— ASSIGNMENT - 9. —

(1)

$M_r = 1100$ N-m.

$d = 50mm = 5 \times 10^{-2}$ m.

$L = 1.5m$.

$$\frac{M}{I} = \frac{\tau}{r}$$

$r = d/2$.

$$\tau_{max} = \frac{1100 \times 5 \times 10^{-2}}{2 \times \frac{\pi}{32} \times (5 \times 10^{-2})^4}$$

$= 44.81$ MPa.

(2)

$$\frac{G\theta}{L} = \frac{M}{I}$$

$$\theta = \frac{ML}{GI}$$

$$= \frac{1100 \times 1.5}{80 \times 10^9 \times \frac{\pi}{32} \times (5 \times 10^{-2})^4}$$

$= 0.0336$ radians

$= 1.925°$

(3)

$$\tau_{max} = \frac{Y}{2} = \frac{1400}{2} = 700 MPa.$$

$$\frac{\tau}{r} = \frac{G\phi}{L}$$

$$\phi = \frac{\tau \times L}{G \times r}$$

$$= \frac{700 \times 1}{80 \times 10^3 \times \frac{(3 \times 10^{-2})}{2}}$$

$= 0.5833$ radians

$= 33.42°$

(4) $\tau_{max} = \frac{Y}{2}$ ... Maximum Shear Stress Criteria.

$= 700 MPa.$

$d_o = 5cm = 5 \times 10^{-2} m$

$d_i = ?$; $G = 80 GPa.$

$$\frac{\tau}{r} = \frac{M}{I}$$

$$700 \times 10^6 \times \frac{\pi}{32} \times \left[d_o^4 - d_i^4\right] \times \frac{1}{d_o/2} = 3750 N\text{-}m.$$

$$\therefore 700 \times 10^6 \times 2 \times \frac{\pi}{32} \times d_o^3 \times \left[1 - \left(\frac{d_i}{d_o}\right)^4\right] = 3750$$

$$1 - \left(\frac{d_i}{d_o}\right)^4 = 0.218.$$

$$\frac{d_i}{d_o} = 0.94$$

$$d_i = 0.94 \times 5 = 4.7\,cm.$$

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$$\frac{\tau}{r} = \frac{M}{I} \quad ; \quad d_o = 8\,cm = 8 \times 10^{-2}$$

$$700 \times 10^6 \times \frac{\pi}{32} \times \left[d_o^4 - d_i^4\right] \times \frac{1}{d_o/2} = 7500\,N\text{-}m.$$

$$700 \times 10^6 \times 2 \times \frac{\pi}{32} \times d_o^3 \times \left[1 - \left(\frac{d_i}{d_o}\right)^4\right] = 7500$$

$$1 - \left(\frac{d_i}{d_o}\right)^4 = 0.1065$$

$$\frac{d_i}{d_o} = 0.9722$$

$$d_i \simeq 7.78\,cm.$$

6, 7.

$\Sigma M_x = 0$

$-M_A - M_C + M_0 = 0$ ... (1)

Geometric Compatibility we have

$\phi_{AB} = \phi_{BC}$. ... (2)

$\frac{M_A}{I_{AB}} = \frac{\phi_{AB} \times G_1}{L_1}$; $\therefore M_A = \frac{\phi_{AB} \times G_1 \times I_{AB}}{L_1}$

$I_{AB} = \pi/32 \times \left(\frac{d_1}{\ }\right)^4$

Similarly $M_B = \frac{\phi_{BC} G_2 I_{BC}}{L_2}$; $I_{BC} = \frac{\pi}{32} \times \left(\frac{d_2}{\ }\right)^4$

From these equations we get.

$$M_A = \frac{M_0}{1 + \left(\frac{L_1}{L_2}\right)\left(\frac{d_2}{d_1}\right)^4}$$

$$M_C = \frac{M_0}{1 + \frac{L_2}{L_1}\left(\frac{d_1}{d_2}\right)^4}$$

8. In figure 1; $M_A = M_C$; $\phi_{AB} = \phi_{BC}$

$\phi_{AB} = \frac{2M_A}{\pi G_1} \times \left(\frac{L_1}{r_1^4}\right)$; $\phi_{BC} = \frac{2M_C}{\pi G_2} \times \left(\frac{L_2}{r_2^4}\right)$.

Using the above relations we get.

$$\left(\frac{G_2}{G_1}\right)\left(\frac{L_1}{L_2}\right)\left(\frac{d_2}{d_1}\right)^4$$

.9.

$$\frac{\tau}{r} = \frac{M}{J}$$

$$\therefore \tau_{max} = \frac{Mr}{J}$$

$$= \frac{M \times d_o/2}{\frac{\pi}{32} \times \left[d_o^4 - \left(\frac{d_o}{2} \right)^4 \right]}$$

$$= \frac{M}{\pi/32 \times d_o^4 \times \frac{15}{16}} \times \frac{d_o}{2}$$

$$\tau_{max} = \frac{256M}{15\pi d_o^3}.$$

$$M = \frac{15\pi d_o^3 \cdot \tau_{max}}{256}.$$

$$H \cdot P = \frac{M_t \times \omega}{76} \quad \ldots \quad \text{where } \omega = \frac{2\pi \times (r \cdot p \cdot m)}{60}$$

$$= \frac{1}{76} \times \frac{15\pi d_o^3 \times \tau_{max} \times 2\pi \times (r \cdot p \cdot m)}{60} \times \frac{1}{256}$$

$$= 2.54 \times 10^{-4} \times [r \cdot p \cdot m] \times \tau_{max} \times d_o^3.$$