Chapter 13

External Problem

Design the formwork for an 8-in.-thick concrete floor slab based on the following data. Hand concrete buggies will be used to place concrete. Formwork is estimated to weight 10 lb/sq ft. Decking will be ¾-in. class I Plyform with face grain across supports. Joists will be 2 × 12's and stringers will be 4 × 10's. All lumber will be Douglas fir (use allowable stress from Table 12-6 and 7-day load duration). Maximum deflection must be limited to l/360 span length. Shores of 8000-lb. capacity will be used. The slab will be 40 ft wide ×50 ft long, poured at one time. Guy-wire bracing capable of caring a load of 2000 lb. each will be used on all four sides of the form, attached at slab elevation and making a 45° angle with the ground.

Solution

➢ ***Design Load***

Concrete = 1 sq ft × $\frac{8\,\text{in}}{12\,\text{in/ft}}$ × 150 lb/cu ft = 100 lb/sq ft

Form work = 10 lb/sq ft

Live load (@ *Hand concrete buggies*) = 75 lb/sq ft

Design load = 185 lb/sq ft

➢ ***Deck Design***

w = (1 sq ft/linear ft) × (185 lb/sq ft) = 185 lb/ft

Properties of Decking (¾-in *Class I Plyform with face grain a cross support*). (Table 12-4)

$EI = 0.298\times10^6\ \frac{\text{lb in}^2}{\text{ft}}$, FbKS= $0.878\times10^3\ \frac{\text{lb in}}{\text{ft}}$, Fslb/$Q$ = $0.517\times10^3\ \frac{\text{lb}}{\text{ft}}$

Assume three or more span

a) Bending

$$l = 10.95\left(\frac{F_b KS}{w}\right)^{1/2} = 10.95\left(\frac{0.878\times10^3}{185}\right)^{1/2} = 23.9\text{ in.}$$

b) Shear

$$l = 20\,\frac{F_s\text{lb}/\text{Q}}{w} + 2d = 20\,\frac{0.517\times10^3}{185} + 2\times0.75 = 57.4\text{ in.}$$

c) Deflection

$$l = 1.94\left(\frac{EI}{w}\right)^{1/3} = 1.94\left(\frac{0.298\times10^6}{185}\right)^{1/3} = 19.81\text{ in} \Leftarrow$$

∴ Deflection governs in this design and the maximum allowable span is 19.81 in. Will select a 18 in (1.5 ft) joist spacing for design.

➢ ***Joist Design***

w = (1.5 ft) × (185 lb/sq ft) = 277.5 lb/ft

Allowable stress of Douglas fir lumber (*used for Joist and Stringer lumber*). (Table 12-6)

F_b = 1450 psi $F_{c\perp}$ = 385 psi F_t = 850 psi

F_v = 185 psi F_c = 1000 psi E = 1.7 × 10^6 psi

Properties section of Stringer lumber (2×12 in). (Table 11-5)

A = 1.5×11.25 = 16.88 in^2 & I = 178 in^4 & S = 31.64 in^3

Assume three or more span

a) Bending

$$l = 10.95\left(\frac{F_b\ S}{w}\right)^{1/2} = 10.95\left(\frac{1{,}450\times\ 31.64}{277.5}\right)^{1/2} = 140.8 \text{ in.} \Leftarrow$$

b) Shear

$$l = 13.3\ \frac{F_v\ A}{w} + 2d\ = 13.3\ \frac{185\times 16.88}{277.5} + 2\times 11.25\ = 172.17 \text{ in.}$$

c) Deflection

$$l = 1.69\left(\frac{E\ I}{w}\right)^{1/3} = 1.69\left(\frac{1.7\times 10^6\ \times 178}{277.5}\right)^{1/3} = 173.95 \text{ in}$$

∴ Thus bending governs and maximum joist span is 140.8-in. Select a stringer spacing (Joist span) of 138 in (11.5 ft).

