ENCE 355 – Introduction to Structural Design
SOLUTIONS to Homework Set No. 11
Fall 2002

PROB # 3-34

Using a W12X45 ($A_g = 13.1\ in.^2$, $d = 12.1$ in., $b_f = 8.05$ in., $t_f = 0.575$ in.)

$F_y = 50$ ksi and $F_u = 70$ ksi from Manual Table 2-1

$$\phi_t P_n = \phi_t F_y A_g = (0.9)(13.1)(50) = 589.5\ k$$

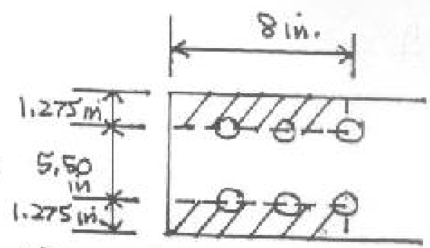
$$A_n = 13.1 - (4)(\tfrac{7}{8})(0.575) = 11.09\ in.^2$$

$\bar{x} = \bar{y}$ for a WT6X22.5 = 1.13 in.

$$U = 1 - \frac{\bar{x}}{L} = 1 - \frac{1.13}{6} = 0.812 < 0.9 \text{ ok}$$

$$\phi_t P_n = (0.75)(70)(0.812 \times 11.09) = 472.8\ k \leftarrow$$

Checking block shear



$$A_{gv} = (4)(8)(0.575) = 18.40\ in.^2$$

$$A_{gt} = (4)(1.275)(0.575) = 2.93\ in.^2$$

$$A_{nv} = (4)(8 - 2.5 \times \tfrac{7}{8})(0.575) = 13.36\ in.^2$$

$$A_{nt} = (4)(1.275 - \tfrac{1}{2} \times \tfrac{7}{8})(0.575) = 1.93\ in.^2$$

$$0.6 F_u A_{nv} = (0.6)(70)(13.36) = 561.2\ k$$
$$> F_u A_{nt} = (70)(1.93) = 135.1\ k$$

∴ Use LRFD Equation J4-3b

$$\phi R_n = \phi [0.6 F_u A_{nv} + F_y A_{gt}] = 0.75 [561.2 + (50)(2.93)]$$
$$= 530.8\ k \le 0.75 [(0.6)(70)(13.36) + (70)(1.93)] = 522.1\ k$$

$$\boxed{\text{Ans.} = 472.8\ k}$$

rgcm

PROB # 4-3

(1) min $A_g = \dfrac{P_u}{\phi_t F_y} = \dfrac{380}{(0.9)(50)} = 8.44 \text{ in.}^2$

(2) Min $A_g = \dfrac{P_u}{\phi_t F_u U}$ + estimated area of holes

Assume $U = 0.9$ and flange $t = 0.515$ in.

$$\text{min } A_g = \frac{380}{(0.75)(65)(0.9)} + (4)\left(\tfrac{7}{8}\right)(0.515) = 10.46 \text{ in.}^2 \leftarrow$$

(3) Preferable min $r = \dfrac{L}{300} = \dfrac{(12)(28)}{300} = 1.12 \text{ in.}^2$

Try W12X40 ($A_g = 11.7 \text{ in.}^2$, $t_f = 0.515$ in., $r_y = 1.94$ in.)

