

Q1 $l = 1.5 \text{ m}$ $EI = 2.2 \times 10^6 \text{ N/m}^2$

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Stress Analysis & CAE
11/01/21

$$y_{\text{max}} = y_{\text{def}} + y_{\text{pl}}$$

$$y_{\text{max}} = \frac{wL^4}{8EI} + \frac{FL^3}{3EI}$$

$$y_{\text{max}} = \frac{1500 \times 1.5^4}{8 \times 2.2 \times 10^6} + \frac{3500 \times 1.5^3}{3 \times 2.2 \times 10^6 \text{ N/m}^2}$$

$$y_{\text{max}} = 0.43 \times 10^{-3} + 1.79 \times 10^{-3}$$

$$y_{\text{max}} = \boxed{2.22 \times 10^{-3} \text{ m}}$$

ii)

$$y_{\text{def}} = y_{\text{max}} - y_{\text{pl}}$$

$$y_{\text{def}} = 5 \times 10^{-3} - 1.79 \times 10^{-3} = 3.21 \times 10^{-3}$$

$$y_{\text{def}} = \frac{wL^4}{8EI}$$

$$y_{\text{pl}} = y - y_{\text{def}} = 5 \times 10^{-3} - 0.43 \times 10^{-3} = 4.57 \times 10^{-3}$$

$$y_{\text{pl}} = \frac{FL^3}{3EI}$$

$$\therefore F = \frac{y_{\text{pl}} \times 3EI}{L^3}$$

$$F = \frac{4.57 \times 10^{-3} \times 3 \times 2.2 \times 10^6}{1.5^3}$$

$$F = 8937 \text{ N}$$

$$\therefore \Delta F = \boxed{8937 \text{ N}}$$

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1. Longitudinal Stress
2. Circumferential Stress
3. Radial Stress

i) Inner Surface Outer surface

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

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

$$11.5 \text{ bar} \times 100,000 = 11.5 \times 10^6 \text{ Pa}$$

$$-11.5 \times 10^6 = \frac{a - b}{0.035^2} \times (0.035^2)$$

$$0 = \frac{a - b}{0.045^2} \times (0.045^2)$$

$$-11.5 \times 10^6 (0.035^2) = 0.035^2 a - b$$

$$0 = 0.045^2 a - b$$

$$b = 0.045^2 a$$

$$11.5 \times 10^6 \times 0.035^2 = 0.035^2 a - b$$

$$b = 0.035^2 a$$

$$11.5 \times 10^6 \times 0.035^2 = 0.045^2 a - 0.035^2 a$$

$$11.5 \times 10^6 \times 0.035^2 = a (0.045^2 - 0.035^2)$$

$$a = \frac{11.5 \times 10^6 \times 0.035^2}{0.045^2 - 0.035^2} = 17.6 \times 10^6$$

$$b = 0.045^2 a = 0.045^2 \times 17.6 \times 10^6 = 35.64 \times 10^3$$

$$\text{iii) @ Inner } \sigma_c = \frac{a+b}{r^2} = \frac{17.6 \times 10^6 + 35.64 \times 10^3}{0.035^2} = 46.7 \text{ MPa}$$

$$\text{@ Outer } \sigma_c = \frac{a+b}{r^2} = \frac{17.6 \times 10^6 + 35.64 \times 10^3}{0.045^2} = 35.2 \text{ MPa}$$

Q3 $\epsilon_x = -10 \times 10^{-6}$ $\epsilon_y = 13 \times 10^{-6}$ $\nu = 0.20$ $E = 165 \times 10^9 \text{ N/m}^2$

$$\sigma_x = \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y) = \frac{165 \times 10^9}{1-0.20^2} \times (-10 \times 10^{-6} + (0.20 \times 13 \times 10^{-6}))$$

$$\sigma_x = -1.27 \text{ MPa} \quad (\text{Compressive})$$

$$\sigma_y = \frac{E}{1-\nu^2} (\epsilon_y + \nu \epsilon_x) = \frac{165 \times 10^9}{1-0.20^2} \times (13 \times 10^{-6} + (0.20 \times -10 \times 10^{-6}))$$

$$\sigma_y = 1.89 \text{ MPa} \quad (\text{Tensile})$$

ii)

$$\sigma_x = 20 \times 10^6 \text{ Pa} \quad \sigma_y = -15 \times 10^6 \text{ Pa}$$

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y) = \frac{1}{165 \times 10^9} \times (20 \times 10^6 - (0.20 \times -15 \times 10^6))$$

$$\epsilon_x = 139.4 \times 10^{-6}$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x) = \frac{1}{165 \times 10^9} \times (-15 \times 10^6 - (0.20 \times 20 \times 10^6))$$

$$\epsilon_y = -115.2 \times 10^{-6}$$

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i)
 $D = 0.2 \text{ m}$ $L = 0.39 \text{ m}$ $t = 1.5 \times 10^{-3} \text{ m}$
 $\eta_L = 0.9$ $\eta_c = 0.6$ $\sigma_{max} = 100 \times 10^6 \text{ N/m}^2$

$$\sigma_c = \frac{pD}{2t\eta_L}$$

$$P = \frac{2t\eta_L\sigma_c}{D}$$

$$P_{maxc} = \frac{2 \times 1.5 \times 10^{-3} \times 0.9 \times 100 \times 10^6}{0.2}$$

$$P_{maxc} = 1.35 \times 10^6 \text{ N/m}^2$$

$$P_{maxc} = 13.5 \text{ Bar}$$

$$\sigma_L = \frac{pD}{4t\eta_c}$$

$$P = \frac{4t\eta_c\sigma_L}{D}$$

$$P_{maxL} = \frac{4 \times 1.5 \times 10^{-3} \times 0.6 \times 100 \times 10^6}{0.2}$$

$$P_{maxL} = 1.8 \times 10^6 \text{ N/m}^2$$

$$P_{maxL} = 18 \text{ Bar}$$

$$\therefore P_{max} = \boxed{13.5 \text{ Bar}}$$

$$C = 0.35m \quad P = 50 \times 10^6 \text{ N/m}^2 \quad E = 165 \times 10^9 \quad \nu = 0.3$$

$$K = \frac{E}{3(1-2\nu)} = \frac{165 \times 10^9}{3(1-2 \times 0.3)} = 137.5 \times 10^9 \text{ N/m}^2$$

$$K = \frac{\sigma}{\epsilon_v} = \frac{-P}{\epsilon_v}$$

$$\epsilon_v = \frac{-P}{K} = \frac{-50 \times 10^6}{137.5 \times 10^9} = -364 \times 10^{-6}$$

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

$$\Delta V = \epsilon_v \times V = -364 \times 10^{-6} \times (0.235)^3$$

$$\Delta V = -15.6 \times 10^{-6} \text{ m}^3$$

i) Orthotropic materials have different elastic constants in different directions. This may be due to grain structure. A material that exhibits these characteristics is wood.