SE / Sem III / Mech/Auto / Choice Base / SOM / NOV-2017

Q.P. code: 27636

1. a. $d = 37.5mm$, $l = 2.4m$, $\delta l = 2.5mm$, $E = 110 kN/m^2$, $G = 42 kN/m^2$

$$E = 2G[1+\mu_m] = 2\times 42\times 10^9 [1+\mu_m]$$

$$110\times 10^9 = E, \quad \mu_m = \underline{0.31}$$

$$k = \frac{mE}{3[m-2]} = \frac{3.22\times 110\times 10^9}{3[3.22-2]} = \underline{96.77\ kN/m^2}$$

b) $$Z_w = \frac{bd^2}{6} = \frac{100\times 200^2}{6} = 66.67\times 10^4\ mm^3$$

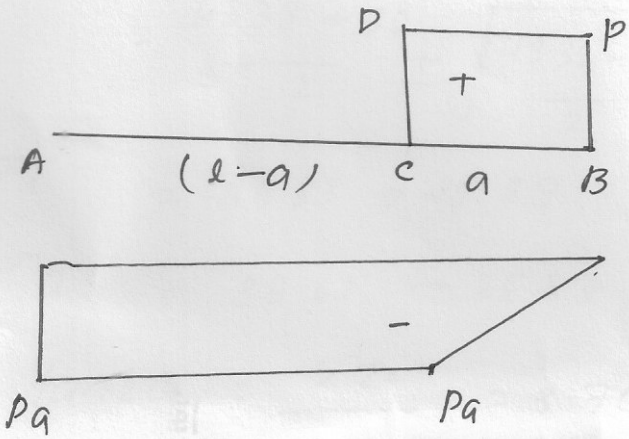
$$Z_s = \frac{bd^2}{6} = \frac{10\times 200^2}{6} = 33\ 66.67\times 10^3\ mm^3$$

$$M_w + M_s = \sigma_w Z_w + \sigma_s Z_s$$

$$= 5\times 66.67\times 10^4 + 100\times 66.67\times 10^3$$

$$= 10000\ N\text{-}m = \underline{10\ kN\text{-}m}$$

c)



S.F A = P

S.F C = P

S.F C = 0

S.F A = 0

B.M B = 0

B.M C = −Pa

B.M A = −Pl + CDl − Pa

= −Pa

d) $$\sigma_c = \frac{pd}{2t}, \quad 380 = \frac{p\times 60}{2\times 2},$$

$$p = \underline{25.33\ N/mm^2}$$

I. e. $d = 50\,mm$, $N = 150$ $\tau = 80\,N/mm^2$

$$\frac{T}{J} = \frac{\tau}{R} \qquad T = \frac{80 \times \pi/32 \times 50^4}{25}$$

$$P = \frac{2\pi NT}{60} = \underline{\underline{30.843\,kW}}$$

II

a. $2P_b + P_s = 450\,kN$ $\quad e_b = e_s$

$$\frac{\sigma_b}{E_b} = \frac{\sigma_s}{E_s} \qquad \sigma_b = \underline{\underline{140\,kN/mm^2}}$$

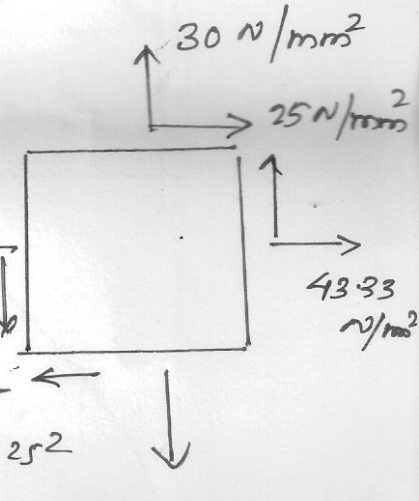
$$\sigma_s = \underline{\underline{342.4\,N/mm^2}}$$