$\phi_t P_n = (0.9)(50)(11.7) = 526.5 \text{ k} > 380 \text{ k}$ ok

$\bar{x} = \bar{y} = 1.09$ in for a WT6X20

$U = 1 - \dfrac{\bar{x}}{L} = 1 - \dfrac{1.09}{8} = 0.864 < 0.9$ ok

$A_n = 11.7 - (4)\left(\tfrac{7}{8}\right)(0.515) = 9.90 \text{ in.}^2$

$\phi_t P_n = (0.75)(65)(0.864)(9.90) = 417 \text{ k} > 380 \text{ k}$ ok

$\dfrac{L}{r} = \dfrac{(12)(28)}{1.94} = 173 < 300$ ok

$\boxed{\text{USE W12X40}}$ rgcm©

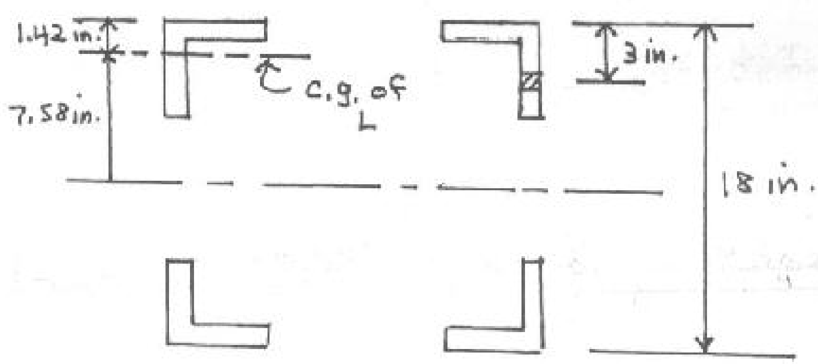
PROB #4-23 (1)

$$P_u = (1.2)(180) + (1.6)(320) = 728\text{ k}$$

$$\text{Min } A_g = \frac{P_u}{\phi_t F_y} = \frac{728}{(0.9)(50)} = 16.18 \text{ in.}^2$$

$$\text{Min } A_n = \frac{P_u}{\phi_t F_u U} = \frac{728}{(0.75)(65)(1.0)} = 14.93 \text{ in.}^2$$

Angle t (in)	Area of 8 1-in. holes (in.^{2})	A_g reqd (in^2)	Angles
7/16	3.50	18.43	4Ls 6x6x$\frac{7}{16}$ (5.08 in.^{2}
$\frac{1}{2}$	4.00	18.93	4Ls 5x5x$\frac{1}{2}$ (4.79 in.^{2} each)
$\frac{9}{16}$	4.50	19.43	4Ls 6x4x$\frac{9}{16}$ (5.27 in.^{2} each)
$\frac{5}{8}$	5.00	19.93	4Ls 5x5x$\frac{5}{8}$ (5.90 in.^{2} each)



PROB # 4-23 (2)

$$A = (4)(4.79) = 19.16 \text{ in.}^2$$

$$I_x = I_y = 4\left[11.3 + (4.79)(7.58)^2\right] = 1146 \text{ in.}^4$$

$$r = \sqrt{\frac{1146}{19.16}} = 7.73 \text{ in.}$$

$$\frac{L}{r} = \frac{(12)(30)}{7.73} = 46.6 < 300 \quad \underline{\underline{ok}}$$

Design of tie plates

Distance between bolt lines $= 18 - (2)(3) = 12$ in.

Min length $= \left(\frac{2}{3}\right)(12) = \underline{\underline{8 \text{ in.}}}$

Min width $= 12 + (2)(1\frac{1}{2}) = \underline{\underline{15 \text{ in.}}}$

Min $t = \left(\frac{1}{50}\right)(12) = 0.24$ in. $\underline{\underline{\text{Say } \frac{1}{4} \text{ in.}}}$

Min preferable spacing of tie plates

r_z of 1 L $= 0.980$ in.

$$\frac{12L}{0.980} = 300$$

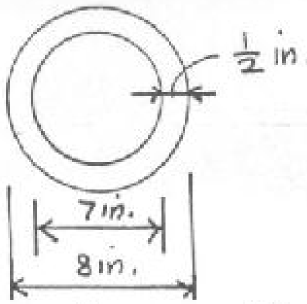
$L = 24.5$ ft $\quad \underline{\underline{\text{Say @ } ℄}}$

$$\boxed{\text{USE 4Ls } 5 \times 5 \times \tfrac{1}{2} \text{ with } \tfrac{1}{4} \times 12 \times 1 \text{ ft 3 in. tie PLs @ ℄ of span.}}$$

