-k end loads from the joists at A and E, and the triangular distributed load shown in Fig. *a*. Its maximum intensity is

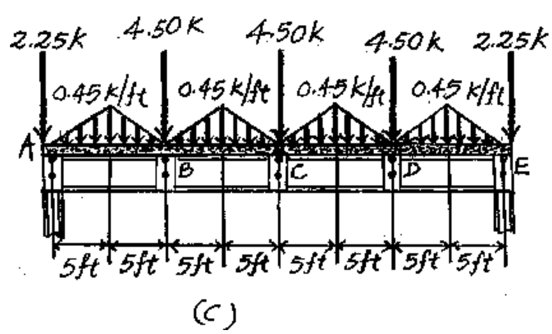
4-in.-thick reinforced stone concrete slab:

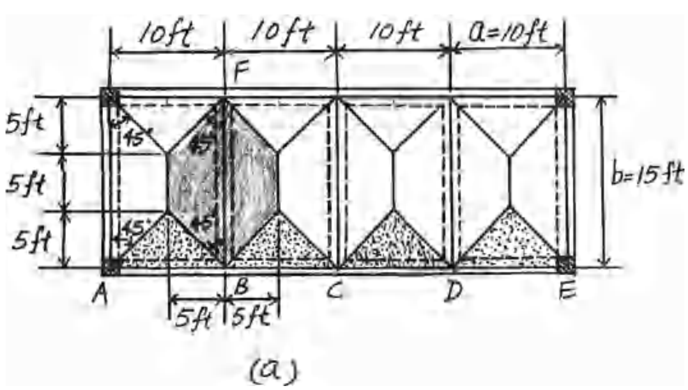
$$(0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(5\text{ ft}) = 0.25\text{ k/ft}$$

$$\text{Live load for classroom: } (0.04\text{ k/ft}^2)(5\text{ ft}) \quad = \frac{0.20\text{ k/ft}}{0.45\text{ k/ft}} \qquad \textbf{Ans.}$$



The loading diagram for the girder $ABCDE$ is shown in Fig. *c*.





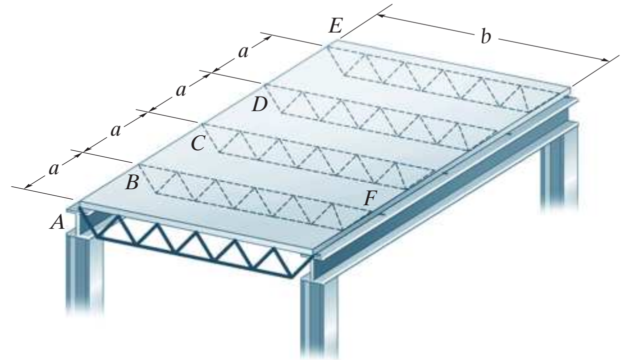
Ans.

Live load for classroom: 0.9 k/ft

$B_y = 4.50$ k

Live load for classroom: $\dfrac{0.20\text{ k/ft}}{0.45\text{ k/ft}}$

2–5. Solve Prob. 2–3 with $a = 7.5$ ft, $b = 20$ ft.



SOLUTION

Beam *BF*. Since $\dfrac{b}{a} = \dfrac{20\text{ ft}}{7.5\text{ ft}} = 2.7 > 2$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this beam is a rectangle, as shown in Fig. *a*, and the intensity of the distributed load is:

$$\text{4-in.-thick reinforced stone concrete slab: } (0.15\text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(7.5\text{ ft}) = 0.375\text{ k/ft}$$

$$\text{Live load from classroom: } (0.04\text{k/ft}^2)(7.5\text{ ft}) = \underline{0.300\text{ k/ft}}$$

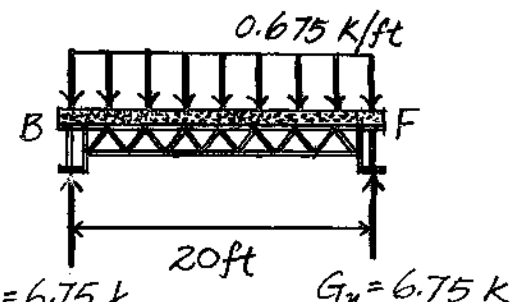
$$0.675\text{ k/ft} \qquad \textbf{Ans.}$$

Due to symmetry, the vertical reactions at *B* and *F* are

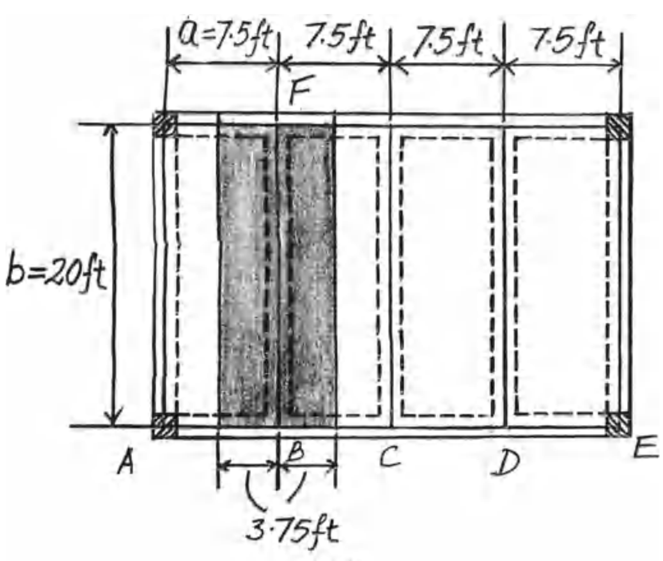
$$B_y = F_y = \frac{(0.675\text{ k/ft})(20\text{ ft})}{2} = 6.75\text{ k} \qquad \textbf{Ans.}$$

The loading diagram for beam *BF* is shown in Fig. *b*.

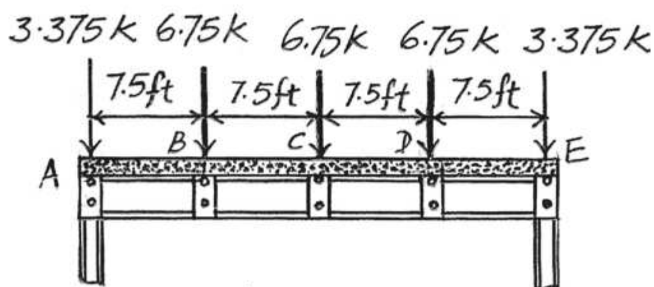
Beam *ABCD*. The loading diagram for this beam is shown in Fig. *c*.



(b)



(a)

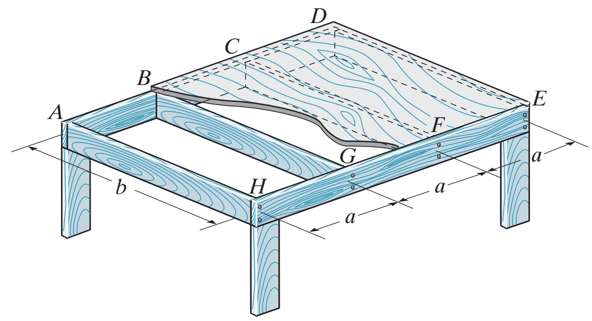


(c)

Ans.
Live load from classroom: 0.675 k/ft

$B_y = 6.75$ k

2–6. The frame is used to support the wood deck in a residential dwelling where the live load is 40 lb/ft^2. Sketch the loading that acts along members BG and $ABCD$. Set $b = 10$ ft, $a = 5$ ft.



