Important Instruction to Examiners:-

1) The answers should be examined by key words & not as word to word as given in the model answers scheme.

2) The model answers & answers written by the candidate may vary but the examiner may try to access the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance.

4) While assessing figures, examiners, may give credit for principle components indicated in the figure.

5) The figures drawn by candidate & model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credit may be given step wise for numerical problems. In some cases, the assumed contact values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding.

7) For programming language papers, credit may be given to any other programme based on equivalent concept.

Important notes to examiner

Q-1 (a) i) Define moment of inertia. state it's value for semi circle about it's centroid.

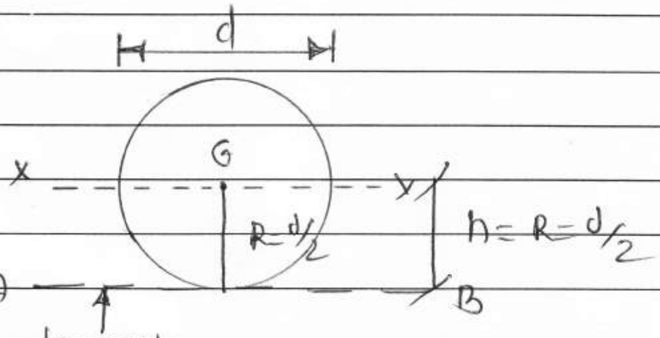
→ a) moment of inertia of section is defined as the product of area of a section and the square of the distance between the centroid of section and reference axis.
it is also called as second moment of area. 01M

b) moment of inertia value for semi circle

$I_{xx} = 0.11 R^4$ ½M

$I_{yy} = \frac{\pi R^4}{8}$ ½M

ii) find moment of inertia of solid circular lamina of diameter 'd' about it's tangent.



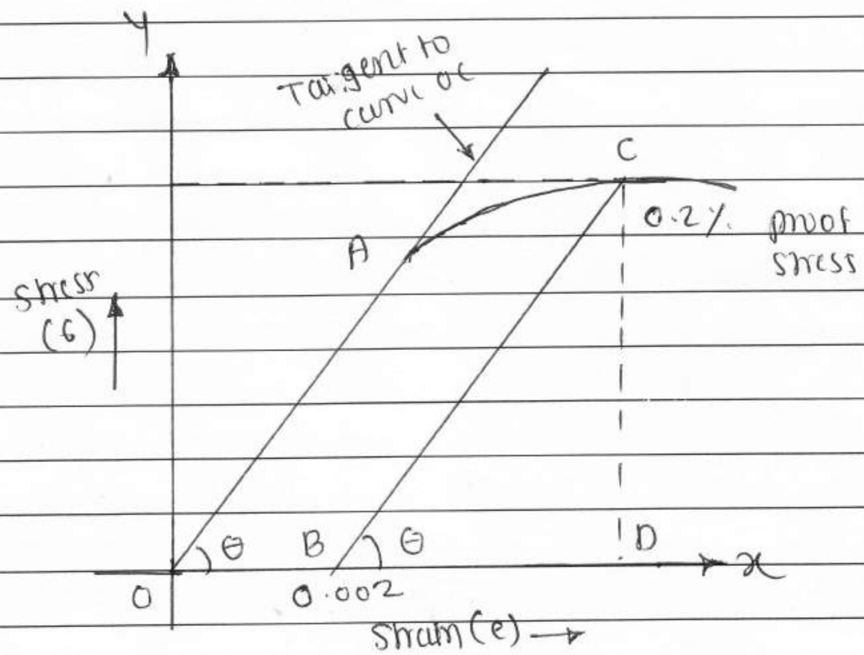
let AB be the tangent to the circular lamina.
By applying parallel axis theorem.

$I_{AB} = I_{tangent} = I_G + Ah^2 = \frac{\pi}{64} d^4 + \left(\frac{\pi d^2}{4} \times \frac{d}{2}\right)^2$ 1M

