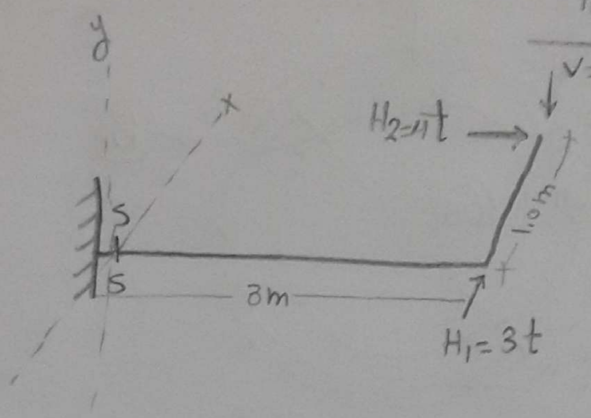
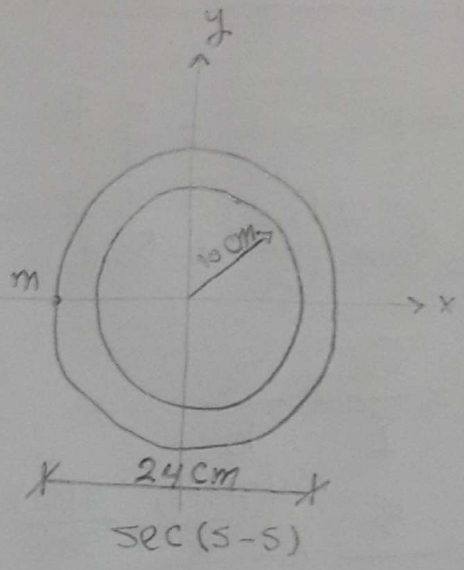
Torsion

Part (2)

[5]





Solution

* Straining actions :-

$N = 4t$

$M_x = 4*3 = 12$ t.m

$M_y = 4*1 - 3*3 = -5$ t.m

$Q_x = 3t \rightarrow$

$Q_y = 4t \downarrow$

$M_t = 4*1 = 4$ t.m ↷

* Properties of area :-

$$A = \frac{\pi (24)^2}{4} - \frac{\pi (20)^2}{4} = 138.23 \text{ cm}^2$$

$$I_x = I_y = \frac{\pi}{4}(12^4 - 10^4) = 8432 \text{ cm}^4$$

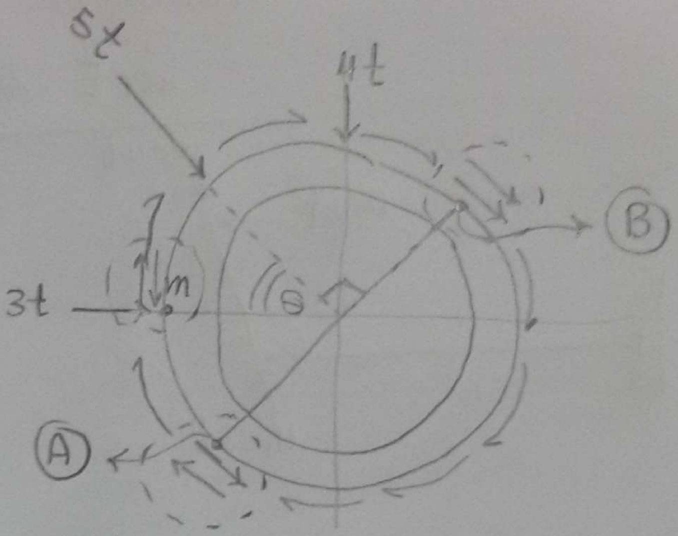
$$I_P = \frac{\pi}{2}(12^4 - 10^4) = 16864 \text{ cm}^4$$

* Shear stress :- (Max)

1) Due to torsion

$$\tau_t = \frac{M_t * R_{ex}}{I_P} = \frac{4*100*12}{16864} = 0.285 \text{ t/cm}$$