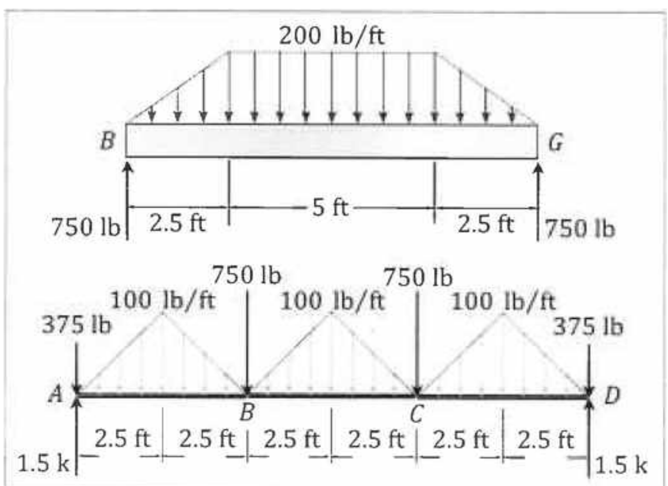
SOLUTION

From Table 1–4,

$LL = 40$ psf

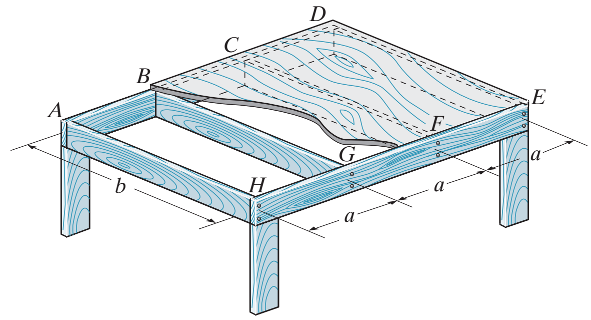
$$\frac{L_2}{L_1} = \frac{b}{a} = \frac{10}{5} = 2 \boxed{\leq 2}$$

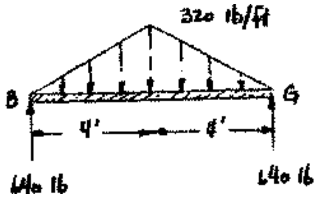
Two-way slab:
Reaction at B: 750 lb↑ **Ans.**
Reaction at A: 1.5 k↑ **Ans.**



Ans.
Reaction at B: 750 lb↑
Reaction at A: 1.5 k↑

2–7. Solve Prob. 2–6 if $b = 8$ ft, $a = 8$ ft.





SOLUTION

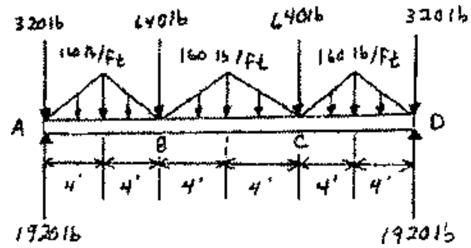
From Table 1–4,
$LL = 40$ psf

$$\frac{L_2}{L_1} = \frac{b}{a} = \frac{8}{8} = 1 \boxed{\leq 2}$$

Two-way slab:

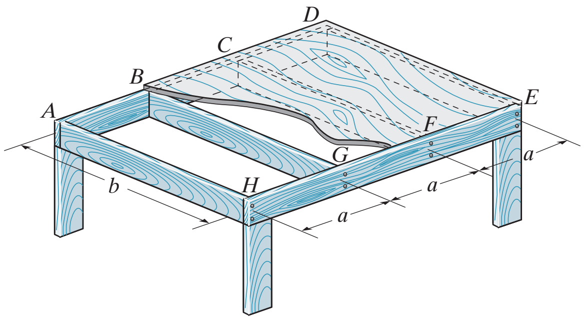
$\boxed{\text{Reaction at } B\text{: 640 lb}\uparrow}$ **Ans.**

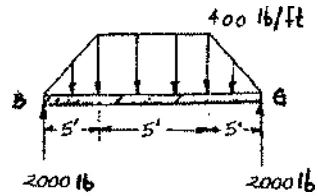
Reaction at A: 1920 lb↑ **Ans.**



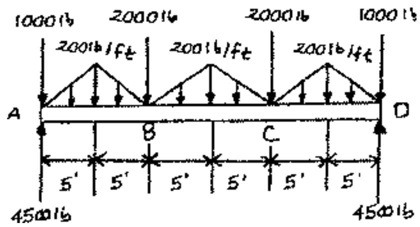
Ans.
Reaction at B: 640 lb↑
Reaction at A: 1920 lb↑

***2–8.** Solve Prob. 2–6 if $b = 15$ ft, $a = 10$ ft.





SOLUTION



$\boxed{\text{From Table 1.4,}}$

$LL = 40$ psf

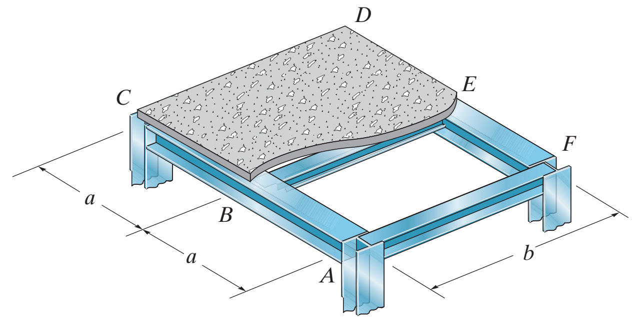
$b/a = 15/10 = \boxed{1.5 \leq 2}$

Two-way slab:

$\boxed{\begin{array}{l}\text{Reaction at } B\text{: } 2 \text{ k}\uparrow \\ \text{Reaction at } A\text{: } 4.5 \text{ k}\uparrow\end{array}}$ **Ans.** **Ans.**

Ans.
Reaction at B: 2 k$\uparrow$
Reaction at A: 4.5 k$\uparrow$

2–9. The steel framework is used to support the 4-in. reinforced stone concrete slab that carries a uniform live loading of 400 lb/ft^2. Sketch the loading that acts along members BE and FED. Set $a = 9$ ft, $b = 12$ ft. *Hint:* See Table 1.2.



SOLUTION

Beam *BE*. Since $\frac{b}{a} = \frac{12 \text{ ft}}{9 \text{ ft}} = \frac{4}{3} < 2$, the concrete slab will behave as a two-way slab. Thus, the tributary area for this beam is the shaded octagonal area shown in Fig. *a*, and the maximum intensity of the trapezoidal distributed load is:

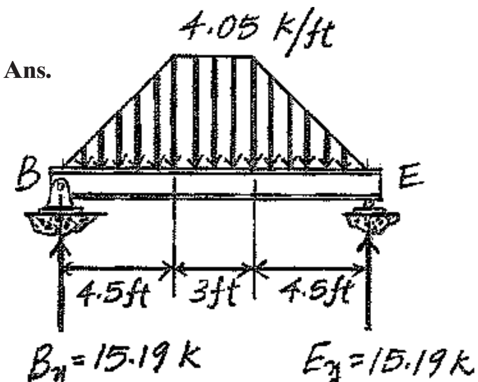
$$\text{4-in.-thick reinforced stone concrete slab: } (0.15 \text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(9 \text{ ft}) = 0.45 \text{ k/ft}$$

$$\text{Floor live load: } (0.4 \text{ k/ft}^2)(9 \text{ ft}) = \frac{3.60 \text{ k/ft}}{4.05 \text{ k/ft}} \qquad \textbf{Ans.}$$

Due to symmetry, the vertical reactions at B and E are

$$B_y = E_y = \frac{\frac{1}{2}(4.05 \text{ k/ft})(3 \text{ ft} + 12 \text{ ft})}{2} = 15.2 \text{ k} \qquad \textbf{Ans.}$$

The loading diagram for beam BE is shown in Fig. *a*.



