$\mathbf{f_c} := 4000$ **psi**

$\mathbf{f_y} := 60000$ **psi**

$\mathbf{L_{ew}} := 24$ **ft**

$\mathbf{L_{ns}} := 18$ **ft**

$\mathbf{col_{ew}} := 16$ **in**

$\mathbf{col_{ns}} := 16$ **in**

Solution

Step 1

Geometry check for use of direct design method

(a) ratio (longer span/shorter span) = $\frac{24}{18} = 1.333$ <2.0; two way action

(b) More than 3 panel in each direction

(c) Assume a thickness of 7"

$$\mathbf{w_d} := 14 + \frac{7}{12} \cdot 150$$

$\mathbf{w_d} = 101.5$ **psf**

$3 \cdot \mathbf{w_d} = 304.5$ **psf**

$\mathbf{w_L} := 115$ **psf** < 3 $\mathbf{w_d}$

Therefore, Direct Method is applicable

Step 2

Minimum slab thickness for delction requirement

$$\mathbf{Ln_{ew}} := \mathbf{L_{ew}} \cdot 12 - 2 \cdot \frac{\mathbf{col_{ew}}}{2}$$

$$\mathbf{Ln_{ns}} := \mathbf{L_{ns}} \cdot 12 - 2 \cdot \frac{\mathbf{col_{ns}}}{2}$$

$\mathbf{Ln_{ew}} = 272$ **in**

$\mathbf{Ln_{ns}} = 200$ **in**

$$\beta := \frac{\mathbf{Ln_{ew}}}{\mathbf{Ln_{ns}}}$$

$\beta = 1.36$

$$\mathbf{h} := \frac{\mathbf{Ln_{ew}} \cdot \left(\left(0.8 + \frac{\mathbf{f_y}}{200000} \right) \right)}{36 + 9 \cdot \beta} \qquad \text{Eq 9-12}$$

$\mathbf{h} = 6.202$

$$\mathbf{h} := \frac{\mathbf{Ln_{ew}} \cdot \left(\left(0.8 + \frac{\mathbf{f_y}}{200000} \right) \right)}{36 + 5 \cdot \beta \cdot (\alpha_m - 0.2)} \qquad \text{Eq 9-11}$$

Need to find α_m

locate the beam centroid

$$(38 \cdot 7)(\mathbf{y} + 3.5) + 12 \cdot \frac{(\mathbf{y}^2)}{2} - 12 \cdot \frac{(13 - \mathbf{y})^2}{2}$$

$\mathbf{y} := 0.20$ **in**

$$\mathbf{I_b} := \frac{1}{3} \cdot (12) \cdot (\mathbf{y})^3 + \frac{1}{12} \cdot (38) \cdot (7)^3 + 38 \cdot 7 \cdot (\mathbf{y} + 3.5)^2 + \frac{1}{3} \cdot 12 \cdot (13 - \mathbf{y})^3$$

$\mathbf{I_b} = 1.312 \times 10^4$ $\mathbf{in}^4$

$$\mathbf{I_s} := \frac{1}{12} \mathbf{bh}^3$$

b=width of slab bound laterally by the centerline of the adjacent panel on each side of the beam

$$\mathbf{Is_{ns}} := \frac{1}{12}\cdot 7^3\cdot \mathbf{L_{ew}}\cdot 12$$

$$\mathbf{Is_{ns}} = 8.232\times 10^3 \qquad \mathbf{in}^4$$

$$\mathbf{Is_{ew}} := \frac{1}{12}\cdot 7^3\cdot \mathbf{L_{ns}}\cdot 12$$

$$\mathbf{Is_{ew}} = 6.174\times 10^3 \qquad \mathbf{in}^4$$

$$\alpha_{\mathbf{1}} := \frac{\mathbf{I_b}}{\mathbf{Is_{ns}}}$$

$$\alpha_{\mathbf{1}} = 1.593$$

$$\alpha_{\mathbf{2}} := \frac{\mathbf{I_b}}{\mathbf{Is_{ew}}}$$

$$\alpha_{\mathbf{2}} = 2.124$$

$$\alpha_{\mathbf{m}} := \frac{2\cdot\left(\alpha_{\mathbf{1}} + \alpha_{\mathbf{2}}\right)}{4}$$

$$\alpha_{\mathbf{m}} = 1.859$$

$$\mathbf{h} := \frac{\mathbf{Ln_{ew}}\cdot\left(\left(0.8 + \frac{\mathbf{f_y}}{200000}\right)\right)}{36 + 5\cdot\beta\cdot\left(\alpha_{\mathbf{m}} - 0.2\right)} \qquad \text{Eq 9-11}$$

$$\mathbf{h} = 6.328 \qquad \mathbf{in}$$

Therefore, the minimum of h in this case from Eq. 9-11 and 9-12 is 6.328 inches. Therefore, for deflection, use h=7 in assumed at the beginning

$$\mathbf{h} := 7 \qquad \mathbf{in}$$

Step 3. Statical Moment Computation

$$\mathbf{w_d} := \frac{\mathbf{h}}{12}\cdot 150 + 14 \quad \mathbf{psf}$$ 14=given floor weight

$$\mathbf{w_L} := 135 \quad \mathbf{psf} \qquad \mathbf{w_d} = 101.5$$

$$\mathbf{w_u} := 1.2\cdot\mathbf{w_d} + 1.6\cdot\mathbf{w_L}$$

$$\mathbf{w_u} = 337.8 \quad \mathbf{psf}$$

E-W Direction

$$\mathbf{L_n} := \mathbf{Ln_{ew}}$$

$$\mathbf{L_n} = 272 \quad \mathbf{in}$$

$$\mathbf{L_n} := \frac{272}{12}$$

$$\mathbf{L_n} = 22.667 \quad \mathbf{ft}$$

$$\mathbf{L_1} := \mathbf{L_{ew}}$$

$$\mathbf{L_1} = 24 \quad \mathbf{ft}$$

$$\mathbf{L_2} := \mathbf{L_{ns}}$$

$$\mathbf{L_2} = 18 \quad \mathbf{ft}$$

$$\mathbf{M_o} := \frac{\left(\mathbf{w_u}\cdot\mathbf{L_2}\cdot\mathbf{L_n}^2\right)}{8}$$

$$\mathbf{M_o} = 3.905 \times 10^5 \quad \mathbf{lb\cdot ft}$$

Moment distribution for interior panels

$$\mathbf{Mu_{negative}} := 0.65\cdot\mathbf{M_o} \qquad \mathbf{Mu_{negative}} = 2.538 \times 10^5 \quad \mathbf{lb\cdot ft}$$

$$\mathbf{Mu_{positive}} := 0.35\cdot\mathbf{M_o} \qquad \mathbf{Mu_{positive}} = 1.367 \times 10^5 \quad \mathbf{lb\cdot ft}$$