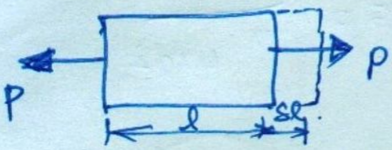
Direct, Bending and Torsional Stresses:-

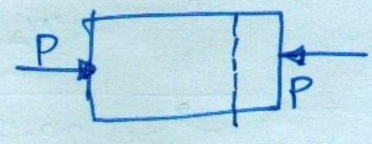
1) Tensile stress:-



$\sigma_t = P/A.$

$e_t = \frac{\delta l}{l}.$

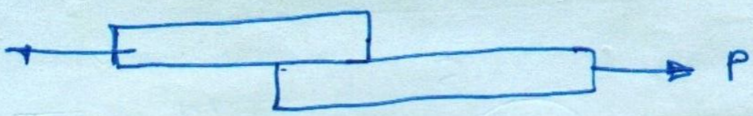
2). Compressive Stress



$\sigma_c = P/A$

$\sigma_c = \frac{\delta l}{l}$

Shear stress:-

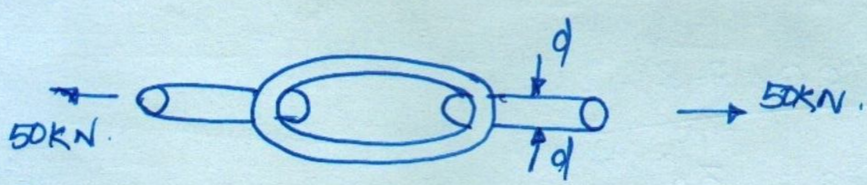


$\sigma_s = P/A.$

Problem

1). A coil chain of a crane is required to carry a maximum load of 50KN. Find the diameter of the link stock, if the ~~perfom~~ permissible tensile stress in the link material is 75mpa.

Given data:-



$P = 50KN = 50\times10^3 N.$

$\sigma_t = 75 MPa = 75\times10^6 N/m^2 \Rightarrow 75 N/mm^2.$

To find:-

$d = ?$

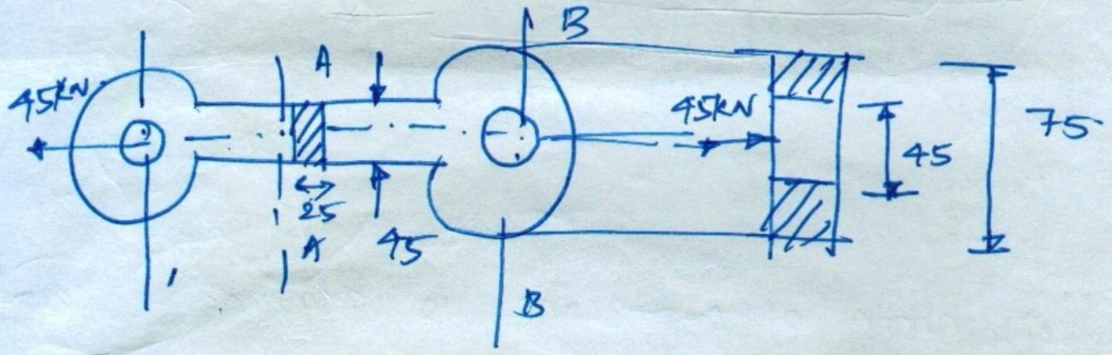
Solution:-

$$\sigma_t = P/A = \frac{50\times10^3}{\pi/4\, d^2} \Rightarrow 75 = \frac{50\times10^3}{\pi/4 \times d^2}.$$

$$\boxed{d^2 = 29.13\ mm}$$

27. A cast iron link is required to transmit a steady tensile load of 45kN. Find the tensile stress induced in the link at section A-A and B-B.

Given data:-



Solution:-

For section A-A:-

Area = 45×25 = 1125 mm^2.