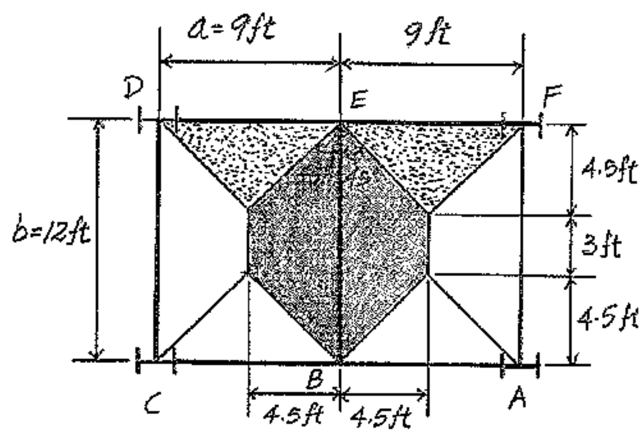
(b)

Beam *FED*. The loadings that are supported by this beam are the vertical reactions of beam BE at E, which is $E_y = 15.19$ k and the triangular distributed load contributed by dotted triangular tributary area shown in Fig. *a*. Its maximum intensity is

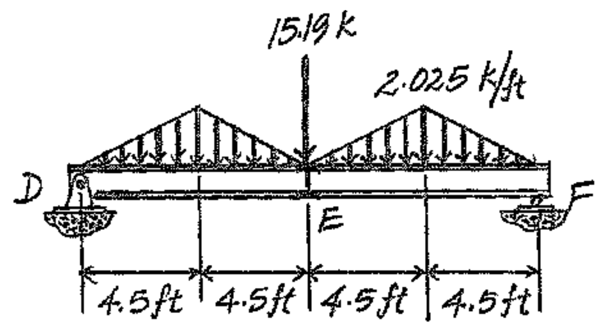
$$\text{4-in.-thick concrete slab: } (0.15 \text{ k/ft}^3)\left(\frac{4}{12}\text{ ft}\right)(4.5 \text{ ft}) = 0.225 \text{ k/ft}$$

$$\text{Floor live load: } (0.4 \text{ k/ft}^2)(4.5 \text{ ft}) = \frac{1.800 \text{ k/ft}}{2.025 \text{ k/ft}} \qquad \textbf{Ans.}$$

The loading diagram for beam FED is shown in Fig. *c*.



(a)



(c)

Ans.

$$\text{Floor live load: } \frac{3.60 \text{ k/ft}}{4.05 \text{ k/ft}}$$

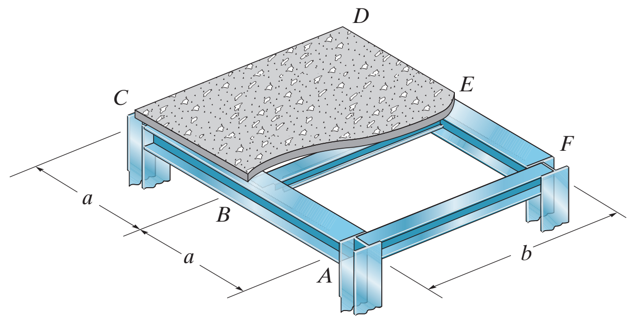
$$B_y = E_y = 15.2 \text{ k}$$

$$\text{Floor live load: } \frac{1.800 \text{ k/ft}}{2.025 \text{ k/ft}}$$

Beam *BE*. $w_{\max} = 4.05$ k/ft

Beam *FED*. 15.2 k at E, $w_{\max} = 2.025$ k/ft

2–10. Solve Prob. 2–9, with $a = 6$ ft, $b = 18$ ft.



SOLUTION

Beam BE. Since $\dfrac{b}{a} = \dfrac{18 \text{ ft}}{6 \text{ ft}} = 3 > 2$, the concrete slab will behave as a one-way slab. Thus, the tributary area for this beam is the shaded rectangular area shown in Fig. *a*, and the intensity of the uniform distributed load is:

4-in.-thick reinforced stone concrete slab: $(0.15 \text{ k/ft}^3)\left(\dfrac{4}{12} \text{ ft}\right)(6 \text{ ft}) = 0.30 \text{ k/ft}$

Floor live load: $(0.4 \text{ k/ft}^2)(6 \text{ ft}) = \dfrac{2.40 \text{ k/ft}}{2.70 \text{ k/ft}}$ **Ans.**

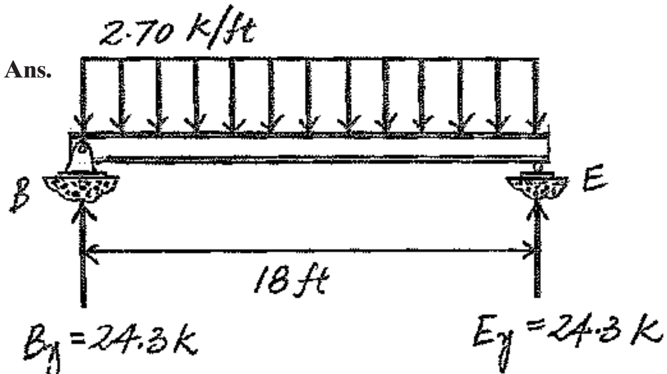
Due to symmetry, the vertical reactions at B and E are

$$B_y = E_y = \frac{(2.70 \text{ k/ft})(18 \text{ ft})}{2} = 24.3 \text{ k} \qquad \textbf{Ans.}$$

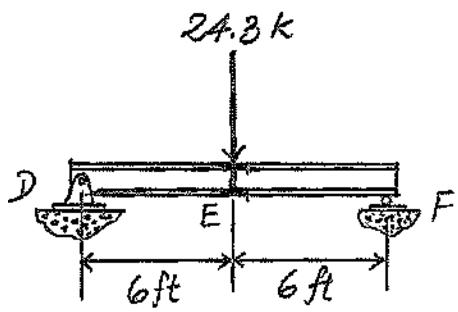
The loading diagram of this beam BE is shown in Fig. *b*.

Beam FED. The only load this beam supports is the vertical reaction of beam BE at E, which is $E_y = 24.3$ k.

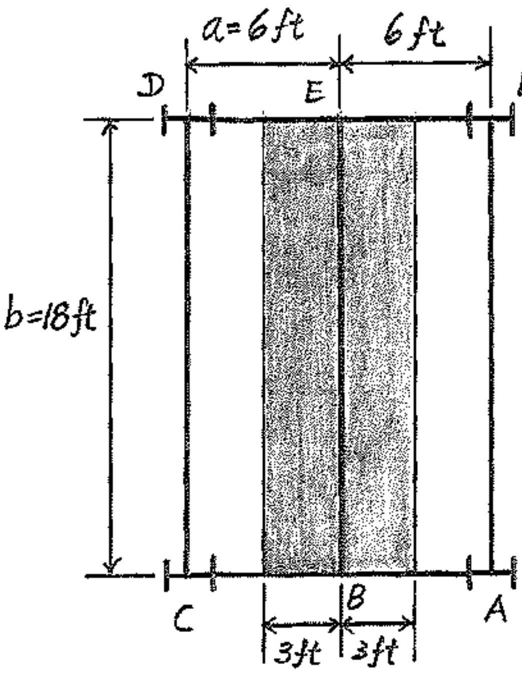
The loading diagram of beam FED is shown in Fig. *c*.



(b)



(c)



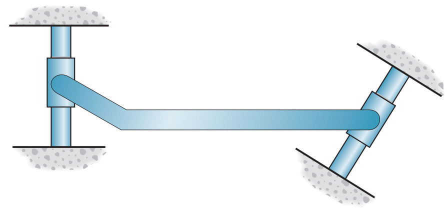
(a)

Ans.