$I_{AB} = \frac{\pi d^4 + 4\pi d^4}{64}$

$I_{AB} = \frac{5\pi d^4}{64}$ $\boxed{I_{AB} = 0.245 d^4}$ 1M

iii) Draw stress-strain curve for HYSD bar. 2 M



2 M

iv) Define proof stress & ultimate stress. 02M

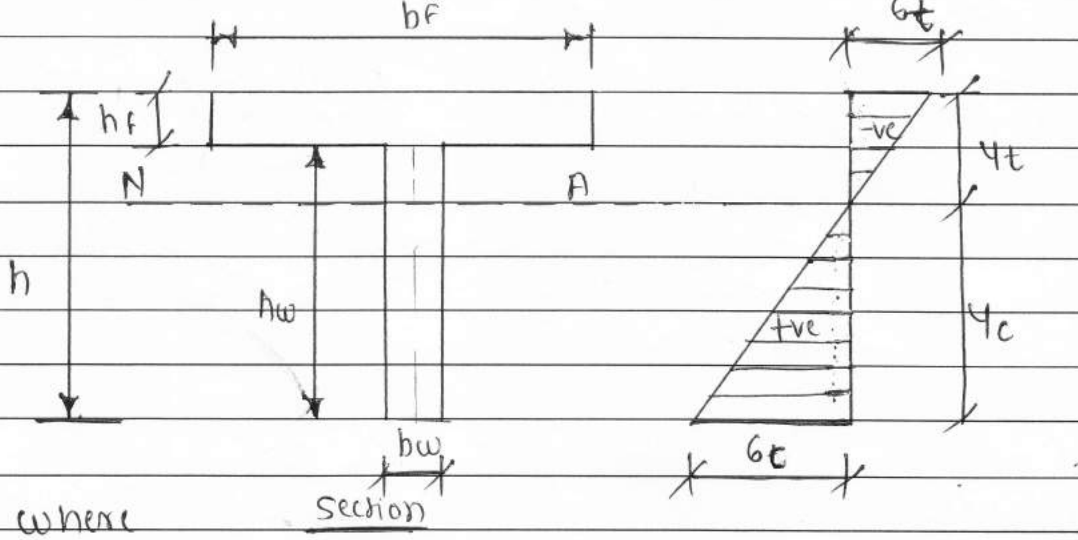
a) proof stress :

offset yield point (proof stress) when a yield point is not easily defined based on the shape of the stress-strain curve an offset yield point is arbitary defined the value for this is commonly set at 0.1 or 0.2% plastic strain 01M

b) ultimate stress

ultimate tensile strength, often shortened to tensile strength or ultimate strength, is the capacity of a material or structure to with stand loads tending to elongate, as opposed to compressive strength, which with stands loads tending to reduce size. 01M

v) Draw a bending stress distribution diagram for a T- section used as cantilever beam



