STATICS – TORSION – TUTORIAL 2

SELF ASSESSMENT EXERCISE No.1

1. A hollow circular tube is 60 mm outer diameter and has a wall 3 mm thick. Calculate the maximum shear stress when a torque of 250 Nm is applied.

The mean diameter is 57 mm $A_o = \pi(0.057)^2/4 = 0.00255\ m^2$

$$\tau_{max} = \frac{T}{2A_o t} = \frac{250}{2\,(0.00255)(0.003)} = 16.3 \times 10^6\ N/m^2$$

or

$J = \pi D^4/32 = 437.6 \times 10\text{-}9\ m^4$

$$\tau_{max} = \frac{TD}{2J} = \frac{250 \times 0.06}{2\,(437.6 \times 10^{-9})} = 17.14 \times 10^6\ N/m^2$$

2 A rectangular tube has outside dimensions 40 mm x 30 mm and has a wall 2 mm thick. Calculate the maximum shear stress when a torque of 300 Nm is applied.

$A_o = 38 \times 28 = 1064\ mm^2$

$$\tau_{max} = \frac{T}{2A_o t} = \frac{300}{2\,(1064 \times 10^{-6})(0.003)} = 70.5 \times 10^6\ N/m^2$$

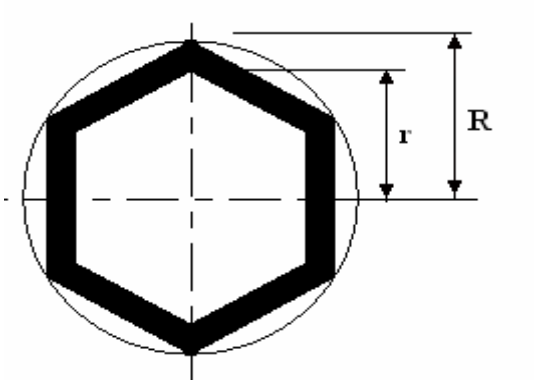
3 A hollow hexagonal tube has a corner radius of 30 mm and a wall thickness of 3 mm. Calculate the maximum shear stress when a torque of 250 Nm is applied.

$R = 0.03\ m \quad t = 0.003\ m \quad r = R - 2t/\sqrt{3} = 26.53\ mm$

$R_m = (R + r)/2 = 28.17\ mm$

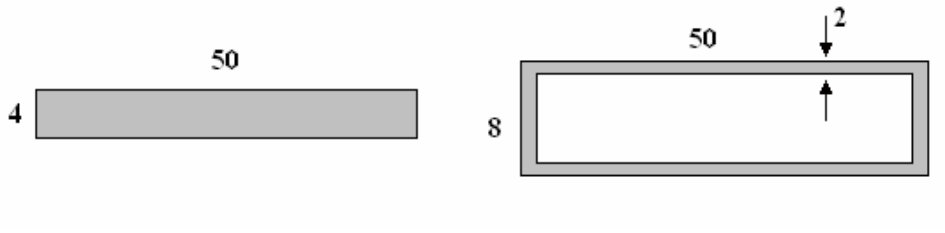
$A_o = (R_m^2)(3)^{3/2}/2 = 2.076 \times 10^{-3}\ m^2$

$$\tau_{max} = \frac{T}{2A_o t} = \frac{250}{2\,(2.076 \times 10^{-3})(0.003)} = 20 \times 10^6\ N/m^2$$



SELF ASSESSMENT EXERCISE No.2

1. Compare the maximum shear stress produced in a thin strip and a hollow rectangular section as shown for a given torque T.



Thin Strip $\tau_{max} = \dfrac{3T}{Bt^2} = \dfrac{3 \text{ x } T}{0.05 \text{ x } 0.004^2} = 3.750 \text{ x } 10^6 T$

Hollow Rectangle $A_o = 48 \text{ x } 6 = 288 \text{ mm}^2$

$$\tau_{max} = \frac{T}{2A_o t} = \frac{T}{2\,(288 \text{ x } 10^{-6})(0.002)} = 0.868 \text{ x } 10^6 \text{ N/m}^2$$

2. Two tubes are made from 3 mm thick metal sheet by rolling them into a cylinder. One has the seam welded and the other does not. The tubes are to transmit a torque of 20 Nm and the maximum shear stress must not exceed 4 MPa. What must be the ratio of the mean diameters of each if they are to have equal torsional strength?

Closed tube $\tau_{max} = 4x10^6 = \dfrac{2T}{\pi D_m^2 t} = \dfrac{2 \text{ x } 20}{\pi \text{ x } D_m^2 \text{ x } 3 \text{ x } 10^{-3}}$

$D_m^2 = 0.00106 \qquad D = 0.0326$

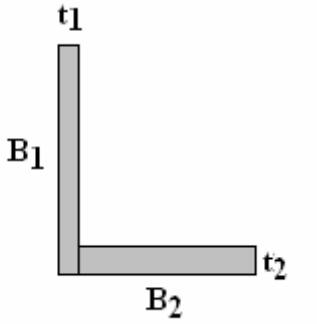
Open tube $\tau_{max} = 4x10^6 = \dfrac{3T}{\pi D_m t^2} = \dfrac{3 \text{ x } 20}{\pi \text{ x } D_m \text{ x } 0.003^2}$

$D_m = 0.53\text{m}$

Ratio = 53/32.6 = 16

3. An 'L' shaped section 0.6 m long is made from thin steel plate 2 mm thick. The section is 60 mm long in both sides. Calculate the maximum shear stress and angle of twist when a torque of 4 Nm is applied. G = 80 GPa.

(Answer 25.42 MPa and 0.095 rad)



$B_1 = B_2 = 60$ mm $\quad t_1 = t_2 = 2$ mm $\quad T = 4$ Nm $\quad G = 80$ GPa

L = 0.6 m

Mean lengths $B_1 = B_2 = 60 - t/2 = 59$ mm

$$\tau_m = \frac{3T}{B_1 t_1^2 + B_2 t_1^2} = 25.4x10^6 \text{ N/m}^2$$

$$\theta = \frac{3TL}{(B_1 t_1^3 + B_2 t_1^3)G} = \frac{3x4x0.6L}{(0.059 \text{ x} 0.002^3 + 0.059 \text{ x} 0.002^3)80x10^9} = 0.095 \text{ rad}$$