Mechanics Assignment 2

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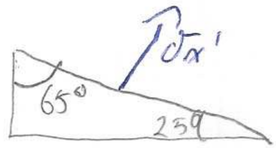


(1) $F = 10\text{ kN}$

$A = 0.08 \cdot 0.12 = 0.0096\text{ m}^2$

$\beta = 25°$

$\sigma_x' = \dfrac{10}{0.0096} = 1041.\overline{6}\text{ kPa}$

$\tau' = \frac{1}{2}\sigma_x \sin(2\theta)$

$= \frac{1}{2} \cdot 1041.\overline{6} \cdot \sin 130$

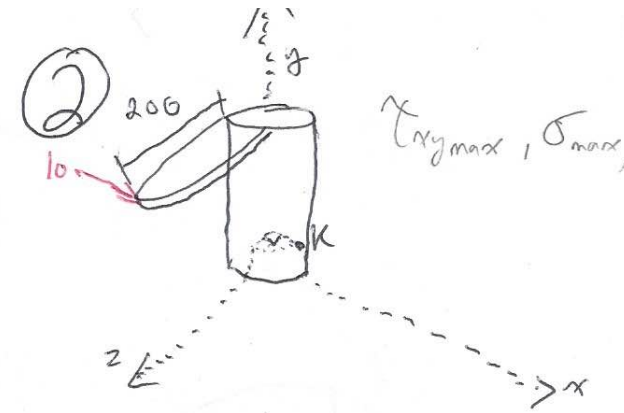
a) $= 399\text{ kPa}$

b) $\sigma' = \sigma_x(\cos\theta)^2$

$= 1041.\overline{6}(\cos 65)^2$

$= 186\text{ kPa}$

②



$\tau_{xy\,max}, \sigma_{max}, \sigma_{min}$?

$T = 200 \cdot 10 = 2000\,kN \cdot mm$

$J = \frac{\pi}{2} \cdot (51^4 - 45^4)$

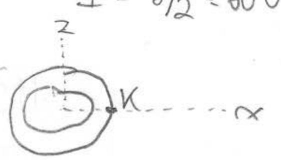
$= 1332288\pi\ mm^4$

$\therefore \tau_T = \frac{2000 \cdot 51}{1332288\pi}$

$= 24.3698\ N/mm^2$

$\tau_v = \frac{VQ}{It}$, $V = 10kN$, $t = 6mm$

$I = J/2 = 666144\pi\ mm^4$

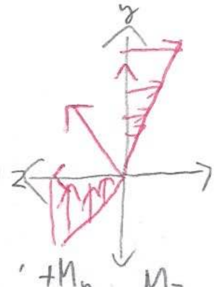


↑Since K is along x-axis, Q=0

$\therefore \tau_v = 0$

@K, $\Sigma M_z = 0$, $-10(150) + M_z$

$M_z = 1500\ kN \cdot mm$



$\sigma_x^B = -\frac{M_z x}{I_z} + \frac{M_x \overset{0}{z}}{I_x}$ $\therefore +M_y, -M_z$

