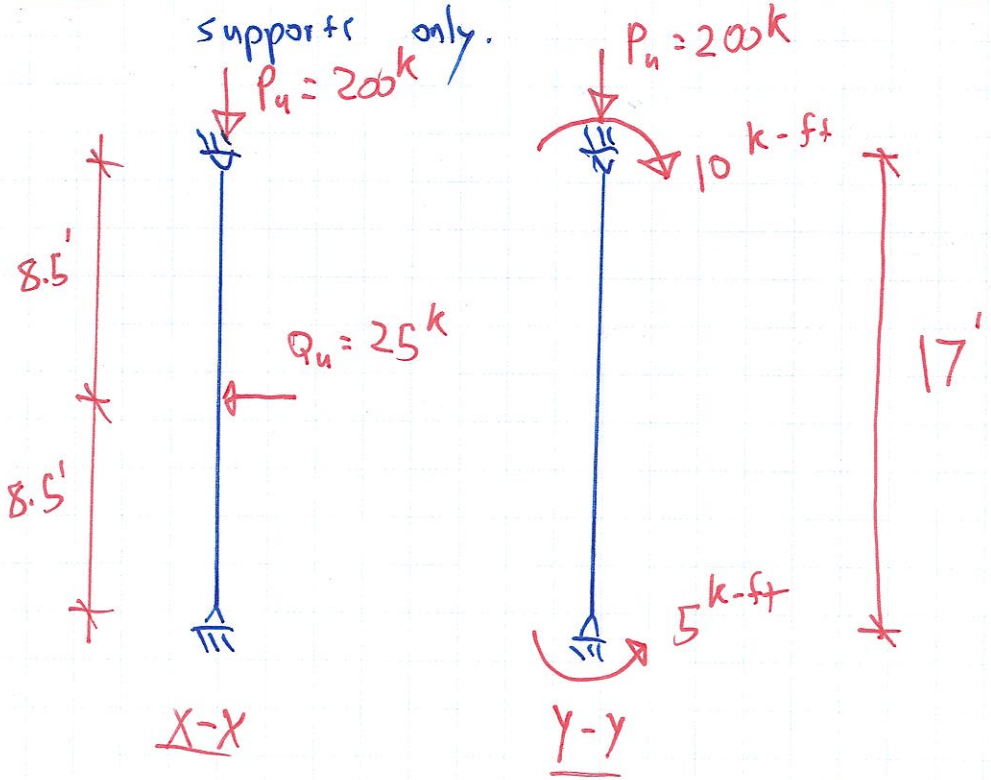
EXAMPLE

GIVEN: The member subjected to the load shown. Braced against LTB at the supports only.



W10X49
A992 steel

REQ'D: Determine the adequacy of the member according to AISC, Include moment amplification

SOLN:

W10x49: $A_g = 14.4\ in^2$, $r_x = 4.35\ in$, $I_x = 272\ in^4$, $I_y = 93.4\ in^4$, $S_y = 18.7\ in^3$, $r_y = 2.54\ in$, $Z_y = 28.3\ in^3$ } Sect. 1, pg 1-28

LOCAL BUCKLING

$$\frac{b_f}{2t_f} = 8.93 \le \frac{65}{\sqrt{F_y}} = \frac{65}{\sqrt{50\ ksi}} = 9.19 \quad \checkmark$$

$$\frac{h}{t_w} = 23.1 \le \frac{254}{\sqrt{F_y}} = \frac{254}{\sqrt{50\ ksi}} = 35.9 \quad \checkmark$$

∴ COMPACT

* no notation for c or f in table

BEAM PROP. TABLES

$L_p = 8.97'$

$L_r = 31.6'$

$\phi BF = 3.71^k$

$\phi_b M_{px} = 227^{k\text{-}ft}$

$\phi_b M_{rx} = 143^{k\text{-}ft}$

$\phi_b M_{py} = 0.9(F_y)Z_y = 0.9(50^{ksi})(28.3\ in^3)\left(\frac{1}{12}\right) = 106^{k\text{-}ft}$

DETERMINE $\phi_c P_n$: $K_x = K_y = 1.0$ $\therefore \left(\frac{KL}{r}\right)_y$ control (ie larger)

$$\left(\frac{KL}{r}\right)_y = \frac{1.0(17')(12)}{2.54''} = 80.32$$

$$f_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2_{max}} = \frac{\pi^2 (29000\ ksi)}{(80.32)^2} = 44.3\ ksi \quad ?\ 0.44 f_y \quad (22\ ksi) \quad \therefore \text{Inelastic Buckling}$$

$$f_{cr} = (0.658^{f_y/f_e}) f_y = (0.658^{50\ ksi/44.3\ ksi})(50\ ksi) = 31.2\ ksi$$

$$\phi_c P_n = \phi_c f_{cr} A_g = 0.9(31.2\ ksi)(14.4\ in^2) = \underline{404\ k}$$

