

**Classroom Problem 4.8-1:** Compute the compressive strength of a **C10 x 30** of **A36** steel,  $F_y = 36 \text{ ksi}$ ;  $F_u = 58 \text{ ksi}$ . The effective length with respect to the x, y, and z axes is 10 ft.

$$\left[ \begin{array}{l} \text{* FROM TABLE 1-5 (1-35)} \\ A = 8.81 \text{ in}^2 \quad r_x = 3.43 \text{ in} \\ \quad \quad \quad \quad r_y = 0.668 \text{ in} \end{array} \right]$$

CHECK FLEXURAL BUCKLING

$$\frac{L_{cy}}{r_y} = \frac{10 \text{ ft} (12 \text{ in/ft})}{0.668 \text{ in}} = 179.64 < 200 \checkmark$$

$$\text{LIMIT} \rightarrow 4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29,000 \text{ ksi}}{36 \text{ ksi}}} = 133.68$$

$$\frac{L_{cy}}{r_y} > 4.71 \sqrt{\frac{E}{F_y}} \Rightarrow \text{USE AISC E3-3}$$

$$F_e = \frac{\pi^2 E}{(L_{cy}/r_y)^2} = \frac{\pi^2 (29,000 \text{ ksi})}{(179.64)^2} = 8.87 \text{ ksi}$$

$$F_n = 0.877 F_e = 0.877 (8.87 \text{ ksi}) = 7.78 \text{ ksi}$$

$$P_n = F_n A_g = 7.78 \text{ ksi} (8.81 \text{ in}^2) = \underline{68.54 \text{ k}}$$

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\* CHECK FLEXURAL-TORSIONAL BUCKLING

$$\frac{L_{cx}}{r_x} = \frac{10 \text{ ft} (12 \text{ in/ft})}{3.43 \text{ in}} = 34.99 < 200 \checkmark$$

$$\frac{L_{cx}}{r_x} < 4.71 \sqrt{E/F_y} \quad \text{USE AISC E3-2}$$

$$F_{ey} = \frac{\pi^2 E}{(L_c/r_y)^2} = \frac{\pi^2 (29,000 \text{ ksi})}{(34.99)^2} = 233,84 \text{ ksi}$$

\* FROM TABLE 1-5 (1-30)

$$F_{ez} = \left[ \frac{\pi^2 E C_w}{(L_z)^2} + GJ \right] \frac{1}{A \bar{r}_o^2}$$

$$\left[ \begin{array}{l} C_w = 79.5 \text{ in}^6 \quad \bar{r}_o = 3.63 \text{ in} \quad J = 1.22 \text{ in}^4 \\ H = 0.921 \end{array} \right]$$

$$F_{ez} = \left[ \frac{\pi^2 (29,000 \text{ ksi}) 79.5 \text{ in}^6}{(120 \text{ in})^2} + 11,200 \text{ ksi} (1.22 \text{ in}^4) \right] \frac{1}{8.81 \text{ in}^2 (3.63 \text{ in})^2}$$

$$= 131.32 \text{ ksi}$$

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$$F_e = \frac{F_{ey} + F_{ez}}{2H} \left[ 1 - \sqrt{1 - \frac{4F_{ey}F_{ez}H'}{(F_{ey} + F_{ez})^2}} \right] \quad F_{ey} + F_{ez} = 365.16 \text{ ksi}$$

$$= \frac{365.16 \text{ ksi}}{2(0.921)} \left[ 1 - \sqrt{1 - \frac{4(233.84 \text{ ksi})(131.32 \text{ ksi})0.921}{(365.16 \text{ ksi})^2}} \right] = 121.05 \text{ ksi}$$

$$\frac{F_y}{F_e} = \frac{36 \text{ ksi}}{121.05 \text{ ksi}} = 0.297 < 2.25 \quad \Rightarrow \text{USE EQ E3-2}$$

$$F_n = F_y \left( 0.658^{F_y/F_e} \right) = 36 \text{ ksi} \left( 0.658^{36/121.05} \right) = 31.79 \text{ ksi}$$

$$P_n = F_n A_g = 31.79 \text{ ksi} (8.81 \text{ in}^2) = \underline{280.04 \text{ k}}$$

\* FLEXURAL CONTROLS  $P_n = 68.53 \text{ k}$

$$\phi P_n = 0.90 (68.53 \text{ k}) = \underline{\underline{61.67 \text{ k}}}$$