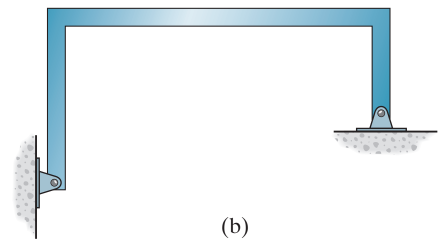
Floor live load: $\dfrac{2.40 \text{ k/ft}}{2.70 \text{ k/ft}}$

$B_y = E_y = 24.3$ k

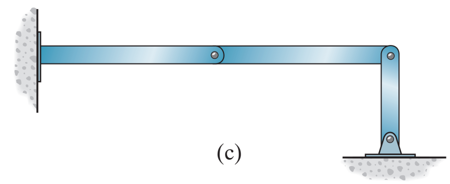
2–11. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.



(a)



(b)



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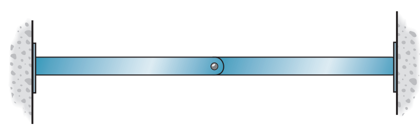
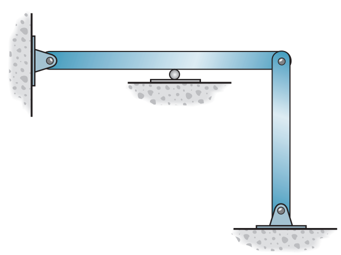


(d)



(e)

SOLUTION

(a) $r = 2 \qquad 3n = 3(1) = 3$

$r < 3n$

Unstable **Ans.**

(b) $r = 4 \qquad 3n = 3(1) = 3$

$r - 3n = 4 - 1 = 1$

Stable and statically indeterminate to the first degree **Ans.**

(c) $r = 9 \qquad 3n = 3(3) = 9$

$r = 3n$

Stable and statically determinate **Ans.**

(d) $r = 8 \qquad 3n = 3(2) = 6$

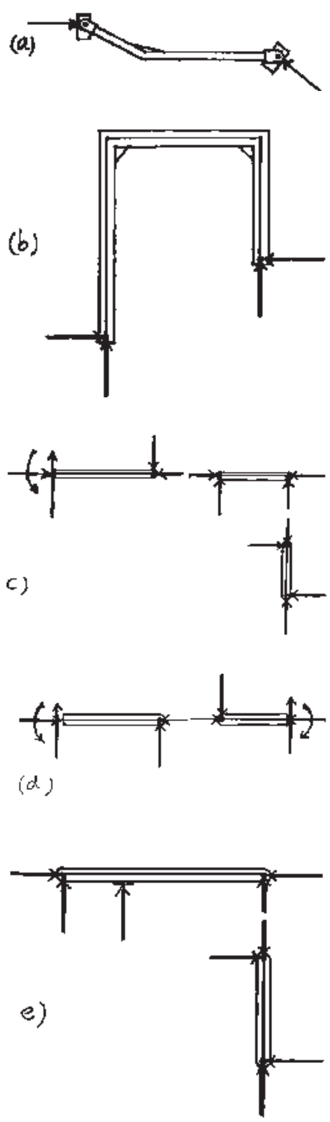
$r - 3n = 8 - 6 = 2$

Stable and statically indeterminate to the second degree **Ans.**

(e) $r = 7 \qquad 3n = 3(2) = 6$

$r - 3n = 7 - 6 = 1$

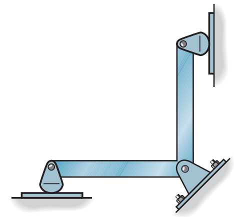
Stable and statically indeterminate to the first degree **Ans.**



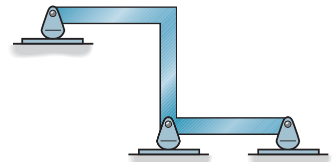
Ans.

(a) Unstable
(b) Stable and statically indeterminate to the first degree
(c) Stable and statically determinate
(d) Stable and statically indeterminate to the second degree
(e) Stable and statically indeterminate to the first degree

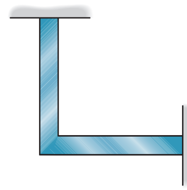
***2–12.** Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.



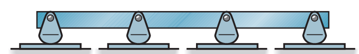
(a)



(b)



(c)



(d)

SOLUTION

(a) $r > 3n$

$4 > 3(1)$

Statically indeterminate to $\boxed{\text{the first degree.}}$ **Ans.**

(b) Parallel reactions

Unstable. **Ans.**

(c) $r > 3n$

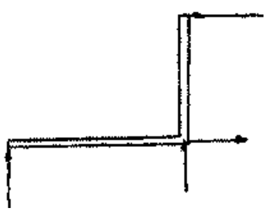
$6 > 3(1)$

Statically indeterminate to $\boxed{\text{the third degree.}}$ **Ans.**

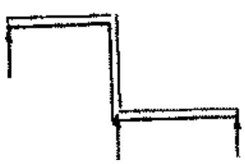
(d) Parallel reactions

Unstable. **Ans.**

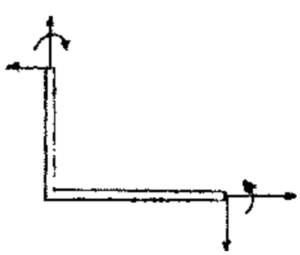
(e)



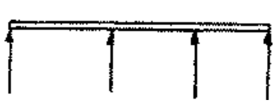
(f)



(g)

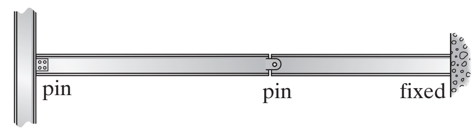


(h)

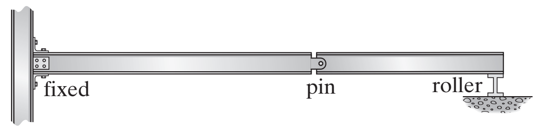


Ans.
(a) Statically indeterminate to the first degree
(b) Unstable
(c) Statically indeterminate to the first degree
(d) Unstable

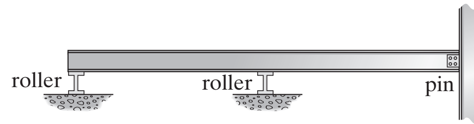
2–13. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy. The supports or connections are to be assumed as stated.



(a)



(b)



(c)

SOLUTION

(a) $r = 7 \qquad 3n = 3(2) = 6 \qquad r - 3n = 7 - 6 = 1$

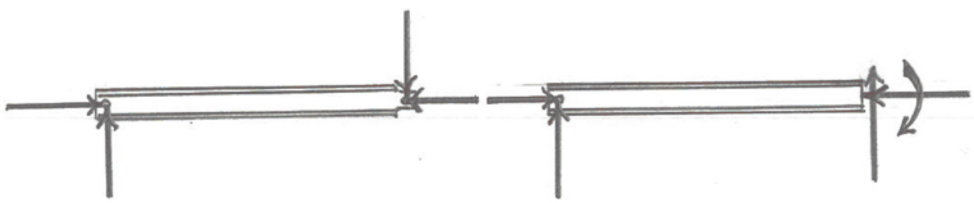
Stable and statically indeterminate to first degree. **Ans.**

(b) $r = 6 \qquad 3n = 3(2) = 6 \qquad r = 3n$

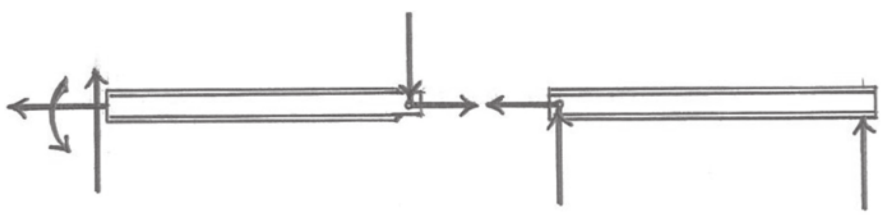
Stable and statically determinate **Ans.**

