

Module: ACHA 5015

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Q1) i)

$$\epsilon_x = -27 \times 10^{-6}$$

$$\epsilon_y = +15 \times 10^{-6}$$

$$\nu = 0.28$$

$$E = 170 \text{ GPa} = 170 \times 10^9 \text{ Pa}$$

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

$$\sigma_x = \frac{170 \times 10^9}{1-0.28^2} (-27 \times 10^{-6} + 0.28 \times 15 \times 10^{-6})$$

$$\sigma_x = -5.76 \times 10^6 \text{ Pa} = -57.6 \text{ MPa}$$

$$\sigma_y = \frac{170 \times 10^9}{1-0.28^2} (+15 \times 10^{-6} + 0.28 \times -27 \times 10^{-6})$$

$$\sigma_y = -53.3 \text{ MPa}$$

$$\sigma_y = -1.37 \times 10^6 \text{ Pa} = -13.7 \text{ MPa}$$

i) ii) $-85 \times 10^6 \text{ Pa}$

$$\sigma_x = -85 \times 10^6 \text{ Pa}$$

$$\sigma_y = 47 \times 10^6 \text{ Pa}$$

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

$$\epsilon_x = \frac{1}{170 \times 10^9} (-85 \times 10^6 - 0.28 \times 47 \times 10^6)$$

$$\epsilon_x = -5.77 \times 10^{-4}$$

$$\epsilon_y = \frac{1}{170 \times 10^9} (47 \times 10^6 - 0.28 \times -85 \times 10^6)$$

$$\epsilon_y = 4.16 \times 10^{-4}$$

Q2) i)

$$\sigma_x = 100 \times 10^6$$

$$\sigma_y = 205 \times 10^6$$

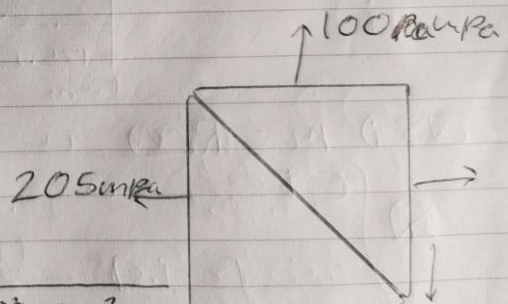
$$\tau_{xy} = 125 \times 10^6$$

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

$$\sigma_{1,2} = \frac{(100 \times 10^6 + 205 \times 10^6)}{2} \pm \sqrt{\left(\frac{100 \times 10^6 - 205 \times 10^6}{2}\right)^2 + (125 \times 10^6)^2}$$

$$\sigma_1 = 288.08 \times 10^6 \text{ Pa}$$

$$\sigma_2 = 16.92 \times 10^6 \text{ Pa}$$



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Q2) ii)

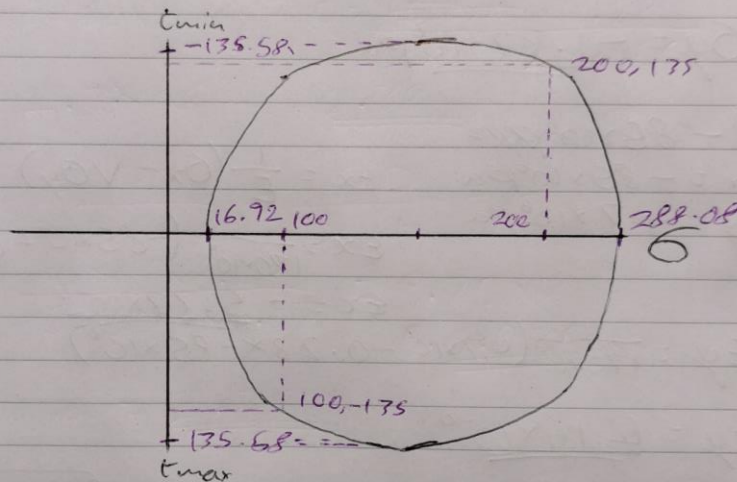
$$G_1 = 288.08 \times 10^6 \quad C_{\max, \min} = \pm \frac{G_1 - G_2}{2}$$

$$G_2 = 16.92 \times 10^6$$

$$C_{\max, \min} = \pm \frac{288.08 \times 10^6 - 16.92 \times 10^6}{2}$$

$$C_{\max} = 135.58 \times 10^6 \quad C_{\min} = -135.58 \times 10^6$$

iii)



Q3) i) $m = R(x)$ ~~$m = \frac{1}{2} \frac{d^2 y}{dx^2}$~~

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

$$\frac{450}{2} (x-1.5)^2 - \frac{2300}{2} (x-1.5) - \frac{800}{2} (x-1.5)^2 + \frac{800}{2} (x-2.5)^2 - 1000 (x-2.5)$$

$$\begin{aligned} \text{ii) } \frac{dy}{dx} &= \frac{1769.4}{2} [x]^2 - \frac{450}{6} [x-0.5]^3 + \frac{450}{6} [x-1.5]^3 \\ &- \frac{2300}{2} [x-1.5]^2 - \frac{800}{6} [x-1.5]^3 + \frac{800}{6} [x-2.5]^3 \\ &- \frac{1000}{2} [x-2.5]^2 + A \end{aligned}$$

