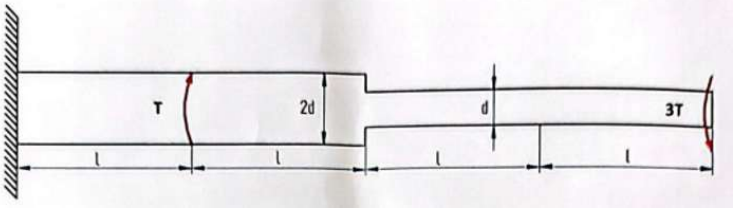
Torsion in Shafts problem Solution

Calculate the maximum value of the torque T which can be applied to the shafts shown in the figures below and the following data:

diameter d = 50 mm, max permited sheer stress k_s = 80MPa, length l = 500 mm, Kirchhoff's module G=85 GPa, also calculate the total twist angle for each shaft.



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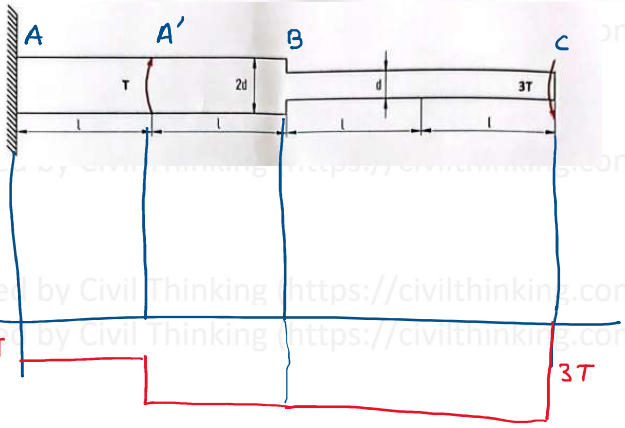

$$\frac{\tau}{\rho} = \frac{T}{J} = \frac{G\phi}{L} \Rightarrow \frac{\tau}{\rho} = \frac{T}{J}$$

$$\frac{\tau_{max}}{R} = \frac{T_{max}}{J}$$

B-C:

$$\frac{80\times10^6}{\frac{0.05}{2}} = \frac{3T}{\frac{\pi\times(\frac{0.05}{2})^4}{2}}$$

$$\Rightarrow T = 654.5\ N.m \quad -(1)$$

For A'B:

$$R = \frac{2d}{2} = d \rightarrow 0.05$$

$$\frac{80\times10^6}{0.05} = \frac{3T}{\frac{\pi\times0.05^4}{2}}$$

$$\Rightarrow T \simeq 5236\ N.m \quad -(2)$$

$$T_{max} = \min(1, 2) = 654.5\ N.m$$

Ans.1

$$\phi_{AB} = \underbrace{\phi_{AA'} + \phi_{A'B}}_{\text{superposition}} = \left(\frac{TL}{GJ}\right)_{AA'} + \left(\frac{TL}{GJ}\right)_{A'B}$$

$$\phi_{AB} = \frac{L}{GJ}\left(T_{AA'} + T_{A'B}\right) = \frac{0.5}{85\times10^9 \times \frac{\pi \times 0.05^4}{2}} \underbrace{(2T+3T)}_{5T}$$

$$= 654.5 \times 5T$$

$$\phi_{AB} = 0.00196 \text{ radians}$$

$$\frac{\tau}{r} = \frac{T}{J} = \frac{G\phi}{L} \Rightarrow \boxed{\phi = \frac{TL}{GJ}}$$

$$\phi_{BC} = \frac{T_{BC} L_{BC}}{G_{BC} J_{BC}} = \frac{3T \times 2l}{85\times10^9 \times \frac{\pi R^4}{2}}$$

$$\phi_{BC} = \frac{3T \times 2 \times 0.5\,m \times 2}{85\times10^9 \times \pi \times 0.025^4} = 0.03765 \text{ rad}$$