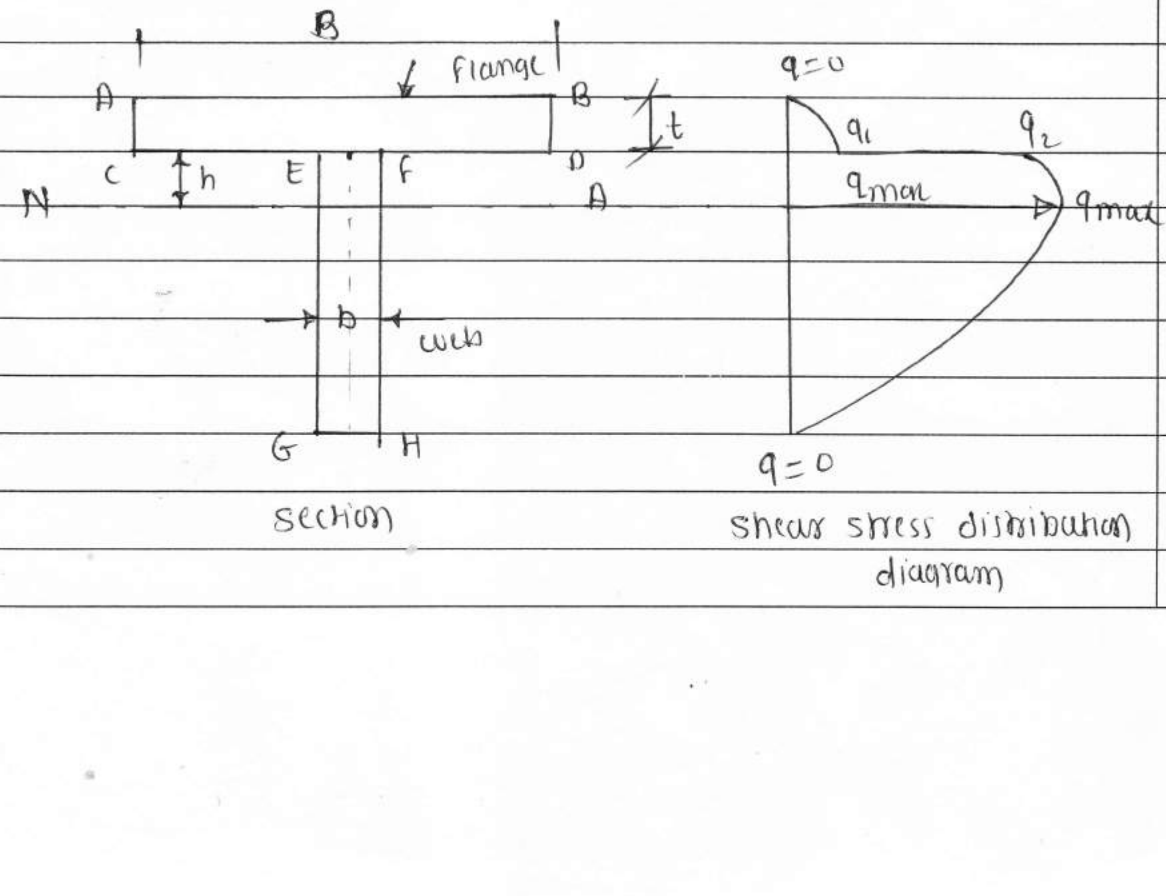
1 M section

1 M Bending stress diagram

where

h = height of the beam
b_w = width of the web
b_f = flange width
h_f = flange thickness
h_w = web height.

vi) Draw shear stress distribution diagram for a T- section used as SSB.

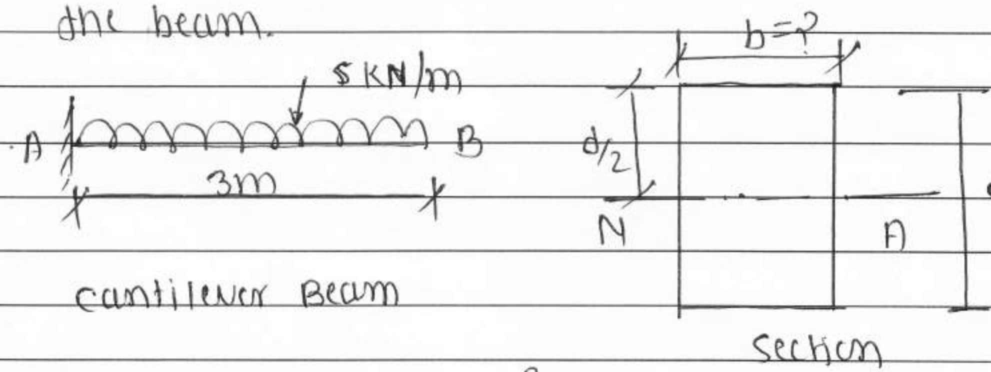


1 M section

1 M shear stress diagram

	vii) Define radius of gyration and slenderness ratio	
	a) radius of gyration radius of gyration or gyration refers to the distribution of the component of an object around an axis in terms of mass moment of inertia; it is the perpendicular distance from the axis of rotation to a point mass (of mass m) that gives an equivalent inertia to the original object (s).	01M
	b) slenderness ratio slenderness ratio is the ratio of the length of a column and the least radius of gyration	01M
	viii) Assumptions in Euler's column Theory i) the material of the column is perfectly homogenous and isotropic ii) The column is initially straight and of uniform lateral dimensions iii) the load on the column is exactly axial. iv) the column is long and fails due to buckling or bending v) the self weight of the column is neglected. vi) The column is stressed up to the limit of proportionality.	1M each

b) i) A cantilever beam of rectangular section supports udl of 5 KN/m. the span of the beam is 3m. if the maximum bending stress is 100 N/mm² and the depth of the beam is 1.5 times the width, determine the size of the beam.



i) $B.M_{max} = (M) = \frac{wL^2}{2}$

$$M = \frac{5 \times 3^2}{2} = 22.5 \text{ KN.m} = 22.5 \times 10^6 \text{ N.mm} \quad \tfrac{1}{2}M$$

$$y = d/2 = \frac{1.5d}{2}$$

$$I = I_{NA} = \frac{bd^3}{12} = \frac{b \times (1.5b)^3}{12} = \frac{(1.5)^3 \times b \times b^3}{12} = \frac{3.375 b^4}{12} \quad \tfrac{1}{2}M \quad \tfrac{1}{2}M$$

ii) To find the size of the beam

$$\frac{M}{I} = \frac{\sigma_b}{y} \qquad \frac{22.5 \times 10^6}{\frac{3.375 b^4}{12}} = \frac{100}{1.5 b/2} \quad 1M$$

$$\therefore \frac{12 \times 22.5 \times 10^6}{3.375 b^4} = \frac{2 \times 100}{1.5 b} \quad \tfrac{1}{2}M$$

$$\frac{12 \times 22.5 \times 10^6 \times 1.5}{3.375 \times 2 \times 100} = \frac{b^4}{b}$$

$$b^3 = 600 \times 10^3$$

$b = 84.34$ mm $\boxed{b = 85 \text{ mm}}$ ½M

$d = 1.5b = 1.5 \times 85 = 127.5$ mm say $= 128$ mm ½M

$b \times d = 85\text{mm} \times 128\text{mm}$ ... Ans

ii) for applying Euler's formula, find the minimum value of slenderness ratio for mild steel strut with both ends fixed Take yield stress as 315 Mpa and E = 210 Gpa

