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Question 1

$$\begin{aligned} \text{i) } \epsilon_x &= 25 \times 10^{-6} & \nu &= 0.28 \\ \epsilon_y &= -16 \times 10^{-6} & E &= 170 \times 10^9 \text{ N/m}^2 \end{aligned}$$

$$\begin{aligned} \sigma_x &= \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y) \\ &= \frac{170 \times 10^9}{1-(0.28)^2} (25 \times 10^{-6} + (0.28 \times -16 \times 10^{-6})) \end{aligned}$$

$$\sigma_x = 3.79 \text{ MPa (tensile)}$$

$$\begin{aligned} \sigma_y &= \frac{E}{1-\nu^2} (\epsilon_y + \nu \epsilon_x) \\ &= \frac{170 \times 10^9}{1-(0.28)^2} (-16 \times 10^{-6} + (0.28 \times 25 \times 10^{-6})) \end{aligned}$$

$$\sigma_y = -1.66 \text{ MPa (compressive)}$$

$$\begin{aligned} \text{ii) } \sigma_x &= 86 \times 10^6 \text{ N/m}^2 \\ \sigma_y &= -45 \times 10^6 \text{ N/m}^2 \end{aligned}$$

$$\begin{aligned} \epsilon_x &= \frac{1}{E} (\sigma_x - \nu \sigma_y) \\ &= \frac{1}{170 \times 10^9} (86 \times 10^6 - (0.28 \times -45 \times 10^6)) \\ &= 5.8 \times 10^{-4} \end{aligned}$$

$$\epsilon_x = 580 \times 10^{-6} \mu\epsilon$$

$$\begin{aligned} \epsilon_y &= \frac{1}{E} (\sigma_y - \nu \sigma_x) \\ &= \frac{1}{170 \times 10^9} (-45 \times 10^6 - (0.28 \times 86 \times 10^6)) \\ &= 406.3 \times 10^{-6} \mu\epsilon \end{aligned}$$

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Question 2

$$\sigma_x = 104 \text{ MPa}$$

$$\sigma_y = 206 \text{ MPa}$$

$$\tau_{xy} = 125 \text{ MPa}$$

$$i) \sigma_1 = \left(\frac{\sigma_x + \sigma_y}{2} \right) + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2}$$

$$\sigma_1 = \left(\frac{104 \times 10^6 + 206 \times 10^6}{2} \right) + \sqrt{\left(\frac{104 \times 10^6 - 206 \times 10^6}{2} \right)^2 + (125 \times 10^6)^2}$$

$$\sigma_1 = 345.92 \text{ MPa}$$

$$3.46 \times 10^8 \text{ Pa}$$

$$\sigma_2 = \left(\frac{104 \times 10^6 + 206 \times 10^6}{2} \right) - \sqrt{\left(\frac{104 \times 10^6 - 206 \times 10^6}{2} \right)^2 + (125 \times 10^6)^2}$$

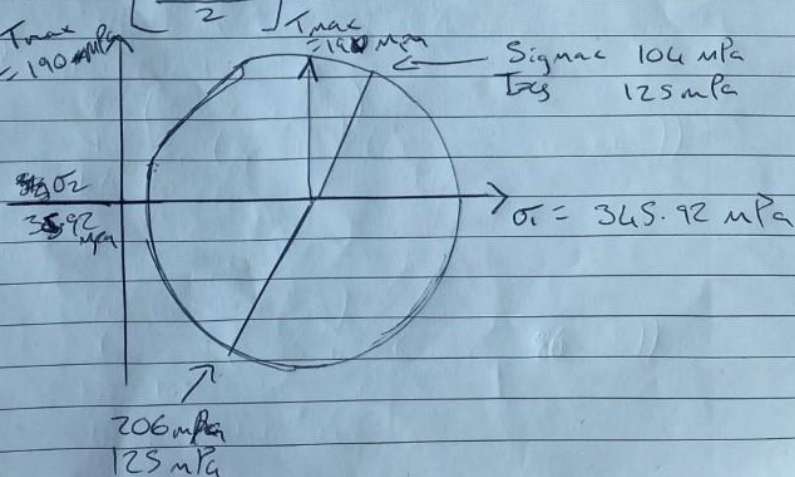
$$\sigma_2 = -35.92 \text{ MPa}$$

$$= 3.59 \times 10^7 \text{ Pa}$$

$$ii) \tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2} = \frac{\sigma_1 - \sigma_2}{2} = 1.91 \times 10^8 \text{ Pa}$$

$$\tau_{min} = -\left[\frac{\sigma_1 - \sigma_2}{2} \right] = -1.91 \times 10^8 \text{ Pa}$$

iii)



