

Teslyn Webber 1901363

Stress Analysis and CAE ACHA5015

11/01/2020 2021

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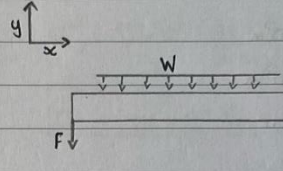
Question One

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

$$\text{Point load} = -3.5 \times 10^3 \text{ N}$$

$$\text{u.d.l} = -1500 \text{ N/m}$$

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



a) Max deflection, $y = \frac{FL^3}{3EI} + \frac{WL^4}{8EI}$

$$y = \frac{-3.5 \times 10^3 (1.5)^3}{3 (2.2 \times 10^6)} + \frac{-1500 (1.5)^4}{8 (2.2 \times 10^6)}$$

$$y = -2.68 \times 10^{-3} \text{ m} + -767 \times 10^{-6} \text{ m}$$

$$y = -3.45 \times 10^{-3} \text{ m}$$
$$= -3.45 \text{ mm}$$

b) $y = -5 \text{ mm}$

$$-5 \times 10^{-3} = \frac{FL^3}{3EI} - 767 \times 10^{-6}$$

$$767 \times 10^{-6} - 5 \times 10^{-3} = \frac{FL^3}{3EI}$$

$$\therefore -4.23 \times 10^{-3} = \frac{FL^3}{3EI}$$

$$F = \frac{-4.23 \times 10^{-3} (3EI)}{L^3}$$

$$F = \frac{-4.23 \times 10^{-3} \times 3 (2.2 \times 10^6)}{(1.5)^3}$$

$$F = -8272 \text{ N}$$

$$\Delta F = -8272 - (-1500) = -6772 \text{ N}$$
$$= -6.77 \text{ kN}$$



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Question Two

$$d_o = 45 \times 10^{-3} \text{ m}$$

$$d_i = 35 \times 10^{-3} \text{ m}$$

$$P = 115 \text{ Bar}$$

a) inside surface

$$r = r_i = \frac{35 \times 10^{-3}}{2} = 0.0175$$

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

outside surface

$$r = r_o = \frac{45 \times 10^{-3}}{2} = 0.0225$$

$$\sigma_R = 0, \text{ atmospheric pressure.}$$

b) $\sigma_{R_i} = a - \frac{b}{r^2}$

$$-100 \times 10^6 = a - \frac{b}{(0.0175)^2}$$

$$-100 \times 10^6 (0.0175)^2 = 0.0175^2 a - b$$

Substitute in $b = 0.023^2 a$

$$-100 \times 10^6 (0.0175)^2 = 0.0175^2 a - 0.023^2 a$$

$$-100 \times 10^6 (0.0175)^2 = a (0.0175^2 - 0.023^2)$$

$$a = \frac{-100 \times 10^6 (0.0175)^2}{(0.0175^2 - 0.023^2)} = 158 \times 10^6$$

$$b = 0.023^2 a$$

$$b = 0.023^2 (158 \times 10^6)$$

$$b = 83.6 \times 10^3$$

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

$$0 = a - \frac{b}{(0.0225)^2}$$

$$0 = 0.023^2 a - b$$

$$b = 0.023^2 a$$

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

$$\sigma_{c_i} = \frac{158 \times 10^6 + 83.6 \times 10^3}{(0.018)^2}$$

$$\sigma_{c_i} = 416 \times 10^6 \text{ N/m}^2$$

$$\sigma_{c_o} = \frac{158 \times 10^6 + 83.6 \times 10^3}{(0.023)^2}$$

$$\sigma_{c_o} = 316 \times 10^6 \text{ N/m}^2$$

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Question Three

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

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

$$\nu = 0.20$$

$$E = 165 \text{ GPa}$$

$$\begin{aligned} \text{a) } \sigma_x &= \frac{E}{(1-\nu^2)} (\epsilon_x + \nu \epsilon_y) \\ \sigma_x &= \frac{165 \times 10^9}{(1-0.2^2)} [-10 \times 10^{-6} + 0.2(13 \times 10^{-6})] \end{aligned}$$

$$\begin{aligned} \sigma_x &= -1.27 \times 10^6 \text{ Pa} \\ &= -1.27 \text{ MPa compressive} \end{aligned}$$

$$\begin{aligned} \sigma_y &= \frac{E}{(1-\nu^2)} (\epsilon_y + \nu \epsilon_x) \\ \sigma_y &= \frac{165 \times 10^9}{(1-0.2^2)} [13 \times 10^{-6} + 0.2(-10 \times 10^{-6})] \end{aligned}$$

$$\begin{aligned} \sigma_y &= 2.27 \times 10^6 \text{ Pa} \\ &= 2.27 \text{ MPa Tensile} \end{aligned}$$

b) at another point:

$$\sigma_x = 20 \text{ MPa}$$

$$\sigma_y = -15 \text{ MPa}$$

$$\begin{aligned} \epsilon_x &= \frac{1}{E} (\sigma_x - \nu \sigma_y) \\ \epsilon_x &= \frac{1}{165 \times 10^9} [20 \times 10^6 - 0.2(-15 \times 10^6)] \end{aligned}$$

$$\epsilon_x = 139 \times 10^{-6}$$

$$\begin{aligned} \epsilon_y &= \frac{1}{E} (\sigma_y - \nu \sigma_x) \\ \epsilon_y &= \frac{1}{165 \times 10^9} [-15 \times 10^6 - 0.2(20 \times 10^6)] \end{aligned}$$

$$\epsilon_y = -115 \times 10^{-6}$$

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Question Four

$$d = 0.20 \text{ m}$$

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

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

$$\eta_L = 0.90$$

$$\eta_c = 0.60$$

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

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

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

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

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

$$P = \frac{2 (1.5 \times 10^{-3}) (100 \times 10^6) (0.9)}{(0.20)}$$

$$P = \frac{4 (1.5 \times 10^{-3}) (100 \times 10^6) (0.6)}{(0.2)}$$

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

$$P = 1.8 \times 10^6 \text{ Pa}$$

$\therefore \text{Max pressure} = 1.35 \times 10^6 \text{ Pa}$ $= 1.35 \text{ MPa}$
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Question Five

$$L = 0.35 \text{ m}$$

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

$$\nu = 0.3$$

$$E = 165 \text{ GPa}$$

$$a) \quad k = \frac{E}{3(1-2\nu)}$$

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

$$k = 1.38 \times 10^{11} \text{ Pa} = 138 \text{ GPa}$$

$$\Delta V = V \epsilon_v$$

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

$$\epsilon_v = \frac{-50 \times 10^6}{138 \times 10^9}$$

$$\epsilon_v = -3.62 \times 10^{-4}$$

$$\Delta V = (0.35)^3 \times -3.62 \times 10^{-4}$$

$$\Delta V = -1.55 \times 10^{-5} \text{ m}^3$$

b) An orthotropic material has different properties in different directions. An example of an orthotropic material is wood.