$$\frac{P_b}{A_b E_b} = \frac{P_s}{A_s E_s}$$

$$P_s = 0.61\,P_b$$

$$P_b = 172.4\,kN, \quad P_s = \underline{\underline{105.2\,kN}}$$

II b. $\sigma_R = \sqrt{30^2 + 25^2}$



$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

$$= \frac{43.33 + 30}{2} \pm \sqrt{\left(\frac{43.33 - 30}{2}\right)^2 + 25^2}$$

$$\sigma_1 = 36.65 + 25.87 = \underline{\underline{62.52\,N/mm^2}}$$

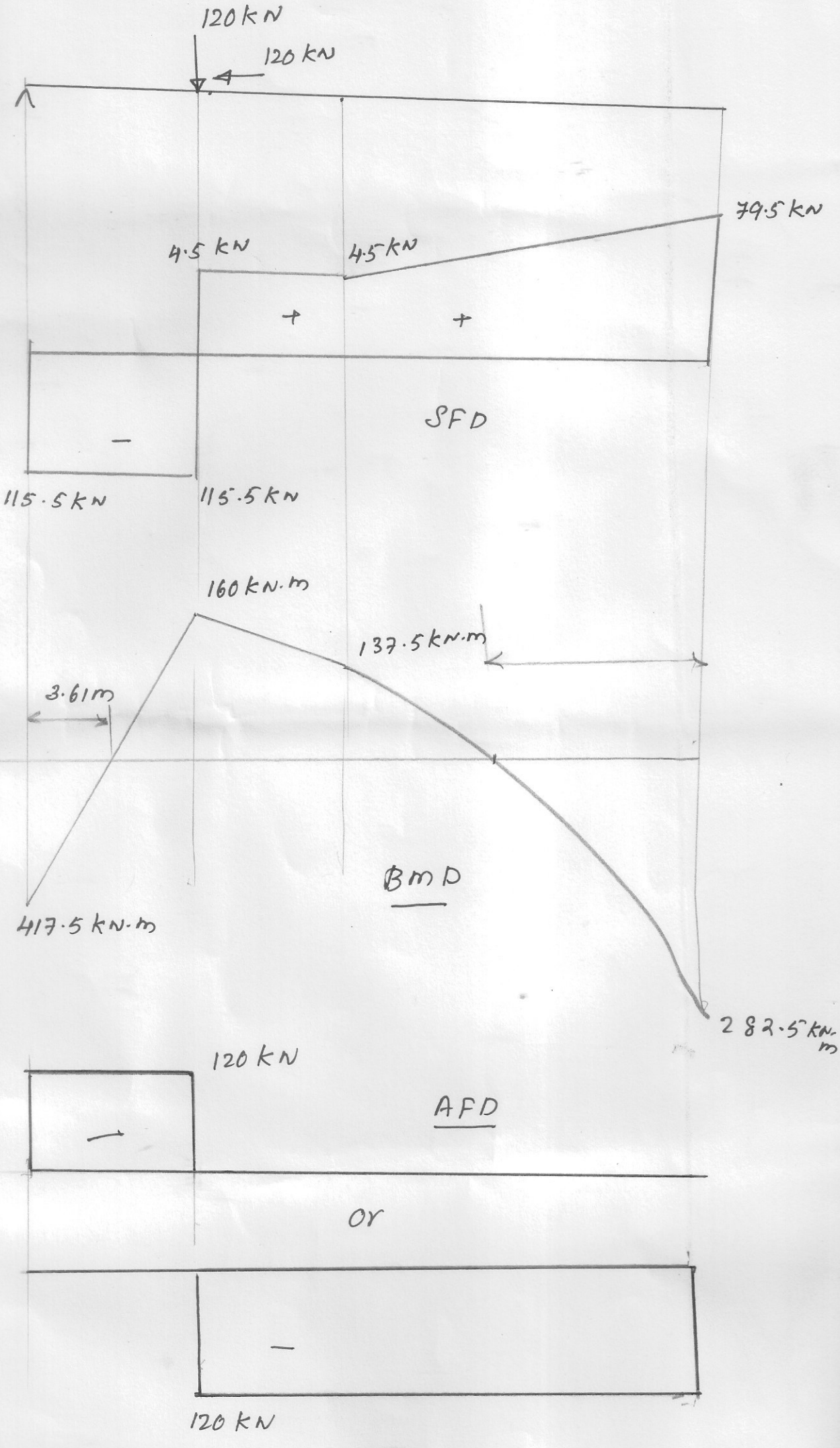
$$\sigma_2 = 36.65 - 25.87 = \underline{\underline{10.78\,N/mm^2}}$$

