

$$\begin{aligned} \text{i) } \epsilon_x &= 25 \times 10^{-6} \\ \epsilon_y &= -11 \times 10^{-6} \\ \nu &= 0.28 \\ E &= 170 \times 10^9 \text{ Pa} \end{aligned}$$

$$\begin{aligned} \text{ii) } \sigma_x &= \frac{E}{1-\nu^2} (\epsilon_x + \nu \epsilon_y) = \frac{170 \times 10^9}{1-0.28^2} \times (25 \times 10^{-6} + (0.28 \times -11 \times 10^{-6})) \\ &= \underline{4.043 \times 10^6 \text{ Pa}} \quad (\text{compressive}) \end{aligned}$$

$$\begin{aligned} \sigma_y &= \frac{E}{1-\nu^2} (\epsilon_y + \nu \epsilon_x) = \frac{170 \times 10^9}{1-\nu^2} \times (-11 \times 10^{-6} + (0.28 \times 25 \times 10^{-6})) \\ &= \underline{-0.738 \times 10^6 \text{ Pa}} \quad (\text{tensile}) \end{aligned}$$

$$\begin{aligned} \text{ii) } \sigma_x &= 81 \times 10^6 \text{ Pa} \\ \sigma_y &= -45 \times 10^6 \text{ Pa} \\ \nu &= 0.28 \\ E &= 170 \times 10^9 \text{ Pa} \end{aligned}$$

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

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

$$= \frac{1}{170 \times 10^9} (81 \times 10^6 - (0.28 \times -45 \times 10^6))$$

$$= \frac{1}{170 \times 10^9} (-45 \times 10^6 - (0.28 \times 81 \times 10^6))$$

$$= \underline{-3.981 \times 10^{-4} \epsilon}$$

09/05/22 2005815 Sam Benbow

Page 2

$$\begin{aligned} 2 \quad \sigma_x &= 108 \times 10^6 \text{ Pa} \\ \sigma_y &= 201 \times 10^6 \text{ Pa} \\ \tau_{xy} &= 125 \times 10^6 \text{ Pa} \end{aligned}$$

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

$$= \frac{108 \times 10^6 + 201 \times 10^6}{2} + \frac{\sqrt{(108 \times 10^6 - 201 \times 10^6)^2 + 4(125 \times 10^6)^2}}{2}$$

$$\sigma_1 = \underline{287.869 \times 10^6 \text{ Pa}}$$

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

$$= \frac{108 \times 10^6 + 201 \times 10^6}{2} - \frac{\sqrt{(108 \times 10^6 - 201 \times 10^6)^2 + 4(125 \times 10^6)^2}}{2}$$

$$\sigma_2 = \underline{21.131 \times 10^6 \text{ Pa}}$$

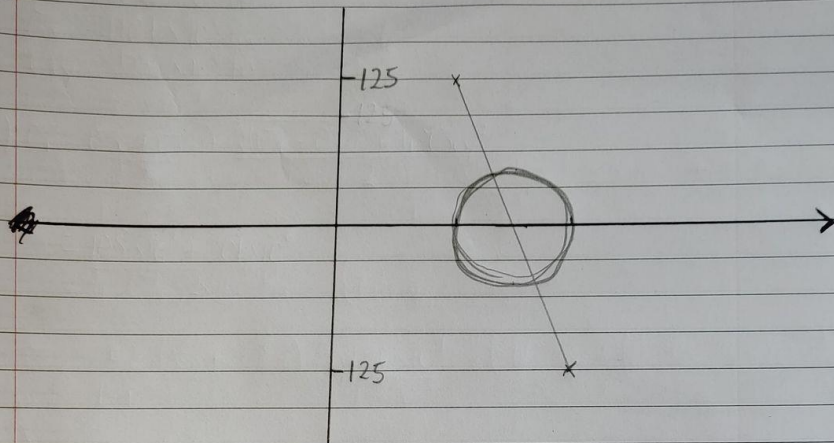
$$ii) \tau_{\max} = \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2}$$

$$\tau_{\max} = \underline{133.369 \times 10^6 \text{ Pa}}$$

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

$$\tau_{\min} = \underline{-133.369 \times 10^6 \text{ Pa}}$$

09/05/22 2005815 Sam Barbow Page 3



$$\tan 2\theta_p = \frac{2\tau}{\sigma_x - \sigma_y} = \frac{2 \times 125 \times 10^6}{108 \times 10^6 - 201 \times 10^6} = 2.688$$

$$\theta_p = \tan(2.688) = -0.047$$

$$\begin{array}{c} \uparrow \\ R_b \\ 2580.6N \end{array}$$

$$\frac{[x-1.5]^2}{2}$$

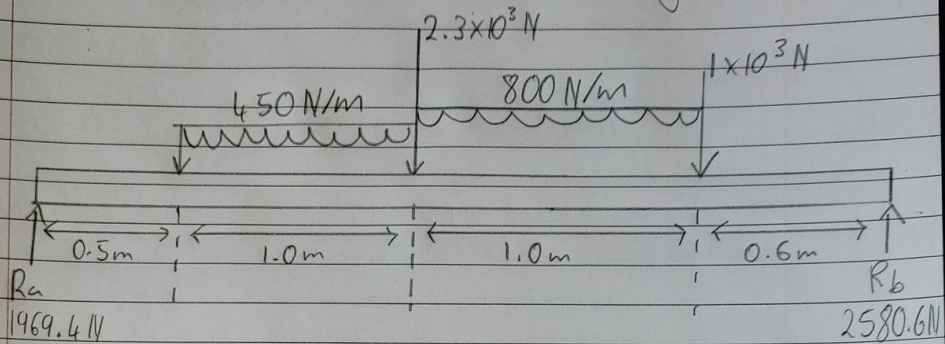
$$\frac{[x-1.5]^3}{6}$$

$$\frac{[x-1.5]^4}{4}$$

$$+Ax+B$$

09/05/22 2005815 Sam Benbow Page 4

3)



