PART B Solution

Q1. The system of signboard mounting can be considered as a Cantilever loaded at A i.e $F = 100N$ & anticlockwise moment $M = 100 \times 1 = 100\,Nm$ at free end.

Deflection at free end $y = \frac{FL^3}{3EI} + \frac{ML^2}{2EI}$ → [2M]

$$5 \times 10^{-3} = \frac{100 \times 5^3}{3 \times 2 \times 10^{11} I} + \frac{100 \times 5^2}{2 \times 2 \times 10^{11} \times I}$$

$\boxed{I = 5.41 \times 10^{-6}\,m^4}$ [2M]

$I = \frac{\pi}{64}[d_o^4 - d_i^4]$

$5.41 \times 10^{-6} = \frac{\pi}{64}[0.15^4 - d_i^4] \Rightarrow \boxed{d_i = 0.141m = 141mm}$ [3M]

$t = \frac{d_o - d_i}{2} = \boxed{4.5mm}$ [3M]

Q2.

Case 1

$\Sigma F_x = 0 \quad N = -P\,KN$

[1M] $\boxed{\sigma_{xx} = \frac{N}{A} = -0.17P \times 10^6\,N/m^2}$

[1M] $\boxed{\epsilon_{xx} = \frac{\sigma_{xx}}{E} = -0.85P\mu}$

[1M] $\boxed{\epsilon_{yy} = -\nu\epsilon_x = 0.213P\mu}$

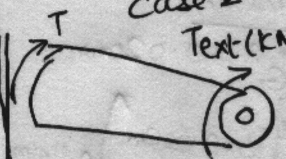
[1M] $\boxed{\gamma_{xy} = \frac{\tau_{xy}}{G} = 0}$

$\theta_a = -30^\circ \quad \epsilon_a = \epsilon_{xx}\cos^2\theta + \epsilon_{yy}\sin^2\theta$

$-500\mu = -0.85P\cos^2(-30^\circ) + 0.213P\sin^2(-30^\circ)$

$\boxed{P = 855KN}$ [1M]

Case 2



$\Sigma M_x = 0 \quad T = -Text\ KNm$

$\tau_{xy} = \frac{Tr}{I_p} = \frac{-Text \times 10^3 \times 0.05}{9.20 \times 10^{-6}}$

$\boxed{\tau_{xy} = -5.435\,Text \times 10^6\,N/m^2}$ [1M]

$A = 5.89 \times 10^3\,mm^2$

$I_p = 9.20 \times 10^6\,mm^4$

$\boxed{\epsilon_{xx} = 0}$ $\boxed{\epsilon_{yy} = 0}$ [2M]

$\boxed{\gamma_{xy} = \frac{\tau_{xy}}{G} = 67.94\,Text\,\mu}$ [1M]

$\epsilon_b = 67.94\,Text\,\sin 30^\circ \cos 30^\circ = 400\mu$

$\boxed{Text = 13.6\,KNm}$ [1M]

$\theta_b = 30^\circ$

Case 3

$\boxed{\epsilon_{xx} = -0.85P\mu}$ [1M]

$\boxed{\epsilon_{yy} = 0.213P\mu}$ [1M]

$\boxed{\gamma_{xy} = 67.94\,Text\,\mu}$ [1M]

$\theta_a = -30^\circ \quad \theta_b = 30^\circ$

$-500 = \epsilon_a = \epsilon_{xx}\cos^2(-30^\circ) + 0.213P\sin^2(\theta a) + 67.94\,Text\,\sin(-30^\circ)\cos(-30^\circ)$ — (A)

$400 = \epsilon_b = \epsilon_{xx}\cos^2 30^\circ + \epsilon_{yy}\sin^2 30^\circ + 67.94\,Text\,\sin 30^\circ \cos 30^\circ$ — (B)

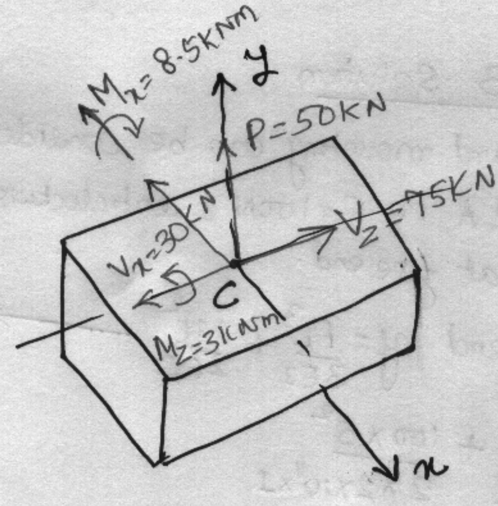
Solving

$\boxed{P = 85.4KN}$ [1M]

$\boxed{Text = 15.3\,KNm}$ [1M]

Q3

ⓐ



[1.5 M]

