EXAMPLE
GIVEN: A W12X170, A992 Steel Column, is to carry an axial service load:

$P_D = 288^k$

$P_L = 432^k$

Column is supported by a 30" X 30" concrete pier w/ $f'_c = 3000$ psi

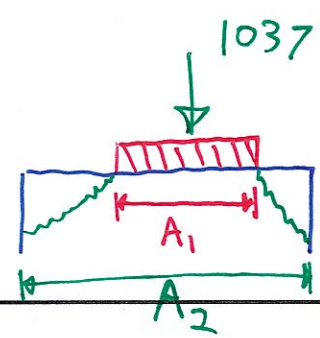
REQ'D: Base Plate w/ A36 steel

SOLN: W12X170: $d = 14.0''$, $b_f = 12.6''$

$$P_u = 1.2(288^k) + 1.6(432^k) = \underline{\underline{1037^k}}$$

* Assume the base pl is smaller than pier ST J8-2 control

$$P_u \le \phi_c P_p = 0.65\left[0.85 f'_c A_1 \sqrt{A_2/A_1}\right] \le 0.65\left[1.7 f'_c A_1\right]$$



Assume $A_2 = 30'' \times 30'' = 900 \text{ in}^2$ and check later

$$1037^k \leq 0.65\left[0.85(3^{ksi})(A_1)\sqrt{\frac{900}{A_1}}\right] \Rightarrow A_1 \geq 435 \text{ in}^2$$

check: $b_f d = (14'')(12.6'') = 176.4 \text{ in}^2 < A_1 = 435 \text{ in}^2$ ✓

check: $\sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{900}{435}} = 1.44 \leq 2.0$ ✓

DETERMINE ℘ DIMENSIONS

try squares ℘ $B = N = \sqrt{435 \text{ in}^2} = 20.9''$

try $21'' \times 21''$ ℘

$A_1 = 21(21) = 441 \text{ in}^2$

$A_2 = 30(30) = 900 \text{ in}^2$

1.43 ≤ 2.0 ✓

Verify: $\phi_c P_p = 0.65(0.85)(3^{ksi})(441 \text{ in}^2)\sqrt{\frac{900 \text{ in}^2}{441 \text{ in}^2}} = 1044.2^k \geq P_u = 1037^k$ ✓

PL THICKNESS:

$$m = \frac{N - 0.95d}{2} = \frac{21'' - 0.95(14.0'')}{2} = 3.85''$$

$$n = \frac{B - 0.8b_f}{2} = \frac{21'' - 0.8(12.6)}{2} = 5.46'' \leftarrow \text{CONTROL}$$

$\lambda = 1.0$

$$n' = \frac{1}{4}\sqrt{b_f d} = \frac{1}{4}\sqrt{(14)(12.6)} = 3.32''$$

largest controls
$\ell = 5.46''$

$$t_{req'd} \geq \ell\sqrt{\frac{2P_u}{0.9 f_y BN}} = (5.46'')\sqrt{\frac{2(1037^k)}{0.9(36^{ksi})(21'')(21'')}} = 2.1''$$

of Base PL

$\Rightarrow 2.25''$

$\boxed{\text{USE } 21'' \times 21'' \times 2\tfrac{1}{4}'' \text{ BASE PL, A36 STEEL}}$

BIAXIAL BENDING

AISC CHAP H, pg 16.1-77

Biaxial bending - bending about 2 axes, typically principle axes

CVEN 446 - load passes through centroid & shear center SI there is no "twisting" or torsion created

(H1-1b)

$$\underbrace{\cancel{\frac{P_r}{\phi 2 P_n}}}_{0,\ \text{for now}} + \left(\frac{M_{rx}}{\phi_b M_{nx}} + \frac{M_{ry}}{\phi_b M_{ny}} \right) \leq 1.0$$

