

K=ANS

MEMBER: WT 10.5 x 41

Table 1-8

$$\frac{KL}{r_x} = \frac{(18)(12)}{3.07} = 70.358$$

$$F_{cx} = \frac{\pi^2 E}{(KL/r_x)^2} = \frac{\pi^2 (29000 \text{ ksi})}{(70.358)^2} = 57.819 \text{ ksi}$$

$$4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29000}{50}} = 113.43$$

$$113.43 > 70.358 \quad \text{USE: } F_{cx} = \left[0.658^{(50/F_y)} \right] F_y$$

$$F_{cx} = \left[0.658^{(50/57.819)} \right] (50) = 34.816 \text{ ksi}$$

$$P_{nx} = F_{cx} (A_g) = (34.816)(26.8) = 933.07 \text{ kips}$$

$$\text{FROM TABLE 4-7 } \phi P_n = 841 \text{ kips} \Rightarrow P_n = \frac{841 \text{ k}}{0.9} = 934.44 \text{ k}$$

$$933.07 \text{ k} \approx 934.44 \quad \therefore \text{OK}$$

K=ANS

$$\frac{KL}{r_y} = \frac{(18)(12)}{(3.00)} = 72$$

$$F_{cy} = \frac{\pi^2 E}{(KL/r_y)^2} = \frac{\pi^2 (29000)}{72^2} = 55.212 \text{ ksi}$$

$$(KL/r)_y = 72 < 4.71 \sqrt{\frac{E}{F_y}} = 113$$

$$F_{cy} = 0.658^{(50/55.212)} (50) = 34.226 \text{ ksi}$$

$$F_{c2} = \frac{GJ}{A_g F_o^2} \Rightarrow \frac{(11260)(15.3)}{(26.8)(21.46)} = 297.95$$

$$x_o = 0 \quad y_o = \bar{y} - \frac{t_y}{2} = 2.48 - \frac{1.48}{2} = 1.74 \text{ in}$$

$$\bar{r}_o^2 = x_o^2 + y_o^2 + \frac{I_x + I_y}{A_g} = 0^2 + 1.74^2 + \frac{253 + 241}{26.8} = 21.46 \text{ in}^2$$

$$H = 1 - \frac{x_o^2 + y_o^2}{\bar{r}_o^2} = 1 - \frac{0^2 + (1.74)^2}{21.46} = 0.65892$$

Table 1-8

$$\begin{aligned} G &= 11260 \\ J &= 15.3 \\ \bar{y} &= 2.48 \text{ in} \\ t_y &= 1.48 \text{ in} \\ I_x &= 253 \text{ in}^4 \\ I_y &= 241 \text{ in}^4 \end{aligned}$$

E4-1

E4-8

E4-2

$$F_{cr} = \left(\frac{F_{cy} + F_{c2}}{2H} \right) \left[1 - \sqrt{1 - \frac{4F_{cy} F_{c2} H}{(F_{cy} + F_{c2})^2}} \right]$$

$$= \left(\frac{34.226 + 297.95}{2(0.65892)} \right) \left[1 - \sqrt{1 - \frac{4(34.226)(297.95)(0.65892)}{(34.226 + 297.95)^2}} \right] = 33.62 \text{ ksi}$$

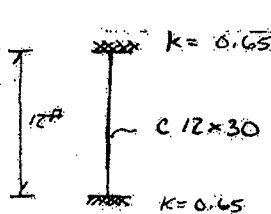
$$P_{ny2} = (33.62)(26.8) = 901.02 \text{ kips}$$

$$\text{FROM TABLE 4-7 } \phi P_n = 811 \text{ kips} \Rightarrow P_n = \frac{811}{0.9} = 901.11 \text{ k}$$

$$901.02 \text{ k} \approx 901.11 \text{ k} \quad \therefore \text{OK}$$

$$Z = 98.208 \text{ in}^3$$

Table 1-5



$$\begin{aligned} &F_y = 50 \text{ ksi} \\ &A_g = 8.81 \text{ in}^2 \\ &F_x = 4.29 \text{ in} \\ &r_y = 0.762 \text{ in} \end{aligned}$$