(c) $r = 4 \qquad 3n = 3(1) = 3 \qquad r - 3n = 4 - 3 = 1$

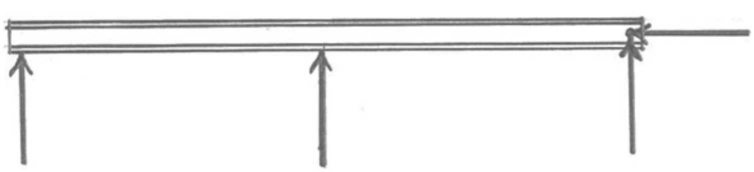
Stable and statically indeterminate to first degree **Ans.**



(a)



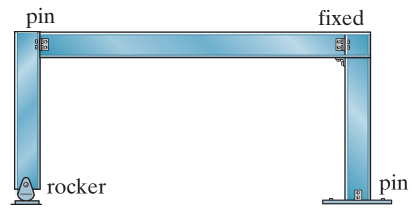
(b)



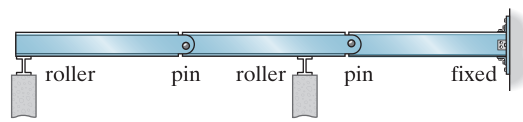
(c)

Ans.
(a) Stable and statically indeterminate to first degree
(b) Stable and statically determinate
(c) Stable and statically indeterminate to first degree

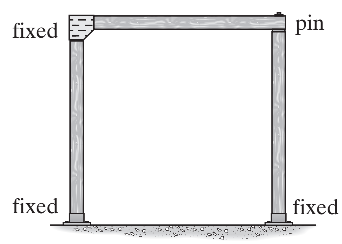
2–14. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy. The supports or connections are to be assumed as stated.



(a)



(b)



(c)

SOLUTION

(a) $r = 5 \qquad 3n = 3(2) = 6$

$r < 3n$

Unstable **Ans.**

(b) $r = 9 \qquad 3n = 3(3) = 9$

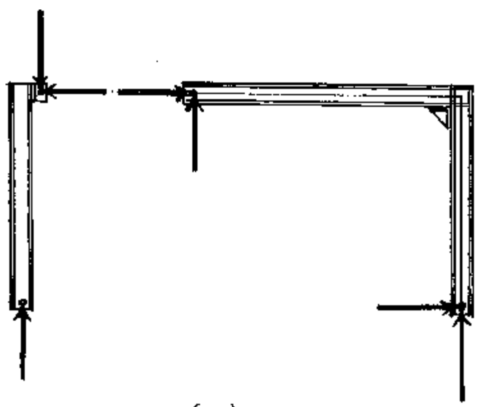
$r = 3n$

Stable and statically determinate **Ans.**

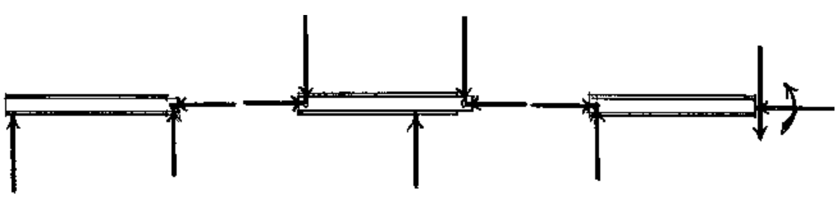
(c) $r = 8 \qquad 3n = 3(2) = 6$

$r - 3n = 8 - 6 = 2$

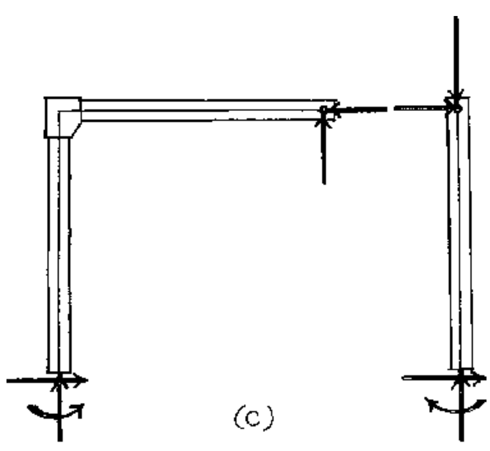
Stable and statically indeterminate to the second degree **Ans.**



(a)



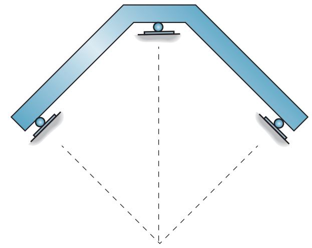
(b)



(c)

Ans.
(a) Unstable
(b) Stable and statically determinate
(c) Stable and statically indeterminate to the second degree

2–15. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.



(a)

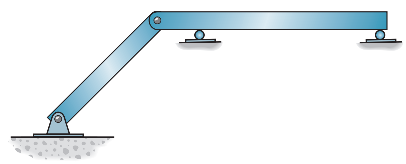
SOLUTION

(a) Since the lines of action of the reactive forces are concurrent, the structure is **unstable**. **Ans.**

(b) $r = 6 \qquad 3n = 3(2) = 6$

$r = 3n$

Stable and statically determinate **Ans.**

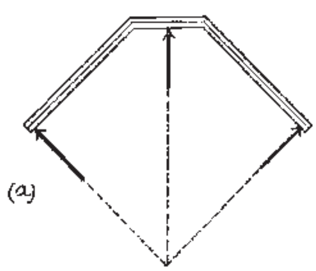


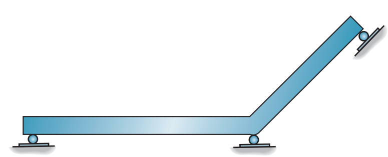
(b)

(c) $r = 3 \qquad 3n = 3(1) = 3$

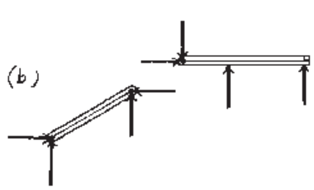
$r = 3n$

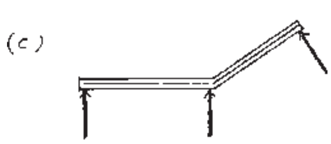
Stable and statically determinate **Ans.**





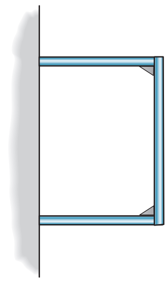
(c)



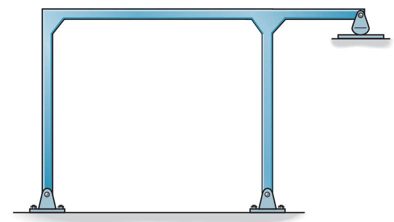


Ans.
(a) Unstable
(b) Stable and statically determinate
(c) Stable and statically determinate

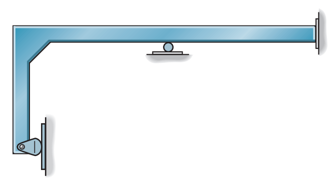
***2–16.** Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.



