Determine the nominal axial compressive strength for a W10×100 column that pinned @ both ends for major and minor axis buckling. (complete calculations for L = 10ft and L = 30ft)

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SOLUTION: $K_x = K_y = 1.0$ $L_y = L_x$ $r_x = 4.60$ $r_y = 2.65$

$a = 29.4 \text{ in}^2$ Table 1.1 - Non slender

$$\frac{K_x L_x}{r_y} = \frac{(1.0) L_x}{4.60} = 0.2174 L_x$$

$$\frac{K_y L_y}{r_y} = \frac{(1.0) L_y}{2.65} = 0.3774 L_y$$ ← governs since $L_x = L_y$

10ft Column

$$F_e = \frac{\pi^2 E}{\left(\frac{K_y L_y}{r_y}\right)^2} = \frac{\pi^2 (29000 \text{ ksi})}{(0.3774 (10 \times 12))^2} = 139.60$$

Limits

$$\left(\frac{K_y L_y}{r_y} \geq 4.71 \sqrt{\frac{E}{F_y}}\right) \text{ or } \left(\frac{K_y}{r_y} < 4.71 \sqrt{\frac{E}{F_y}}\right)$$

(45.28 ≥ 114.15) NO (45.28 < 114.15) YES

$$F_{CR10} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y = \left[0.658^{\left(\frac{50}{139.60}\right)}\right] 50$$

$= 43.04 \text{ ksi}$

$P_{CR10} = F_{CR10} \times A_g = (43.04 \text{ ksi})(29.4 \text{ in}^2)$

$= \underline{1265.35 \text{ kips}}$

30ft Column

$$F_e = \frac{\pi^2 E}{\left(\frac{K_y L_y}{r_y}\right)^2} = \frac{\pi^2 (29000 \text{ ksi})}{(0.3774 (30 \times 12))^2} = 15.51$$

Limits

$$\frac{K_y L_y}{r_y} = 135.95 \qquad 4.71\sqrt{\frac{E}{F_y}} = 114.15$$

$$\therefore \quad \frac{K_y L_y}{r_y} > 4.71\sqrt{\frac{E}{F_y}}$$

$$F_{cr30} = 0.877 F_e$$

$$= 0.877 (15.5) = 13.60 \text{ ksi}$$

$$P_{cr30} = F_{cr30} \times A_g$$

$$= 13.60 \times 29.4$$

$$= \underline{\underline{399.88 \text{ kips}}}$$

Results:

$P_{cr10} = 1265$ Kips

$P_{cr30} = 400$ Kips

The 30ft column strength is much smaller because it will buckle more easily than the 10ft column. The reason is based on the effective length difference in the two columns.

GIVEN: W14×82 13ft Long column. For major axis the column is fixed / pinned. For minor axis the column is pinned / pinned.

REQUIRED: Find the nominal design strength by
Ⓐ AISC E3.2 and 3.3
Ⓑ Using AISC design tables.

SOLUTION: Ⓐ W14×82 properties:

$A_g = 24.0 \text{ in}$ $\quad r_x = 6.05 \quad r_y = 2.48 \quad L_x = L_y = 13^{ft}$

$K_x = 0.8$ (major) $\quad K_y = 1.0$ (minor)

Shape is not slender according to table 1.1

Calculations: $\left(\frac{KL}{r}\right)$

$$\frac{K_x L_x}{r_x} = \frac{(0.8)(13 \times 12)}{6.05} = 20.63$$

$$\frac{K_y L_y}{r_y} = \frac{(1.0)(13 \times 12)}{2.48} = 62.90 \leftarrow \text{governs}$$

Limit states

$$4.71\sqrt{\frac{E}{F_y}} = 4.71\sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 114.15$$

$$\frac{K_y L_y}{r_y} \leq 4.71\sqrt{\frac{E}{F_y}} \therefore F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] F_y$$

Critical Stress

$$F_e = \frac{\pi^2 (E)}{\left(\frac{K_y L_y}{r_y}\right)^2} = \frac{\pi^2\, 29000 \text{ ksi}}{(62.90)^2} = 72.34$$

$$F_c = \left[0.658^{\frac{50}{72.34}}\right] 50 = 37.44 \text{ ksi}$$

Nomanal Design Load

$$\phi P_n = \phi (A_g F_{cr})$$

$$= 0.9(24.0 \times 37.44)$$

$\phi P_n = \underline{808.70 \text{ Kips}}$ (Design)

$P_n = \underline{898.55 \text{ Kips}}$ (nominal)

③ From design tables

$KL = (1.0)(13) = 13^{ft}$

From table 4.1 (Page 4-14)

$\underline{\underline{\phi_c P_n = 810}}$ kips (Design)

$\underline{\underline{P_n = 900 \text{ Kips}}}$ (nominal)

GIVEN: W18 × 119 12 ft long column. For major axis it is fixed / pinned. For minor axis it is continually supported. (colum is made from A992 steel)

REQUIRED: Find the nominal design load.

