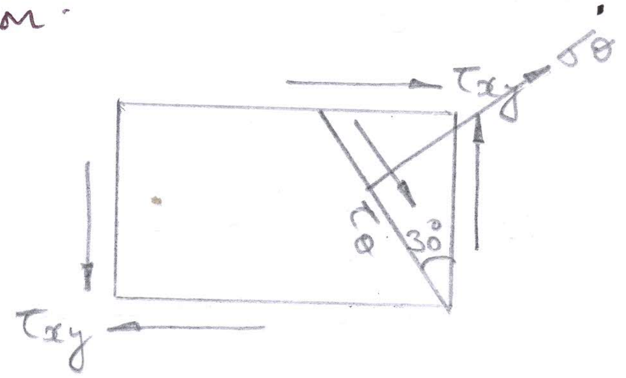
Solutions for IAT - 1 (2016-17, odd)

Sem : 5th A & B CI : RPR.

Sub : DME I (10ME52) Max. Marks : 50

1A A point in a machine member is subjected to pure shear stress of magnitude $50 N/mm^2$. Determine i) Stresses acting in a plane inclined at $30°$ to vertical plane ii) principal stresses and their locations and iii) Max. shear stress and its location.



Ans: data

$\tau_{xy} = 50 N/mm^2$

$\theta = 30°$

to find

i) σ_θ, τ_θ

2) σ_1 & σ_2, θ_1 & θ_2.

3) τ_{max}, θ_3.

1) σ_θ, τ_θ

$\sigma_\theta = \tau_{xy} \sin 2\theta$

$= 43.3 N/mm^2$

$\tau_\theta = \tau_{xy} \cos 2\theta$.

$= 25 N/mm^2$.

2) σ_1, σ_2 and θ_1, θ_2

$\sigma_1 = \tau_{xy} = 50 N/mm^2$

$\sigma_2 = -\tau_{xy} = -50 N/mm^2$

$\theta_1 = 90^\circ$ (measured in CCW direction with X +ve).

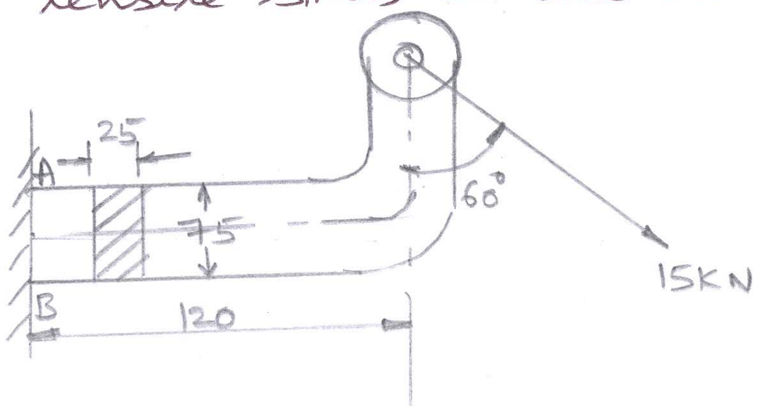
$\theta_2 = 270^\circ$ (" " ")

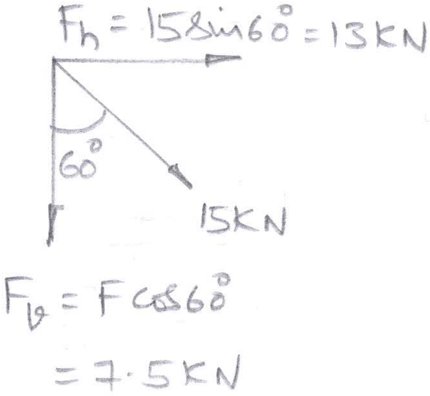
3) τ_{max}, θ_3

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \tau_{xy} = 50 N/mm^2$$

$\theta_3 = 90^\circ$

1B A bracket shown in figure 1B, is subjected to a pull of 15 KN at 60° to the vertical. Determine the max. tensile stress in the bracket.





Ans: data

$b = 25 mm$

$h = 75 mm$

$A = 1875 mm^2$

to find

Max. tensile stress in the bracket.

i) Consider F_v : This force produces B.M in the section

$$\sigma_{b1} = \frac{M_b}{Z_b}.$$

where $M_b = F_v \times 120$

$= 7.5 \times 10^3 \times 120$

$= 9 \times 10^5$ N-mm.

$$Z_b = \frac{bh^2}{6} = \frac{25 \times 75^2}{6} = 23.43 \times 10^3 \text{ mm}^3.$$

$$\therefore \sigma_{b1} = \frac{9 \times 10^5}{23.43 \times 10^3} = 38.41 \text{ N/mm}^2$$

$(\sigma_{b1})_A = 38.41$ N/mm^2

$(\sigma_{b1})_B = -38.41$ N/mm^2.

ii) consider F_h : This is an eccentric load for the section AB. Therefore it induces both direct and bending stresses in the section AB.

