Example Problem 7.1

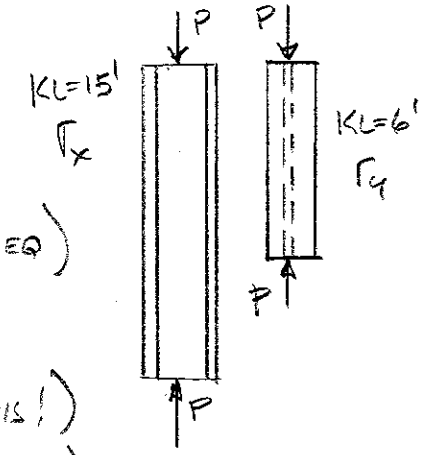
Given: The following members are being considered for use as a concentrically loaded column. The column has effective lengths, KL, of 15 ft in one direction and 6 ft in the orthogonal direction. The load consists of 1 part Dead Load, 1.5 parts Live Load and 2 parts Snow Load.

a) W10x19
b) Rectangular HSS 10x4x1/2
c) Round HSS 7.5x0.500

Wanted: Determine the capacity of each section for each condition. Consider both ASD and LRFD, expressing the results in comparable terms.

Solution:

NOTE: IT IS BEST TO ORIENT THE STRONG AXIS OF THE COLUMN WITH THE LONGEST KL.



COMPUTE COMPOSITE LOAD FACTORS

LRFD: LC-3a CONTROLS (VERIFY THIS!)

$$P_U = 1.2\left(\frac{1}{4.5}P_{S,EQ}\right) + 1.6\left(\frac{2}{4.5}P_{S,EQ}\right) + 1\left(\frac{1.5}{4.5}P_{S,EQ}\right)$$

$$P_U = 1.31\,P_{S,EQ}$$

ASD: LC-4 & LC-6 CONTROL EQUALLY (VERIFY THIS!)

$$P_a = 1\left(\frac{1}{4.5}P_{S,EQ}\right) + .75\left(\frac{1.5}{4.5}P_{S,EQ}\right) + .75\left(\frac{2}{4.5}P_{S,EQ}\right)$$

$$P_a = 0.806\,P_{S,EQ}$$

PART (a) CHECK LOCAL BUCKLING (SCM TABLE B4.1)

CASE 3: $\frac{b_f}{2t_f} = 5.09 \le .56\sqrt{\frac{29{,}000\ ksi}{50\ ksi}} = 13.5$ ∴ NOT SLENDER

CASE 10: $h/t_w = 35.4 \le 1.49\sqrt{\frac{29{,}000\ ksi}{50\ ksi}} = 35.9$ ∴ NOT SLENDER

SECTION IS NOT SLENDER ∴ Q = 1

USE EITHER SCM E3 OR E7
↖ USE

PROBLEM 7.1 (CONTINUED)

SLENDERNESS: $\left(\frac{KL}{r}\right)_x = \frac{15'(12''/FT)}{4.14''} = 43.5$

$\left(\frac{KL}{r}\right)_y = \frac{6'(12''/FT)}{.874''} = 82.4$ ← GOVERNS

DETERMINE F_{cr} & P_N

$\frac{KL}{r} = 82.4 \leq 4.71\sqrt{\frac{29000KSI}{50KSI}} = 113.4$ ∴ USE SCM EQ E3-2

$F_e = \frac{\pi^2(29,000KSI)}{(82.4)^2} = 42.2\ KSI$

$F_{cr} = \left[.658^{(50/42.2)}\right](50\ KSI) = 30.4\ KSI$

$P_N = (30.4\ KSI)(5.62\ in^2) = 171.1K$

LRFD: $\phi = .9$; $P_U = 1.31\,P_{s,EQ} \leq .9(171.1^K) = 154.0K$

$$P_{s,EQ} \leq 117.4^K$$ ← ANSWER (a)

ASD: $\Omega = 1.67$; $P_a = 0.806\,P_{s,EQ} \leq 171.1^K/1.67 = 102.4K$

$$P_{s,EQ} = 127.2^K$$ ← ANSWER (a)

PART (b): CHECK LOCAL BUCKLING (DIFFERENT THAN W SECTION!)

