Paper: Mechanics Of Materials

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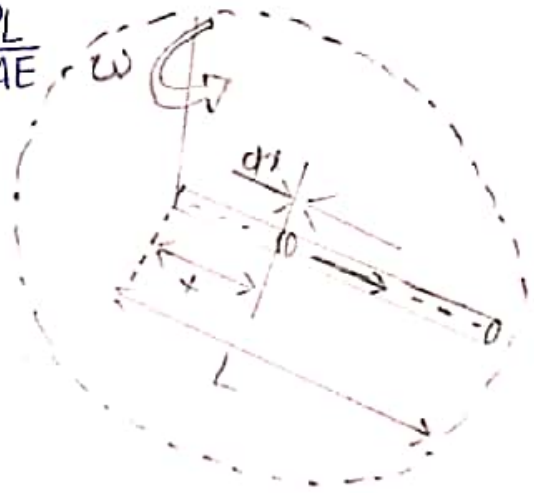
Question NO 1:- A uniform slender rod of length L and cross section area A is rotating in a horizontal plan about a verticle axis through one end. If the unit mass of the rod is P, and it is rotating at a constant angular velocity of ω rad/sec. Show that the total elongation of the rod is $P\omega^2 L^3/3E$.

Solution:-

$$\delta = \frac{PL}{AE}$$



From the figure:

$$d\delta = \frac{dP_x}{AE}$$

Where

dP = centrifugal force of differential mass

$$dP = dM\omega^2 x = (\rho A\, dx)\omega^2 x$$

$$dP = \rho A\omega^2 x\, dx$$

$$d\delta = \frac{(\rho A\omega^2 x\, dx)x}{AE}$$

$$\delta = \frac{\rho\omega^2}{E}\int_0^L x^2 dx = \frac{\rho\omega^2}{E}\left[\frac{x^3}{3}\right]_0^L$$

$$\delta = \frac{\rho\omega^2}{E}[L^3 - 0^3]$$

$$\boxed{\delta = \rho\omega^2 L^3/3E}.$$

Question NO2:-

A steel propeller shaft is to transmit 4.5 mw at 3Hz without exceeding a shearing stress of 50mpa or twisting more than 1° in a length of 26 diameter. Compute the proper diameter if G=83 Gpa.

Solution:-

$$T = \frac{P}{2\pi f} = \frac{4.5(1000000)}{2\pi(3)}$$

$$T = 238732.41\ N.m$$

Based on maximum allowable Shearing Stress:

$$\tau_{max} = \frac{16T}{\pi d^3}$$

$$50 = \frac{16(238732.41)(1000)}{\pi d^3}$$

$$\boxed{d = 289.71mm}$$

Based on maximum allowable angle of twist

$$\theta = \frac{TL}{JG}$$

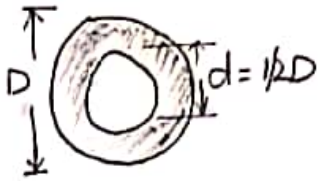
$$1°\left(\frac{\pi}{180°}\right) = \frac{238732.41(26d)(1000)}{\frac{1}{32}\pi d^4(83000)}$$

$$\boxed{d = 352.08mm}$$

Use the larger diameter, thus, d=352mm.

Answer.

Question NO3:- Show that the hollow circular shaft whose inner diameter has a torsional strength equal to 15/16 of that of a solid shaft of the same outside diameter.



Solution:-

Hollow Circular Shaft

$$\tau_{max-hollow} = \frac{16TD}{\pi(D^4-d^4)}$$

$$= \frac{16TD}{\pi[D^4-(\frac{1}{2}D)^4]}$$

$$= \frac{16TD}{\pi(\frac{15}{16}D^4)}$$

$$= \frac{16^2T}{15\pi D^3}$$

Solid Circular Shaft

$$\tau_{max-solid} = \frac{16T}{\pi D^3}$$

$$= \frac{15}{16}\left[\frac{16^2T}{15\pi D^3}\right]$$

$$\tau_{max-solid} = \frac{15}{16} \times \tau_{max-hollow}.$$