2) Due to shear force :-



$$Q = \sqrt{Q_x^2 + Q_y^2} = 5 \ t$$

$$\theta = \tan^{-1}\frac{Q_y}{Q_x} = 53.1^\circ$$

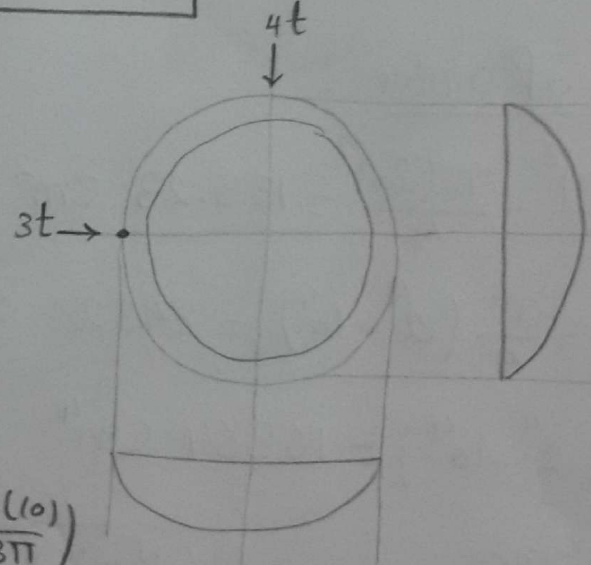
$$\therefore \tau = \frac{Q}{I} * \frac{S}{b}$$

$$= \frac{5}{8432} * \frac{\left(\frac{\pi(12)^2}{2} * \frac{4(12)}{3\pi} - \frac{\pi(10)^2}{2} * \frac{4(10)}{3\pi}\right)}{(2+2)} = 0.072 \ t/cm$$

$\therefore \tau_{max}$ is at (B)

$$\tau_{max} = 0.285 + 0.072 = 0.357 \ t/cm$$

at Point (m)



Shear stress at Point (m) results from (Q_y), not from (Q_x)

$$\tau_y = \frac{Q_y}{I_x} * \frac{S_x}{b}$$

$$= \frac{4}{8432} * \frac{\left(\frac{\pi(12)^2}{2} * \frac{4(12)}{3\pi} - \frac{\pi(10)^2}{2} * \frac{4(10)}{3\pi}\right)}{4} = 0.057 \ t/cm$$

$$\therefore \tau_{total} = 0.285 - 0.057 = 0.228 \ t/cm$$

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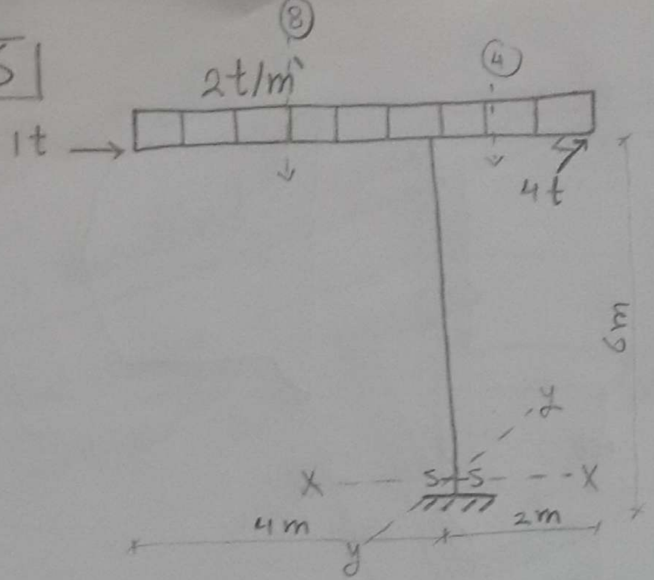
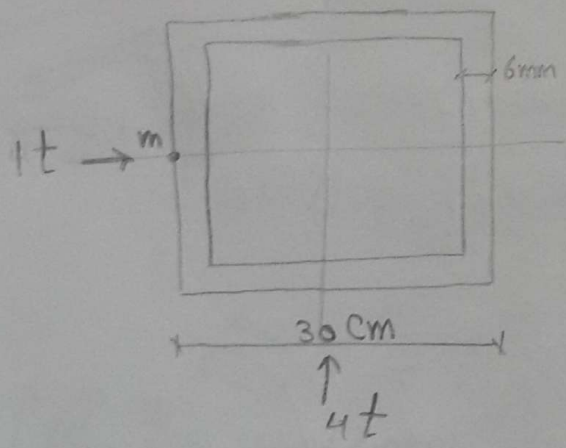