- ***Stringer Design***

w = 11.5 ft × 185 lb/sq ft = 2127.5 lb/ft

Allowable stress of Douglas fir lumber (*used for Joist and Stringer lumber*). (Table 12-6)

F_b = 1450 psi $F_{c\perp}$ = 385 psi F_t = 850 psi

F_v = 185 psi F_c = 1000 psi E = 1.7 × 10^6 psi

Properties section of Stringer lumber (4 × 10 in). (Table 12-5)

A = 3.5×9.25 = 32.38 in^2 & I = 230.8 in^4 & S = 49.91 in^3

a) Bending

$$l = 10.95\left(\frac{F_b\ S}{w}\right)^{1/2} = 10.95\left(\frac{1{,}450\times\ 49.91}{2127.5}\right)^{1/2} = 63.9 \text{ in.}$$

b) Shear

$$l = 13.3\ \frac{F_v\ A}{w} + 2d\ = 13.3\ \frac{185\times 32.38}{2127.5} + 2\times 9.25\ = 55.9 \text{ in.}$$

c) Deflection

$$l = 1.69\left(\frac{E\,I}{w}\right)^{1/3} = 1.69\left(\frac{1.7\times10^{6}\times230.8}{2127.5}\right)^{1/3} = 96.2 \text{ in}$$

d) Shore strength

$$l = \frac{8000}{2127.5}\times 12\ {}^{\text{in}}\!/_{\text{ft}} = 45.1 \text{ in} \leftarrow$$

$\therefore$ Thus the maximum stringer span is limited by shore strength to 45.1 in. Select a shore spacing of 42 in (3.5 ft).

- ***Check Crushing point***

  P = 277.5 lb/ft × 11.5 ft = 3191.25 lb

  Bearing area (A) = 3.5 in × 4.75 in = 16.625 sq. in.

  $$f_{c\perp} = \frac{P}{A} = \frac{3191.25}{16.625} = 191.95 \text{ psi} < 385 \text{ psi} \qquad \therefore \text{ Ok.}$$

- ***Check for Lateral Braces***

Concrete = 1 sq ft × $\frac{8\text{ in}}{12\text{ in/ft}}$ × 150 lb/cu ft	= 100 lb/sq ft
Form work	= 10 lb/sq ft
Design dead load (dl)	= 110 lb/sq ft

H = 0.02 × dl × ws ……………………………….. equation (12-4)

– For the 40-ft face, width of slab (ws) is 50 ft.

H_{40} = 0.02 × 110 × 50 = 110 lb/lin ft > 100 lb/lin ft $\therefore$ Ok.

$\therefore$ in this face, we need lateral brace = H_{40} × 40 ft = 4400 lb.

Where we have Guy-wire bracing capable of carrying a load of 2000 lb, so we need:

$$\frac{4400\text{ lb/40-ft face}}{2000\text{ lb/Guy-wire}} = 2.2 \approx 3 \text{ Guy-wire/40-ft face}$$

– For the 50-ft face, width of slab (ws) is 40 ft.

H_{50} = 0.02 × 110 × 40 = 88 lb/lin ft < 100 lb/lin ft $\therefore H_{50}$ = 100 lb/lin ft

$\therefore$ in this face, we need lateral brace = H_{50} × 50 ft = 5000 lb.

Where we have Guy-wire bracing capable of carrying a load of 2000 lb, so we need:

$$\frac{5000\text{ lb/50-ft face}}{2000\text{ lb/Guy-wire}} = 2.5 \approx 3 \text{ Guy-wire/50-ft face}$$

- ***Final Design***

  Decking: ¾ in lumber. (*Class I Plyform with face grain a cross support*).

  Joists: 2×12’s at 18-in spacing. (*Douglas fir lumbers*)

  Stringer: 4×10’s at 138-in spacing. (*Douglas fir lumbers*).

Shores: 8000-lb commercial at 42-in spacing, with 3 Guy-wire bracing on all four sides of the form, attached at slab elevation and making a 45° angle with the ground.