ME 325 – Homework #5
Due: Wed., Mar. 25, 2009

1. Problem 8-32.
2. Problem 8-37.
3. Problem 8-39.
4. Problem 8-40.

① Problem 8-32

Members: $S_y = 57$ ksi

$$S_{sy} = 0.577 \cdot S_y = 0.577 \cdot (57) = 32.9 \text{ ksi}$$

Bolts: $S_y = 92$ ksi

$$S_{sy} = 0.577 \cdot S_y = 0.577 \cdot (92) = 53.08 \text{ ksi}$$

Shear of bolts

$$A_s = \frac{3 \cdot \pi \cdot \left(\frac{3}{8}\right)^2}{4} = 0.331 \text{ in}^2$$

$$n = \frac{A_s \cdot S_{sy}}{F} = \frac{0.331 \cdot 53.08 \cdot 10^3}{5400} = 3.25$$

Bearing on bolts

$$A_b = 3 \cdot \frac{3}{8} \cdot \frac{5}{16} = 0.352 \text{ in}^2$$

$$n = \frac{A_b \cdot S_y}{F} = \frac{0.352 \cdot 92 \cdot 10^3}{5400} = 6$$

Bearing on members

$$n = \frac{A_b \cdot S_y}{F} = \frac{0.352 \cdot 57 \cdot 10^3}{5400} = 3.7$$

Tension of members

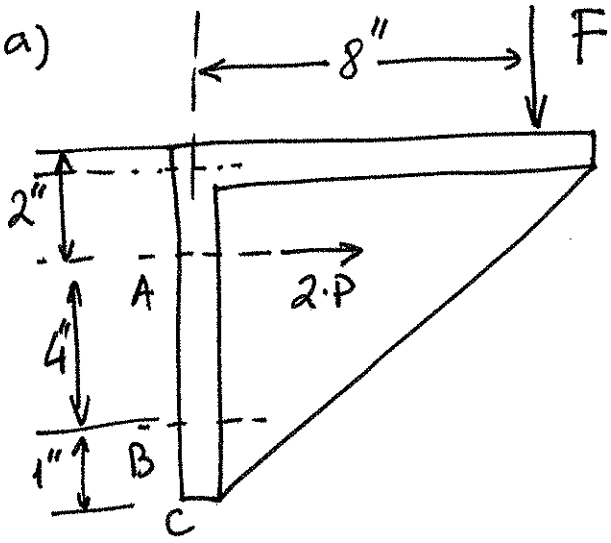
$$A_t = \left(2\frac{3}{8} - 2 \cdot \frac{3}{8}\right) \cdot \frac{5}{16} = 0.508 \text{ in}^2$$

$$n = \frac{A_t \cdot S_y}{F} = \frac{0.508 \cdot 57 \cdot 10^3}{5400} = 5.36$$

$n = 3.25$ based on shear of bolts

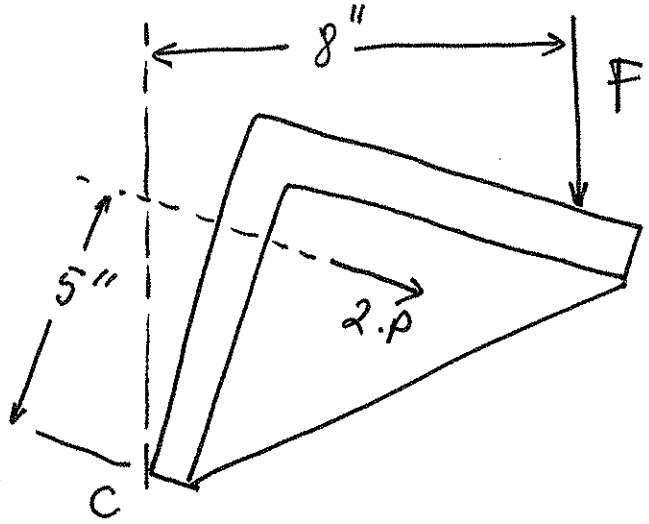
(2) Problem 8-37

(a)



The bracket rotates around point C as the bolts deform under the action of force F.