$$\sigma_t = \frac{F_h}{A} = \frac{13 \times 10^3}{1875} = 6.93 \text{ N/mm}^2.$$

$$\sigma_{b2} = \frac{M_b}{Z_b} = \frac{F_h \cdot e}{\left(\frac{bh^2}{6}\right)} = \frac{13 \times 10^3 \times 60}{\left(\frac{25 \times 75^2}{6}\right)}$$

$= 33.28$ N/mm^2

$(\sigma_{b2})_A = 33.28$ N/mm^2

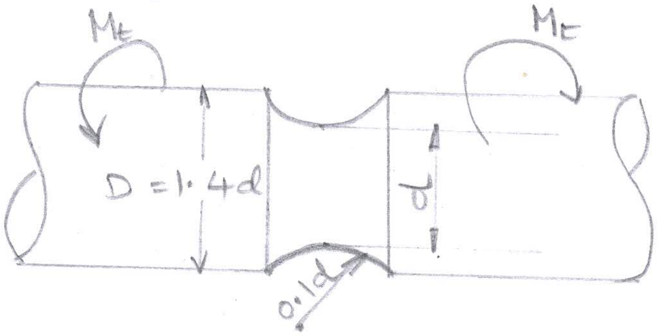
$(\sigma_{b2})_B = -33.28$ N/mm^2.

$\therefore$ Max. tensile stress at A $= \sigma_{b1} + \sigma_{b2} + \sigma_t$

$= 38.41 + 33.28 + 6.93$

$= 78.62$ N/mm^2.

2A A grooved shaft shown in figure is to transmit 5KW at 120 RPM. Determine the dia. of shaft at the groove, if it is made of C15 steel ($\sigma_y = 235.4$ MPa) & F.S = 2.



Ans: data

$N = 5KW$

$n = 120 rpm$

$\sigma_y = 235.4 MPa$

$FS = 2$

to find

$d = ?$

$$M_t = 9550 \times 10^3 \times \frac{N}{n}$$

$$= 9550 \times 10^3 \times \frac{5}{120}$$

$$= 397.91 \times 10^3 \text{ N-mm}$$

$$\sigma_{max} = \frac{\sigma_y}{FS} = \frac{235.4}{2} = 117.7 \text{ N/mm}^2$$

$$\tau_{max} = \frac{\sigma_{max}}{2} = 58.85 \text{ N/mm}^2$$

Fig 4.18A / P 4.18

$r = 0.1d$

$\frac{r}{d} = 0.1$

$D = 1.4d$

$$\frac{D}{d} = 1.4$$

$$\therefore K_\tau = 1.48$$

Now $K_\tau = \dfrac{\tau_{max}}{\tau_{nom}} = \dfrac{\tau_{max}}{\left(\frac{M_t}{Z_t}\right)} = \dfrac{\tau_{max} \times Z_t}{M_t}$.

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

$$\therefore \cancel{K_\tau}\ 1.48 = \frac{58.85 \times \pi d^3}{16 \times 397.91 \times 10^3}$$

$$\Rightarrow d = 37.07\,mm \text{ say } 37.5\,mm.$$

$\therefore$ dia of shaft at groove $= 37.5\,mm$.

2 B Determine the diameter of a round rod to sustain a combined torsional load of 1500 N-m and a bending moment of 1000 N-m by the following theories of failure. Material selected for the rod has a value of 300 MPa and 180 MPa for the normal stress and shear stress at yield respectively. Take a value of 2.5 for F.S.

(i) Max. shear stress theory &

ii) octahedral shearing stress theory.

Ans: data

$M_t = 1500$ N-m
$= 1500 \times 10^3$ N-mm.

$M_b = 1000 \times 10^3$ N-mm.

$\sigma_y = 300\ N/mm^2$

$\tau_y = 180\ N/mm^2$ (additional data)

$n = 2.5$

to find

$d = ?$

Torsional shear stress $(\tau) = \dfrac{M_t}{Z_t}$

$$= \frac{1500 \times 10^3 \times 16}{\pi d^3}$$

$$= \left(\frac{7.64 \times 10^6}{d^3}\right) N/mm^2$$

Bending stress $(\sigma_b) = \dfrac{M_b}{Z_b}$

$$= \frac{1000 \times 10^3 \times 32}{\pi d^3}$$

$$= \left(\frac{10.18 \times 10^6}{d^3}\right) N/mm^2$$

Max. principal stress $(\sigma_1) = \dfrac{\sigma_b}{2} + \sqrt{\left(\dfrac{\sigma_b}{2}\right)^2 + \tau^2}$

$$= \frac{10.18 \times 10^6}{2d^3} + \sqrt{\left(\frac{10.18 \times 10^6}{2d^3}\right)^2 + \left(\frac{7.64 \times 10^6}{d^3}\right)^2}$$

