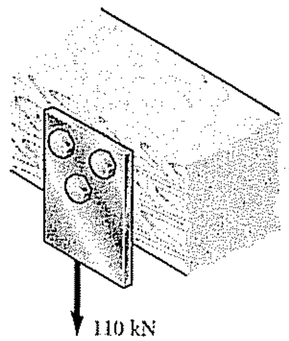
CIEG 212

Solution for Homework Assignment #3

Problem 1.43



1.43 Three steel bolts are to be used to attach the steel plate shown to a wooden beam. Knowing that the plate will support a 110 kN load, that the ultimate shearing stress for the steel used is 360 MPa, and that a factor of safety of 3.35 is desired, determine the required diameter of the bolts.

For each bolt $P = \frac{110}{3} = 36.667$ kN

Required $P_u = (F.S.)P = (3.35)(36.667) = 122.83$ kN

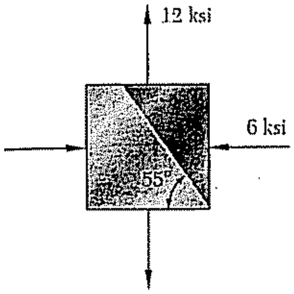
$$\tau_u = \frac{P_u}{A} = \frac{P_u}{\frac{\pi}{4}d^2} = \frac{4P_u}{\pi d^2}$$

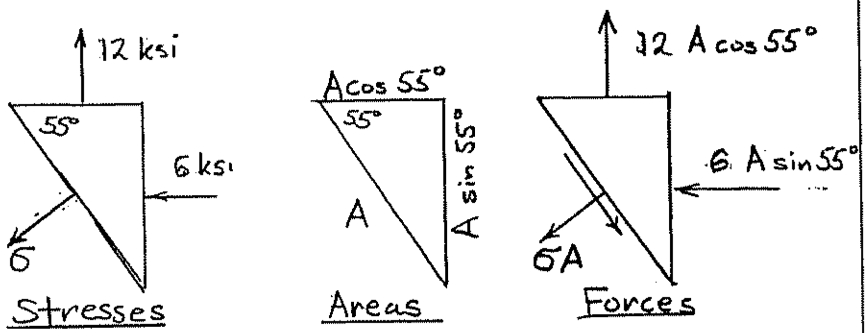
$$d = \sqrt{\frac{4P_u}{\pi \tau_u}} = \sqrt{\frac{(4)(122.83\times10^3)}{\pi(360\times10^6)}} = 20.8\times10^{-3} \text{ m}$$

$d = 20.8$ mm ◄

Problem 7.3

7.1 through 7.4 For the given state of stress, determine the normal and shearing stresses exerted on the oblique face of the shaded triangular element shown. Use a method of analysis based on the equilibrium of that element, as was done in the derivations of Sec. 7.2.





$+\swarrow \Sigma F = 0$

$\sigma A - 12 A \cos 55° \cos 55° + 6 A \sin 55° \sin 55° = 0$

$\sigma = 12 \cos^2 55° - 6 \sin^2 55° = -0.078 \text{ ksi}$ ◀

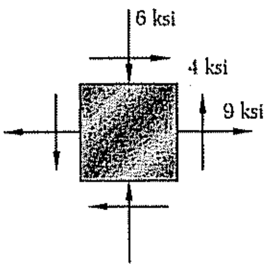
$+\searrow \Sigma F = 0$

$\tau A - 12 A \cos 55° \sin 55° - 6 A \sin 55° \cos 55°$ ◀

$\tau = 18 \cos 55° \sin 55° = 8.46 \text{ ksi}$

Problem 7.5

7.5 through 7.8 For the given state of stress, determine (*a*) the principal planes, (*b*) the principal stresses.



