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2003848

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A B C D E F G

Q1 $\epsilon_x = 26 \times 10^{-6} = 28 \times 10^{-6}$
 $\epsilon_y = -14 \times 10^{-6} = -14 \times 10^{-6}$
 $\nu = 0.28$
 $E = 170 \times 10^9 \text{ Pa}$

i) $\sigma_x = \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y)$

$$= \frac{170 \times 10^9}{1-0.28^2} \times (28 \times 10^{-6} + 0.28 \times -14 \times 10^{-6})$$

$$= 4441840.28 \text{ Pa (tensile)}$$

$$= 4.44 \times 10^6 \text{ Pa}$$

$$\sigma_y = \frac{E}{1-\nu^2} (\epsilon_y + \nu \epsilon_x)$$

$$= \frac{170 \times 10^9}{1-0.28^2} (-14 \times 10^{-6} + (0.28 \times 28 \times 10^{-6}))$$

$$= -1136284.72 \text{ Pa (compressive)}$$

$$= -1.14 \times 10^6 \text{ Pa}$$

ii) $\sigma_x = 8 \text{ MPa} = 84 \times 10^6 \text{ Pa}$

$$\sigma_y = 4 \text{ MPa} = 48 \times 10^6 \text{ Pa}$$

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y)$$

$$= \frac{1}{170 \times 10^9} (84 \times 10^6 - (0.28 \times 48 \times 10^6))$$

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$$\epsilon_x = \frac{1}{E} (4.15 \times 10^{-4})$$

$$\begin{aligned}\epsilon_y &= \frac{1}{E} (\sigma_y - \nu \sigma_x) \\ &= \frac{1}{170 \times 10^9} (48 \times 10^6 - (0.28 \times 84 \times 10^6))\end{aligned}$$

$$\epsilon_y = \underline{1.44 \times 10^{-4}}$$

Q2

i) $\sigma_x = 108 \text{ MPa} = 108 \times 10^6 \text{ Pa}$
 $\sigma_y = 204 \text{ MPa} = 204 \times 10^6 \text{ Pa}$
 $\tau_{xy} = 125 \text{ MPa}$

$$\begin{aligned}\sigma_1 &= \frac{(\sigma_x + \sigma_y)}{2} + \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} \\ &= \left(\frac{108 \times 10^6 + 204 \times 10^6}{2} \right) + \frac{\sqrt{(108 \times 10^6 - 204 \times 10^6)^2 + 4 \times 125 \times 10^6^2}}{2} \\ &= \underline{281.57 \times 10^6 \text{ Pa}}\end{aligned}$$

$$\begin{aligned}\sigma_2 &= \left(\frac{\sigma_x + \sigma_y}{2} \right) - \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} \\ &= \left(\frac{108 \times 10^6 + 204 \times 10^6}{2} \right) - \frac{\sqrt{(108 \times 10^6 - 204 \times 10^6)^2 + 4 \times 125 \times 10^6^2}}{2} \\ &= \underline{30.43 \times 10^6 \text{ Pa}}\end{aligned}$$