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Q3 iii)

$$y = \frac{1969.4[x]^3}{6} - \frac{450[x-0.5]^4}{24} + \frac{450[x-1.5]^4}{24} \\ - \frac{2300[x-1.5]^3}{6} - \frac{800[x-1.5]^4}{24} + \frac{800[x-2.5]^4}{24} \\ - \frac{1000[x-2.5]^3}{6} + Ax + b$$

iv) ⑥ $x=0 \quad y=0$

⑦ $x=3.1 \quad y=0$

$$0 = 0 - 0 + 0 - 0 - 0 + 0 - 0 + 0 + b = 0$$

$$b = \underline{\underline{0}}$$

$$y=0 = \frac{1969.4[3.1]^3}{6} - \frac{450[3.1-0.5]^4}{24} + \frac{450[3.1-1.5]^4}{24} \\ - \frac{2300[3.1-1.5]^3}{6} - \frac{800[3.1-1.5]^4}{24} + \frac{800[3.1-2.5]^4}{24} \\ - \frac{1000[3.1-2.5]^3}{6} + A(3.1)$$

$$A = \frac{1}{3.1} \left(-\frac{1969.4[3.1]^3}{6} + \frac{450[3.1-0.5]^4}{24} - \frac{450[3.1-1.5]^4}{24} \right. \\ \left. + \frac{2300[3.1-1.5]^3}{6} + \frac{800[3.1-1.5]^4}{24} - \frac{800[3.1-2.5]^4}{24} \right. \\ \left. + \frac{1000[3.1-2.5]^3}{6} \right) = -\underline{\underline{2330.38}}$$

$$\checkmark \text{ E.I. } y = \frac{1969.4[1.55]^3}{6} - \frac{450[1.55-0.5]^4}{24} + \frac{450[1.55-1.5]^4}{24} \\ - \frac{2300[1.55-1.5]^3}{6} - \frac{800[1.55-1.5]^4}{24} - 2330.38$$

$$E.I.y = -1130.92 / 1.05 \times 10^6$$

$$y = -1.08 \times 10^{-3} \text{ m} \\ = \underline{\underline{-1.08 \text{ mm}}}$$

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Q4) i)

$$OD = 280 \text{ mm} = 0.28 \text{ m}$$

$$ID =$$

$$L = 600 \text{ mm} = 0.6 \text{ m}$$

$$\mu_c = 55\% = 0.55$$

$$\mu_e = 67\% = 0.67$$

$$p = 14 \text{ bar} = 14 \times 10^5 \text{ Pa}$$

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

$$\sigma_c = \frac{PD}{2t\mu_c}$$

$$t = \frac{PD}{\sigma_c 2\mu_c}$$

$$t = \frac{14 \times 10^5 \times 0.28}{150 \times 10^6 \times 2 \times 0.55}$$

$$t_c = 2.38 \times 10^{-3} \text{ m} = \underline{\underline{2.38 \text{ mm}}}$$

$$\text{ii) } \sigma_c = \frac{PD}{4t\mu_c} = \frac{PD}{6.4t\mu_c} = \sigma$$

$$t_c = \frac{14 \times 10^5 \times 0.28}{150 \times 10^6 \times 4 \times 0.67} = 9.75 \times 10^{-4} \text{ m}$$
$$= \underline{\underline{0.975 \text{ mm}}}$$

$$\text{iii) } t_{\min} = \underline{\underline{2.38 \text{ mm}}}$$

Q5) i) steel

$$L = 1.35 \text{ m}$$

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

$$ID = 19.05 - 1.2 \times 2 = 16.65 \times 10^{-3} \text{ m}$$

$$E = 200 \times 10^9 \text{ Pa}$$

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

$$I = \frac{\pi ((19.05 \times 10^{-3})^4 - (16.65 \times 10^{-3})^4)}{64} = \underline{\underline{2.69 \times 10^{-9} \text{ m}^4}}$$

$$\text{ii) } \mu = \underline{\underline{0.25}}$$

$$\text{iii) } F_{cr} = \frac{\pi^2 EI}{L^2} = \frac{0.25 \times \pi^2 \times 200 \times 10^9 \times 2.69 \times 10^{-9}}{1.35^2}$$

$$F_{cr} = \underline{\underline{228.32 \text{ N}}}$$

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$$iv) K^2 = \frac{I}{A} \quad K = \sqrt{\frac{I}{A}}$$

$$A = \pi \times 9.525^2 \times 10^{-6} = \pi \times 8.325^2 \times 10^{-6} = 6.73 \times 10^{-5} \text{ m}^2$$

$$K = \sqrt{\frac{2.69 \times 10^{-1}}{6.73 \times 10^{-5}}} = 6.32 \times 10^{-3}$$

$$SR = \frac{1.35}{6.32 \times 10^{-3}} = \underline{\underline{213.6}}$$

for this case consider buckling
as failure for steel is 120 or
above.