$\sigma_x = 9 \text{ ksi} \qquad \sigma_y = -6 \text{ ksi} \qquad \tau_{xy} = 4 \text{ ksi}$

(a) $\tan 2\theta_p = \dfrac{2\tau_{xy}}{\sigma_x - \sigma_y} = \dfrac{(2)(4)}{9+6} = 0.5333$

$2\theta_p = 28.07° \qquad \theta_p = 14.04°, \; 104.04°$ ◀

(b) $\sigma_{max,min} = \dfrac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

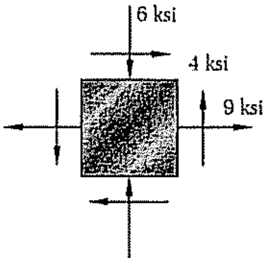
$= \dfrac{9-6}{2} \pm \sqrt{\left(\dfrac{9+6}{2}\right)^2 + (8)^2}$

$= 1.5 \pm 8.5 \text{ ksi}$

$\sigma_{max} = 10 \text{ ksi}$ ◀

$\sigma_{min} = -7 \text{ ksi}$ ◀

Problem 7.9



7.9 through 7.12 For the given state of stress, determine (*a*) the orientation of the planes of maximum in-plane shearing stress, (*b*) the maximum in-plane shearing stress, (*c*) the corresponding normal stress.

$\sigma_x = 9$ ksi $\qquad \sigma_y = -6$ ksi $\qquad \tau_{xy} = 4$ ksi

(a) $\tan 2\theta_s = -\dfrac{\sigma_x - \sigma_y}{2\tau_{xy}} = -\dfrac{9+6}{(2)(4)} = -1.875$

$2\theta_s = -61.93°$ $\qquad \theta_s = -30.96°,\ 59.04°$

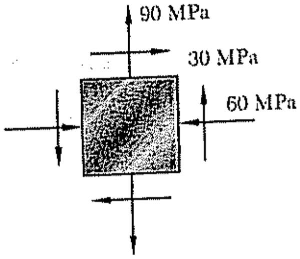
(b) $\tau_{max} = \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$= \sqrt{\left(\dfrac{9+6}{2}\right)^2 + (4)^2} = 8.5$ ksi

(c) $\sigma' = \sigma_{ave} = \dfrac{\sigma_x + \sigma_y}{2} = \dfrac{9-6}{2} = 1.5$ ksi

Problem 7.13

7.13 through 7.16 For the given state of stress, determine the normal and shearing stresses after the element shown has been rotated through (*a*) 25° clockwise, (*b*) 10° counterclockwise.



$\sigma_x = -60 \text{ MPa} \qquad \sigma_y = 90 \text{ MPa} \qquad \tau_{xy} = 30 \text{ MPa}$

$\frac{\sigma_x + \sigma_y}{2} = 15 \text{ MPa} \qquad \frac{\sigma_x - \sigma_y}{2} = -75 \text{ MPa}$

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\tau_{xy} = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\sigma_{y'} = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$$

(a) $\theta = -25^\circ \qquad 2\theta = -50^\circ$

$\sigma_{x'} = 15 - 75\cos(-50^\circ) + 30\sin(-50^\circ) = -56.2 \text{ MPa}$ ◄

$\tau_{x'y'} = +75\sin(-50^\circ) + 30\cos(-50^\circ) = -38.2 \text{ MPa}$ ◄

$\sigma_{y'} = 15 + 75\cos(-50^\circ) - 30\sin(-50^\circ) = 86.2 \text{ MPa}$ ◄

(b) $\theta = 10^\circ \qquad 2\theta = 20^\circ$

$\sigma_{x'} = 15 - 75\cos(20^\circ) + 30\sin(20^\circ) = -45.2 \text{ MPa}$ ◄

$\tau_{x'y'} = +75\sin(20^\circ) + 30\cos(20^\circ) = 53.8 \text{ MPa}$ ◄

$\sigma_{y'} = 15 + 75\cos(20^\circ) - 30\sin(20^\circ) = 75.2 \text{ MPa}$ ◄