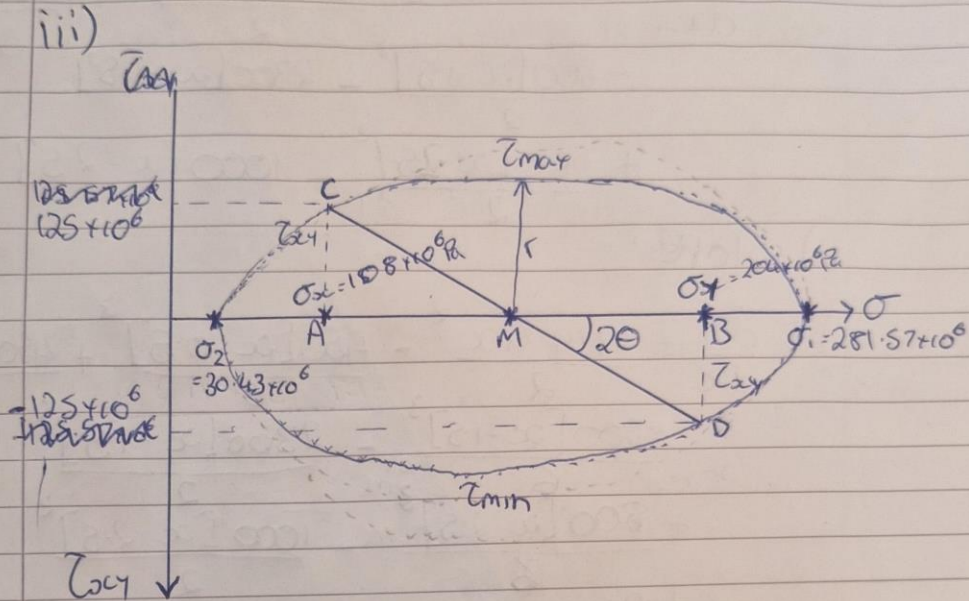
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$$\text{ii) } \tau_{\max} = \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$

$$= 125.57 \times 10^6 \text{ Pa}$$

$$\tau_{\min} = - \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$$

$$= -125.57 \times 10^6 \text{ Pa}$$



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Q3

i) $R_A = 1969.4 \text{ N}$
 $R_B = 2580.6 \text{ N}$

Bending moment

$$EI \frac{d^2 y}{dx^2} = 1969.4(x) - \frac{450[x-0.5]^2}{2} + \frac{450[x-1.5]^2}{2} - \frac{800[x-1.5]^2}{2} - 2300[x-1.5] + \frac{800[x-2.5]^2}{2} - 1000[x-2.5]$$

ii) Slope

$$EI \frac{dy}{dx} = \frac{1969.4x^2}{2} - \frac{450[x-0.5]^3}{6} + \frac{450[x-1.5]^3}{6} - \frac{800[x-1.5]^3}{6} - \frac{2300[x-1.5]^2}{2} + \frac{800[x-2.5]^3}{6} - \frac{1000[x-2.5]^2}{2} + A$$

iii) Deflection

$$EI y = \frac{1969.4x^3}{6} - \frac{450[x-0.5]^4}{24} + \frac{450[x-1.5]^4}{24} - \frac{800[x-1.5]^4}{24} - \frac{2300[x-1.5]^3}{6} + \frac{800[x-2.5]^4}{24} - \frac{1000[x-2.5]^3}{6} + A(x) + B$$

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$$iv) y=0 \quad x=0$$

$$0 = 0 - 0 + 0 - 0 - 0 + 0 - 0 + A(0) + B$$

$$B = 0$$

$$y=0 \quad x=3.1$$

$$0 = \frac{1969 \cdot 4(3.1)^3}{6} - \frac{450(3.1-0.5)^4}{24} + \frac{450(3.1-1.5)^4}{24} \\ - \frac{800(3.1-1.5)^4}{24} - \frac{2300(3.1-1.5)^3}{6} \\ + \frac{800(3.1-2.5)^4}{24} - \frac{1000(3.1-2.5)^3}{6} + A(3.1) + 0$$

$$3.1A = -\frac{1969 \cdot 4(3.1)^3}{6} + \frac{450(3.1-0.5)^4}{24} - \frac{450(3.1-1.5)^4}{24} \\ + \frac{800(3.1-1.5)^4}{24} + \frac{2300(3.1-1.5)^3}{6} \\ - \frac{800(3.1-2.5)^4}{24} + \frac{1000(3.1-2.5)^3}{6} - 0$$

$$3.1A = -2940.03$$

$$A = -948.39$$

$$A = -948.4 \quad B = 0$$

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$$v) EI = 1.84 \text{ MPa} = 1.84 \times 10^6$$

