ENGR 350 - Mechanics of Materials, Fall 2013

Homework #1

Due: Fri., Sept. 5

1. Problem P1.5, p. 17
2. Problem P1.8, p. 17
3. Problem P1.16, p. 18
4. Problem P1.26, p. 20
5. Problem P1.27, p. 20
6. Problem P1.29, p. 21

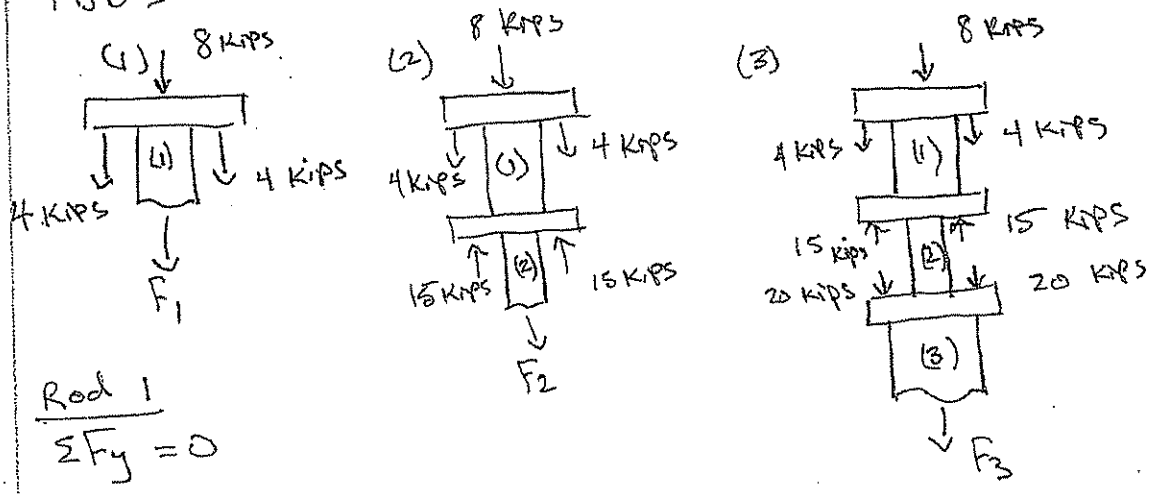
(all problems are from the textbook).

1.5

rod (1) $d_1 = 2$ in Aluminum
rod (2) $d_2 = 1.5$ in Brass
rod (3) $d_3 = 3.0$ in Steel

Determine normal stresses in each:

FBD's



Rod 1

$\Sigma F_y = 0$

$F_1 = (-8-4-4)$ Kips

$F_1 = -16$ kips ↓

Stresses:

$\sigma_1 = \dfrac{-16 \text{ Kips}}{\frac{\pi}{4}(2 \text{ in})^2} = \boxed{-5.09 \text{ Ksi}}$

$\boxed{5.09 \text{ Ksi (C)}}$

Rod 2

$F_2 = (15+15-4-4-8)$ Kips

$F_2 = 14$ Kips ↑

$\sigma_2 = \dfrac{14 \text{ Kips}}{\frac{\pi}{4}(1.5 \text{ in})^2} = \boxed{7.92 \text{ Ksi (T)}}$

