

11/01/2021

STRESS ANALYSIS AND CAE ACHA5015

BENJAMIN GILBERT

1801217

1. a.

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

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

$$F = -3500 \text{ N}$$

$$W = -1500 \text{ N m}^{-1}$$

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

$$= \frac{-3500 \times (1.5)^3}{3 \times 2.2 \times 10^6} + \frac{-1500 \times (1.5)^4}{8 \times 2.2 \times 10^6} = \boxed{-2.22 \times 10^{-3} \text{ m}} \quad \text{2dp}$$

$$b. \quad y = y_{PL} + y_{WDL}$$

$$y_{PL} = y - y_{WDL} = -5 \times 10^{-3} - (-2.22 \times 10^{-3})$$

$$y_{PL} = -2.78 \times 10^{-3} \text{ m}$$

$$y_{PL} = \frac{FL^3}{3EI} \quad F = \frac{y_{PL} \times 3EI}{L^3} = \frac{-2.78 \times 10^{-3} \times 3 \times 2.2 \times 10^6}{(1.5)^3}$$

$$\boxed{F = -5436.44 \text{ N}} \quad \text{2dp}$$

$$\boxed{\Delta F = 1936.44 \text{ N}} \quad \text{2dp}$$

2.

Benjamin Gilbert 180217

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

a.

b. $\lambda_o = 45 \text{ mm} = 45 \times 10^{-3} \text{ m}$

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

$$P = 115 \text{ Bar} = 115 \times 10^5 \text{ Pa}$$

$$r_o = 22.5 \times 10^{-3}$$

$$r_i = 17.5 \times 10^{-3}$$

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

outer $0 = a - \frac{b}{(22.5 \times 10^{-3})^2}$

A $0 = b - (22.5 \times 10^{-3})^2 a$

inner

$$\sigma_R = a - \frac{b}{r^2} \quad -115 \times 10^5 = a - \frac{b}{(17.5 \times 10^{-3})^2}$$

$$2b. \quad -3521.875 = a - b$$

$$-3521.875 = a - (17.5 \times 10^{-3})^2 - b$$

$$\frac{b}{(17.5 \times 10^{-3})^2} - 115 \times 10^5 = a$$

$$\frac{b}{(17.5 \times 10^{-3})^2} = a + 115 \times 10^5$$

$$b = a(17.5 \times 10^{-3})^2 + 3521.875$$

$$B \quad 3521.875 = b - a(17.5 \times 10^{-3})^2$$

$$B - A$$

$$3521.875 = b - a(17.5 \times 10^{-3})^2$$

$$-0 = b - a(22.5 \times 10^{-3})^2$$

$$3521.875 = -a(17.5 \times 10^{-3})^2 + a(22.5 \times 10^{-3})^2$$

$$\frac{3521.875}{a} = - (17.5 \times 10^{-3})^2 + (22.5 \times 10^{-3})^2$$

$$\frac{1}{a} = \frac{(-17.5 \times 10^{-3})^2 + (22.5 \times 10^{-3})^2}{3521.875}$$

4

Benjamin Gilbert 1801217

$$a = \frac{3521.875}{(22.5 \times 10^{-3})^2 - (17.5 \times 10^{-3})^2}$$

$$a = 17609375$$

$$a = 17.61 \times 10^6 \text{ Nm}^{-2}$$

zdp

~~Ben~~

$$0 = b - (22.5 \times 10^{-3})^2 a$$

$$b = (22.5 \times 10^{-3})^2 \times 17609375$$

$$b = 8914.746014$$

$$b = 8.91 \times 10^3$$

zdp

$$2 C. r_i = \sigma_c = \frac{a+b}{r^2} = \frac{17.61 \times 10^6 + 8.91 \times 10^3}{(17.5 \times 10^{-3})^2} = 46718750 \text{ Pa}$$

$$= 46.72 \text{ MPa}$$

zdp

$$r_o = \sigma_c = \frac{a+b}{r^2} = \frac{17.61 \times 10^6 + 8.91 \times 10^3}{(22.5 \times 10^{-3})^2} = 35218750 \text{ Pa}$$

$$= 35.22 \text{ MPa}$$

zdp

3.

$$\begin{aligned}\epsilon_x &= -10 \times 10^{-6} \\ \epsilon_y &= +13 \times 10^{-6}\end{aligned}$$

$$\nu = 0.20$$

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

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

$$\sigma_x = -1271875 \approx -1.27 \times 10^6 \text{ Pa} = -1.27 \text{ MPa}$$

compressive

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

$$\sigma_y = 1890625 \approx 1.89 \times 10^6 \text{ Pa} = 1.89 \text{ MPa}$$

tensile

6

Benjamin Gilbert 1101217

$$3 \quad b \quad \sigma_x = 20 \times 10^6$$

$$\sigma_y = -15 \times 10^6$$

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

$$\epsilon_x = 1.39 \times 10^{-4}$$

2dp

$$\approx 13.9 \times 10^{-3}$$

$$\approx 13.94$$

$$\boxed{= 139.39 \times 10^{-6}}$$

2dp

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

$$\boxed{\epsilon_y = -115.15 \times 10^{-6}}$$

4.

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

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

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

$$\eta_c = 0.9$$

$$\eta_c = 0.6$$

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

$$\sigma_c = 0.8 \times 100 \times 10^6 = 80 \times 10^6$$

$$\sigma_c = 0.6 \times 100 \times 10^6 = 60 \times 10^6$$

7

Benjamin Gilbert 180217

7

$$\sigma_c = \frac{Pd}{2t\eta_c}$$

$$\sigma_c = \frac{Pd}{46\eta_c}$$

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

$$P = \frac{46\eta_c\sigma_c}{d}$$

$$P = \frac{2 \times 1.5 \times 10^{-3} \times 0.8 \times 100 \times 10^6}{0.2}$$

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

$$P = 1350000 = 1.35 \times 10^6 \text{ Nm}^{-2}$$

$$P = 1800000 = 1.8 \times 10^6 \text{ Nm}^{-2}$$

5. $L = 80.35 \text{ m}$
 $P = 50 \times 10^6 \text{ Nm}^{-2}$
 $\nu = 0.3$
 $E = 165 \times 10^9 \text{ Nm}^{-2}$

$$k = \frac{E}{3(1-2\nu)} = \frac{165 \times 10^9}{3(1-(2 \times 0.3))} = 137.5 \times 10^9 \text{ Nm}^{-2}$$

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

$$\epsilon_v = \frac{-P}{k} = \frac{-50 \times 10^6}{137.5 \times 10^9} = -363.64 \times 10^{-6}$$

8

Benjamin Gilbert 1801217

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

$$\Delta V = \epsilon_v \times V = -363.44 \times 10^{-6} \times (0.35)^3$$

$$= -15.591065 \times 10^{-6}$$

$$\hat{=} \boxed{-15.59 \times 10^{-6} \text{ m}^3}$$

Zdp

5b. Orthotropic materials have different elastic constants in different directions. This may be due to grain structure of tube directions in composites. ~~Other~~ Another example is the grain in wood.