$$x = 1.55 \text{ m}$$

$$1.84 \times 10^6 y = \frac{1969(1.55)^3}{6} - \frac{450[1.55 - 0.5]^4}{24}$$

$$+ \frac{450[1.55 - 1.5]^4}{24} - \frac{800[1.55 - 1.5]^4}{24}$$

$$- \frac{2300[2.271.55 - 1.5]^3}{6} + (-948.4 \times 1.55) + 0$$

$$1.84 \times 10^6 y = -270.81$$

$$y = \frac{-270.81}{1.84 \times 10^6}$$

$$= -1.47 \times 10^{-4} \text{ m}$$

Q4

Thin walled

$$d = 280 \text{ mm} = 280 \times 10^{-3} \text{ m}$$

$$L = 600 \text{ mm} = 600 \times 10^{-3} \text{ m}$$

$$n_c = 68\% = 0.68$$

$$n_L = 54\% = 0.54$$

$$P = 14.8 \text{ Bar} = 14.8 \times 10^5 \text{ Pa}$$

$$\sigma_{\max} = 150 \text{ MPa} = 150 \times 10^6 \text{ Pa}$$

$$t = ?$$

$$i) \quad \sigma_c = \frac{pD}{2t n_L} \quad t = \frac{pD}{2\sigma_c n_L} = \frac{14.8 \times 10^5}{2 \times 150 \times 10^6 \times 0.54} \times 280 \times 10^{-3}$$

$$= 2.56 \times 10^{-3} \text{ m} \quad = 2.56 \text{ mm}$$

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$$\text{ii) } \sigma_L = \frac{PD}{4t n_c} \quad t = \frac{PD}{4\sigma_L n_c}$$

$$t = \frac{14.8 \times 10^5 \times 280 \times 10^{-3}}{4 \times 150 \times 10^6 \times 0.68}$$
$$= \underline{\underline{1.02 \times 10^{-3} \text{ m}}}$$

$$\text{iii) } 2.56 \times 10^{-3} \text{ m}$$
$$= \underline{\underline{2.56 \text{ mm}}}$$

Q5

$$L = 1.34 \text{ m}$$

$$d_o = 19.05 \text{ mm} = 19.05 \times 10^{-3} \text{ m}$$

$$t = 1.2 \text{ mm} = 1.2 \times 10^{-3} \text{ m}$$

$$d_i = 16.65 \text{ mm} = 16.65 \times 10^{-3} \text{ m}$$

$$E = 200 \times 10^9$$

bottom restrained

Top unrestrained

$$n = 1$$

$$\text{i) } I = \frac{\pi}{64} (d_o^4 - d_i^4)$$

$$= \frac{\pi}{64} (19.05 \times 10^{-3})^4 - (16.65 \times 10^{-3})^4$$

$$= 2.69 \times 10^{-9} \text{ m}^4$$

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ii) $n=1$

one end fixed one end free

iii)

$$F_{cr} = \frac{n^2 \pi^2 EI}{L^2}$$

$$= \frac{1 \times \pi^2 \times 200 \times 10^9 \times 2.69 \times 10^{-9}}{1.34^2}$$

$$= 2957.14 \text{ N}$$

iv) $k = \frac{I}{A}$

$$A = \frac{\pi}{4} (d_o^2 - d_i^2)$$

$$= \frac{\pi}{4} (19.05 \times 10^{-3})^2 - 16.65 \times 10^{-3})^2$$

$$= 6.73 \times 10^{-5} \text{ m}^2$$

SR ~~AN~~ $k = \frac{2.69 \times 10^{-9}}{6.73 \times 10^{-5}} = 3.997 \times 10^{-5} \text{ m}^2$

$$SR = \frac{L}{k} = \frac{1.34}{3.997 \times 10^{-5}} = \underline{\underline{33525.14}}$$

$$33525.14 > 120 \therefore \text{Strut}$$