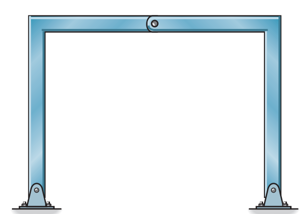
(a)



(b)



(c)



(d)

SOLUTION

(a) $r = 6 \qquad 3n = 3(1) = 3$

$r - 3n = 6 - 3 = 3$

Stable and statically indeterminate to the third degree **Ans.**

(b) $r = 5 \qquad 3n = 3(1) = 3$

$r - 3n = 5 - 3 = 2$

Stable and statically indeterminate to the second degree **Ans.**

(c) $r = 5 \qquad 3n = 3(1) = 3$

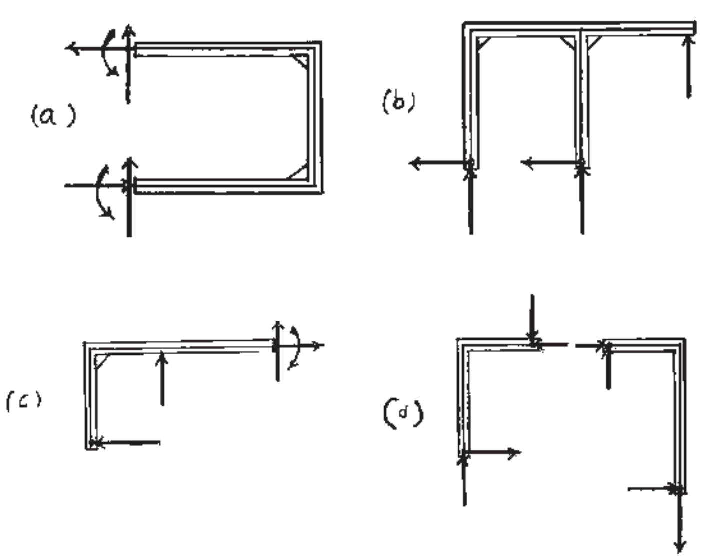
$r - 3n = 5 - 3 = 2$

Stable and statically indeterminate to the second degree **Ans.**

(d) $r = 6 \qquad 3n = 3(2) = 6$

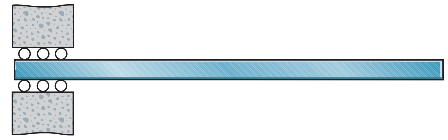
$r = 3n$

Stable and statically determinate. **Ans.**

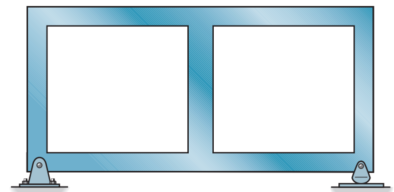


Ans.
(a) Stable and statically indeterminate to the third degree
(b) Stable and statically indeterminate to the second degree
(c) Stable and statically indeterminate to the second degree
(d) Stable and statically determinate

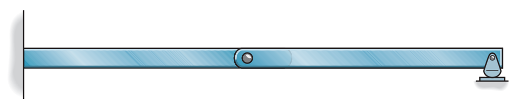
2–17. Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy.



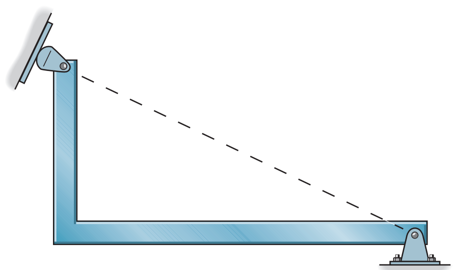
(a)



(b)



(c)



(d)

SOLUTION

(a) $r = 2 \qquad 3n = 3(1) = 3 \qquad r < 3n$

Unstable. **Ans.**

(b) $r = 12 \qquad 3n = 3(2) = 6 \qquad r > 3n$

$r - 3n = 12 - 6 = 6$

Statically indeterminate to the sixth degree. **Ans.**

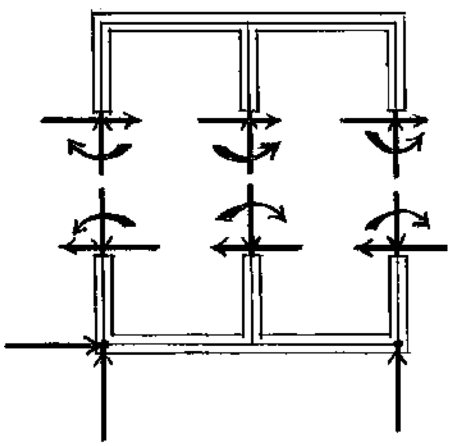
(c) $r = 6 \qquad 3n = 3(2) = 6$

$r = 3n$

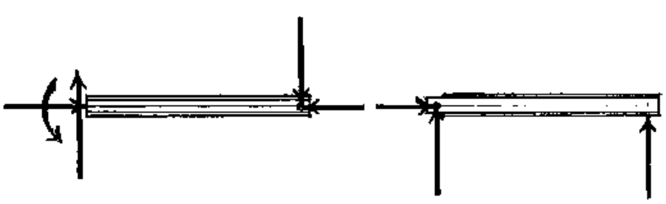
Stable and statically determinate. **Ans.**

(d) Unstable since the lines of action of the reactive force components are concurrent. **Ans.**

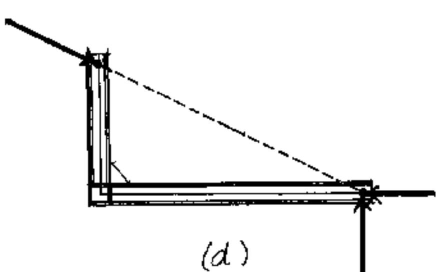
(a)



(b)



(c)



(d)

Ans.

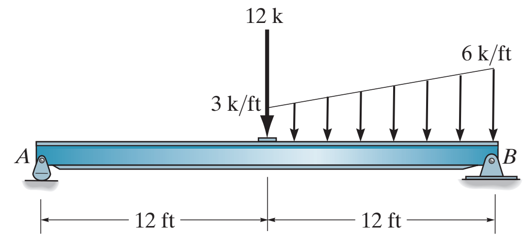
(a) Unstable

(b) Statically indeterminate to the sixth degree

(c) Stable and statically determinate

(d) Unstable since the lines of action of the reactive force components are concurrent

2–18. Determine the reactions on the beam.



SOLUTION

Equations of Equilibrium. Referring to the FBD of the beam shown in Fig. *a*, $\mathbf{N}_A$ and $\mathbf{B}_y$ can be determined directly by writing the moment equations of equilibrium about points B and A, respectively.

$\circlearrowleft +\Sigma M_B = 0; \quad \frac{1}{2}(3)(12)(4) + 3(12)(6) + 12(12) - N_A(24) = 0$

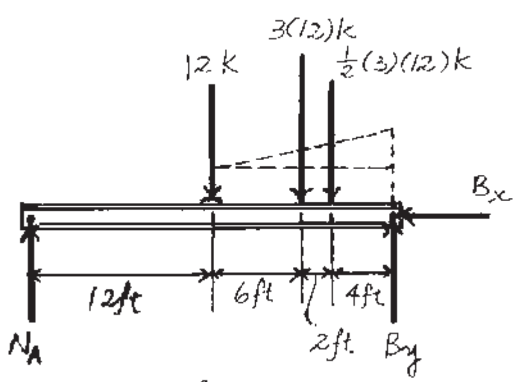
$N_A = 18.0\text{ k}$ **Ans.**

$\circlearrowleft +\Sigma M_A = 0; \quad B_y(24) - 12(12) - 3(12)(18) - \frac{1}{2}(3)(12)(20) = 0$

$B_y = 48.0\text{ k}$ **Ans.**

Write the force equation of equilibrium along the x-axis.

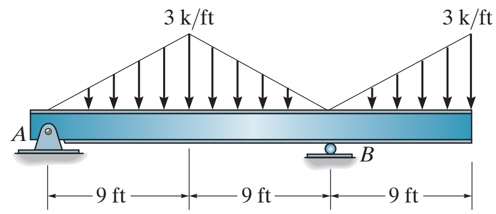
$\xrightarrow{+} \Sigma F_x = 0, \quad b_x = 0$ **Ans.**



(a)

Ans.
$N_A = 18.0\text{ k}$
$B_y = 48.0\text{ k}$
$B_x = 0$

2–19. Determine the reactions at the supports.