Deformed position (a little exagerated to illustrate the point)



$$\sum M_C = 0$$

$$F \cdot 8 = 2 \cdot P \cdot 5 \Rightarrow$$

$$\Rightarrow P = F \cdot \frac{8}{10} = \frac{8}{10} \cdot 1250$$

$$= 1000 \text{ lb (per bolt)}$$

(b) $A_t = 0.0775 \text{ in}^2 \quad S_p = 85 \text{ Ksi}$

$$F_i = 0.9 (A_t \cdot S_p) = 0.9 \cdot (0.0775)(85) = 5.93 \text{ kip}$$

Factor of safety against yielding of the bolt:

$$n = \frac{S_p \cdot A_t - F_i}{C \cdot P} \Rightarrow \frac{85 \cdot 10^3 \cdot (0.0775) - 5.93 \cdot 10^3}{0.173 \cdot 1000} = 3.8$$

(c) The total clamping force is:

$$N = 4 \cdot F_i = 4 \cdot (5.93) = 23.72 \text{ kip}$$

$$V_{crit} = \mu N = 0.25(23.72) = 5.93 \text{ kip}$$

$$n = \frac{V_{crit}}{V} = \frac{5.93 \cdot 10^3}{1250} = 4.74$$

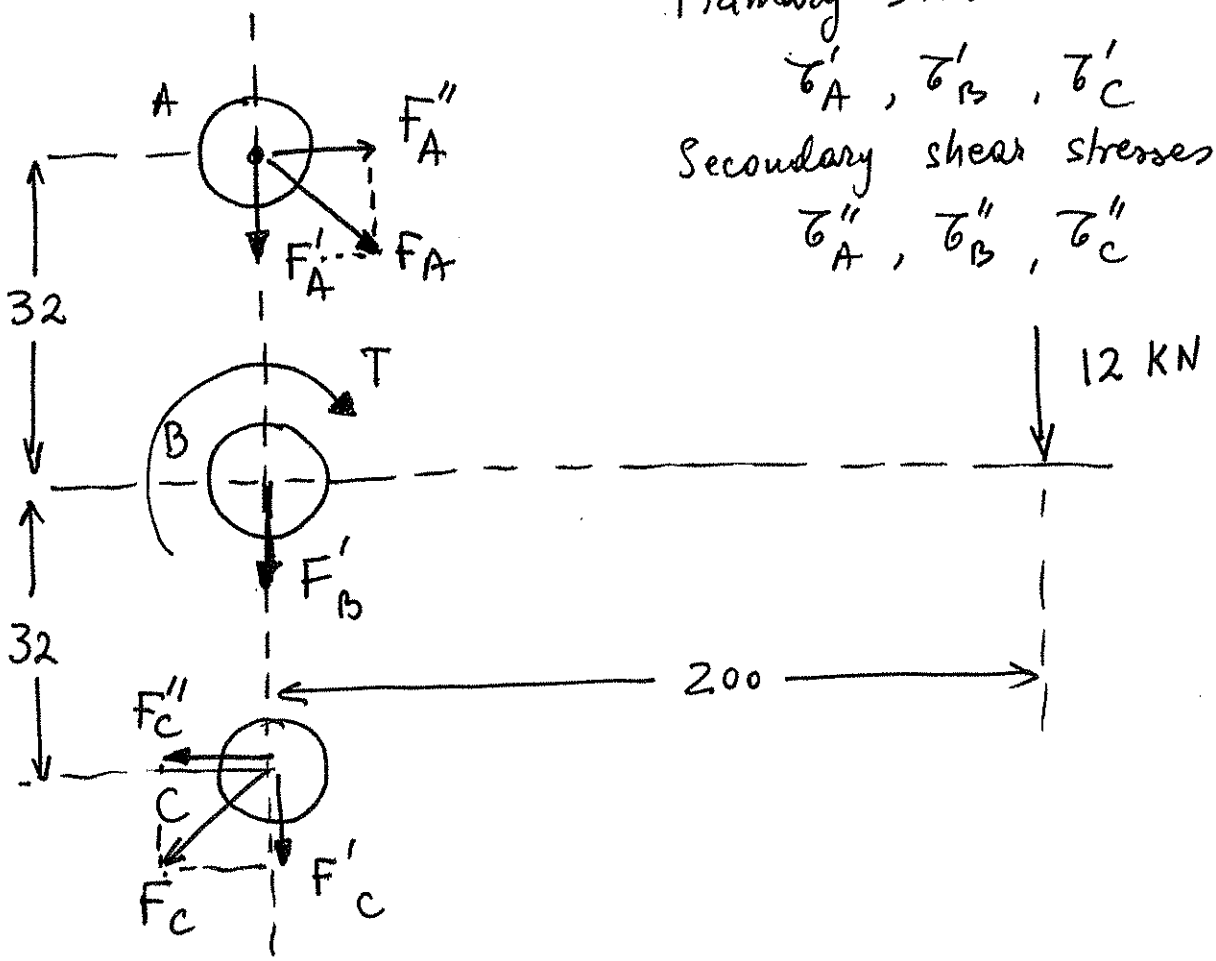
(d) $$A_S = 2 \frac{\pi}{4} d^2 = 2 \cdot \frac{\pi}{4} \left(\frac{3}{8}\right)^2 = 0.221 \text{ in}^2$$