Rod 3

$F_3 = (-20-20+15+15-8-4-4)$ Kips

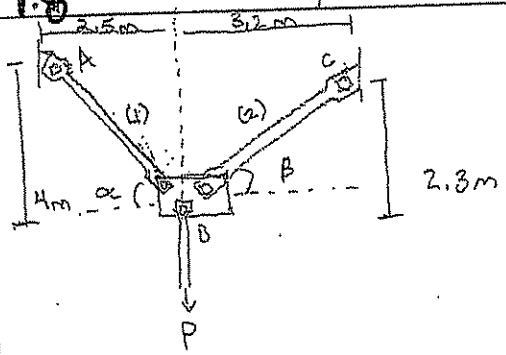
$F_3 = (-26 \text{ Kips})$ ↓

$\sigma_3 = \dfrac{-26 \text{ Kips}}{\frac{\pi}{4}(3.0 \text{ in})^3}$

$= -3.678$ Ksi

$\boxed{3.678 \text{ Ksi (C)}}$

1.8



$P = 50$ KN

limiting $\sigma = 130$ MPa

$\tan\alpha = \frac{4.0\,m}{11.6\,m} = 1.16 \qquad \alpha = 57.995°$

$\tan\beta = \frac{2.3\,m}{3.2\,m} = 0.7188 \qquad \beta = 35.707°$

$\Sigma F_x = F_2 \cos\beta = F_1 \cos\alpha$

$\Sigma F_y = F_2 \sin\beta + F_1 \sin\alpha - P$

Solve for F_1 & F_2

$F_2 = F_1 \frac{\cos\alpha}{\cos\beta}$ .. plug into other eqn and solve for F_1

$F_1 \frac{\cos\alpha}{\cos\beta} \sin\beta + F_1 \sin\alpha = P$

$F_1 (\cos\alpha \tan\beta + \sin\alpha) = P$

$F_1 = \frac{P}{1.2289} = \frac{50\,KN}{1.2289} = 40.686\,KN$

$F_2 = F_1 \frac{\cos\alpha}{\cos\beta} = 40.686\,KN \frac{\cos 57.995°}{\cos 35.707°} = 26.553\,KN$

$A_1 \geq \frac{F_1}{\sigma_1} = \frac{(40.686\,KN)(1000\,N/KN)}{130\,N/mm^2} = 312.97\,mm^2$

$312.97\,mm^2 = \frac{\pi}{4} d^2$ $\qquad \boxed{d \geq 19.962\,mm}$

$A_2 \geq \frac{F_2}{\sigma_2} = \frac{(26.553\,KN)(1000\,N/KN)}{130\,N/mm^2} = 204.272\,mm^2$

$204.272\,mm^2 = \frac{\pi}{4} d^2$ $\qquad \boxed{d \geq 16.127\,mm}$

Problem 1.16

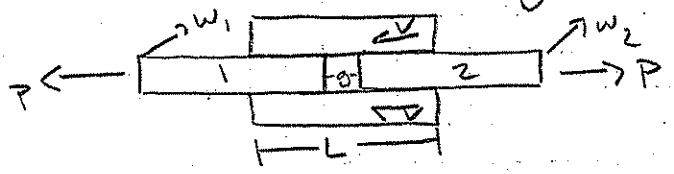
Given: Two 6in wide wooden boards are to be joined by splice plates that will be fully glued on the contact surfaces. The glue to be used can safely provide a shear strength of 120psi.

- gap of .5in is required between boards 1 & 2

Find: Determine the smallest allowable length L that can be used for the splice plates for an applied load of P = 10,000lb.

Solution: P = 10000lb w_1 = 6in w_2 = 6in g = .5in

V_g = 120 psi



$\Sigma F_x = P - V - V = 0$

$P = 2V$

$V = \frac{10000lb}{2}$

$V = 5000lb$

$A_{min} = \frac{5000lb}{120\ psi}$

$A_{min} = 41.667\ in^2$

$A = L_g(w)$

$L_g = \frac{41.667\ in^2}{6\ in}$

$L_g = 6.944in$

$L = L_{g1} + L_{g2} + g$

$= 6.944in + 6.944in + .5in$

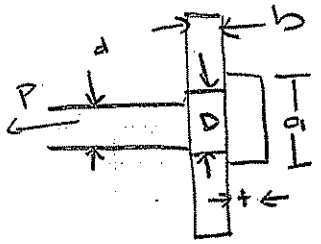
$\boxed{L = 14.39in}$

Problem 1.26

Given: The $d = 15$ mm diameter solid rod shown passes through a $D = 20$ mm-diameter hole in the support plate. When a load P is applied to the rod, the rod head rests on the support plate. The support plate has a thickness of $b = 12$ mm. The rod head has a diameter of $a = 30$ mm and the head has a thickness of $t = 10$ mm. If the normal stress produced in the rod by load P is 225 MPa.

