

Stress analysis

$$A=2 \quad B=0 \quad C=0 \quad D=3 \quad E=5 \quad F=0 \quad G=4$$

Q 1)

$$\begin{aligned}\epsilon_x &= 24 \times 10^{-6} \\ \epsilon_y &= -10 \times 10^{-6} \\ r &= 0.28 \\ E &= 170 \times 10^9 \text{ pa}\end{aligned}$$

$$i) \sigma_1 = \frac{E}{(1-r^2)} (\epsilon_x + (r\epsilon_y))$$

$$\sigma_1 = \frac{170 \times 10^9}{(1-0.28^2)} (24 \times 10^{-6} + (0.28 \times -10 \times 10^{-6}))$$

$$\sigma_1 = 3.91 \times 10^6 \text{ pa}$$

$$\sigma_2 = \frac{E}{(1-r^2)} (-\epsilon_y + (r\epsilon_x))$$

$$\sigma_2 = \frac{170 \times 10^9}{1-0.28^2} (-(-10 \times 10^{-6}) + (0.28 \times 24 \times 10^{-6}))$$

$$\sigma_2 = -0.61 \times 10^6 \text{ pa}$$

$$\sigma_x = 3.91 \times 10^6 \text{ pa}$$

$$\sigma_y = -0.61 \times 10^6 \text{ pa}$$

ii)

$$E = 170 \times 10^9$$

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$$\sigma_x = 80 \times 10^6$$

$$\sigma_y = 44 \times 10^6$$

$$\nu = 0.28$$

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

$$\epsilon_x = \frac{1}{170 \times 10^9} \times (80 \times 10^6 - (0.28 \times 44 \times 10^6))$$

$$\epsilon_x = 3.98 \times 10^{-4}$$

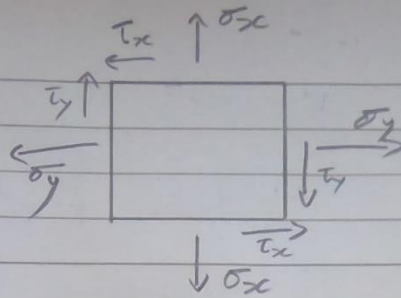
$$\epsilon_y = \frac{1}{E} \times (\sigma_y - (\nu \sigma_x))$$

$$\epsilon_y = \frac{1}{170 \times 10^9} \times (44 \times 10^6 - (0.28 \times 80 \times 10^6))$$

$$\epsilon_y = 127.06 \times 10^{-6}$$

Q2

i)



$$\begin{aligned}\sigma_x &= 105 \times 10^6 \\ \sigma_y &= 200 \times 10^6 \\ \tau_{xy} &= 125 \times 10^6\end{aligned}$$

$$\sigma_{1,2} = \left(\frac{\sigma_x + \sigma_y}{2} \right) \pm \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$\sigma_1 = \left(\frac{105 \times 10^6 + 200 \times 10^6}{2} \right) + \frac{\sqrt{(105 \times 10^6 - 200 \times 10^6)^2 + (4 \times 125 \times 10^6)^2}}{2}$$

$$\sigma_1 = 329.28 \times 10^6 \text{ pa}$$

$$\sigma_2 = \left(\frac{105 \times 10^6 + 200 \times 10^6}{2} \right) - \frac{\sqrt{(105 \times 10^6 - 200 \times 10^6)^2 + (4 \times 125 \times 10^6)^2}}{2}$$

$$\sigma_2 = -24.28 \times 10^6 \text{ pa}$$

$$\text{ii) } \tau_{\max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{329.28 \times 10^6 - (-24.28 \times 10^6)}{2}$$

$$\tau_{\max} = 176.78 \times 10^6$$

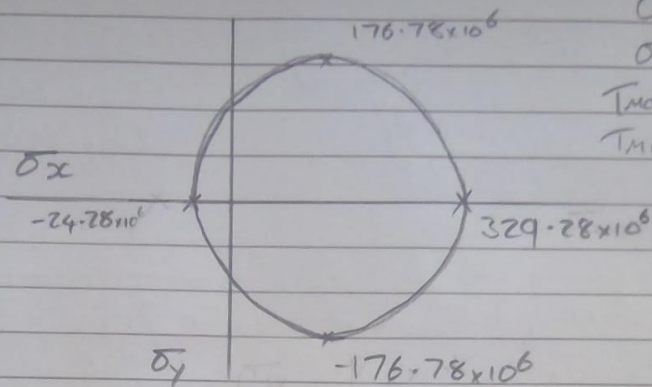
$$\tau_{\min} = - \left[\frac{\sigma_1 - \sigma_2}{2} \right] = - \left[\frac{329.28 \times 10^6 - (-24.28 \times 10^6)}{2} \right]$$