$$\tau = \frac{F}{A_S} = \frac{1250}{0.221} = 5.66 \text{ ksi}$$

$$S_y = 92 \text{ ksi} \Rightarrow S_{sy} = 0.577 \cdot S_y = 0.577 \cdot 92 = 53.08$$

$$n = \frac{53.08}{5.66} = 9.38$$

③ Problem 8-39



Primary shear stresses: $\tau'_A, \tau'_B, \tau'_C$

Secondary shear stresses: $\tau''_A, \tau''_B, \tau''_C$

$$F'_A = F'_B = F'_C = \frac{F}{3} = \frac{12}{3} = 4 \text{ KN}$$

$F''_B = 0$ $\qquad T = 12 \text{ KN} \cdot 200 \text{ mm} = 2400 \text{ N} \cdot \text{m}$

Because of symmetry $F''_A = F''_C$. $\Rightarrow$

$$\Rightarrow T = F''_A \cdot 64 \text{ mm} \Rightarrow F''_A = \frac{2400 \text{ N} \cdot \text{m}}{0.064} = 37.5 \text{ KN}$$

So, $F''_A = F''_C = 35.5 \text{ KN}$ $\qquad F''_B = 0$

The maximum forces are at A and C

$$F_A = F_C = \sqrt{4^2 + 37.5^2} = 37.7 \text{ KN}$$

$$F_B = F'_B = 4 \text{ KN}$$

Shear on bolts :

$$A_s = \frac{\pi \cdot (12)^2}{4} = 113 \text{ mm}^2$$

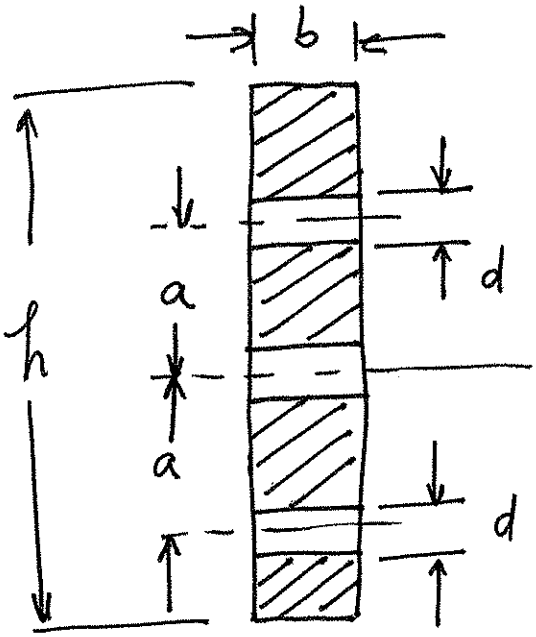
$$\tau = \frac{37.7 \cdot 10^3}{113} = 334 \text{ MPa}$$

Bearing on member :

$$A_b = 12 \cdot 8 = 96 \text{ mm}^2$$

$$\sigma = \frac{37.7 \cdot 10^3}{96} = 393 \text{ MPa}$$

Bending of plate :



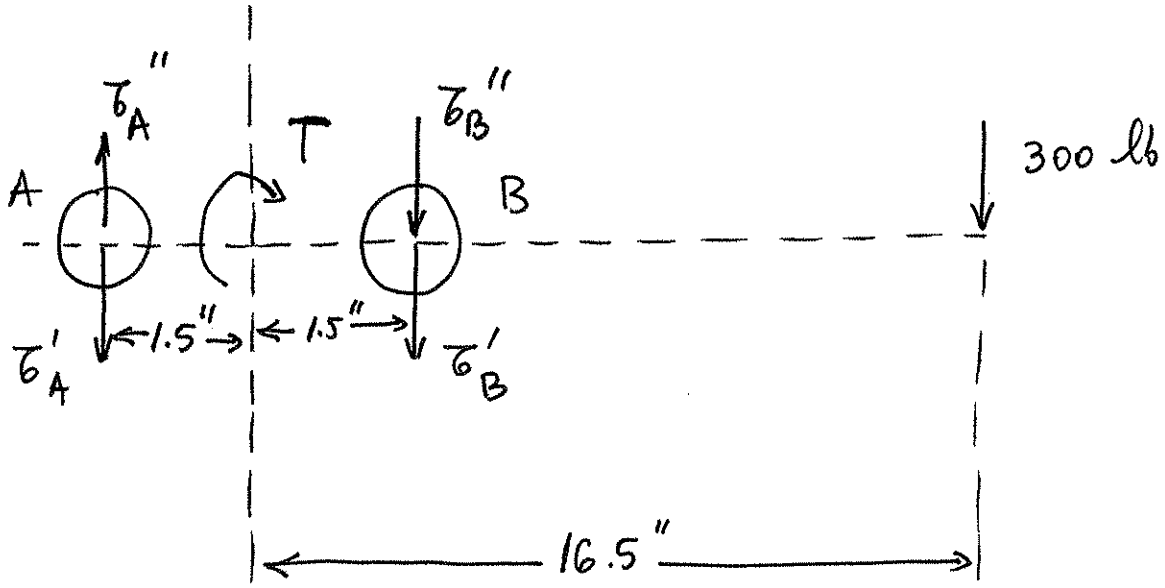
$$I = \frac{b h^3}{12} - \frac{b d^3}{12} - 2\left(\frac{b d^3}{12} + b \cdot d \cdot a^2\right) =$$