@K $(x = 51)$

$\sigma_x^B = -\frac{1500 \cdot 51}{666144\pi} = -0.114840034/\pi = kN/mm^2$

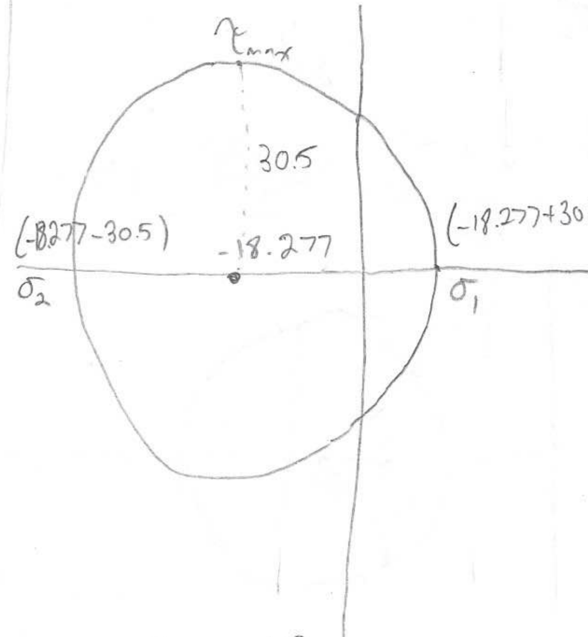
$-36.5547 = N/mm^2$

Since no axial, $\sigma_x^A = 0$

$\sigma_{avg} = \frac{-36.5547}{2} = -18.2774$

$R = \sqrt{(-18.2774)^2 + 24.3698^2}$

$= 30.5\ N/mm^2 = 30.5\ MPa$



$\sigma_2 = -48.777\ MPa$

$\sigma_1 = 12.223\ MPa$

$\tau_{max} = R = 30.5\ MPa$

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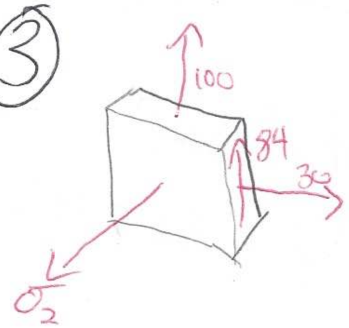
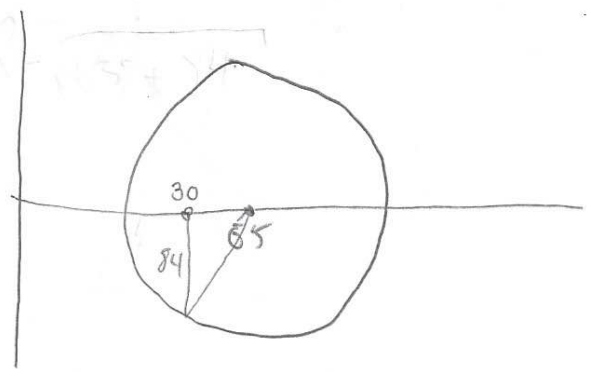
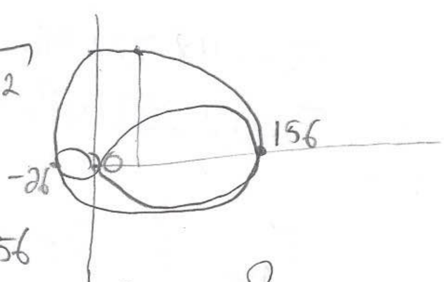


a) $\dfrac{\sigma_x + \sigma_y}{2} = \dfrac{100+30}{2} = 65$



$R = \sqrt{(65-30)^2 + 84^2}$

$= 91$



$\sigma_2 = 65 + 91 = 156$

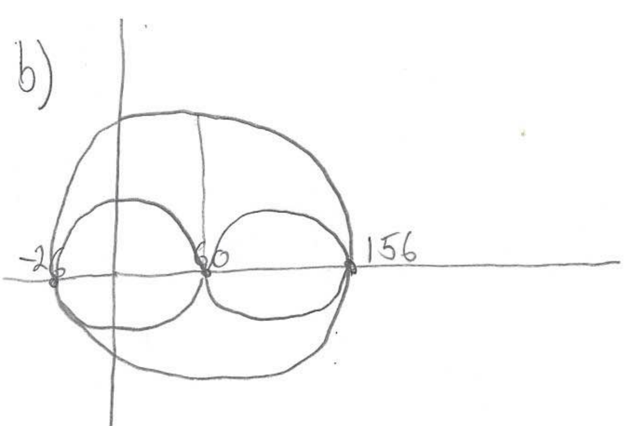
$\sigma_1 = 65 - 91 = -26$

$\sigma_z = 0$

$\tau_{max} = R$

$= 91$ MPa

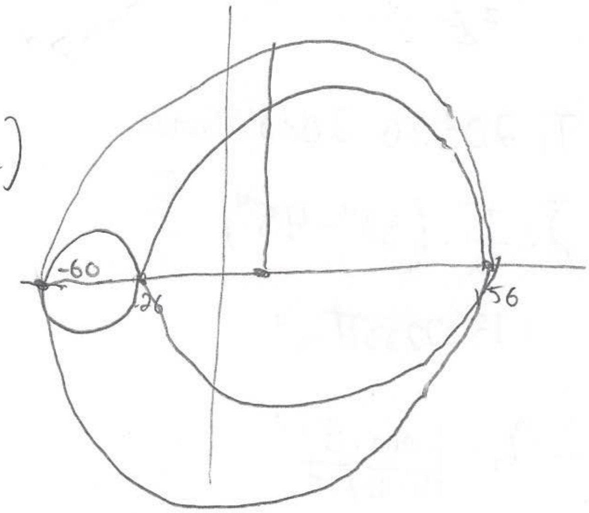
b)



$\tau_{max} = R$

$= 91$ MPa

c)



$\tau_{max} = \dfrac{156 + 60}{2}$

$= 108$ MPa

Question 4

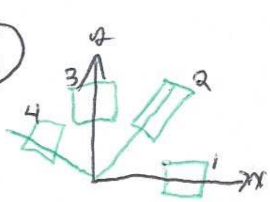
It is extremely important for civil engineers to study stress. Knowledge of stress, especially principle stresses, would give an engineer the necessary information to design against failure modes. They could also choose a material that's more appropriate for the given stresses such that they do not overdesign.

