

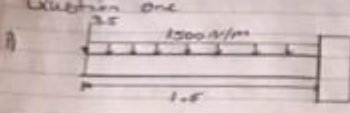
Stress analysis and CAE

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Question one

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1500 N/m

1.5

1500

3500

3.5 kN = 3500 N

$E = 2.2 \times 10^6 \text{ N/m}^2$

$L = 1.5 \text{ m}$

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

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

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

$$= 431.46 \times 10^{-6} + 1.79 \times 10^{-3}$$

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

ii) $y = y_{\text{pl}} - y_{\text{due}}$

$$y_{\text{pl}} = y - y_{\text{due}} = 6 \times 10^{-3} - 431.46 \times 10^{-6}$$

$$= 4.57 \times 10^{-3}$$

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

$$f = \frac{4.57 \times 10^{-3} \times (3 \times 2.2 \times 10^6)}{1.5^3}$$

$$f = 8936.89 \text{ N}$$

$$\Delta f = 5436.89 \text{ N}$$

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Question two

a)

$$\begin{aligned} R_0 &= 0.045 \text{ m} & r_0 &= 0.0225 \text{ m} \\ d_i &= 0.035 \text{ m} & r_i &= 0.0175 \text{ m} \\ P &= 115 \times 10^5 \text{ N/m}^2 \end{aligned}$$

$$\sigma_{r0} = 0.0225 \quad \sigma_z = 0$$

$$\sigma_{ri} = 0.0175 \quad \sigma_z = -P_c = -115 \times 10^5$$

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

$$-115 \times 10^5 = \frac{a-b}{(0.0175)^2}$$

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

$$0 = b - (0.0225)^2 a \quad -115 \times 10^5 = b - (0.0175)^2 a \quad \text{--- (1)}$$

(2) - (1)

$$\begin{aligned} -115 \times 10^5 &= - (0.0175)^2 a + (0.0225)^2 a \\ -115 \times 10^5 (0.0175)^2 &= (0.0225)^2 a - (0.0175)^2 a \\ -115 \times 10^5 (0.0175)^2 &= a (0.0225^2 - 0.0175^2) \end{aligned}$$

$$a = \frac{115 \times 10^5 (0.0175)^2}{(0.0225^2 - 0.0175^2)} = 11.05 \times 10^6$$

$$\therefore b = - (0.0225)^2 \times 11.05 \times 10^6 = -5.59 \times 10^3$$

$$a = 11.05 \times 10^6 \text{ Pa} \quad b = -5.59 \times 10^3 \text{ Pa}$$

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17/02/2014

c) @ r: $\sigma = a + \frac{b}{r} = 11.05 \times 10^6 + \frac{(-5.89 \times 10^6)}{0.0175}$
 $= 10.73 \times 10^6 \text{ MPa}$

@ r: $\sigma_c = a + \frac{b}{r} = 11.05 \times 10^6 + \frac{(-5.89 \times 10^6)}{0.0225}$
 $= 10.80 \times 10^6$

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Question 3

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

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

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

$$\nu = 0.20$$

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$$a) \sigma_x = \frac{E}{1-\nu^2} (E_x + \nu E_y)$$

$$= \frac{165 \times 10^9}{1-0.2^2} (-10 \times 10^{-6} + 0.2 \times 13 \times 10^{-6}) = -1.27 \times 10^6 \text{ Pa}$$

Compressive

$$\sigma_y = \frac{E}{1-\nu^2} (E_y + \nu E_x)$$

$$= \frac{165 \times 10^9}{1-0.2^2} (13 \times 10^{-6} + 0.2 \times -10 \times 10^{-6}) = 1.89 \times 10^6 \text{ Pa}$$

Tension

$$ii) \begin{aligned} x &= 20 \text{ MPa} = 20 \times 10^6 = \sigma_x \\ y &= -15 \text{ MPa} = -15 \times 10^6 = \sigma_y \end{aligned}$$

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

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

$$E_x = 139.4 \times 10^{-6} \text{ } \mu\text{E}$$

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

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

$$= -115.15 \times 10^{-6} \text{ } \mu\text{E}$$

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Cuestión 14

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

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

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

$$n_c = 0.9$$

$$n_t = 0.6$$

$$\sigma_{\max} = 100 \times 10^6 \text{ N/m}^2$$

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

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

$$p = \frac{2 \times 1.5 \times 10^{-3} \times 0.9 \times 100 \times 10^6}{0.2}$$
$$= 1.35 \times 10^6 \text{ N/m}^2$$
$$= 13.5 \text{ Bar}$$

$$\sigma_t = \frac{pD}{4tn_t}$$

$$p = \frac{4tn_t\sigma_t}{D}$$

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

$$p = 1.8 \times 10^6$$

$$p_{\max} = 18 \text{ bar}$$

$$p_{\max} = 13.5 \text{ bar}$$

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Question 5

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i) $L = 0.35 \text{ m}$
 $P = 50 \times 10^6$
 $V = 0.3$
 $E = 165.06 \text{ GPa } 165 \times 10^9$

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

$$K = \frac{\sigma}{\epsilon} = \frac{-P}{\epsilon V}$$

$$\epsilon V = \frac{-P}{K} = \frac{-50 \times 10^6}{137.5 \times 10^9} = -363.64 \times 10^{-6}$$

$$\Delta V = L^3 \times \epsilon V$$

$$\Delta V = (0.35)^3 \times -363.64 \times 10^{-6} = -15.59 \times 10^{-6} \text{ m}^3$$

$$\Delta V = -15.59 \times 10^{-6} \text{ m}^3$$

- ii) The term anisotropic material means it has different elastic constants in different directions. This is down to grain and fibre such as wood.