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Question 3

$$i) \frac{EI d^2 y}{dx^2} = \frac{1969.4(x)}{2} - \frac{450(x-0.5)^2}{2} + \frac{450(x-1.5)^2}{2} - 2300(x-1.5) - \frac{800(x-1.5)^2}{2} + \frac{800(x-2.5)^2}{2}$$

$$ii) EI \frac{dy}{dx} = \frac{1969.4(x)^2}{2} - \frac{450(x-0.5)^3}{6} + \frac{450(x-1.5)^3}{6} - \frac{2300(x-1.5)^2}{2} - 800(x-1.5)^2 + \frac{800(x-2.5)^3}{6} + A$$

$$iii) EI y = \frac{19.69.4(x)^3}{6} - \frac{450(x-0.5)^4}{24} + \frac{450(x-1.5)^4}{24} - \frac{2300(x-1.5)^3}{6} - \frac{800(x-1.5)^4}{24} + \frac{800(x-2.5)^4}{24} + Ax + B$$

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Question 4

$$d = 0.28 \text{ m}$$

$$\sigma_{\max} = 150 \times 10^6 \text{ N/m}^2$$

$$L = 0.6 \text{ m}$$

$$P = 14.4 \times 10^5 \text{ N/m}^2$$

$$nL = 0.56$$

$$n_c = 0.65$$

i)

$$\sigma_c = \frac{Pd}{2 + nL}$$

ii)

$$\sigma_c = \frac{Pd}{4 + n_c}$$

$$t_c = \frac{Pd}{2\sigma_c nL}$$

$$t_c = \frac{Pd}{4\sigma_c n_c}$$

$$t_c = \frac{14.4 \times 10^5 \times 0.28}{2 \times 150 \times 10^6 \times 0.56}$$

$$t_c = \frac{14.4 \times 10^5 \times 0.28}{4 \times 150 \times 10^6 \times 0.65}$$

$$t_c = 2.4 \text{ mm}$$

$$t_c = 1.03 \text{ mm}$$

iii)

The minimum thickness = 2.4 mm

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Question 5

$$L = 1.36$$

$$t = 0.0012 \text{ m}$$

$$d_i = 0.01905 \text{ m}$$

$$\nu = 0.25$$

$$I = 3.93 \times 10^{-9}$$

$$d_o = 0.02145 \text{ m}$$

$$E = 2 \times 10^{-8}$$

$$\text{i)} \quad I = \frac{\pi d_o^4 - d_i^4}{64} \quad I = \frac{\pi \times 0.02145^4 - 0.01905^4}{64}$$

$$I = 3.93 \times 10^{-9} \text{ m}^4$$

$$\text{ii)} \quad \text{Top is unrestrained} \quad \infty \quad \nu = 0.25$$

$$\text{iii)} \quad F_{cr} = \frac{\pi^2 EI}{L^2} = \frac{0.25 \times \pi^2 \times 2 \times 10^8 \times 3.93 \times 10^{-9}}{1.36^2}$$

$$= 104.85 \text{ N}$$

$$\text{iv)} \quad A = \frac{\pi d_o^2}{4} - \frac{\pi d_i^2}{4} = 7.63 \times 10^{-5}$$

$$= \frac{\pi \times 0.02145^2}{4} - \frac{\pi \times 0.01905^2}{4}$$

$$K = \frac{\sqrt{I}}{A} = \frac{\sqrt{3.93 \times 10^{-9}}}{7.63 \times 10^{-5}} = 7.18 \times 10^{-3} \text{ m}$$

$$SR = \frac{L}{K} = \frac{1.36}{7.18 \times 10^{-3}} = 189.62$$