$$\tau_{\min} = -176.78 \times 10^6$$

iii

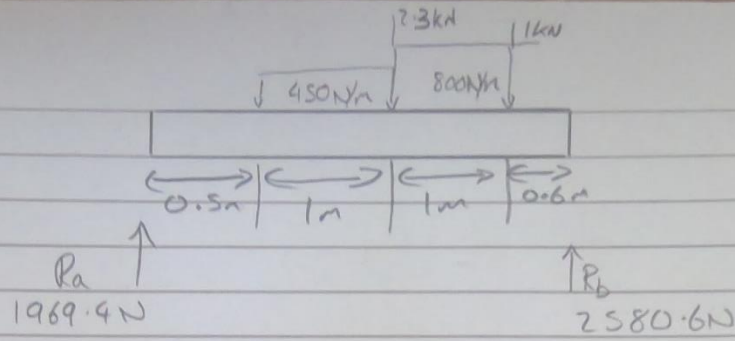
Mohr's circle

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Q3

page 5



i)

$$E_y \frac{d^2 y}{dx^2} = M = R_a(x) - 450 \left[\frac{x-0.5}{2} \right]^2 + 450 \left[\frac{x-1.5}{2} \right]^2 - 2300[x-1.6] - 800 \left[\frac{x-1.5}{2} \right]^2 + 800 \left[\frac{x-2.5}{2} \right]^2 - 1000[x-2.6]$$

Continued

$$EI \frac{dy}{dx} = 1969.4 \left[\frac{x}{2} \right]^2 - 450 \left[\frac{x-0.5}{6} \right]^3 + 450 \left[\frac{x-1.5}{6} \right]^3 - 2300 \left[\frac{x-1.6}{2} \right]^2 - 800 \left[\frac{x-1.5}{6} \right]^3 + 800 \left[\frac{x-2.5}{6} \right]^3 - 1000 \left[\frac{x-2.6}{2} \right]^2$$

$$EI y = 1969.4 \left[\frac{x}{6} \right]^3 - 450 \left[\frac{x-0.5}{24} \right]^4 + 450 \left[\frac{x-1.5}{24} \right]^4 - 2300 \left[\frac{x-1.6}{6} \right]^3 - 800 \left[\frac{x-1.5}{24} \right]^4 + 800 \left[\frac{x-2.5}{24} \right]^4 - 1000 \left[\frac{x-2.6}{6} \right]^3$$

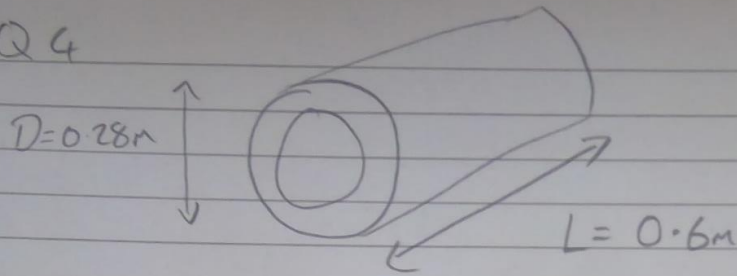
$$\text{iv } y = 0 \quad x = 0$$

$$0 = 0 - 0 + 0 - 0 - 0 + 0 - 0 + B$$

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

$$0 = \frac{1969.4 [3.1]^3}{6} - \frac{450 [2.6]^4}{24} + \frac{450 [1.6]^4}{24} - \frac{2300 [1.5]^3}{6} - \frac{800 [1.6]^4}{24} + \frac{800 [0.6]^4}{24} - \frac{1000 [0.5]^3}{6}$$

Q 4



$$\eta_L = 50\% = 0.5$$

$$\eta_c = 64\% = 0.64$$

$$P = 14.5 \text{ bar} = 14.5 \times 10^5$$

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

i) min thickness circumferential stress

$$\begin{aligned} \text{Min } t &= \frac{PD}{2\sigma_c \eta_L} \\ &= \frac{14.5 \times 10^5 \times 0.28}{2 \times 150 \times 10^6 \times 0.5} \end{aligned}$$

$$\begin{aligned} \text{Minimum thickness} &= 2.71 \times 10^{-3} \text{ m} \\ \text{from circumferential} &= 2.7 \text{ mm} \\ \text{stress} \end{aligned}$$

$$\text{ii) Minimum thickness from longitudinal stress} = \frac{PD}{4\sigma_L \eta_c}$$

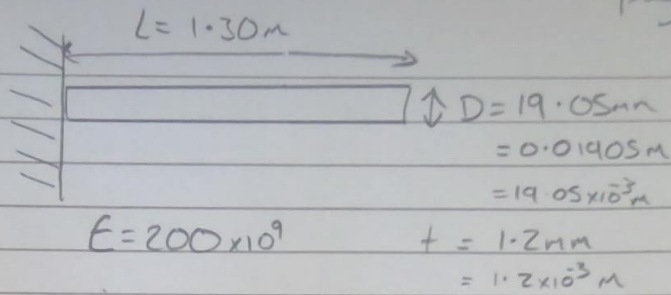
$$= \frac{14.5 \times 10^5 \times 0.28}{4 \times 150 \times 10^6 \times 0.64}$$

$$= 1.05 \times 10^{-3} \text{ m}$$

$$= 1.05 \text{ mm}$$

iii) Overall minimum thickness of tank is 2.7mm

Q5)



i)

Second moment of area =

$$I_{xx} = \frac{\pi}{64} (d^4 - d_i^4)$$

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

$$A = 2.69 \times 10^{-9}$$

ii)

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

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

$$n = \frac{F \times 1.3^2}{\pi^2 \times 200 \times 10^9}$$