M_{rx} = factored Mom. about X-X

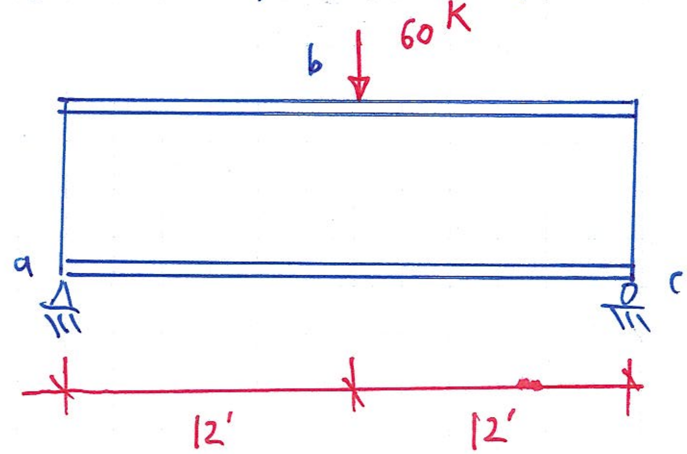
M_{ry} = " " " Y-Y

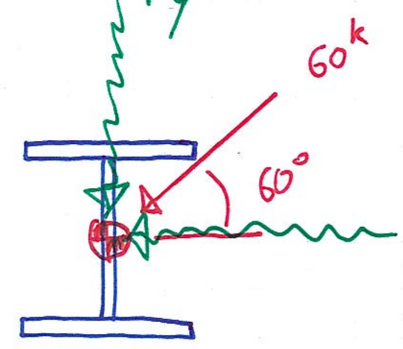
$\phi_b M_{nx}$ = Design " " X-X

$\phi_b M_{ny}$ = " " " Y-Y

EXAMPLE

GIVEN: A W14X109, A992 STEEL





$P_y = 60^k \sin(60°) = 52^k$

$P_x = 60^k \cos(60°) = 30^k$

Laterally braced @ "a" & "c" only ⇒ $L_b = 24^{ft}$

REQ'D: Is the beam adequate

W14X109:

$\phi_b M_{px} = 720^{\,k\text{-}ft}$ $\quad L_p = 13.2'$

$\phi_b M_{rx} = 454^{\,k\text{-}ft}$ $\quad L_r = 48.5'$

$\phi_b BF = 7.54^{\,k}$

X-X "Beam Tables"

Y-Y "Sect prop"

$Z_y = 92.7 \text{ in}^3$

$S_y = 61.2 \text{ in}^3$

$$\phi_b M_{py} = 0.9\,(50^{ksi})\,(92.7\ in^3)\left(\tfrac{1}{12}\right) = 348\ ^{k\text{-}ft}$$

$$M_{max} = \frac{PL}{4}$$

DEMAND

$$M_{ux} = \frac{P_y L}{4} = \frac{52^k\,(24^{ft})}{4} = 311.8\ ^{k\text{-}ft}$$

$$M_{uy} = \frac{P_x L}{4} = \frac{30^k\,(24^{ft})}{4} = 180.8\ ^{k\text{-}ft}$$

* No notation "f" ∴ compact for flexure & no local buckling issues

$\phi_b M_{nx}$:

$$L_p = 13.2' < L_b = 24 < L_r = 48.5' \quad \therefore \text{Inelastic LTB}$$

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

$C_b = 1.32$ (p 3-18, Table 3-1)

$$\phi_b M_n = 1.32\left[720^{k\text{-}ft} - 7.54^{k}\left(24' - 13.2'\right)\right] \leq 720^{k\text{-}ft}$$

$$= 843^{k\text{-}ft} \leq 720^{k\text{-}ft}$$

LTB

Plastic Moment (Basic Strength)

* LTB DOES NOT CONTROL

$$\phi_b M_{nx} = \underline{\underline{720^{k\text{-}ft}}}$$

$\underline{\phi_b M_{ny}}$:

$$\phi_b M_{ny} = 0.9 M_{py} \leq 0.9(1.6) f_y S_y$$

$$= 348^{k\text{-}ft} \leq 0.9(1.6)(50^{ksi})(61.2\ in^3)\left(\tfrac{1}{12}\right) = 367.2^{k\text{-}ft}$$

smallest controls

-or-

$$\frac{Z_y}{S_y} = \frac{92.7}{61.2} = 1.51 < 1.6 \checkmark$$

INTERACTION: (H1-1b)