SOLUTION

Equations of Equilibrium. Referring to the FBD of the beam shown in Fig. *a*, $\mathbf{N}_B$ and $\mathbf{A}_y$ can be determined directly by writing the moment equations of equilibrium about points *A* and *B*, respectively.

$$\circlearrowleft + \Sigma M_A = 0; \qquad N_B(18) - \frac{1}{2}(3)(18)(9) - \frac{1}{2}(3)(9)(24) = 0$$

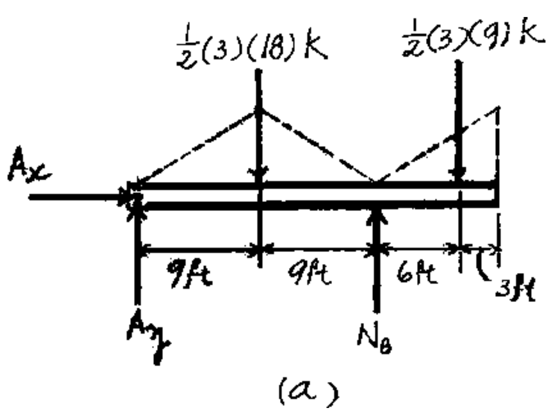
$N_B = 31.5 \text{ k}$ **Ans.**

$$\circlearrowleft + \Sigma M_B = 0; \qquad \frac{1}{2}(3)(18)(9) - \frac{1}{2}(3)(9)(6) - A_y(18) = 0$$

$A_y = 9.00 \text{ k}$ **Ans.**

Write the force equation of equilibrium along the *x* axis.

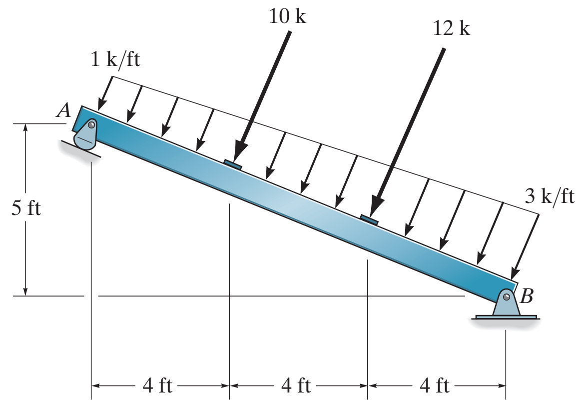
$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x = 0$ **Ans.**



(a)

Ans.
$N_B = 31.5 \text{ k}$
$A_y = 9.00 \text{ k}$
$A_x = 0$

***2–20.** Determine the reactions on the beam.



SOLUTION

Equations of Equilibrium. Referring to the FBD of the beam shown in Fig. *a*, $\mathbf{N}_A$ can be obtained directly by writing the moment equation of equilibrium about point B.

$\circlearrowleft + \Sigma M_B = 0; \qquad 10(8.667) + B(6.50) + 25(4.333) - N_A(13) = 0$

$N_A = 21.5 \text{ k}$ **Ans.**

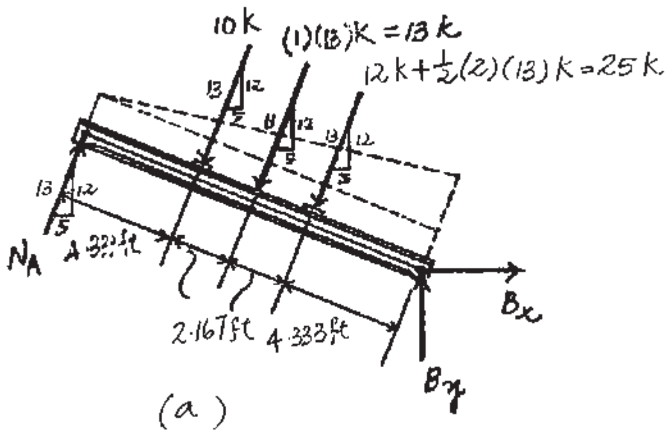
Using this result to write the force equation of equilibrium along the x and y axis,

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad B_x + 21.5\left(\frac{5}{13}\right) - (10 + 13 + 25)\left(\frac{5}{13}\right) = 0$

$B_x = 10.19 \text{ k} = 10.2 \text{ k}$ **Ans.**

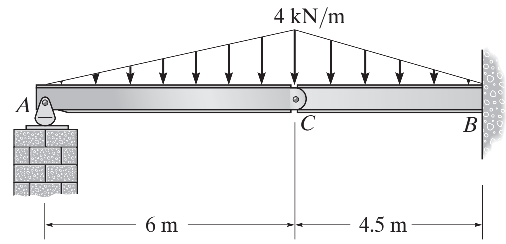
$+\uparrow \Sigma F_y = 0; \qquad B_y + 21.5\left(\frac{12}{13}\right) - (10 + 13 + 25)\left(\frac{12}{13}\right) = 0$

$B_y = 24.46 \text{ k} = 24.5 \text{ k}$ **Ans.**



Ans.
$N_A = 21.5 \text{ k}$
$B_x = 10.2 \text{ k}$
$B_y = 24.5 \text{ k}$

2–21. Determine the reactions at the supports A and B of the compound beam. There is a pin at C.



SOLUTION

Member AC:

$\circlearrowright + \Sigma M_C = 0;\ -A_y(6) + 12(2) = 0$

$A_y = 4.00\ \text{kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\ C_y + 4.00 - 12 = 0$

$C_y = 8.00\ \text{kN}$

$\overset{+}{\rightarrow} \Sigma F_x = 0;\ C_x = 0$

Member CB:

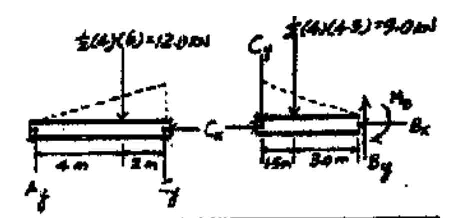
$\circlearrowright + \Sigma M_B = 0;\ -M_B + 8.00(4.5) + 9(3) = 0$

$M_B = 63.0\ \text{kN} \cdot \text{m}$ **Ans.**

$+\uparrow \Sigma F_y = 0;\ B_y - 8 - 9 = 0$

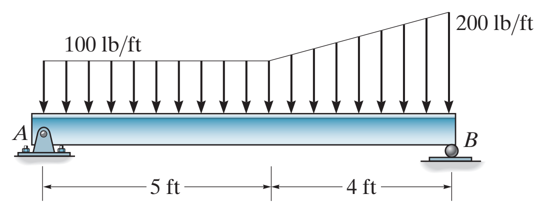
$B_y = 17.0\ \text{kN}$ **Ans.**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\ B_x = 0$ **Ans.**



Ans.
$A_y = 4.00\ \text{kN}$
$M_B = 63.0\ \text{kN} \cdot \text{m}$
$B_y = 17.0\ \text{kN}$
$B_x = 0$

2–22. Determine the reactions at the supports.



SOLUTION

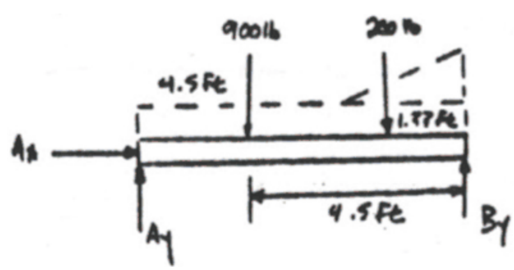
$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$ **Ans.**

$\circlearrowright + \Sigma M_B = 0; \quad 900(4.5) + 200(1.333) - A_y(9) = 0$

$A_y = 480 \text{ lb}$ **Ans.**

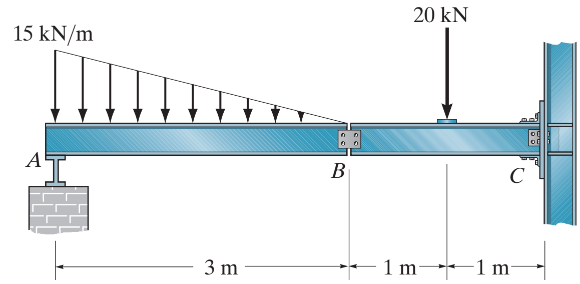
$+\uparrow \Sigma F_y = 0; \quad 480 - 1100 + B_y = 0$

$B_y = 620 \text{ lb}$ **Ans.**



Ans.
$A_x = 0$
$A_y = 480 \text{ lb}$
$B_y = 620 \text{ lb}$

2–23. Determine the reactions at the supports A and C of the compound beam. Assume C is fixed, B is a pin, and A is a roller.



