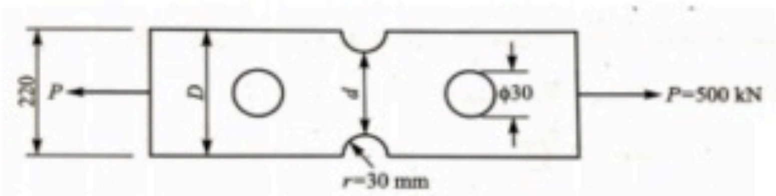
USN

Internal Assessment Test 4 – Jan. 2021

Sub:	Design of Machine Elements I					Sub Code:	18ME52	Branch:	Mech
Date:	09.01.2021	Duration:	90 min's	Max Marks:	50	Sem / Sec:	V/A&B		OBE

	<u>Answer All the Questions</u>	MARKS	CO	RBT
1	A machine weighing 30 kN is raised by a Single start square threaded screw of 50 mm diameter, 8 mm pitch screw jack at a maximum speed of 8m/min. If the coefficient of friction for the threads is 0.2, Determine the power required to lift the machine. The thrust collar of the screw has inside diameter 30 mm and outside diameter 60 mm. The coefficient of friction of collar is 0.2.	[20]	CO4	L3
2 a)	Derive an expression for impact stress induced in a member subjected to bending.	[10]	CO4	L3
b)	A cantilever beam of width 60 mm, depth 140 mm is 1.2 m long. A weight of 1 kN is dropped from a height of 20 mm at its free end. Determine (i) Impact factor (ii) Instantaneous maximum deflection (iii) Instantaneous maximum stress. (iv) Instantaneous maximum load. Take E = 200 GPa.	[10]		
3	A bar of rectangular cross section is subjected to an axial pull of 500 kN. Calculate its thickness if the allowable tensile stress in the bar is 200 MPa.	[10]	CO4	L3



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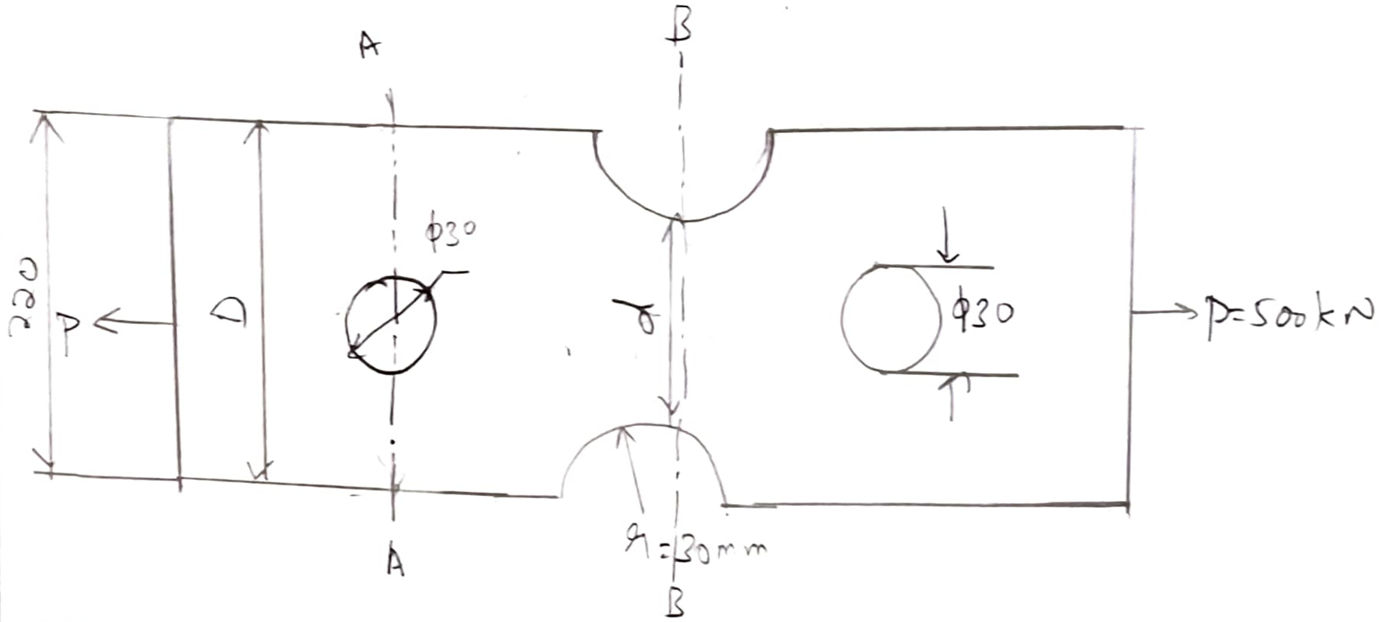
DME IAT-IV