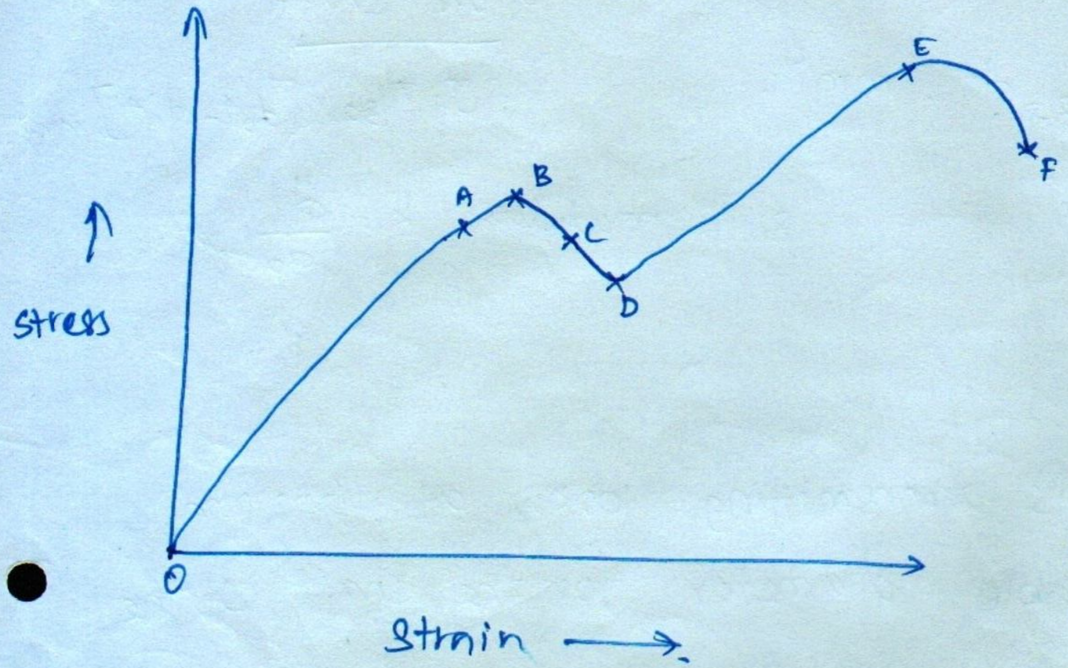
$$\sigma_t = P/A = \frac{45\times10^3}{1125} \Rightarrow \sigma_t = 40\ N/mm^2$$

for section B-B:-

Area = $\overset{(75-45)}{30} \times 20 \Rightarrow 600\ mm^2$.

$\sigma_t = P/A = 45\times10^3/600.$ $\sigma_t = 75\ N/mm^2$

Stress - strain diagram



upto OA the Hook's law will be applicable.

B - yield point. (deformation starts)

C - upper yield point.

D - lower yield point.

E = ~~Ulimi~~ ultimate point.

F = Breaking point.

Torsional and bending Stresses :-

Maximum shear stress : $\boxed{\frac{\tau}{r} = \frac{T}{J} = \frac{C\theta}{l}}$ $r = D/2$

For solid shaft.

Torque, $T = \pi/16 \times \tau \times d^3$.

For hollow shaft

Torque, $T = \pi/16 \times \tau \times \frac{[d_o^4 - d_i^4]}{d_o}$

J = Polar moment of inertia.

Solid shaft:-

$J = \pi/32\, d^4$. mm^4.

Hollow Shaft

$J = \pi/32 \times [d_o^4 - d_i^4]$, mm^4

Bulk modulus, $K = \frac{d_i}{d_o}$ %.

Problems:-

1). A shaft is transmitting 100kW at 160rpm. Find the suitable diameter for the shaft is the maximum torque transmitted exceeds the mean torque by 25%. Take max. allowable shear stress 70 mpa.

Given data:-

$P = 100kW = 100 \times 10^3 W$.

$N = 160$ rpm.