CASE 12: $b/t = 18.5 \not\leq 1.40\sqrt{\frac{29,000KSI}{46KSI}} = 14.06$ ∴ SLENDER

$b_E = 1.92(.465'')\sqrt{\frac{29000}{46}}\left[1 - \frac{0.38}{18.5}\sqrt{\frac{29,000}{46}}\right] = 10.8''$ (EQ E7-18)

$b_E = 10.8'' \not\leq b = (b/t)t = (18.5)(.465'') = 8.6''$ ∴ $A_{EFF} = A_g$

$Q_a = 1$, $Q_s = 1$ $\Big\}$ $Q = Q_s Q_a = 1.0$ ∴ LOCAL BUCKLING HAS NO EFFECT IN THIS CASE

SLENDERNESS

$(KL/r)_x = \frac{15'(12''/FT)}{3.34''} = 53.9$ ← GOVERNS

$(KL/r)_y = \frac{6'(12''/FT)}{1.59''} = 45.3$

PROBLEM 7.1 (CONTINUED)

DETERMINE SCM E7 EQUATION TO USE, F_{cr}, & P_N

$$\frac{KL}{r} = 53.9 \le 4.71\sqrt{\frac{29000\ ksi}{(1)(46\ ksi)}} = 118.2 \quad \therefore \text{USE E7-2}$$

$$F_e = \frac{\pi^2(29{,}000\ ksi)}{(53.9)^2} = 98.6\ ksi$$

$$F_{cr} = (1)\left[.658^{\frac{(1)(46)}{98.6}}\right](46\ ksi) = 37.8\ ksi$$

$$P_N = (37.8\ ksi)(11.6\ in^2) = 439\ k$$

LRFD: $P_u = 1.31\,P_{s,EQ} \le .9(439^k) = 395^k$

$$\boxed{P_{s,EQ} \le 301^k} \leftarrow \text{ANSWER (b)}$$

ASD: $P_a = 0.806\,P_{s,EQ} \le 439^k/1.67 = 263^k$

$$\boxed{P_{s,EQ} \le 326^k} \leftarrow \text{ANSWER (c)}$$

PART (c): CHECK LOCAL BUCKLING

CASE 15: $b/t = 16.1 \le .11\frac{29{,}000\ ksi}{42\ ksi} = 76.0$ ∴ NOT SLENDER

SLENDERNESS: $\left(\frac{KL}{r}\right)_x = \frac{15'(12''/ft)}{2.49''} = 72.3$ ← GOVERNS

$$\left(\frac{KL}{r}\right)_y = \frac{6'(12''/ft)}{2.49''} = 28.9$$

DETERMINE SCM EQ, F_{cr} & P_N

$$KL/r = 72.3 \le 4.71\sqrt{\frac{29{,}000\ ksi}{42\ ksi}} = 123.8 \quad \therefore \text{EQ E3-2}$$

$$F_e = \frac{\pi^2(29{,}000\ ksi)}{(72.3)^2} = 54.8\ ksi$$

$$F_{cr} = \left[.658^{42/54.8}\right](42\ ksi) = 30.47\ ksi$$

$$P_N = (30.47\ ksi)(10.3\ in^2) = 314\ k$$

PROBLEM 7.1 (CONTINUED)

LRFD: $P_u = 1.31 P_{s,EQ} \leq .9 (314K) = 282K$

$$\boxed{P_{s,EQ} \leq 215K}$$ ← ANSWER (c)

ASD: $P_a = 0.806 P_{s,EQ} \leq 314K/1.67 = 188K$

$$\boxed{P_{s,EQ} \leq 233K}$$ ← ANSWER (c)

SOLUTION SUMMARY

PART	SECTION	STEEL	LRFD	ASD
(a)	W10x19	A992	117 K	127 K
(b)	HSS 10x4x1/2	A500, GRB, RECT	301 K	326K
(c)	HSS 7.5x1/2	A500, GR.B, RND	215 K	233K

- TO SEE EFFECT OF GENERAL SLENDERNESS, EXPERIMENT WITH LOWER VALUES OF $(KL)_x$ & $(KL)_y$.
- EXPERIMENT WITH DIFFERENT SECTIONS, LOAD COMBINATIONS, AND LENGTHS TO GET A FEEL FOR THE BEHAVIOR OF THE EQUATIONS