

MODULE : STRESS ANALYSIS & CAE (ACHA 5015)

DATE : 11th JANUARY 2021 at 09:00

STUDENT NAME : SAMUEL JAMES DIGBY

STUDENT NUMBER : 1901067

Q1a

$$EI = 2.2 \times 10^6 \text{ N}\cdot\text{m}^2$$

$$L = 1.5 \text{ m}$$

$$F = 3.5 \times 10^3 \text{ N}$$

$$W = 1500 \text{ N/m}$$

$$\text{Force at free end} = \frac{FL^3}{3EI} + \frac{WL^4}{8EI}$$

$$\frac{3.5 \times 10^3 \times 1.5^3}{3 \times 2.2 \times 10^6} + \frac{1500 \times 1.5^4}{8 \times 2.2 \times 10^6}$$

$$= 2.221 \times 10^{-3} \text{ m}$$

$$= \underline{2.221 \text{ mm}}$$

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Q1b

$$5 - 2.221 = 2.779 \text{ mm}$$

$$\frac{1500 \times 10^4}{8 \times 2.2 \times 10^6} = 431.46 \times 10^{-6} \text{ m}$$

$$= 0.000431 \text{ m}$$

$$\frac{3.5 \times 10^3 \times 1.5^3}{3 \times 2.2 \times 10^6} = 1789.77 \times 10^{-6} \text{ m}$$

$$\delta = 0.000431 \text{ m} \quad 5 \times 10^{-3} - 0.000431 = 4.569$$

$$F = \frac{4.569 \times 1.5^3}{3 \times 2.2 \times 10^6} =$$

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Q2 a

$$OD = 45 \times 10^3 \text{ m} \quad OR = 0.0225 \text{ m}$$

$$ID = 35 \times 10^3 \text{ m} \quad iR = 0.0175 \text{ m}$$

$$P = 115 \times 10^5 \text{ Pa}$$

① inside $r = iR = 0.0175$

$$\sigma_r = 115 \times 10^5 \text{ Pa}$$

outer $r = OR = 0.0225 \text{ m}$

$$\sigma_r = 0$$

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Q2b

inner

outer

$$\sigma_R = a - \frac{b}{r^2}$$

$$\sigma_R = \frac{ab}{r^2}$$

$$115 \times 10^5$$

$$115 \times 10^5 \times 0.0175^2 = b - 0.0175^2 a$$

$$0 = b - 0.0225^2 a$$

$$b = 0.0225^2 a$$

$$\cancel{100 \times 10^5} \quad 115 \times 10^5 \times 0.0175^2 = 0.0225^2 a - 0.0175^2 a$$

$$115 \times 10^5 \times 0.0175^2 = a (0.0225^2 - 0.0175^2)$$

$$a = \frac{115 \times 10^5 \times 0.0175^2}{0.0225^2 - 0.0175^2} = \underline{17.609 \times 10^6}$$

$$b = 0.0225^2 \times a = \underline{8.915 \times 10^3}$$

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Q2c

$$\sigma_c = a + \frac{b}{r^2}$$

$$\sigma_c \text{ inner} = 17.609 \times 10^6 + \frac{8.915 \times 10^3}{0.0175^2}$$

$$= 46.719 \times 10^6 \text{ Pa}$$

$$= \underline{46 \text{ MPa}}$$

$$\sigma_c \text{ outer} = 17.609 \times 10^6 + \frac{8.915 \times 10^3}{0.0225^2}$$

$$= 35.219 \times 10^6 \text{ Pa}$$

$$= \underline{35 \text{ MPa}}$$

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Q3a

$$V = 0.20$$

$$E = 165 \times 10^9 \text{ Pa}$$

$$\epsilon_x = -10 \times 10^6$$

$$\epsilon_y = 13 \times 10^6$$

$$\sigma_x = \frac{165 \times 10^9}{1 - 0.2^2} (-10 \times 10^6 + (0.2 \times 13 \times 10^6))$$

$$= -1.27 \times 10^{18} \text{ Pa (compressive)}$$

$$\sigma_y = \frac{165 \times 10^9}{1 - 0.2^2} (13 \times 10^6 + (0.2 \times -10 \times 10^6))$$

$$= 1.89 \times 10^{18} \text{ Pa (tensile)}$$

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Q3b

$$\sigma_x = 20 \text{ mpa} = 20 \times 10^6 \text{ pa}$$

$$\sigma_y = -15 \text{ mpa} = -15 \times 10^6 \text{ pa}$$

$$\epsilon_x = \frac{1}{165 \times 10^9} (\cancel{\sigma} 20 \times 10^6 - (0.2 \times -15 \times 10^6))$$

$$= \underline{139.39 \times 10^{-6}}$$

$$\epsilon_y = \frac{1}{165 \times 10^9} (-15 \text{ mpa} - (0.2 \times 20 \times 10^6))$$

$$= \underline{-66.67 \times 10^{-6}}$$

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Q4

$$D = 200 \text{ mm} = 200 \times 10^{-3} \text{ m}$$

$$L = 390 \times 10^{-3} \text{ m}$$

$$t = 1.5 \times 10^{-3} \text{ m}$$

$$\sigma = 100 \times 10^6 \text{ Pa}$$

$$\eta_L = 90\%$$

$$\eta_C = 60\%$$

$$P = \frac{100 \times 10^6 \times 2 \times 1.5 \times 0.9}{200 \times 10^{-3}}$$

$$= 1.35 \times 10^6 \text{ Pa}$$

$$P = \frac{100 \times 10^6 \times 4 \times 1.5 \times 10^{-3} \times 0.6}{200 \times 10^{-3}}$$

$$= \cancel{900 \times 10^3 \text{ Pa}} \quad 1.8 \times 10^6 \text{ Pa}$$

$$\therefore P_{\text{max}} = \cancel{900 \times 10^3 \text{ Pa}} \quad 1.35 \text{ MPa}$$

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Q5 a

$$L = 350 \times 10^{-3} \text{ m} = 0.35 \text{ m}$$

$$P = 50 \times 10^6 \text{ Pa}$$

$$\nu = 0.3$$

$$E = 165 \times 10^9 \text{ Pa}$$

$$K = \frac{165 \times 10^9}{3(1 - 2 \times 0.3)} = 1.375 \times 10^{11}$$

$$\epsilon_v = \frac{P}{K} = \frac{50 \times 10^6}{1.375 \times 10^{11}} = 363.64 \times 10^{-6}$$

$$\epsilon_v = \frac{\Delta V}{V}$$

$$\Delta V = \epsilon_v \times V = 363.64 \times 10^{-6} \times 350^3 = 15.59 \text{ mm}^3$$

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Q5b

Orthotropic materials are materials that have non constant elastic values