$$\tan 2\theta = \frac{2\tau}{\sigma_x - \sigma_y} = 3.76$$

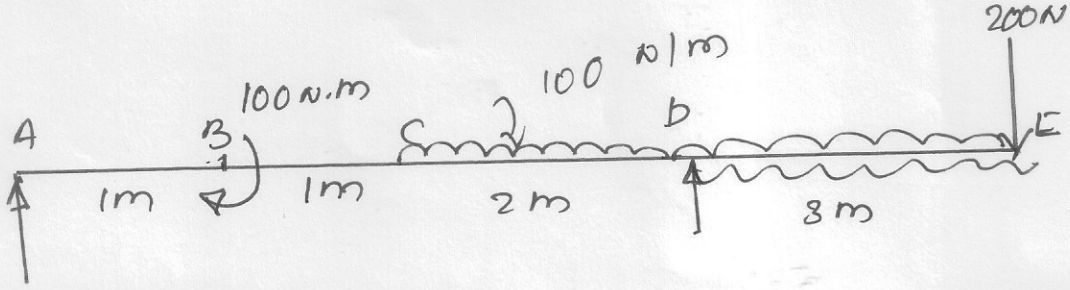
$$2\theta = 75^0$$

$$\theta_1 = 37.5^0 \qquad \theta_2 = 90 + \theta_1 = \underline{\underline{127.5^0}}$$

III a.


120 kN
120 kN
79.5 kN
4.5 kN
4.5 kN
+
+
SFD
−
115.5 kN
115.5 kN
160 kN.m
137.5 kN.m
3.61m
BMD
417.5 kN.m
282.5 kN.m
120 kN
AFD
−
Or
−
120 kN

(4)



$V_A + V_D = 400$ ↓

$V_D = 525N$ ↑ $V_A = 125N$ ↓

$$M_x = EI\frac{d^2y}{dx^2} = -125x + \langle x-1\rangle^0 - \frac{100\langle x-2\rangle^2}{2} + 525\langle x-4\rangle + \frac{100\langle x-4\rangle^2}{2}$$

$$EI\frac{dy}{dx} = -\frac{125x^2}{2} + \frac{\langle x-1\rangle^1}{1} - \frac{100\langle x-2\rangle^3}{6} + \frac{525\langle x-4\rangle^2}{2} + \frac{100\langle x-4\rangle^3}{3}$$

$$EI\,y = -\frac{125x^3}{6} + \frac{100\langle x-1\rangle^2}{2} - \frac{100\langle x-2\rangle^4}{24} + \frac{525\langle x-4\rangle^3}{6} + \frac{100\langle x-4\rangle^4}{24}$$

$x = 0,\ y = 0,\ C_2 = 0$

$x = 4\ \ y = 0\ \ C_1 = 237.5$

$$\text{Slope at } E = \frac{1}{EI}\left[-\frac{125\times 7^2}{2} + 100\times 6 - \frac{100\times 5^3}{6} + \frac{525\times 3^2}{2} + \frac{100\times 3^3}{3} + 237.5\right]$$

$$= \frac{1498.33}{EI} = 0.535 \text{ rad} \quad \text{[check calculations]}$$

$$\text{Deflection at } E = 237.5\times 7 - \frac{125\times 7^3}{6} + \frac{100\times 6^2}{2} + \frac{100\times 5^4}{24} + \frac{525\times 3^3}{6} + \frac{100\times 3^4}{24}$$

$$y = \frac{-3587.5}{EI} \quad \text{(check calculations)}$$

$$= \frac{-3587.5}{200\times 14} = 1.28 \text{ mm}$$

IV a $\quad \sigma_d = \dfrac{450 \times 10^3}{1500 \times 1000} = 0.3\ N/mm^2$

$$I_{xx} = \frac{1500 \times 1000^3}{12} = 1.25 \times 10^{11}\ mm^4$$

$$I_{yy} = \frac{1500^3 \times 1000}{12} = 2.8125 \times 10^{11}\ mm^4$$

$$\sigma_{bx} = \frac{450 \times 10^3 \times 250 \times 500}{1.25 \times 10^{11}} = 0.45\ N/mm^2$$

$$\sigma_{by} = \frac{450 \times 10^3 \times 250 \times 750}{2.8125 \times 10^{11}} = 0.3\ N/mm^2$$

at A $[x, y] = [-750, -500]$ mm

at B $[x, y] = [+750, -500]$ mm

at C $[x, y] = [750, 500]$ mm

at D $[x, y] = [-750, 500]$ mm

σ_R at A $= 0.3 - 0.45 - 0.3 = -0.45\ N/mm^2$ (T)