Stress transformation about axis with different angles are found in several applications of angled members, such as:

- Framing of a building
- Truss bridge
- Lattice towers

The Mohr's Circle is vastly superior to the formula method. This is because the formula is easy to forget, while the Mohr's Circle is easy to derive and visualize. It is quick to calculate since it is simple geometry and is nothing more than trigonometry. This means that it is less likely to make a mistake. As well, it is easier to catch mistakes with Mohr's Circle, as one can visualize it their answer makes sense or not.

(5)



$\varepsilon_1 = 420E\text{-}6 \text{ in/in}$, $\varepsilon_2 = -45\mu$, $\varepsilon_4 = 165\mu$
$, 420\mu$

a) ε_3?, $\varepsilon_3 = \varepsilon_y$

$\varepsilon_1 = \varepsilon_x$, $\varepsilon_x = 420\mu$

$\varepsilon_2 = \varepsilon_x \cos^2 45 + \varepsilon_y \sin^2 45 + \gamma_{xy} \sin 45 \cos 45$

$= 420 \cdot 1/2 + \varepsilon_y \cdot 1/2 + \gamma_{xy} \cdot 1/2$, $-45 - \frac{1}{2}(420) = 1/2\{\varepsilon_y + \gamma_{xy}\}$

(1) $-510 = \varepsilon_y + \gamma_{xy}$

$\varepsilon_4 = 420 \cdot 1/2 + \varepsilon_y \cdot 1/2 - \gamma_{xy} \cdot 1/2$

$165 - \frac{420}{2} = 1/2\{\varepsilon_y - \gamma_{xy}\}$

(2) $-90 = \varepsilon_y - \gamma_{xy}$, plug in (1)

$-90 = \varepsilon_y - [-510 - \varepsilon_y]$

$-600 = 2\varepsilon_y$

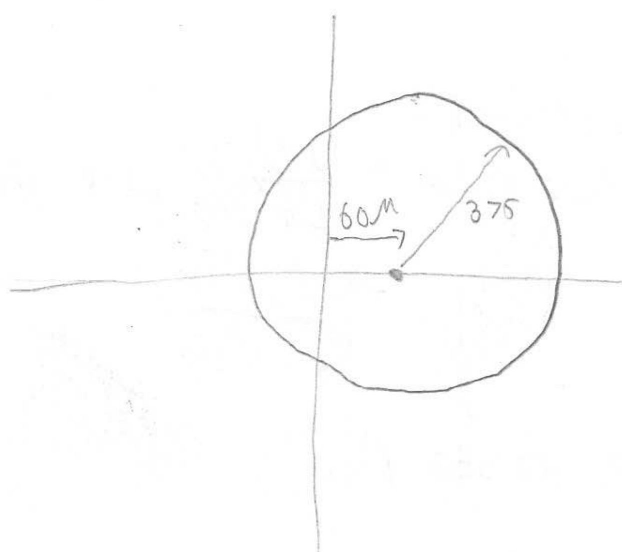
$\varepsilon_y = \varepsilon_3 = -300\mu$ in/in

$\therefore \gamma_{xy} = -210\mu$

b) $\varepsilon_{ave} = \frac{-300 + 420}{2} = 60\mu$

$R = \sqrt{\left(\frac{-300-420}{2}\right)^2 + \left(\frac{-210}{2}\right)^2}$

$= 375\mu$



$\varepsilon_1 = 375 + 60 = 435\mu$

$\varepsilon_2 = 60 - 375 = -315\mu$

$\gamma_{max} = 2R = 750\mu$

(6)

$E = 29E6$ psi , $\varepsilon_x, \varepsilon_y$

$\nu = 0.30$

$E\varepsilon_x = \sigma_x - \nu(\sigma_y + \sigma_z)$

$\tau_{xz} = G\,\gamma_{xz}$

1) $E\varepsilon_x = \sigma_x - \nu(\sigma_y + \sigma_z)$, $\sigma_x \,\&\, \sigma_z = 0$