Buckling strength about y-axis

$$\left(\frac{KL}{r}\right)_y = \frac{(0.65)(12)(12)}{0.762} = 122.63 \Rightarrow \left(\frac{KL}{r}\right)_y > 4.71 \sqrt{\frac{E}{F_y}}$$

$$F_{cy} = \frac{\pi^2(E)}{(KL/r)_y^2} = \frac{\pi^2(29000)}{122.63^2} = 16.97 \text{ ksi}$$

$$F_{cy} = 0.657 F_c = 0.657 (16.97) = 11.036 \text{ ksi}$$

$$P_n = F_{cy} (A_g) = 11.036 (8.81) = 97.22 \text{ kips}$$

Flexural-torsional buckling about the y and z axes

$$\left(\frac{KL}{r}\right)_x = \frac{(0.65)(12)(12)}{4.29} = 21.816 \Rightarrow \left(\frac{KL}{r}\right)_x < 4.71 \sqrt{\frac{E}{F_y}}$$

$$F_{cx} = \frac{\pi^2(E)}{(KL/r)_x^2} = \frac{\pi^2(29000)}{21.816^2} = 601.26 \text{ ksi}$$

$$\begin{aligned} F_{cz} &= \left(\frac{\pi^2 E C_w}{(K_z L)^2} + GJ \right) \frac{1}{A_g F_o^2} \\ &= \left\{ \frac{\pi^2 (29000) (151)}{[(0.65)(12)(12)]^2} + 11200 (0.861) \right\} \frac{1}{(8.81)(4.54)^2} \\ &= 80.271 \text{ ksi} \end{aligned}$$

Table 1-5

$$\begin{aligned} C_w &= 151 \text{ in}^6 \\ F_o &= 4.54 \text{ in} \\ H &= 0.919 \\ G &= 11,200 \text{ ksi} \\ J &= 0.861 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} F_c &= \left(\frac{F_{cx} + F_{cz}}{2H} \right) \left[1 - \sqrt{1 - \frac{4 F_{cy} F_{cz} H}{(F_{cx} + F_{cz})^2}} \right] \\ &= \left(\frac{601.26 + 80.271}{(2)(0.919)} \right) \left[1 - \sqrt{1 - \frac{4(11.036)(80.271)(0.919)}{(601.26 + 80.271)^2}} \right] \\ &= 79.295 \text{ ksi} \end{aligned}$$

$$F_{cr} = 0.658 \left(\frac{50}{79.295} \right) (50) = 38.462$$

$$P_n = F_{cr} (A_g) = (38.462) (8.81) = 338.32 \text{ k}$$

4.9-10 2L6x4x5/8 LLBB, $\frac{3}{8}$ in spacing between them,
 $F_y = 50 \text{ ksi}$, $KL = 18'$ in every axis, two intermediate
 fully tightened bolts. $A_g = 11.7 \text{ in}^2$

1. Buckling about x-axis:

$$r_x = 1.89 \text{ in}$$

$$\frac{KL}{r_x} = \frac{18 \times 12 \text{ in}}{1.89 \text{ in}} = 114.29 > 113$$

$$F_e = \frac{\pi^2 \times 29000 \text{ ksi}}{(KL/r_x)^2} = \frac{\pi^2 \times 29000 \text{ ksi}}{(114.29)^2}$$

$$= 21.91 \text{ ksi}$$

$$\Rightarrow F_{cr} = 0.877 \times F_e$$

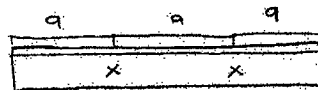
$$= 19.23 \text{ ksi}$$

$$\phi P_n = 0.9 \times 11.7 \text{ in}^2 \times 19.23 \text{ ksi} = \boxed{202.33 \text{ kips}}$$