①

Answer-3



To find the required thickness of the given plate, select two sections, one across the hole i.e. AA the other across the notch i.e. BB

i) Consider the section A-A

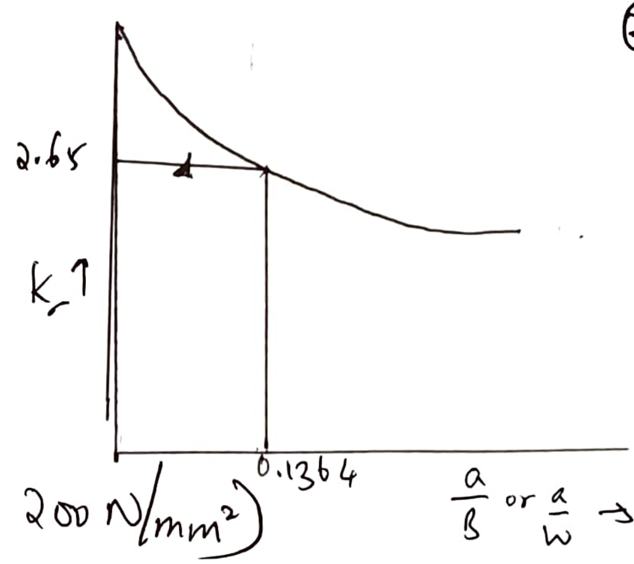
Width of the plate W = 220 mm; Diameter of hole d or a = 30 mm; $\frac{a}{B}$ or $\frac{a}{W} = \frac{30}{220} = 0.1364$

From figure for $\frac{a}{B}$ or $\frac{a}{W} = 0.1364$

Stress concentration factor $k_{t} = 2.65$

Also $K_\sigma = \dfrac{\sigma_{max}}{\sigma_{nom}}$

i.e. $2.65 = \dfrac{200}{\sigma_{nom}}$



$[\because \sigma_{max} = 200\ N/mm^2]$

$\therefore \sigma_{nom} = 75.472\ N/mm^2$

For Axial Load $\sigma_{nom} = \dfrac{F}{A} = \dfrac{F}{(W-a)h}$ or $\dfrac{F}{(B-a)t}$

i.e. $75.472 = \dfrac{500\times10^3}{(220-30)h}$

$\therefore h = 34.868\ mm$

ii) Consider the section B-B

W or $D = 220mm$; $d = D - 2R = 220 - 2\times30$
$= 160mm$;

$\sigma_{max} = 200\ Mpa$, $P = F = 500kN = 500\times10^3 N$

$\therefore \dfrac{W}{d}$ or $\dfrac{D}{d} = \dfrac{220}{160} = 1.375$; $\dfrac{r}{d} = \dfrac{30}{160} = 0.1875$

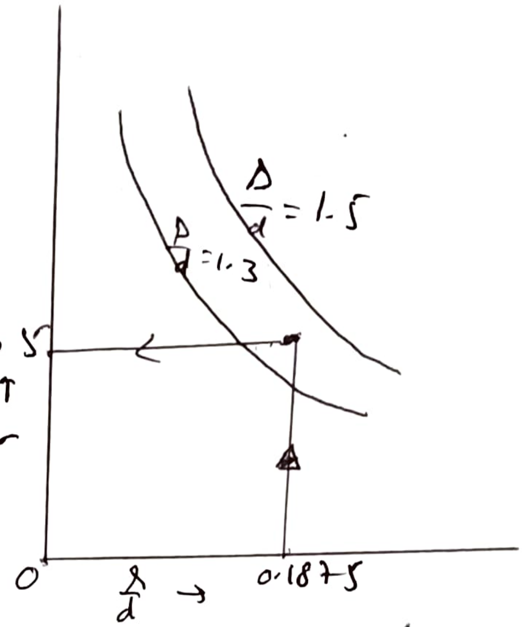
From fig for $\frac{r}{b}$ or $\frac{r}{d} = 0.1875$ and $\frac{D}{d}$ or $\frac{B}{b} = 1.375$