$T_{max} = 1.25 T_{mean}$

$\tau = 70MPa = 70 \times 10^6/10^6\ N/m^2 \Rightarrow 70 N/mm^2$.

$P = \frac{2\pi NT}{60} \Rightarrow P = \frac{2 \times \pi \times 160 \times T}{60}$.

$T = \frac{60 \times 100 \times 10^3}{2 \times \pi \times 160} \Rightarrow \boxed{T = 5968.31\ N\text{-}m.}$

$\boxed{T = 5968.31 \times 10^3\ N\text{-}mm.}$

$\boxed{T_{mean} = 5.968 \times 10^6 \text{ N-mm}}$

$T_{max} = 1.25\, T_{mean}.$

$\boxed{T_{max} = 7.46 \times 10^6 \text{ N-mm}.}$

Diameter of the shaft:-

$\frac{T}{J} = \frac{\tau}{r} = \frac{C\theta}{l}.$

$\frac{T}{J} = \frac{\tau}{r}.$

$$\frac{T}{\pi/32 \times d^4} = \tau/\,d/2$$

$$T = \tau/\,d/2 \times \pi/32 \times d^4.$$

$$T = \frac{\cancel{2} \times \tau \times \pi \times d^{3}}{\cancel{d} \times \cancel{32}\, 16}$$

$$7.46 \times 10^6 = \frac{70 \times \pi \times d^3}{16}$$

$\boxed{d^3 = 542763.83}$

$\boxed{d = 81.57 \text{ mm}.}$

diameter of the shaft (d) = 85 mm.

[From PSG D.D. Book
Pg.no 7.25]

27. A shaft is transmitting 9.75 kW power at 180 rpm, if the allowable shear stress of the shaft material is 60 MPa. Find the suitable diameter of the shaft. The shaft is not to twist upto 1° in the length of 3 m. Take C = 80 GPa.

Given data:-

$P = 9.75\,kW = 9.75 \times 10^3\,W.$

$N = 180\,rpm.$

$\tau = 60\,MPa = 60 \times 10^6\,N/m^2 \Rightarrow 60\,N/mm^2$

$\theta = 1° \Rightarrow 0.0175$ radians.

$l = 3\,m = 3000\,mm.$

$C = 80\,GPa \Rightarrow 80 \times 10^9\,N/m^2 = 80 \times 10^3\,N/mm^2.$

$$P = \frac{2\pi NT}{60}.$$

$$9.75 \times 10^3 = \frac{2 \times \pi \times 180 \times T}{60}$$

$$\boxed{T = 517.2535\,N\text{-}m.}$$

$$\boxed{T = 517.2535 \times 10^3\,N\text{-}mm.} \Rightarrow \boxed{T = 5.17 \times 10^5\,N\text{-}mm}$$

$\frac{T}{J} = \frac{\tau}{r}.$ $\frac{T}{J} = \frac{C\theta}{l}.$

Sol $\frac{5.173 \times 10^5}{\pi/32 \times d^4} = \frac{60}{d/2}.$ $\frac{5.173 \times 10^5}{\pi/32\, d^4} = \frac{80 \times 10^3 \times 0.0175}{3000}$

$\frac{\pi/32\, d^4}{d/2} = \frac{5.173 \times 10^5}{60}$ $\pi/32\, d^4 = \frac{5.173 \times 10^5 \times 3000}{80 \times 10^3 \times 0.0175}$

$\frac{\pi/32 \times 2 \times d^{\cancel{4}}}{\cancel{d}} = 8621.67$ $\pi/32 \times d^4 = 1108500$

$\pi/16 \times d^3 = 8621.67$ $d^4 = 1108500 \times (32/\pi)$

$d^3 = \frac{8621.67}{0.19635}$ $d^4 = 11291088.28$

$d^3 = 43909.70$ $\boxed{d = 57.97\ mm}$

$\boxed{d = 35.28\ mm}$

Take the largest diameter (d) = 57.97 mm.

Diameter (d) = 60mm. [From PSG D.D. Book pg.no 7.25].