σ_R at B $= 0.3 + 0.3 - 0.45 = 0.15\ N/mm^2$ (C)

σ_R at C $= 0.3 + 0.45 + 0.3 = 1.05\ N/mm^2$ (C)

σ_R at D $= 0.30 + 0.45 - 0.3 = 0.45\ N/mm^2$ (C)

IV b.

$$P = \frac{2\pi NT}{60}$$

$$300 \times 10^3 = \frac{2\pi \times 80 \times T}{60}$$

$$T = 35809.86\ N\text{-}m$$

$$T_{max} = 1.4 \times T_{mean}$$

$$= 50133.8 \text{ N-m}$$

$$\frac{T}{J} = \frac{\tau}{R}$$

$$\frac{50133.8 \times 10^3}{\frac{\pi}{32}\left[D^4 - 0.6D^4\right]} = \frac{60}{D/2}$$

$$D = 169.69 \text{ mm} = \underline{170 \text{ mm}}$$

$$d = \underline{101.815 \text{ mm}} = \underline{102 \text{ mm}}$$

V a. $$\sigma_{c0} = \frac{P}{A}\left[1 + \sqrt{1 + \frac{2AEh}{P\lambda}}\right]$$

$$120 = \frac{200 \times 9.81}{\pi/4 \times 28^2}\left[1 + \sqrt{1 + \frac{2 \times \pi/4 \times 28^2 \times 2 \times 10^5 \times h}{200 \times 9.81 \times 3000}}\right]$$

$$h = \underline{32.094 \text{ mm}}$$

b. $$I = \frac{150 \times 250^3}{12} = 195 \times 10^6 \text{ mm}^4$$

$$m = wl/4$$

$$\frac{m}{I} = \frac{\sigma}{y} \qquad m = \frac{\sigma}{y} \times I = \frac{7}{125} \times 195 \times 10^6 = 10.9 \times 10^6 \text{ N-mm}$$

$$\frac{wl}{4} = m, \qquad w = \underline{33.65 \text{ kN}}$$

$$\tau_{max} = 1.5\,\tau_{av.}$$

$$\frac{w}{2} \times \frac{1.5 \times 1}{250 \times 150} = 1$$

$$w = \underline{50 \text{ kN}}$$

Or $$\frac{SA\bar{y}}{Ib} = \frac{\frac{w}{2} \times 150 \times \frac{125}{2}^2}{195 \times 10^6 \times 150}$$

$$= \underline{50 \text{ kN}}$$

VI a.

$$P_R = \frac{\sigma_c A}{1 + \alpha \cdot l_{eff}/k^2}$$

$$k^2 = \frac{I}{A} = \frac{\pi/64\,[200^4 - 150^4]}{\pi/4\,[200^2 - 150^2]} = 3906.25$$

$$k = 62.5$$

$$P_R = \frac{560 \times \pi/4\,[200^2 - 150^2]}{1 + \frac{1}{1600} \times \frac{(4 \times 1000)^2}{3906.25}} = 2162.05\ kN$$

$$\text{Safe load} = \frac{2162.05}{6} = \underline{\underline{360.34\ kN}}$$

VI b. Load on steel $= \frac{200}{3} \times 10^3\ N$

Load on each copper $= \frac{200}{3} \times 10^3\ N$

$$\sigma_c = \sigma_s = P/A = \frac{200 \times 10^3}{3 \times 500} = \underline{\underline{133.33\ N/mm^2}}$$

Due to temp. difference

$\alpha_s A_s = \alpha_c A_c$ Tension in steel = comp. in Cu

$\sigma_s \times 500 = \alpha \times \sigma_c \times 500$

$$[\alpha_c - \alpha_s]\,t = \frac{\sigma_c}{E_c} + \frac{\sigma_s}{E_s}$$

$$[1.85 \times 10^{-5} - 1.2 \times 10^{-5}] \times 100 = \frac{\sigma_c}{0.8 \times 10^5} + \frac{2\sigma_c}{2 \times 10^5}$$

$\sigma_c = 28.88\ N/mm^2$ (c)

$\sigma_s = 57.77\ N/mm^2$ (T)

[Tension in steel = compression in Cu]

Total Stress [comp] in Cu $= 133.33 + 28.88 = \underline{\underline{162.21\ N/mm^2}}$

Total Stress in steel $= 133.33 - 57.77 = \underline{\underline{75.56\ N/mm^2}}$