Stress conc. factor $k_\sigma = 2.05$

Also $k_\sigma = \frac{\sigma_{max}}{\sigma_{nom}}$

i.e. $2.05 = \frac{200}{\sigma_{nom}}$

$\therefore \sigma_{nom} = 97.561 \ N/mm^2$



For axial load $\sigma_{nom} = \frac{F}{A}$ where $A = h.d$

$\therefore 97.561 = \frac{500 \times 10^3}{h \times 160}$

$h = 32 \ mm$

Thickness of plate $h = 34.868$ mm, say 35 mm

(Adopt the larger value)

(4)

Answer-1

Given $W = 30kN = 30{,}000\,N$

$l = p = 8mm \quad d = 50\,mm$

$V = 8\,m/min \quad \mu = 0.2 \quad N = ?$

$d_{ci} = 30mm \quad d_{co} = 60mm \quad \mu_c = 0.2$

* Minor diameter of the screw

$d_1 = d - P = 50 - 8 = 42mm$

* Pitch diameter $d_2 = \frac{d+d_1}{2} = \frac{50+42}{2} = 46mm$

* $\tan\alpha = \frac{l}{\pi d_2} = \frac{8}{\pi \times 46} = 0.055$

(1) Power required to lift the machine

Velocity $= V = 8\,m/min = 8 \times 1000\,mm/min$

$\therefore$ Speed of the screw $n = \frac{V}{l} = \frac{8000}{8} = 1000rpm$

mean diameter of collar

$d_c = \frac{d_{co}+d_{ci}}{2} = \frac{60+30}{2}$

$= 45mm$

From eqn 18.29

Total frictional torque including collar friction

$$m_t = W\left[\frac{d_2}{2}\left(\frac{\tan\alpha + \mu}{1 - \mu\tan\alpha}\right) + \frac{\mu_c d_c}{2}\right].$$

$$M_t = 30{,}000\left[\frac{46}{2}\left(\frac{0.055 + 0.2}{1 - (0.2 \times 0.055}\right) + \frac{0.2 \times 45}{2}\right]$$

$$M_t = 313255.81 \text{ N-mm}$$

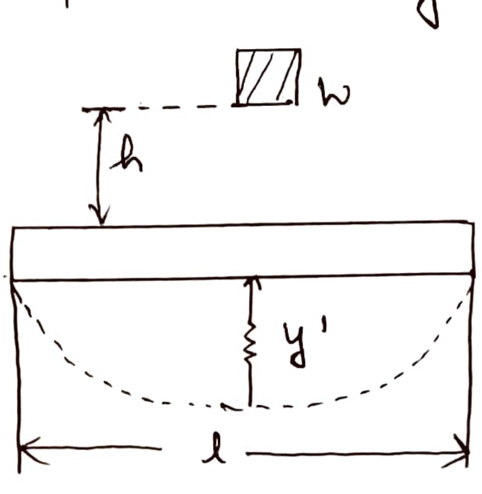
$$M_t = 9550 \times 1000 \times \frac{N}{n}$$

$$313255.81 = 9550 \times 1\cancel{000} \times \frac{N}{1\cancel{000}}$$

$$\boxed{N = 32.80\,\text{kw}}$$

<u>Answer-2</u>

(a) <u>Impact and bending</u>



Consider a weight 'W' is dropped from a height 'h' as a simply supported beam as shown in figure which produces an instantaneous deflection 'y' and stress σ_b'

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(6)

Let A = Cross section of beam

I = Moment of Inertia of beam

M = Bending moment of beam

l = Length of beam

δ_{max} (or) y' = Deflection of beam due to impact

δ_{st} or y = Static deflection due to weight 'W'