$$= \left(\frac{14.27 \times 10^6}{d^3}\right) N/mm^2$$

Min. principal stress $(\sigma_2) = \dfrac{10.18 \times 10^6}{2d^3} - \sqrt{\left(\dfrac{10.18 \times 10^6}{2d^3}\right)^2 + \left(\dfrac{7.64 \times 10^6}{d^3}\right)^2}$

$$= -\left(\frac{4.09 \times 10^6}{d^3}\right) N/mm^2$$

(i) Max. shear stress theory

$$\sigma_1 - \sigma_2 = \frac{\sigma_y}{n}$$

$$\Rightarrow d = 53.48 \text{ mm}$$

octahedral shearing stress theory

$$\sqrt{\sigma_1^2+\sigma_2^2-\sigma_1\sigma_2} = \frac{\sigma_y}{n}$$

$\Rightarrow d = 51.81 \text{ mm}$

$\therefore$ select $d = 55 \text{ mm}$ (T14.6 / P14.13).

3A An elevator carrying a load of 10KN is descending by means of a steel rope at a speed of 1m/sec. The c/s area of rope is 400 mm². The rope is suddenly brought to rest by braking. The elevator comes to rest after 30 sec of descent. Calculate the stress induced in the rope due to sudden stoppage, if the Young's modulus for the rope material is 80,000 MPa.

Ans: data

$F = 10 \text{ KN}$

$v = 1 \text{ m/sec}$

$A = 400 \text{ mm}^2$

$t = 30 \text{ sec}$

$E = 80{,}000 \text{ MPa}$

$= 80{,}000 \text{ N/mm}^2$

to find

$\sigma_i = ?$

Resilience of rope = K.E of elevator

$$\frac{\sigma_i^2}{2E} \times V = \frac{1}{2} m v^2$$

$$\frac{\sigma_i^2}{2E}(Al) = \frac{1}{2}\left(\frac{F}{g}\right) v^2 \quad \text{---(1)}$$

where l = length of rope
= dist. moved by elevator after the brake is applied.
= dist. moved in 30 sec. time.

retardation $(a) = \frac{1}{30}$ m/sec^2.

Now, $v^2 - u^2 = -2as$.

here $v = 0$

$u = 1$ m/sec.

$\therefore \quad 0 - 1 = -2 \times \frac{1}{30} \times s$.

$s = 15$ m

$\therefore$ length of rope $(l) = 15$ m
$= 15000$ mm.

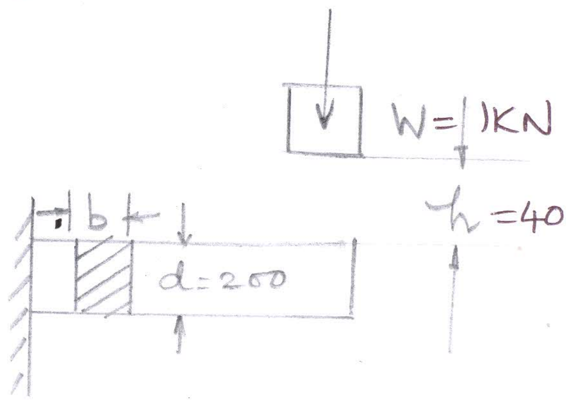
Sub in (1)

$$\frac{\sigma_i^2 \times (400 \times 15000)}{2 \times 80,000} = \frac{1}{2}\left(\frac{10 \times 10^3}{9.81}\right) 1^2 \times 10^3$$

$\Rightarrow \sigma_i = 116.58$ N/mm^2.

3B A cantilever beam of span 800 mm has a rectangular cross section of depth 200 mm. The free end of beam is subjected to a transverse load of 1 KN that drops on to it from a height of 40 mm. Selecting C40 steel ($\sigma_y = 328.6$ MPa) and FS = 3, determine the width of rectangular section. Take E = 206.8 GPa. 9

Ans: <u>data</u>



$l = 800$ mm

$d = 200$ mm

$W = 1$ KN.

$h = 40$ mm

$$\sigma_{bi} = \frac{\sigma_y}{FS} = \frac{328.6}{3} = 109.53 \text{ N/mm}^2$$

<u>to find</u>

$b = ?$

$$\sigma_{bi} = (\sigma_b)_{st}\left[1 + \sqrt{1 + \frac{2h}{\delta_{st}}}\right] \quad \text{---(1)}$$

$$(\sigma_b)_{st} = \frac{M_b}{Z_b} = \frac{Fl}{\left(\frac{bd^2}{6}\right)} = \left(\frac{120}{b}\right) \text{ N/mm}^2$$

$$\delta_{st} = \frac{Fl^3}{3EI} = \frac{1\times10^3 \times 800^3 \times 12}{3 \times 206.8\times10^3 \times b \times 200^3}$$

$$= \left(\frac{1.24}{b}\right) \text{ mm.}$$

Sub in (1).

$$109.53 = \frac{120}{b}\left[1 + \sqrt{1 + \frac{2 \times 40b}{1.24}}\right]$$

Solving, $b = 79.82\,mm$.