SOLUTION

Equations of Equilibrium. First consider the equilibrium of the FBD of segment AB in Fig. *a*. $\mathbf{N}_A$ and $\mathbf{B}_y$ can be determined directly by writing the moment equations of equilibrium about points B and A, respectively.

$\circlearrowleft+\Sigma M_B = 0;\quad \frac{1}{2}(15)(3)(2) - N_A(3) = 0 \quad N_A = 15.0\text{ kN}$ **Ans.**

$\circlearrowleft+\Sigma M_A = 0;\quad B_y(3) - \frac{1}{2}(15)(3)(1) = 0 \quad B_y = 7.50\text{ kN}$

Write the force equation of equilibrium along the x axis.

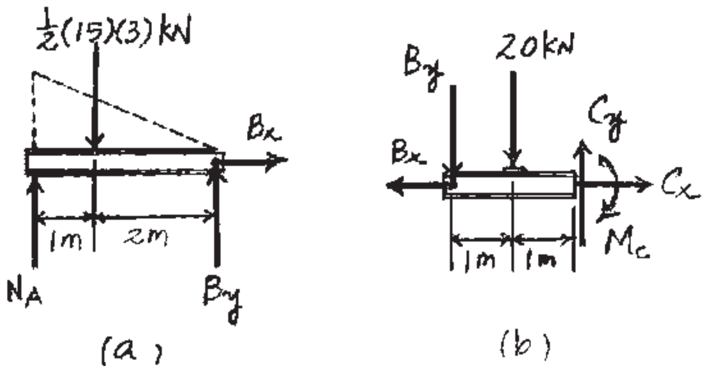
$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad B_x = 0.$

Then consider the equilibrium of the FBD of segment BC using the results of B_x and B_y.

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad C_x = 0$

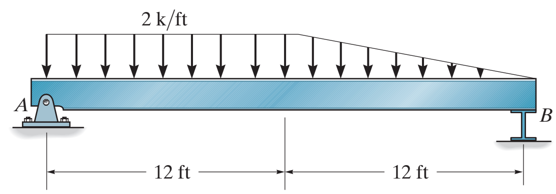
$+\uparrow\Sigma F_y = 0;\quad C_y - 20 - 7.50 = 0 \quad C_y = 27.5\text{ kN}$ **Ans.**

$\circlearrowleft+\Sigma M_C = 0;\quad 7.50(2) + 20(1) - M_C = 0 \quad M_C = 35.0\text{ kN}\cdot\text{m}$ **Ans.**



Ans.
$N_A = 15.0\text{ kN}$
$C_x = 0$
$C_y = 27.5\text{ kN}$
$M_C = 35.0\text{ kN}\cdot\text{m}$

***2–24.** Determine the reactions on the beam. The support at B can be assumed to be a roller.



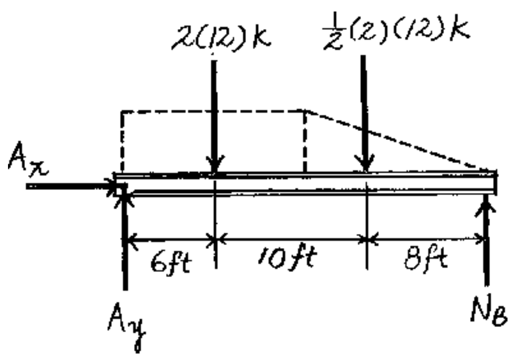
SOLUTION

Equations of Equilibrium:

$\circlearrowleft + \Sigma M_A = 0; \qquad N_B(24) - 2(12)(6) - \frac{1}{2}(2)(12)(16) = 0 \qquad N_B = 14.0 \text{ k}$

$\circlearrowleft + \Sigma M_B = 0; \qquad \frac{1}{2}(2)(12)(8) + 2(12)(18) - A_y(24) = 0 \qquad A_y = 22.0 \text{ k}$

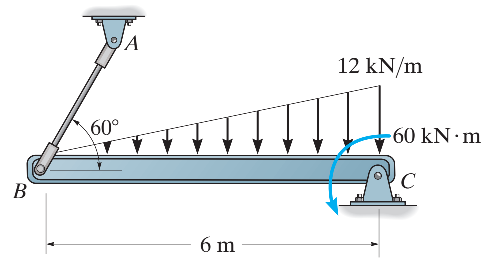
$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x = 0$



(a)

Ans.
$N_B = 14.0$ k
$A_y = 22.0$ k
$A_x = 0$

2–25. Determine the horizontal and vertical components of reaction at the pins A and C.



SOLUTION

Equations of Equilibrium. Referring to the FBD of the beam shown in Fig. *a*, $\mathbf{F}_{AB}$ and $\mathbf{C}_y$ can be determined directly by writing the moment equations of equilibrium about points C and B, respectively,

$$\circlearrowleft + \Sigma M_C = 0; \quad \frac{1}{2}(12)(6)(2) + 60 - (F_{AB}\sin 60°)(6) = 0$$

$$F_{AB} = 25.40 \text{ kN}$$

$$\circlearrowleft + \Sigma M_B = 0; \quad C_y(6) + 60 - \frac{1}{2}(12)(6)(4) = 0$$

$$C_y = 14.0 \text{ kN} \qquad \textbf{Ans.}$$

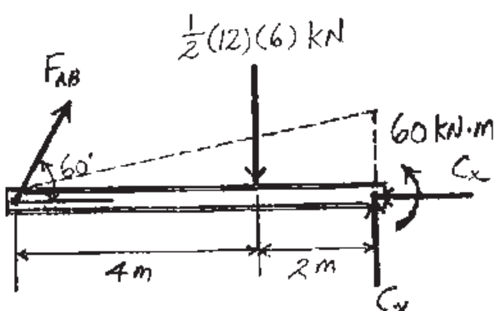
Using the result of $\mathbf{F}_{AB}$ to write the force equation of equilibrium along the x axis,

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 25.40 \cos 60° - C_x = 0 \quad C_x = 12.70 \text{ kN} = 12.7 \text{ kN} \qquad \textbf{Ans.}$$

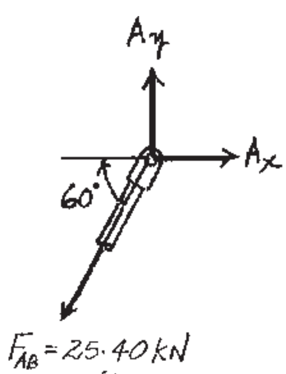
Referring to the FBD of pin A, Fig. b, the force equations of equilibrium written along the x and y axis give

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad A_x - 25.40 \cos 60° = 0 \quad A_x = 12.70 \text{ kN} = 12.7 \text{ kN} \qquad \textbf{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad A_y - 25.40 \sin 60° = 0 \quad A_y = 22.0 \text{ kN} \qquad \textbf{Ans.}$$



(a)



(b)

Ans.
$C_y = 14.0$ kN
$C_x = 12.7$ kN
$A_x = 12.7$ kN
$A_y = 22.0$ kN