2. Flexural-Torsional Buckling:

$$r_y = 1.66 \text{ in}$$

$$\frac{KL}{r_y} = \frac{18 \times 12 \text{ in}}{1.66 \text{ in}} = 130.12$$



$$3a = KL \Rightarrow @ = \frac{18 \times 12 \text{ in}}{3} = \underline{72 \text{ in}}$$

$$r_2 = 0.859 \text{ in}$$

(single angle)

$$\frac{K_2 a}{r_2} = \frac{72 \text{ in}}{0.859 \text{ in}} = 83.82 < 0.75 \times \left(\frac{KL}{r_y} \right) = 97.56 \checkmark$$

$$\left(\frac{KL}{r}\right)_m = \sqrt{\left(\frac{KL}{r_y}\right)^2 + \left(\frac{a}{r_z}\right)^2} = \sqrt{(130.12)^2 + (83.82)^2}$$

$$= 154.78$$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)_m^2} = \frac{\pi^2 \times 29,000 \text{ ksi}}{(154.78)^2} = 11.94 \text{ ksi} < 0.44 F_y$$

$$\Rightarrow F_{ey} = 0.877 \times F_e = 10.48 \text{ ksi}$$

$$F_{ez} = \frac{6J}{A_g \bar{r}_o^2} = \frac{11200 \times 2 \times 0.775}{11.7 \times (3.05)^2} \text{ ksi}$$

$$\bar{r}_o = 3.05 \text{ in}$$

$$J = 2 \times (0.775)^4 \text{ in}^4$$

$$H = 0.684 \text{ in}$$

$$= 159.5 \text{ ksi}$$

(J)

Table 1-1

$$\Rightarrow F_{cr} = \frac{F_{ey} + F_{ez}}{2H} \left(1 - \sqrt{1 - \frac{4F_{ey}F_{ez}H}{(F_{ey} + F_{ez})^2}} \right)$$

$$= \frac{10.48 + 159.5}{2 \times 0.684} \left(1 - \sqrt{1 - \frac{4 \times 10.48 \times 159.5 \times 0.684}{(10.48 + 159.5)^2}} \right)$$

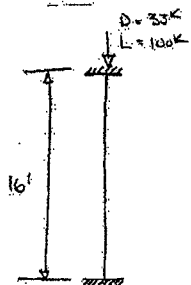
$$= 10.26 \text{ ksi}$$

$$\Rightarrow P_n = F_{cr} \times A_g = 10.26 \text{ ksi} \times 11.7 \text{ in}^2 = 120 \text{ kips}$$

$$\phi P_n = 0.9 \times 120 \text{ kips} = 108 \text{ kips}$$

So it has more strength for x-axis buckling than for flexural torsional buckling.

We can't compare with the table 4-9 because it is for $f_y = 36 \text{ ksi}$.



GIVEN: Column as shown, A36 steel.

REQUIRED: Design a double angle section (gusset plate = $\frac{3}{8}$ ") for the column and specify # of intermediate connectors

SOLUTION: Loading

$$\begin{aligned} P &= 1.2 D + 1.6 L \\ &= 1.2(33) + 1.6(100) \\ &= 199.6 \text{ K} \end{aligned}$$

Design

$$(KL)_x = (KL)_y = (16)(0.65) = 10.4$$

From Table 4-9 (4-133)

2L5 $\times$ $3\frac{1}{2}$ $\times$ $\frac{5}{8}$

$$\begin{aligned} KL \text{ } x-x & \cdot 10 \Rightarrow 234 \text{ K} \\ & 12 \Rightarrow 204 \text{ K} \end{aligned}$$

X-axis strength check

$$\left(\frac{KL}{r}\right)_x = \frac{(10.4)(12.7/4)}{156} = 80$$

$$F_c = \frac{\pi^2 29000}{(80)^2} = 44.72$$

$$F_{cr} = 0.658^{59/44.72} 50$$

$$= 31.31 \text{ ksi}$$

$$\phi P_n = \phi A_g F_{cr} = 0.9(2 \times 4.72)(31.31)$$

$$= 277.31 \text{ Kips}$$