

University of Wales Trinity Saint David

Wales Institute of Science & Art



Exam

Stress Analysis and CAE

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Stress Analysis and CAE Exam

A - 1
B - 9
C - 0
D - 1
E - 1
F - 6
G - 1

Question 1

i) $\epsilon_x = 21 \times 10^{-6}$
 $\epsilon_y = -16 \times 10^{-6}$
 $E = 170 \times 10^9 \text{ N/m}^2$
 $\nu = 0.28$

$$\sigma_x = \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y)$$

$$\sigma_x = \frac{170 \times 10^9}{1 - (0.28)^2} (-15 \times 10^{-6} + (0.28 \times -16 \times 10^{-6}))$$

$$\sigma_x = -3.59 \times 10^6 \text{ (compressive)}$$

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

$$= \frac{170 \times 10^9}{1 - (0.28)^2} \times (-16 \times 10^{-6} + (0.28 \times -15 \times 10^{-6}))$$

$$= -3.72 \times 10^6 \text{ (compressive)}$$

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$$\text{ii) } \sigma_x = +86 \times 10^6 \text{ N/m}^2$$

$$\sigma_y = -41 \times 10^6 \text{ N/m}^2$$

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

$$\epsilon_x = \frac{1}{170 \times 10^9} (86 \times 10^6 - (0.28 \times -41 \times 10^6))$$

$$\epsilon_x = 5.74 \times 10^{-4}$$

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

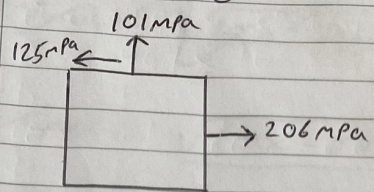
$$\epsilon_y = \frac{1}{170 \times 10^9} (-41 \times 10^6 - (0.28 \times 86 \times 10^6))$$

$$\epsilon_y = -3.82 \times 10^{-4}$$

$$\epsilon_y = 383 \mu\epsilon$$

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Question 2



$$i) \sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$\sigma_1 = \frac{101 + 206}{2} + \frac{\sqrt{(101 - 206)^2 + 4 \times 125^2}}{2}$$

$$\sigma_1 = 345.24 \text{ MPa}$$

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

~~$$\sigma_2 = \frac{101 + 206}{2} - \frac{\sqrt{(101 - 206)^2 + 4 \times 125^2}}{2}$$~~

$$\sigma_2 = \frac{101 + 206}{2} - \frac{\sqrt{(101 - 206)^2 + 4 \times 125^2}}{2}$$

$$\sigma_2 = -38.24 \text{ MPa}$$

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ii) ~~$\tau_{max} = \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}$~~

$$\tau_{max} = \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$= \frac{\sqrt{(101 - 206)^2 + 4 \times 125^2}}{2}$$

$$= 191.74 \text{ MPa}$$

$$\tau_{min} = -\frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$= -\frac{\sqrt{(101 - 206)^2 + 4 \times 125^2}}{2}$$

$$= -191.74 \text{ MPa}$$

iii)

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Question 3

~~Part 1~~

$$i) EI \frac{d^2 y}{dx^2} = \frac{1969.4[x]}{2} - \frac{450[x-0.5]^2}{2} - \frac{2300[x-1.5]}{2}$$

$$* - \frac{800[x-1.5]^2}{2} + \frac{800[x-2.5]^2}{2}$$

$$ii) EI \frac{dy}{dx} = \frac{1969.4[x]^2}{2} - \frac{450[x-0.5]^3}{6} + \frac{450[x-1.5]^3}{6}$$

$$* \frac{2300[x-1.5]^2}{2} - \frac{800[x-1.5]^3}{6} + \frac{600[x-2.5]^3}{6} + A$$

$$iii) EI y = \frac{1969.4[x]^3}{6} - \frac{450[x-0.5]^4}{24} + \frac{450[x-1.5]^4}{24}$$

$$* - \frac{2300[x-1.5]^4}{24} + \frac{800[x-2.5]^4}{24} + Ax + B$$

iv) @ $x=0$ $y=0$
Sub into eqn iii)
 $B=0$

$$A = \frac{1969.4 \times 3.1^3}{6} - \frac{450(3.1-0.5)^4}{24}$$

$$@ x = 3.1m \quad y = 0$$

$$* + \frac{450(3.1-1.5)^4}{24} - \frac{2300(3.1-1.5)^4}{24}$$

Sub into eqn iii)

$$* + \frac{800(3.1-2.5)^4}{24} + 3.1 + 0$$

$$= 4669.05$$

~~Answer~~

V) Substitute $x = 1.16$ into eqn 3

$$\frac{1969.4 \times 1.16^3}{6} - \frac{450 (1.16 - 0.5)^4}{24}$$

$$+ \frac{450 (1.16 - 1.5)^4}{24} - \frac{2300 (1.16 - 1.5)^4}{24} + \frac{800 (1.16 - 2.5)^4}{24}$$

$$+ 4669.05 \times 1.16$$

$$y = 6031.32$$

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Question 4

$$\begin{aligned} \text{i) } d &= 280 \text{ mm} / 1000 = 0.28 \text{ m} \\ L &= 600 \text{ mm} / 1000 = 0.6 \text{ m} \\ \mu_L &= 0.56 \\ \mu_c &= 0.61 \\ \sigma_{\max} &= 150 \times 10^6 \text{ N/m}^2 \\ P &= 14.1 \times 10^5 \text{ N/m}^2 \end{aligned}$$

$$\sigma_c = \frac{Pd}{2\epsilon\mu_c}$$

$$\epsilon = \frac{Pd}{2\sigma_c\mu_c}$$

$$\epsilon = \frac{14.1 \times 10^5 \times 0.28}{2 \times 150 \times 10^6 \times 0.56}$$

$$\epsilon = 2.35 \text{ mm}$$

$$\text{ii) } \sigma_L = \frac{Pd}{4\epsilon\mu_c}$$

$$\epsilon = \frac{Pd}{4\sigma_L\mu_c}$$

$$\epsilon = \frac{14.1 \times 10^5 \times 0.28}{4 \times 150 \times 10^6 \times 0.61}$$

$$\epsilon = 1.08 \text{ mm}$$

$$\text{iii) } \therefore T_{\min} = 2.35 \text{ mm}$$

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Question 5

~~1~~ $L = 1.36$ ~~mm~~

$$t = 0.0012 \text{ m}$$

$$d_i = 0.01905 \text{ m}$$

$$d_o = 0.0012 \times 2 + 0.01905 = 0.02145 \text{ m}$$

~~1~~ $E = 2 \times 10^{-8}$

$$i) \quad I = \frac{\pi d_o^4 - d_i^4}{64}$$

$$I = \frac{\pi \times 0.02145^4 - 0.01905^4}{64}$$

$$I = 8.3 \times 10^{-9} \text{ m}^4$$

ii) $\lambda = 0.25$ as the top is unrestricted

$$iii) \quad F_{cr} = \frac{\lambda \pi^2 EI}{L^2} = \frac{0.25 \times \pi^2 \times 2 \times 10^8 \times 8.3 \times 10^{-9}}{1.36^2}$$

$$= 221.45 \text{ N}$$

$$iv) \quad A = \frac{\pi d_o^2}{4} - \frac{\pi d_i^2}{4}$$

$$= \frac{\pi \times 0.02145^2}{4} - \frac{\pi \times 0.01905^2}{4}$$

$$= 7.63 \times 10^{-5}$$