$$= \frac{8 \cdot (136)^3}{12} - \frac{8 \cdot 12^3}{12} - 2\left[\frac{8 \cdot 12^3}{12} + 8 \cdot 12 \cdot 32^2\right] = 1.48 \cdot 10^6 \text{ mm}^4$$

$$\sigma = \frac{Mc}{I} = \frac{(12 \cdot 200) \cdot 68}{1.48 \cdot 10^{6}} = 110 \text{ MPa}$$

④ Problem 8-40

Shear of bolt : $A_s = \frac{\pi}{4}(0.5)^2 = 0.196 \text{ in}^2$



Primary shear stresses :

$$\tau'_A = \frac{F/2}{A_s} = \frac{150}{0.196} = 765 \text{ psi}$$

$$\tau'_B = \tau'_A = 765 \text{ psi}$$

$T = 300 \cdot 16.5 = 4950 \text{ lb.in}$

$F''_A = F''_B$ (because of symmetry)

$F''_A \cdot 3'' = T \rightarrow F''_A = \frac{T}{3} = \frac{4950}{3} = 1650 \text{ lb}$

Secondary shear stresses :

$$\tau''_A = \tau''_B = \frac{F''_A}{A_s} = \frac{1650}{0.196} = 8418 \text{ psi}$$ (equal but opposite signs)

The maximum shear stress is at B :

$$\sigma_B = \sigma_B' + \sigma_B'' = 765 + 8418 = 9183 \text{ psi}$$

$$S_{sy} = 0.577 \cdot 85 = 49 \text{ Ksi}$$

$$n = \frac{49}{9.183} = 5.35$$

Bearing on bolt:

$$A_b = \frac{1}{2} \cdot \frac{3}{8} = 0.1875 \text{ in}^2$$

$$\sigma = \frac{F}{A_b} = \frac{F_B' + F_B''}{A_b} = \frac{1650 + 150}{0.1875} = 9600 \text{ psi}$$

$$n = \frac{S_y}{\sigma} = \frac{85}{9.6} = 8.85$$

Bearing on members:

$$S_y = 54 \text{ Ksi}$$

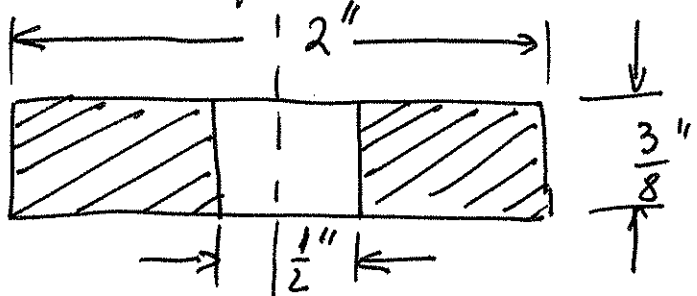
$$n = \frac{S_y}{\sigma} = \frac{54}{9.4} = 5.63$$

Strength of members:

The critical location is at the right-hand bolt:

$$M = 300 \cdot 15 = 4500 \text{ lb.in}$$

Cross-section through the member:



$$I = \frac{0.375 \cdot (2)^3}{12} - \frac{0.375 \cdot (0.5)^3}{12} = 0.246 \text{ in}^4$$

$$\sigma = \frac{Mc}{I} = \frac{4500 \cdot (1)}{0.246} = 18300 \text{ psi}$$

$$n = \frac{S_y}{\sigma} = \frac{54 \cdot 10^3}{18300} = 2.95$$