i) Bending Moment

$$EI \frac{d^2y}{dx^2} = 1969.4[x] - \frac{450[x-0.5]^2}{2} + \frac{450[x-1.5]^2}{2} - \frac{800[x-1.5]^2}{2} - \frac{2300[x-1.5]}{2} + \frac{800[x-2.5]^2}{2} - \frac{1000[x-2.5]}{2}$$

ii) Slope

$$EI \frac{dy}{dx} = \frac{1969.4[x]^2}{2} - \frac{450[x-0.5]^3}{6} + \frac{450[x-1.5]^3}{6} - \frac{800[x-1.5]^3}{6} - \frac{2300[x-1.5]^2}{2} + \frac{800[x-2.5]^3}{6} - \frac{1000[x-2.5]^2}{2} + A$$

iii) Deflection

$$EI y = \frac{1969.4[x]^3}{6} - \frac{450[x-0.5]^4}{24} + \frac{450[x-1.5]^4}{24} - \frac{800[x-1.5]^4}{24} - \frac{2300[x-1.5]^3}{6} + \frac{800[x-2.5]^4}{24} - \frac{1000[x-2.5]^3}{6} + Ax + B$$

09/05/22 2005815 Sam Barbow Page 5

iv)  $y=0$   $x=0$

$$0 = 0 - 0 + 0 - 0 - 0 + 0 - 0 + A(0) + B$$

$\therefore \underline{B=0}$

$y=0$   $x=3.1$

$$0 = \frac{1969.4[3.1]^3}{6} - \frac{450[2.6]^4}{24} + \frac{450[1.6]^4}{24} - \frac{800[1.6]^4}{24}$$

$$- \frac{2300[1.6]^3}{6} + \frac{800[0.6]^4}{24} - \frac{1000[0.6]^3}{6} + 3.1A$$

$$A = \frac{7226.183}{-3.1} = \underline{-2330.382}$$

v)  $EI = 1.81 \times 10^6 \text{ Pa}$

$x = 3.1 \times 0.5 = 1.55 \text{ m}$

$$1.81 \times 10^6 y = \frac{1969.4[1.55]^3}{6} - \frac{450[1.05]^4}{24} + \frac{450[0.05]^4}{24} - \frac{800[0.05]^4}{24}$$

$$- \frac{2300[0.05]^3}{6} - 2330.382[1.55]$$

$$y = \frac{1.81 \times 10^6 y}{1.81 \times 10^6} = \underline{-1.333 \times 10^{-3} \text{ m}}$$

04/05/22 2005815 Sam Benbow Page 6

$$\begin{aligned} 4) \quad L &= 0.6 \text{ m} \\ \phi_0 &= 0.28 \text{ m} \\ \eta_c &= 65\% \text{ or } 0.65 \\ \eta_i &= 51\% \text{ or } 0.51 \\ \sigma_{\max} &= 150 \times 10^6 \text{ Pa} \\ P_{\max} &= 14.8 \times 10^5 \text{ Pa} \end{aligned}$$

$$i) \quad \sigma_c = \frac{p \phi}{2t \eta_i}$$

$$t = \frac{p \phi}{2 \eta_i \sigma_c} = \frac{14.8 \times 10^5 \times 0.28}{2 \times 0.51 \times 150 \times 10^6} = \underline{2.708 \times 10^{-3} \text{ m}}$$

$$ii) \quad \sigma_i = \frac{p \phi}{4t \eta_c}$$

$$t = \frac{p \phi}{4 \eta_c \sigma_c} = \frac{(14.8 \times 10^5) \times 0.28}{4 \times 0.65 \times 150 \times 10^6} = \underline{1.063 \times 10^{-3} \text{ m}}$$

$$iii) \quad \underline{2.708 \times 10^{-3} \text{ m}}$$

09/05/22 2005815 Sam Barrow Page 7

5)  $l = 1.31 \text{ m}$

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

$$\phi_i = 0.01905 - (0.0012 \times 2) = 0.0167 \text{ m}$$

$$E = 200 \times 10^9 \text{ Pa}$$

$$i) I = \frac{\pi (\phi_o^4 - \phi_i^4)}{64} = \frac{\pi (0.01905^4 - 0.0167^4)}{64}$$

$$= \underline{2.647 \times 10^{-9} \text{ m}^4}$$

ii)  $n = 1$

$$iii) F_{cr} = \frac{n \pi^2 E I}{L^2} = \frac{1 \times \pi^2 \times (200 \times 10^9) \times (2.647 \times 10^{-9})}{1.31^2} = \underline{3044.676}$$

$$iv) k = \frac{I}{A} = \frac{2.647 \times 10^{-9}}{6.598 \times 10^{-5}} = 4.0118 \times 10^{-5}$$

$$A = \frac{\pi (\phi_o^2 - \phi_i^2)}{4} = 6.598 \times 10^{-5} \text{ m}^2$$

$$SL = \frac{L}{k} = \frac{1.31}{4.0118 \times 10^{-5}} = \underline{32653.672} \therefore \text{Strut}$$