→ $$\sigma = \frac{\pi^2 E}{\left(\frac{Le}{K}\right)^2} = \frac{\pi^2 E}{\lambda^2}$$ 1M

$$\therefore \lambda^2 = \frac{\pi^2 E}{\sigma}$$ 1M

$$\therefore \lambda = \sqrt{\frac{\pi^2 E}{\sigma}}$$

$$\lambda = \sqrt{\frac{\pi^2 \times 210 \times 10^3}{315}}$$ 1M

$$\boxed{\lambda = 81.11}$$ 1M

iii) Differentiate gradual load and sudden load 4M

gradual load	sudden load	
i) The type of loading starting from zero and slowly increasing uniformly.	i) when a load as a whole is applied instantly on a body, then it is called as suddenly applied load.	1M each
ii) UTM is used for gradual load	ii) Load acting on weighing machine.	
iii) Example : tension test on mild steel	iii) Load of person while entering into lift.	
iv) Formula for stress $\sigma = \frac{P}{A}$	iv) Formula for stress $\sigma = \frac{2P}{A}$	

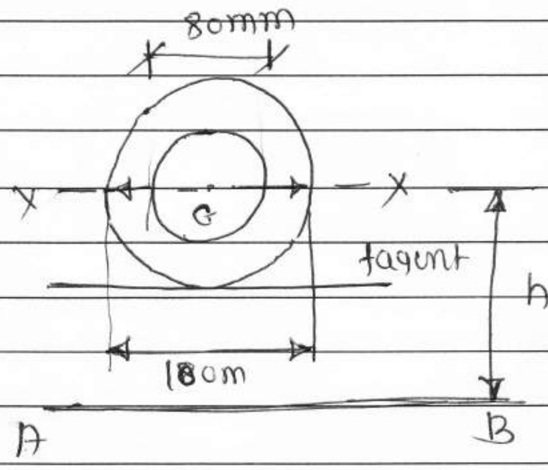
Q-2 (a) A hollow circular section of external diameter 100 mm has a uniform thickness of 10 mm calculate its moment of inertia with respect to
i) Diameter
ii) Tagent to bottom of circle
iii) the axis parallel to and 20 mm below the tagent