DETERMINE $\phi_b M_{nx}$: $L_p = 8.97' < L_b = 17' < L_r = 31.6'$ $\therefore$ Inelastic LTB

$$\phi_b M_{nx} = C_b[\phi_b M_{px} - \phi BF(L_b - L_p)] \le \phi_b M_{px}$$

$C_b = 1.32$, p3-18

$$= 1.32[227\ k\text{-ft} - 3.71\ k(17' - 8.97')] \le 227\ k\text{-ft}$$

$= 260^{k\text{-ft}} \leq 227^{k\text{-ft}}$ ← plastic mom. controls

$\phi_b M_{nx} = \underline{227^{k\text{-ft}}}$

DETERMINE $\phi_b M_{ny}$

$$\frac{Z_y}{S_y} = \frac{28.3}{18.7} = 1.51 < 1.6$$

$\therefore \quad \phi_b M_{ny} = \phi_b M_{py} = \underline{106^{k\text{-ft}}}$

SUMMARY:

$\phi_c P_n = 404^{k}$
$\phi_b M_{nx} = 227^{k\text{-ft}}$
$\phi_b M_{ny} = 106^{k\text{-ft}}$

} CAPACITY, DESIGN

Calc. M_{ux}, M_{uy}, & apply the interaction equation

DETERMINE M_{ux}: Appx 8

$$M_{ux} = B_{1x} M_{ntx} + \cancel{B_{2x} M_{ltx}}^{\,0} \quad \text{(no sidesway)} \qquad (A\text{-}8.1)$$

$$B_{1x} = \frac{C_{mx}}{1 - \alpha \frac{P_u}{P_{e1x}}} \geq 1.0$$

$C_{mx} = 1.0$ "transverse load"

$$P_{e1x} = \frac{\pi^2 E I_x}{(kL)_x^2} = \frac{\pi^2 (29000\ ksi)(272\ in^4)}{(1.0(17')(12))^2} = 187^{k}$$

$\alpha = 1.0$ "LRFD"

$$B_{1x} = \frac{1.0}{1 - 1.0\left(\frac{200^k}{187^k}\right)} = 1.12 \geq 1.0$$

1.12 controls

PART 2

*** SUPPOSE THE AXIAL LOAD WERE TENSION. ASSUME THAT GSY IS OK FOR TENSION.

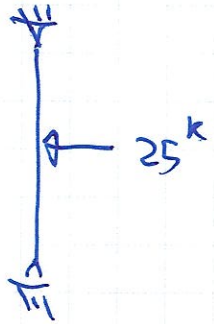
GSY: $\phi_t P_n = 0.9 A_g f_y = 0.9(14.4\ in^2)(50\ ksi) = 648^k$

$M_{ux} = 106.25^{k-ft}$
$M_{uy} = 10^{k-ft}$
} from part 1, No mom. magnification or reduction.

DETERMINE $\phi_b M_{nx}$: C_b may be increased by $\sqrt{1 + \frac{P_u}{P_{ey}}}$

$$P_{ey} = \frac{\pi^2 EI}{(L_b)^2} = \frac{\pi^2(29000\ ksi)(93.4\ in^4)}{(17 \times 12)^2} = 642.2^k$$

$$\sqrt{1 + \frac{200^k}{642.2^k}} = 1.145$$



$C_b = 1.32$ "Table 3-1"

$C_{b,new} = 1.32\,(1.145) = 1.512$

$$\phi_b M_{nx} = C_b\left[\phi_b M_{px} - \phi BF\,(L_b - L_p)\right] \le \phi_b M_{px}$$

$$= 1.512\left[227^{k\text{-}ft} - 3.71^{k}\,(17' - 8.97')\right] \le 227^{k\text{-}ft}$$

$$= 298.2^{k\text{-}ft} \le 227^{k\text{-}ft}$$

↑ Plastic Mom. still controls

$\phi_b M_{nx} = 227^{k\text{-}ft}$

* y Axis, Minor Axis has no LTB limit state

INTERACTION EQUATION:

$$\frac{P_u}{\phi_t P_n} = \frac{200^k}{648^k} = 0.3 \geq 0.20 \quad \therefore \text{ H1-1a applies}$$

9 GSY Strength

$$\frac{P_u}{\phi_t P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) \leq 1.0$$

$$0.3 + \frac{8}{9}\left(\frac{106.25^{k\text{-}ft}}{227^{k\text{-}ft}} + \frac{10^{k\text{-}ft}}{106^{k\text{-}ft}}\right) \leq 1.0$$

$$0.81 \leq 1.0 \quad \checkmark \quad \therefore \text{ Member is Adequate}$$