SOLUTION: <u>W18×119 Properties:</u>

$A_g = 35.1\,in^2$ $\quad r_x = 7.90 \quad r_y = 2.69$

$\quad K_x = 0.8 \quad K_y = 0$

$L_x = L_y = 12^{ft}$ (major) (minor)

Shape is not slinder according to table 1.1 (1-18 page)

<u>$\frac{KL}{r}$ Calculations:</u>

$$\frac{K_x L_x}{r_x} = \frac{(0.8)(12 \times 12)}{7.90} = 14.58 \leftarrow \text{governs}$$

$$\frac{K_y L_y}{r_y} = 0$$

<u>Limit State:</u>

$$4.71\sqrt{\frac{E}{F_y}} = 114.15$$

$$\frac{K_x L_x}{r_x} \leq 4.71\sqrt{\frac{E}{F_y}} \quad \therefore \ F_c = \left[0.658^{\frac{F_y}{F_e}}\right] F_y$$

<u>Critical Stress</u>

$$F_e = \frac{\pi^2 (E)}{\left(\frac{K_x L_x}{r_x}\right)} = \frac{\pi^2 (2900\,ksi)}{(14.58)^2} = 1346.43$$

$$F_{cr} = \left[0.658^{\frac{50}{1346.48}}\right] 50\,ksi = 49.22\,Ks$$

<u>Nominal Design Load:</u>

$$\phi P_n = \phi (A_g \ F_{cr})$$

$$= 0.9\,(35.1 \times 49.22\,ksi)$$

$$\underline{\underline{\phi P_n = 1555.14\,Kips}} \quad \text{(Design)}$$

$$\underline{\underline{P_n = 1727.93\,Kips}} \quad \text{(Nominal)}$$

DESIGN: A 20ft column. Major axis is fixed/pinned minor is pinned/pinned. The minor axis is pinned at the top, middle and bottom. The column must support 110^K dead load and 110^K live load. Complete the design for a <u>W12</u> A992 and for a <u>W14</u> A992.

SOLUTION: <u>Column Loading</u>

$$1.2(110^K) + 1.6(110^K) = 308^K$$

<u>Column Properties</u>

translation allowed

$L_x = 20ft$ $\qquad K_{major(x)} = 2.0$

$L_y = 20ft$ $\qquad K_{minor(y)} = 0.5$

<u>Governing</u>

$$\frac{K_x L_x}{r_x} = \frac{K_y L_y}{r_y} \rightarrow \frac{(KL)_x}{(KL)_y} = \frac{r_x}{r_y} = 4$$

assuming r_x/r_y is less than 4 major axis will govern

<u>W12 Design</u>

Assume a: W12 × 120 $\quad (\frac{r_x}{r_y} = 1 \therefore (KL)_{eq} = 40)$

iteration	r_x/r_y	$(KL)_{eq}$	Section
1	1.0	40	W12×120
2	1.76	22.72 (24)	W12 × 58
3	2.10	19.1 (20)	W12 × 53
4	2.11	19.0	W12 × 53

Selected member based on major axis buckling is a W12 × 53.

<u>Governing Check</u>

$$\frac{(KL)_x}{r_x} = \frac{(2)(20)(12)}{5.23} = 91.79 \leftarrow \text{governs}$$

$$\frac{(KL)_Y}{r_Y} = \frac{(0.5)(20)(12)}{2.48} = 48.39$$

Major axis does govern therefore design is acceptable.

W14 Design

Assume W14 by $(r_x/r_y) = 1.0$ $(KL)_{eq} = 40$

Iteration	r_x/r_y	$(KL)_{eq}$	Section
1	1.0	40	W14×90
2	1.66	24.1 (26)	W14×74
3	2.44	16.4 (17)	W14×53
4	3.07	13.0	W14×43

NOTE W14×43 is slender for compression
∴ I will select a W14×48

governing check

$$\left(\frac{KL}{r}\right)_x = \frac{(2.0)(20)}{5.95} = 82.05 \leftarrow \text{governs}$$

$$\left(\frac{KL}{r}\right)_y = \frac{(0.5)(20)}{1.91} = 62.82$$

major axis governs again, assumption was correct

Results: Beams selected:

W12×53

W14×48