✓ gcm

PROB # 5-2

Using the pipe section shown



$$A = \frac{(\pi)(8)^2}{4} - \frac{(\pi)(7)^2}{4} = 11.79 \text{ in.}^2$$

$$I = \frac{\pi d^4}{64} = \frac{(3.1416)(8)^4}{64} - \frac{(3.1416)(7)^4}{64} = 83.2 \text{ in.}^4$$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{83.2}{11.79}} = 2.66 \text{ in.}$$

(a) L = 30.0 ft

$$L/r = \frac{(12)(30)}{2.66} = 135.34 < 200 \quad \text{ok}$$

$$F_{cr} = \frac{(\pi)^2(29{,}000)}{(135.34)^2} = 15.63 \text{ ksi} < 36 \text{ ksi} \quad \text{ok}$$

$$P_{cr} = (15.63)(11.79) = \boxed{184.3 \text{ k}}$$

(b) L = 20.0 ft

$$\frac{L}{r} = \frac{(12)(20)}{2.66} = 90.23 < 200 \quad \text{ok}$$

$$F_{cr} = \frac{(\pi)^2(29{,}000)}{(90.23)^2} = 35.16 \text{ ksi} < 36 \text{ ksi} \quad \text{ok}$$

$$P_{cr} = (35.16)(11.79) = \boxed{414.5 \text{ k}}$$

(c) L = 15.0 ft

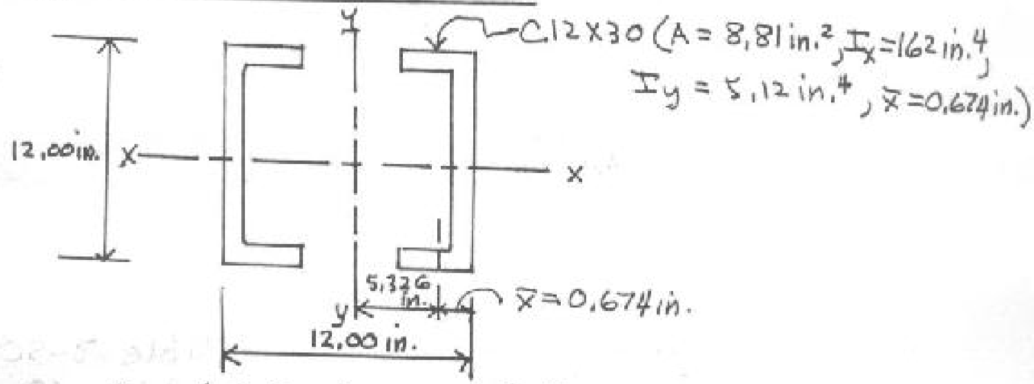
$$\frac{L}{r} = \frac{(12)(15)}{2.66} = 67.67 < 200 \quad \text{ok}$$

$$F_{cr} = \frac{(\pi)^2(29{,}000)}{(67.67)^2} = 62.50 \text{ ksi} > 36 \text{ ksi}$$

$\boxed{\therefore \text{ Euler equation not applicable}}$

PROB# 5-4

Using the section shown



$A = (2)(8.81) = 17.62 \text{ in.}^4$

$I_x = (2)(162) = 324 \text{ in.}^4$

$I_y = (2)(5.12) + (2)(8.81)(5.326)^2 = 510 \text{ in.}^4$

$r_y = \sqrt{\frac{324}{17.62}} = 4.29 \text{ in.}$

$\frac{L}{r} = \frac{(12)(40)}{4.29} = 111.89$

$F_{cr} = \frac{(\pi)^2(29{,}000)}{(111.89)^2} = 22.86$

$P_{cr} = (22.86)(2 \times 8.81) = \boxed{402.8 \text{ k}}$

✓ gcm©

PROB# 5-6

Using a W14X30 (A_g = 8.85 in.², r_y = 1.49 in.)

$KL = (0.8)(18) = 14.4 \text{ ft}$

$\frac{K_y L_y}{r_y} = \frac{(12)(14.4)}{1.49} = 115.97$

$\phi_c F_{cr} = 15.91$ ksi from Table 3-50 in AISC Specification (Part 16)

$\phi_c F_{cr} = (15.91)(8.85) = \boxed{140.8 \text{ k}}$ ✓ gcm©