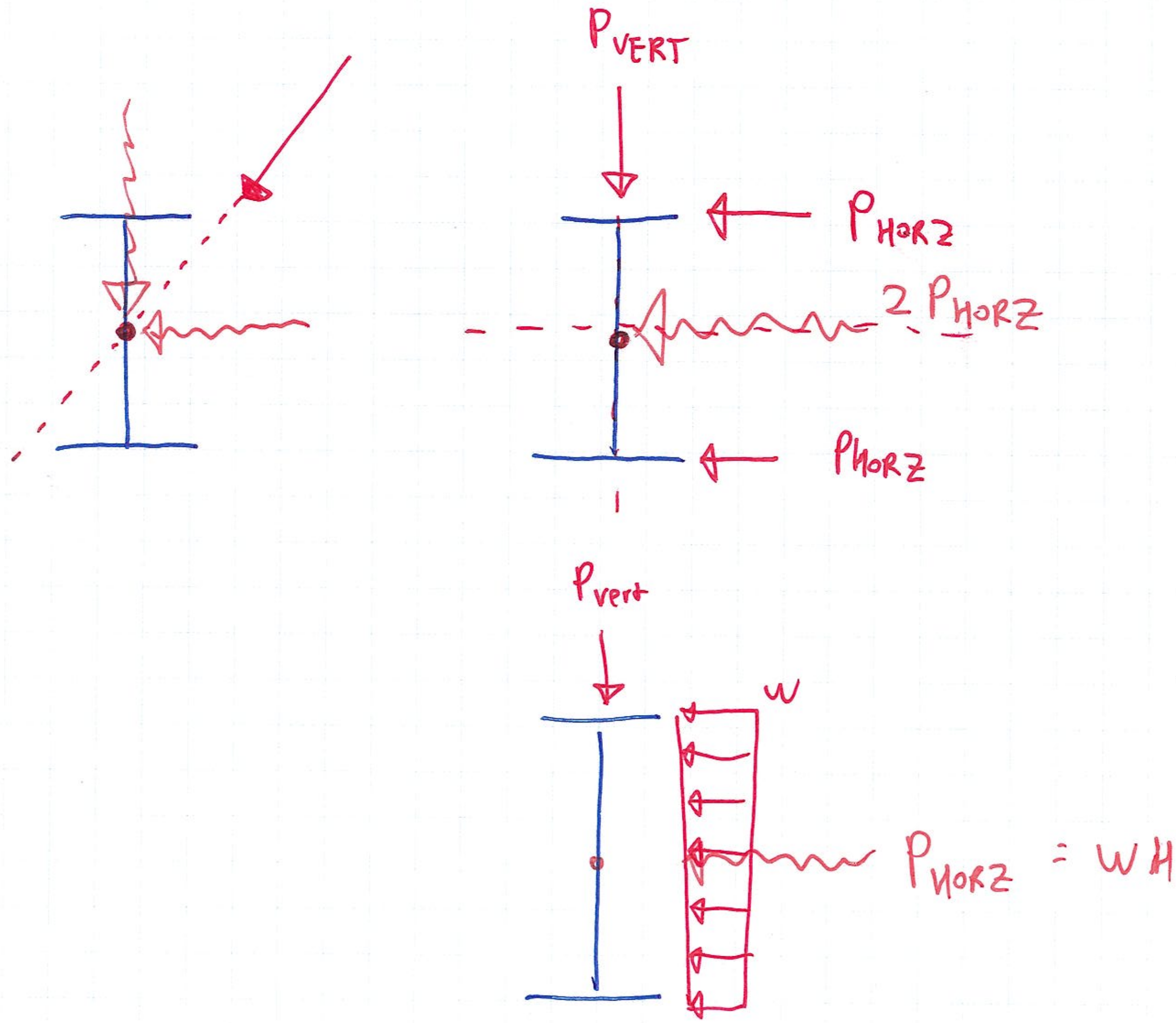
x-x demand y-y demand

$$\left[\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right] \leq 1.0$$

x-x capacity y-y capacity

$$\left[\frac{311.8^{\,k\text{-}ft}}{720^{\,k\text{-}ft}} + \frac{180.8^{\,k\text{-}ft}}{348^{\,k\text{-}ft}}\right] = 0.95 \leq 1.0 \quad \checkmark$$

∴ BEAM IS ADEQUATE


P VERT
P HORZ
2 P HORZ
P HORZ
P vert
w
P HORZ = wH