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Stress Analysis and CAE

code: ACHA5015

Date: 11/01/21

Q1 a) $EI = 2.2 \times 10^6 \text{ Nm}^2$

$L = 1.5 \text{ m}$

~~Slope $\frac{d\delta}{dx} = \frac{FL^2}{2EI}$~~

Deflection = $\frac{WL^4}{8EI} + \frac{FL^3}{3EI}$

$$= \frac{1500 \times 1.5^4}{8 \times 2.2 \times 10^6} + \frac{3000 \times 1.5^3}{3 \times 2.2 \times 10^6}$$

$$= 4.31 \times 10^{-4} + 1.53 \times 10^{-3}$$

$$= 1.961 \times 10^{-3} \text{ m}$$

b)

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Q2 a) Boundary condition

Inside surface = $r = r_i = 22.5 \times 10^{-3}$

$$\sigma_R = -p = -115 \times 10^5$$

outer surface = $r_o = 17.5 \times 10^{-3}$

$$\sigma_R = 0$$

b) Lamé's equation

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

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

outer surface

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

$$0 = a - \frac{b}{0.0175^2}$$

$$0 = 0.0175^2 a - b$$

$$b = 0.0175^2 a$$

inner surface

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

$$-115 \times 10^5 = a - \frac{b}{0.0225^2}$$

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

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

↓

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

$$a = -29.1 \times 10^6$$

$$b = 0.0175^2 \times -29.1 \times 10^6 = -8.91 \times 10^3$$

$$c) \quad r_i) = \sigma_C = a + \frac{b}{r^2} = -29.1 \times 10^6 + \frac{-8.91 \times 10^3}{0.0225^2} = -46.7 \times 10^6 \text{ Pa}$$

$$r_o) = a + \frac{b}{r^2} = -29.1 \times 10^6 + \frac{-8.91 \times 10^3}{0.0175^2} = -58.2 \times 10^6 \text{ Pa}$$

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Q3) $\epsilon_x = -10 \times 10^{-6}$

$\epsilon_y = 13 \times 10^{-6}$

$\nu = 0.20$

$E = 165 \times 10^9 \text{ N/m}^2$

$$a) \sigma_x = \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y) = \frac{165 \times 10^9}{1-0.2^2} \times (-10 \times 10^{-6} + (0.2 \times 13 \times 10^{-6}))$$
$$= -1.72 \times 10^6$$

$$\sigma_y = \frac{E}{1-\nu^2} (\epsilon_y + \nu \epsilon_x) = \frac{165 \times 10^9}{1-0.2^2} \times (13 \times 10^{-6} + (0.2 \times -10 \times 10^{-6}))$$
$$= 1.89 \times 10^6$$

$$b) \epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y) = \frac{1}{165 \times 10^9} (-1.72 \times 10^6 - (0.2 \times 1.89 \times 10^6)) = -1.27 \times 10^{-5}$$
$$= \cancel{1.27 \times 10^{-5}}$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x) = \frac{1}{165 \times 10^9} (1.89 \times 10^6 - (0.2 \times -1.72 \times 10^6))$$
$$= \cancel{1.35 \times 10^{-5}} \quad (1.35 \times 10^{-5})$$

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Q4)

$$D = 0.2 \text{ m}$$

$$L = 0.39 \text{ m}$$

$$t = 1.5 \text{ mm}$$

$$\sigma_{\text{max}} = \sigma_{\text{max}} = 100 \times 10^6$$

$$R_c = 0.9$$

$$R_c = 0.6$$

$$\sigma_c = \frac{pD}{2tR_c}$$

$$\sigma_L = \frac{pD}{4tR_c}$$

$$\sigma_c = \frac{pD}{2tR_c}$$

↓

$$p = \frac{2tR_c\sigma_c}{D}$$

$$p = \frac{2 \times 0.0015 \times 0.9 \times 100 \times 10^6}{0.2}$$

$$= 1.35 \times 10^6$$

$$\sigma_L = \frac{pD}{4tR_c}$$

↓

$$p = \frac{4tR_c\sigma_L}{D}$$

$$p = \frac{2 \times 0.0015 \times 0.6 \times 100 \times 10^6}{0.2}$$

$$= 0.9 \times 10^6$$

$$p_{\text{max}} = 1.35 \times 10^6$$

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Q5)

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

$$P = 50 \times 10^6$$

$$\nu = 0.3$$

$$E = 165 \times 10^9$$

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

$$K = \frac{\sigma}{\epsilon_v} = \frac{P}{\Delta v}$$

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

$$\Delta v = l^3 \times \epsilon_v = (0.35)^3 \times -363.64 \times 10^{-6} \\ = -1.56 \times 10^{-5} \text{ m}^3$$

b) orthotropic materials have different elastic constants in different directions.