$E\varepsilon_x = -\nu\sigma_y$, from strain gauge, $\varepsilon_x = \varepsilon_1 = -60E{-6}$ in/in

$29E6 \cdot -60E{-6} = -0.3 \cdot \frac{P}{2 \cdot 6}$

$P = 69600$ lbs

2) $G = \frac{E}{2(1+\nu)} = \frac{29E6}{2 \cdot 1.3} = 11.1538E6$ psi

Knowing that $\varepsilon_1 = \varepsilon_x$, $\varepsilon_3 = \varepsilon_y$

$\varepsilon_2 = \varepsilon_1 \cos^2 45 + \varepsilon_3 \sin^2 45 + \gamma_{xy} \cos 45 \sin 45$

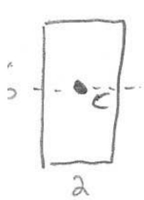
$240 = \frac{1}{2}(-60) + \frac{1}{2}(200) + {}^1/_2\,\gamma_{xy}$

$\gamma_{xy} = 340\,\mu$ in/in

$\tau_{xy} = G\,\gamma_{xy}$

$= 11.1538E6 * 340E{-6}$

$= 3792.292$ lb/in² $= \frac{VQ}{It}$, note that $Q_x = V$



$= \frac{V \cdot [3 \times 2] \cdot 1.5}{\left[\frac{1}{12} \cdot 2 \cdot 6^3\right] \cdot 2}$

$V = 30338$ lbs

7

$\beta = 18^\circ$

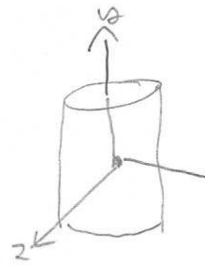
$t = 6\,mm$

$E = 200E6\ kPa$

$\nu = 0.3$

$\varepsilon_a = 280\mu$

$d = 600\,mm$



x, due to confinement, ε_x & $\varepsilon_z = 0$

$\sigma_z = 0$

From hoop stress,

$$2\sigma_x \Delta x t = p2r\Delta x$$

$$2\sigma_x t = p2r$$

$$\sigma_x = \frac{pr}{t}$$

From longitudinal stress

$$\sigma_y \cdot t \cdot 2\pi r = P\pi r^2$$

$$\sigma_y = \frac{Pr}{2t}$$

$$E\varepsilon_x = \sigma_x - \nu\sigma_y$$

$$= \frac{Pr}{t}\left(1 - \frac{\nu}{2}\right)$$

$$E\varepsilon_y = \sigma_y - \nu\sigma_x$$

$$= \frac{Pr}{t}\left(\frac{1}{2} - \nu\right)$$

0 since no shear stress applied due to symmetry

$$280 = \varepsilon_x \cos^2 18 + \varepsilon_y \sin^2 18 + \cancel{\gamma_{xy}} \sin 18 \cos 18$$

$$\frac{280 - \varepsilon_y \sin^2 18}{\cos^2 18} = \varepsilon_x$$

$$\frac{280 - \frac{Pr}{Et}\left(\frac{1}{2} - \nu\right)\sin^2 18}{\cos^2 18} = \frac{Pr}{Et}\left(1 - \frac{\nu}{2}\right)$$

$$280 = \frac{Pr}{Et}\left[\cos^2 18\left(1 - \frac{\nu}{2}\right) + \sin^2 18\left(\frac{1}{2} - \nu\right)\right.$$

$$P = \frac{\frac{280E\text{-}6 \cdot 6 \cdot 200E6}{300}}{\left[\cos^2 18(0.85) + \sin^2 18(0.2)\right]}$$

$P = 1421445\ Pa$

Question 8

Strain analysis is very useful for the below applications:

- Helical pile load tests
- Concrete compression/tension tests
- Compare strains of different materials using E

Normal strain about an axis with different angles is significant because it is a result of biaxial normal strain as well as shear strain. In contrast, strain about the normal x or y axis is only a product of uniaxial normal strain. Thus, an engineer would need to design to these other contributors as well.

Computer programming seems like a much better way to solve stress transformation problems. This is because by hand, one will often need to have 3 equations with 3 unknowns, which is tedious to solve. This can be quickly solved by the computer and would minimize mistakes.