4.6-2 A 20-foot **(6,000 mm)** long column is pinned at the bottom and fixed against rotation but free to translate at the top. It must support a service dead load of 110 kips **(490 k N)** and a service live load of 110 kips **(490 k N)** .

a. Select a W12 of A992 steel $(F_y = 50 \text{ Ksi})$. Use the column load tables.

1. Use LRFD.
2. Use ASD.

b. Select a W18 **(W460)** of A529 Grade 55 steel $(F_y = 55 \text{ ksi } (380 \text{ MPa}))$. Use the trial-and-error approach covered in Section 4.6.

PART a) $K = 2.0$ TABLE C-A-7.1 $\lambda = KL = 2.0(20\text{ft}) = 40\text{ft}$

LRFD $P_u = 1.2D + 1.6L = 1.2(110^k) + 1.6(110^k) = 308^k$

$\phi_c P_n = 308^k$

* FROM TABLE 4-1a (4-1a) (4-19) $\Rightarrow$ W12x120

$\phi_c P_n = 338^k$

ASD $P_a = D + L = 110^k + 110^k = 220^k$

*FROM TABLE 4-1a $\Rightarrow$ W12x120 $\frac{P_n}{\Omega_c} = 225^k$

4.6.2 TRIAL & ERROR

a) LRFD SELECT A W18 $F_y = 55\,ksi$

$P_u = 308^k$ TRY $F_n = \frac{2}{3}F_y = \frac{2}{3}(55\,ksi) = 36.7\,ksi$

$$REQ.\ A_g = \frac{P_u}{\phi_c F_n} = \frac{308^k}{0.9(36.7\,ksi)} = 9.33\,in^2$$

- TRY W18X40 $\begin{cases} A_g = 11.8\,in^2 > REQ.\ A_g \\ r_{min} = 1.27\,in \end{cases}$

$$\frac{L_c}{r_{min}} = \frac{2.0(20ft)(12in/ft)}{1.27in} = 377.95 > 200^*$$

$$4.71\sqrt{E/F_y} = 4.71\sqrt{\frac{29{,}000\,ksi}{55\,ksi}} = 108.15$$

$$\frac{L_c}{r} > 4.71\sqrt{E/F_y} \Rightarrow USE\ EQ.\ E3\text{-}3$$

*

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29{,}000\,ksi)}{(377.95)^2} = 2\,ksi$$

$$F_n = 0.877\,F_e = 0.877(2.00\,ksi) = 1.76\,ksi$$

$$\phi_c P_n = \phi_c F_n A_g = 0.9(1.76\,ksi)(11.8\,in^2) = 18.66^K$$

$\phi_c P_n \ll P_u$ N.G.

- TRY W18×86 [$A_g = 25.3\,in^2$ $r_{min} = 2.63\,in$

$$\frac{L_c}{r} = \frac{2.0(20ft)(12in/ft)}{2.63in} = 182.51 < 200 \checkmark$$

$$\frac{L_c}{r} > 4.71\sqrt{E/F_y} \Rightarrow \text{USE EQ. E3-3}$$

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29{,}000ksi)}{(182.51)^2} = 8.59ksi$$

$$F_n = 0.877F_e = 0.877(8.59\,ksi) = 7.54\,ksi$$

$$\phi_c P_n = \phi_c F_n A_g = 0.9(7.54\,ksi)(25.3in^2) = 171.59^k$$

$\phi_c P_n < P_u$ N.G.

$$\Rightarrow \text{REQ. } A_g = \frac{P_u}{\phi_c F_n} = \frac{308^k}{0.9(8ksi)} = 42.78\,in^2$$

- TRY W18×143 [$A_g = 42.0in^2$ $r_{min} = 2.72in$

$$\frac{L_c}{r} = \frac{2.0(20ft)(12in/ft)}{2.72in} = 176.47 < 200 \checkmark$$

$$\frac{L_c}{r} > 4.71\sqrt{E/F_y} \longrightarrow \text{USE EQ. E3-3}$$

4.6.2

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29{,}000\,ksi)}{(176.47)^2} = 9.19\,ksi$$

$$F_n = 0.877 F_e = 0.877(9.19\,ksi) = 8.06\,ksi$$

$$\phi_c P_n = \phi_c F_n A_g = 0.9(8.06\,ksi)(42.0\,in^2) = 304.68$$

$\phi_c P_n < P_u$ BY 3k! N.G.

USE W18x153!

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b) ASD $P_a = 220^k$

$$\text{REQ. } A_g = \frac{P_a}{\Omega_c(8ksi)} = \frac{220^k}{1.67(8ksi)} = 16.47\,in^2$$

- TRY W18x143 [$A_g = 42.0\,in^2$ $r_{min} = 2.72\,in$

$$\frac{L_c}{r} = \frac{2.0(20ft)(12in/ft)}{2.72in} = 176.47 < 200 \checkmark$$

$$\frac{L_c}{r} > 4.71\sqrt{E/F_y} \Rightarrow \text{USE EQ. E3-3}$$

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = 9.19\,ksi$$

4.6.2

$$F_n = 0.877 F_e = 0.877(9.19\text{ksi}) = 8.06\text{ksi}$$

$$\frac{P_n}{\Omega_c} = \frac{F_n A_g}{\Omega_c} = \frac{(8.06\text{ksi})(42.0\text{in}^2)}{1.67} = 202.71\text{k}$$

$$\frac{P_n}{\Omega_c} < P_a \quad \underline{\text{N.G.}}$$

- TRY W18 x 158 $\quad A_g = 46.3\text{in}^2 \quad r_{min}\ 2.74\text{in}$

$$\frac{L_c}{r} = \frac{2.0(20\text{ft})(12\text{in/ft})}{2.74} = 175.18 < 200 \checkmark$$

$$\frac{L_c}{r} > 4.71\sqrt{E/F_y} = 108.15 \Longrightarrow \text{USE EQ E3-3}$$

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2(29{,}000\text{ksi})}{(175.18)^2} = 9.33\text{ksi}$$

$$F_n = 0.877 F_e = 8.18\text{ksi}$$

$$\frac{P_a}{\Omega_c} = \frac{F_n A_g}{\Omega_c} = \frac{8.18\text{ksi}(46.3\text{in}^2)}{1.67} = 226.77\text{k}$$

$$\frac{P_a}{\Omega_c} > 220^k \quad \underline{\text{O.K.}}$$

$$\underline{\text{USE W18 x 158}}$$