Find:
a) bearing stress acting between the support plate and the rod head.
b) the average shear stress produced in the rod head
c) the punching shear stress produced in support plate by the rod head.

Solution: $d = 15$mm $D = 20$mm $b = 12$mm $a = 30$mm
$t = 10$mm $P = 225$ MPa



a) $A_{rod} = \pi/4 (15\text{mm})^2$
$= 176.715\ \text{mm}^2$

$F_{rod} = \sigma_{rod} A_{rod}$
$= 225\ \text{MPa}\ (176.715)\text{mm}^2$
$= 39760.782\ \text{N}$

$A_{contact} = \pi/4 [(30\text{mm})^2 - (20\text{mm})^2]$
$= 392.699\ \text{mm}^2$

$\sigma_b = \dfrac{F_{rod}}{A_{contact}}$
$= \dfrac{39760.782\ \text{N}}{392.699\ \text{mm}^2}$

$\boxed{\sigma_b = 101.3\ \text{MPa}}$

b) $A_v = \pi (15\text{mm})(10\text{mm})$
$= 471.239\ \text{mm}^2$

$\tau = \dfrac{39760.782\ \text{N}}{471.239\ \text{mm}^2}$

$\boxed{\tau = 84.4\ \text{MPa}}$

C $A_V = \pi(30mm)(12mm)$

$= 1130.973\ mm^2$

$C = \frac{39760.782\ N}{1130.973\ mm^2}$

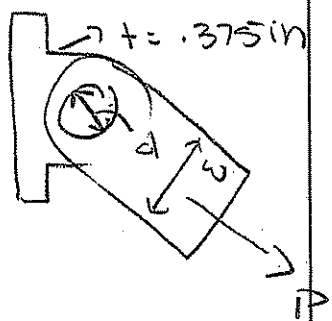
$C = 35.2\ MPa$

Problem 1.27

Given: The Rectangular bar is connected to the support bracket with a circular pin. The bar width is $w = 1.75$ in. and the bar thickness is .375 in.

Find: For an applied load of $P = 5600$ lb determine the average bearing stress produced in the bar by the .625 in diameter pin.

Solution: $d_p = .625$ in $t = .375$ in $P = 5600$ lb $w = 1.75$ in

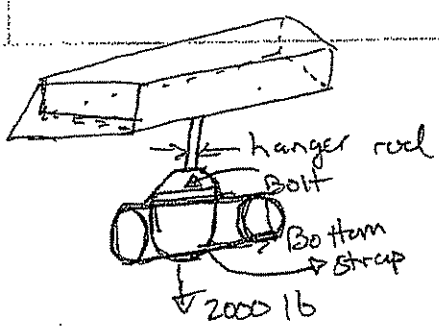


$$\sigma_b = \frac{P}{(d_p)(t)}$$

$$= \frac{5600\ \text{lb}}{(.625\ \text{in})(.375\ \text{in})}$$

$$\boxed{\sigma_b = 23893.33\ \text{psi}}$$

1.29



$D_{pipe} = 8\,in$ Weight = 2000 lb

$D_{rod} = 0.5\,in$ (hanger rod)

$D_{Bolt} = 0.625\,in$

Bottom Strap => $t = 3/16\,in$ $w = 1.75\,in$ $l = 36\,in$

a) normal stress in hanger rod

$$A_{rod} = \frac{\pi}{4}(0.5\,in)^2 = 0.1964\,in^2$$

$$\sigma_{rod} = \frac{2{,}000\,lb}{0.1964\,in^2} = \boxed{10{,}185.92\,psi}$$

B) shear stress in bolt

$$A_{Bolt} = \frac{\pi}{4}(0.625\,in)^2 = 0.3068\,in^2$$

$$\tau_{Bolt} = \frac{2000\,lb}{2(0.3068\,in^2)} = \boxed{3{,}259.50\,psi}$$

c)

$$\sigma_B = \frac{2000\,lb}{2(0.625\,in)(3/16\,in)} = \boxed{8533.3\,psi}$$