σ_{bmax} or σ_{b_i} or σ_b' = Stress induced in the beam due to impact

σ_{bst} or σ_b = Bending stress due to static weight W

h = Height through which the weight falls

W = Weight of the body

Now, the work done by falling weight is given by the expression $W(h+y')$ (or) $W(h+\delta_{max})$ — (1)

Let W_e be the equivalent static load which produces the same amount of deflection y', then strain energy

$$U = \frac{1}{2} W_e y' \quad — (2)$$

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Equating ① and ②

$$\frac{1}{2} W_e y' = W(h+y')$$

$$W_e = 2W = \left(\frac{h+y'}{y'}\right) \quad \text{— ③}$$

the deflection of the beam under static equivalent load W_e at the Centre of beam is given by.

$$y' = \frac{W_e l^3}{48EI} \quad \text{— ④}$$

Substituting the value of W_e in equation ④

$$y' = \frac{2W(h+y')}{y'} \cdot \frac{l^3}{48EI} \quad \text{— ⑤}$$

But, $\frac{Wl^3}{48EI} = y$ = Static deflection due to weight 'W'

Eqn ⑤ becomes

$$y' = \frac{2(h+y')}{y'} \cdot y$$

(or) $y'^2 - 2yy' - 2hy = 0$

$$\therefore y' = \frac{2y \pm \sqrt{4y^2 + 8hy}}{2}$$

$$= \frac{2y + \sqrt{4y^2\left(1 + \frac{2hy}{y^2}\right)}}{2}$$

$$= \frac{2y + 2y\sqrt{1 + \frac{2h}{y}}}{2}$$

$$y' = y\left[1 + \sqrt{1 + \frac{2h}{y}}\right]$$

or $\delta_{max} = \delta_{st}\left[1 + \sqrt{1 + \frac{2h}{\delta_{st}}}\right]$ Eqn 3-2 DHB

Multiplying both sides of above eqn by $\frac{8EI}{l^3}$

$$\delta_{max} \frac{8E_c}{l^2} = \delta_{st} \cdot \frac{8E_c}{l^2}\left[1 + \sqrt{1 + \frac{2h}{\delta_{st}}}\right]$$

$$\sigma_b' = \sigma_b\left[1 + \sqrt{1 + \frac{2h}{\delta_{st}}}\right] \rightarrow \text{Eqn } 3.26\text{ C}$$

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Impact factor = $\left[1 + \sqrt{1 + \frac{2h}{\delta_{st}}}\right]$

(2b) <u>Given</u> $b = 50mm$ $d = 140mm$

$l = 1.2m = 1200mm$

$W = 1kN = 1000N$

$h = 20mm$ $E = 200 Gpa = 20 \times 10^4 N/mm^2$

<u>Maximum bending moment</u>

$M_b = W \times l = 1000 \times 1200 = 12 \times 10^5 Nmm$

<u>Maximum static Deflection</u> (: Cantilever)

$$y = \frac{Wl^3}{3EI}$$

$$I = \frac{bd^3}{12} = \frac{60 \times 140^3}{12} = 13720000 mm^4$$

$$\therefore y = \frac{1000 \times (1200)^3}{3 \times 20 \times 10^4 \times 1372 \times 10^4} = 0.2099mm$$

i) <u>Impact factor</u>

$$\boxed{1 + \sqrt{1 + \frac{2h}{y}}} = 1 + \sqrt{1 + \frac{2 \times 20}{0.2099}}$$

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ii) Instantaneous maximum Deflection

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$$\boxed{y' = y \times \text{Impact factor}}$$

$= 0.2099 \times 14.84 = 3.1149\ mm$

iii) Instantaneous maximum ~~force~~ Stress

$$\boxed{\sigma_b' = \sigma_b \times \text{Impact factor}}$$

= Where $\sigma_b = \frac{M_b}{I}(c) = \frac{12 \times 10^5}{1372 \times 10^4}\left(\frac{140}{2}\right)$

$= 6.12\ N/mm^2$

$\sigma_b' = 6.12 \times 14.84$

$= 90.82\ N/mm^2$

iv) Instantaneous maximum load

$W' = W \times \text{Impact factor}$

$= 1000 \times 14.84$

$= 14840\ N$