Solution

* Straining actions :-

$N = -2*6 = -12\ t$

$M_y = 4*1 - 8*2 + 1*6 = -6\ t.m$

$M_x = -4*6 = -24\ t.m$

$Q_y = 4\ t \uparrow$

$Q_x = 1\ t \rightarrow$

$M_t = 4*2 = 8\ t.m$ ↶

* Properties of area :-

$A = (30)^2 - (28.8)^2 = 70.56\ cm^2$

$I_x = I_y = \frac{(30)^4}{12} - \frac{(28.8)^4}{12} = 10169.1\ cm^4$

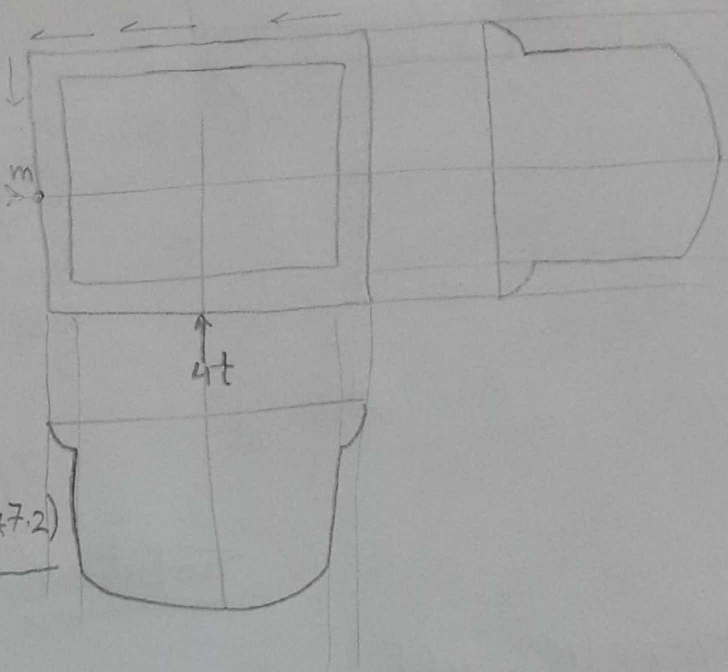
* Shear stress :-

1) Due to torsion :-

$A` = (29.4)^2 = 864.36\ cm^2$

$$\tau_t = \frac{M_t}{2A`.t_{min}} = \frac{8*100}{2*864.36*0.6} = 0.77\ t/cm$$

2) Due to shear:



The shear stress results from (Q_y), not (Q_x):

$$\tau = \frac{Q_y}{I_x} * \frac{S_x}{b}$$

$$= \frac{4t}{10169.1} * \frac{(30*0.6*14.7)+(2*0.6*14.4*7.2)}{0.6*2}$$

$= 0.1275$ t/cm

$\therefore \tau_{total} = 0.77 - 0.1275 = 0.6425$ t/cm

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[7]

A) $\tau = \frac{M_t * t_{max}}{0.33 * \sum b t^3} = \frac{0.1*100*0.3}{0.33(20*4)*(0.3)^3} = 4.2$ t/cm^2

$\theta = \frac{M_t * L}{0.33\, G.\sum b t^3} = \frac{0.1*100*2*100}{0.33*800*(20*4)*0.3^3} = 3.5$ rad.

B) $A` = 19.7*19.7 = 388.09$ cm^2

$\tau = \frac{M_t}{2A`.t_{min}} = \frac{0.1*100}{2*388.09*0.3} = 0.042$ t/cm^2

$\theta = \frac{M_t * L}{4G.A`} * \sum b/t = \frac{0.1*100*2*100}{4*800*388.09} * \frac{(20*4)}{0.3} = 0.42$ rad