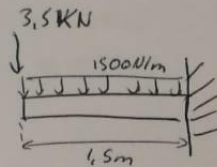


Question 1

$l = 1.5 \text{ m}$
 $F = 3.5 \text{ kN} = 3500 \text{ N}$
 $w = 1500 \text{ N/m}$
 $EI = 2.2 \times 10^6 \text{ Nm}^2$



a) Deflection $y = \frac{FL^3}{3EI} + \frac{wL^4}{8EI}$

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

$$y = -1.179 \times 10^{-3} - 4.3 \times 10^{-4} = -2.22 \times 10^{-3} \text{ m}$$

$= -2.22 \text{ mm}$

b) F ? deflection = 5mm

$y_{pc} = y_{max} - y_{due}$

$y_{pc} = 5 \times 10^{-3} - 4.3 \times 10^{-4}$
 $= 4.57 \times 10^{-3} \text{ m}$

$y_{pc} = \frac{FL^3}{3EI} \rightarrow F = \frac{y_{pc} \times 3 \times EI}{L^3}$

~~$y = \frac{FL^3}{3EI} + \frac{wL^4}{8EI}$~~
 ~~$\frac{FL^3}{3EI} = y - \frac{wL^4}{8EI}$~~
 ~~$F = \left(y - \frac{wL^4}{8EI} \right) \frac{3EI}{L^3}$~~

~~$F = \left(5 \times 10^{-3} - \frac{1500 \times 1.5^4}{8 \times 2.2 \times 10^6} \right) \frac{3 \times 2.2 \times 10^6}{1.5^3}$~~

~~$F = \frac{1.0053 \times 10^{-3} \times 3 \times 2.2 \times 10^6}{1.5^3}$~~
 ~~$F = 187 \times 10^6$~~

~~$F = 203.4 \text{ N}$~~

$F = \frac{4.57 \times 10^{-3} \times 3 \times 2.2 \times 10^6}{1.5^3} = 8936.8 \text{ N}$

$\Delta F = 8936.8 - 3500 = \boxed{5436.8 \text{ N}}$

Question 2

$$d_o = 45 \text{ mm} = 0,045 \text{ m} \quad r_o = 0,0225 \text{ m}$$

$$d_i = 35 \text{ mm} = 0,035 \text{ m} \quad r_i = 0,0175 \text{ m}$$

$$p = 115 \text{ bar} = 115 \times 10^5 \text{ N/m}^2$$

a) Boundary Conditions

Inside surface $\rightarrow r = r_i = 0,0175 \text{ m}$
 $\sigma_r = -p = -115 \times 10^5$

Outside surface $\rightarrow r = r_o = 0,0225 \text{ m}$
 $\sigma_r = 0$

b) Inner surface

Outer surface

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

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

$$-115 \times 10^5 = a - \frac{b}{0,0175^2}$$

$$0 = a - \frac{b}{0,0225^2}$$

$$-115 \times 10^5 \times (0,0175^2) = 0,0175^2 a - b$$

$$b = 0,0225^2 a$$

$$-115 \times 10^5 \times 0,0175^2 = 0,0175^2 a - 0,0225^2 a$$

$$b = 0,0225^2 \cdot 16,2 \times 10^6$$

$$b = 8201,25$$

$$-115 \times 10^5 \times 0,0175^2 = a (0,0175^2 - 0,0225^2)$$

$$a = \frac{-115 \times 10^5 \times 0,0175^2}{0,0175^2 - 0,0225^2} = 16211162,26 = \boxed{16,2 \times 10^6}$$

c) $\sigma_{c1} = 16,2 \times 10^6 + \frac{8201,25}{0,0175^2}$

$$\sigma_{c2} = 16,2 \times 10^6 + \frac{8201,25}{0,0225^2}$$

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

$$\sigma_{c1} = 42,98 \text{ MPa}$$

$$\sigma_{c2} = 17,54 \text{ MPa}$$

$$\sigma_{c2} = 32,4 \text{ MPa}$$

Question 3

$$\epsilon_1 = -10 \times 10^{-6}$$

$$\epsilon_2 = 13 \times 10^{-6}$$

$$\nu = 0,2$$

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

$$a) \sigma_1 = \frac{E}{1-\nu^2} (\epsilon_1 + \nu \epsilon_2) = \frac{165 \times 10^9}{1-0,2^2} (-10 \times 10^{-6} + 0,2 \times 13 \times 10^{-6})$$

$$\sigma_1 = -1271875 \text{ Pa} \approx -1,2 \text{ MPa}$$

↓
compressive

$$\sigma_2 = \frac{E}{1-\nu^2} (\epsilon_2 + \nu \epsilon_1) = \frac{165 \times 10^9}{1-0,2^2} (13 \times 10^{-6} + (-10 \times 10^{-6} \times 0,2))$$

$$\sigma_2 = 1890625 \text{ Pa} \approx 1,81 \text{ MPa}$$

↓
tensile

$$b) \sigma_x = 20 \text{ MPa} = 20 \times 10^6 \text{ N/m}^2$$

$$\sigma_y = -15 \text{ MPa} = -15 \times 10^6 \text{ N/m}^2$$

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y) = \frac{1}{165 \times 10^9} (20 \times 10^6 - 0,2 \times (-15 \times 10^6))$$

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

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x) = \frac{1}{165 \times 10^9} (-15 \times 10^6 - (0,2 \times 20 \times 10^6))$$

$$\epsilon_y = -15 \times 10^{-6}$$

Question 4

$$D = 0,2 \text{ m}$$

$$l = 0,39 \text{ m}$$

$$t = 1,5 \times 10^{-3} \text{ m} = 0,0015 \text{ m}$$

$$R_L = 0,9$$

$$R_c = 0,6$$

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

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

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

$$p_{\max_L} = \frac{2 \times 1,5 \times 10^{-3} \times 0,9 \times 100 \times 10^6}{0,2}$$

$$p_{\max_L} = 1,35 \times 10^6 \text{ N/m}^2$$

$$p_{\max_L} = 13,5 \text{ bar}$$

$$\boxed{p_{\max} = 13,5 \text{ bar}}$$

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

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

$$p_{\max_L} = \frac{4 \times 1,5 \times 10^{-3} \times 0,6 \times 100 \times 10^6}{0,39}$$

$$p_{\max_L} = 923076,9231$$

$$p_{\max_L} = 9,23 \times 10^6 \text{ N/m}^2$$

$$p_{\max_L} = 92,3 \text{ bar}$$

Question 5

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

$$p = 50 \text{ MPa} = 50 \times 10^6 \text{ N/m}^2$$

$$\nu = 0.3$$

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

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

~~Area~~

$$K = \frac{\sigma}{\epsilon_v} = \frac{-p}{\epsilon_v} \quad \epsilon_v = \frac{-p}{K} = \frac{-50 \times 10^6}{137.5 \times 10^9} = \boxed{-360 \times 10^{-6}}$$

$$\Delta V = 13 \times \epsilon_v = (0.35)^3 \times (-360 \times 10^{-6}) = \boxed{-0.154 \times 10^{-6} \text{ m}^3}$$

b)

Orthotropic materials have different elastic constants in different directions. ~~This may be due to grain structure of tube~~

For example wood.