$V_x = -30\,KN$

$P = 50\,KN$

$V_z = -75\,KN$

$M_x = (50 \times 0.130) - (75 \times 0.2)$

$M_x = -8.5\,KNm$

$M_y = 0$

$M_z = 30 \times 0.10 = 3\,KNm$

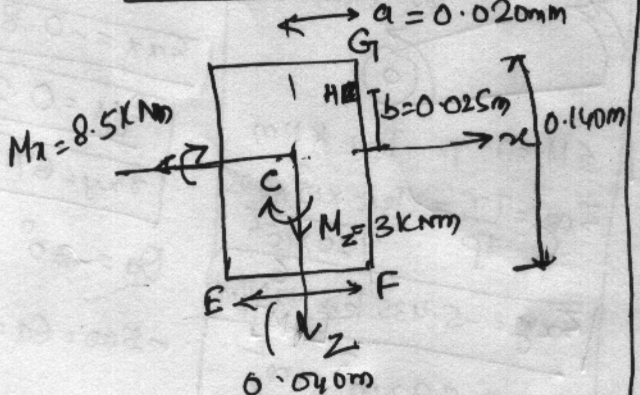
$0.5 \times 7M = [3.5M]$

ⓑ $A = 0.040 \times 0.140 = 5.6 \times 10^{-3}\,m^2$

$I_x = \frac{1}{12}(0.040)(0.140)^3 = 9.15 \times 10^{-6}\,m^4$ — [1m]

$I_z = \frac{1}{12}(0.140)(0.040)^3 = 0.747 \times 10^{-6}\,m^4$ — [1m]

Normal stress at H

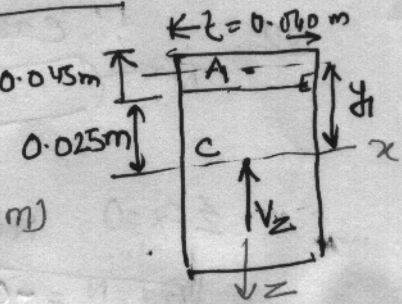


[2m] $\sigma_y = \frac{P}{A} + \frac{(M_z)a}{I_z} - \frac{(M_x)b}{I_x}$

$= \frac{50KN}{5.6 \times 10^{-3}} + \frac{3KN \times 0.020}{0.747 \times 10^{-6}} - \frac{8.5 \times 0.025}{9.15 \times 10^{-6}}$

$\boxed{\sigma_y = 66\,MPa}$ — [2m]

Shear stress at H.



$\boxed{y_1 = 0.0475m}$ [1m]

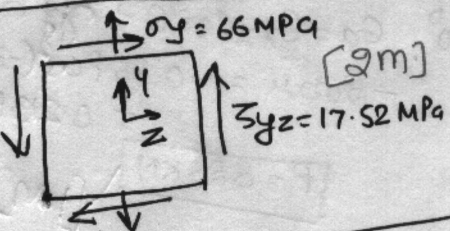
$Q = A_1 y_1$

$= 0.040 \times 0.045 \times 0.0475$

$\boxed{Q = 85.5 \times 10^{-6}\,m^3}$ [2m]

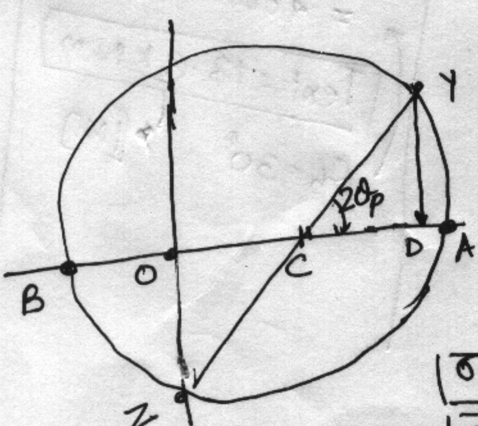
$\tau_{yz} = \frac{V_z Q}{I_x t} = \frac{75 \times 85.5 \times 10^{-6}}{9.15 \times 10^{-6} \times 0.040}$

$\boxed{\tau_{yz} = 17.52\,MPa}$ — [2m]



[2m]

ⓒ



$OC = 33\,MPa$

$\tau_{max} = R = \sqrt{33^2 + 17.52^2}$

$\boxed{\tau_{max} = 37.4\,MPa}$ — [1M]

$\boxed{\sigma_{max} = OC + R = 70.4\,MPa}$ — [1M]

$\boxed{\sigma_{min} = OC - R = -7.4\,MPa}$ — [1M]

$\tan 2\theta = \frac{17.52}{33}$

$\boxed{2\theta_{p_1} = 27.96^\circ}$

$\boxed{2\theta_{p_2} = 207.96}$

$\boxed{\theta_{p_1} = 13.98^\circ}$ — [2M]

$\boxed{\theta_{p_2} = 103.98^\circ}$ [2M]