i) To find M.I w.r.t diameter
let
I_{dia} = M.I w.r.t diameter

$I_{dia} = I_{xx} = I_G = \frac{\pi}{64}(D^4 - d^4)$ — 1M

$I_{dia} = \frac{\pi}{64}(100^4 - 80^4)$

$\boxed{I_{dia} = 2.898 \times 10^6\ mm^4}$ — 1M



ii) To find the M.I w.r.t tagent to the circle — ½M for fig

$I_{tgt} = I_G + Ah^2$ — ½M

$A = \frac{\pi}{4}(D^2 - d^2) = \frac{\pi}{4}(100^2 - 80^2)$

$A = 2827.33 mm^2$ — ½M

$h = D/2 = \frac{100}{2} = 50 mm$ — ½M

$I_{tgt} = 2.898 \times 10^6 + 2827.33 \times 50^2$ — 1M

$\boxed{I_{tgt} = 9.966 \times 10^6\ mm^4}$

iii) To find the M.I for the axis parallel to and 20mm below the tagent

using parallel axis theorem. we get

$I_{AB} = I_G + Ah^2$ ½M

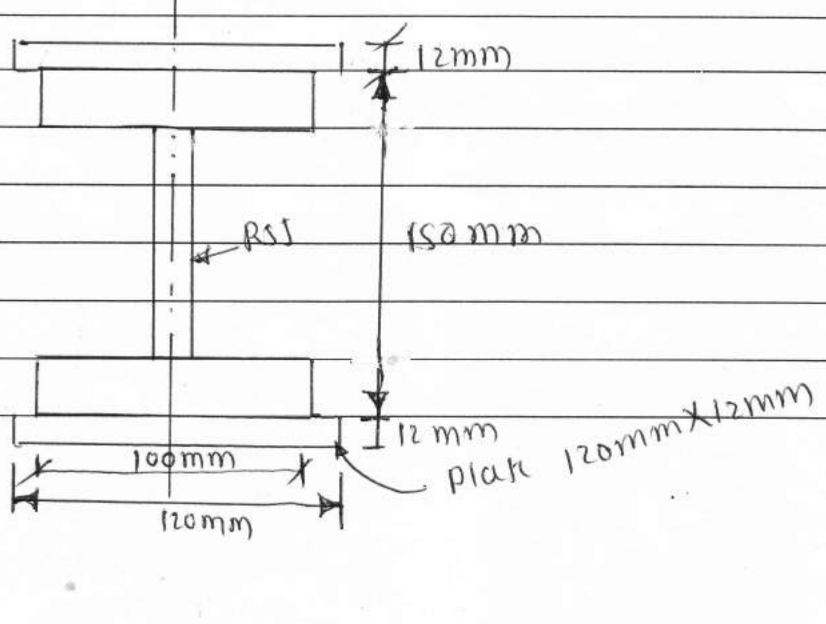
$h = \frac{D}{2}$ + Distn besn two parallel axis ½M

$h = \frac{100}{2} + 20$ $\boxed{h = 70\text{ mm}}$

$I_{AB} = 2.898 \times 10^6 + 2827.33 \times 70^2$

$\boxed{I_{AB} = 16.75 \times 10^6\text{ mm}^4}$ 02M

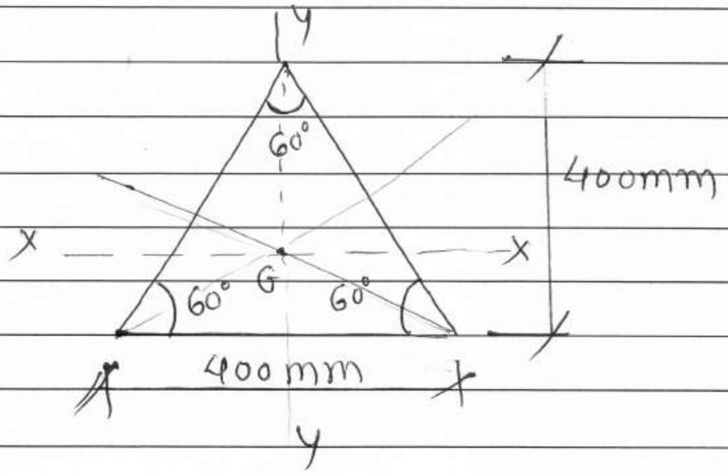
b) A steel stanchion is built up of 100mm x 150 mm RSJ with one 120mm x 12mm plate revetted to each flange.
the over all depth of Stachion is is 174mm.
calculate moment of inertia about the centroidal axes properties of RSJ are Area = 2167mm²
$I_{xx} = 8.39 \times 10^6\text{ mm}^4$ $I_{yy} = 0.98 \times 10^6\text{ mm}^4$



1M

	Given data	
	for RSJ	
	$A = 2167\ mm^2$	
	$I_{xx} = 8.39 \times 10^6\ mm^4$	
	$I_{yy} = 0.98 \times 10^6\ mm^4$	
	i) To find I_{xx} & I_{yy} of plate (120x12mm) from dia	
	$b = 120\ mm,\ d = 12\ mm$	
	$I_{xx\,plate} = 2\left[\frac{bd^3}{12} + Ah^2\right]$	1M
	$A = 120 \times 12 = 1440\ mm^2$	
	$h = \left(\frac{150}{2} + \frac{12}{2}\right) = 75 + 6 = 81\ mm$	1M
	$I_{xx} = 2\left[\frac{120 \times 12^3}{12} + 1440 \times 81^2\right]$	
	$I_{xx} = 18.930 \times 10^6\ mm^4$	1M
	Now	
	$I_{xx\,total} = I_{xx\,RSJ} + I_{xx\,plate}$	1M
	$= 8.39 \times 10^6 + 18.43 \times 10^6$	
	$\boxed{I_{xx\,total} = 27.32 \times 10^6\ mm^4}$	
	similar	
	$I_{yy\,plate} = 2\left[\frac{db^3}{12}\right] = 2\left[\frac{12 \times 120^3}{12}\right]$	1M
	$\boxed{I_{yy\,plate} = 3.456 \times 10^6\ mm^4}$	1M
	$I_{yy} = I_{yy\,RSJ} + I_{yy\,plate}$	
	$= 0.98 \times 10^6 + 3.456 \times 10^6$	
	$\boxed{I_{yy\,total} = 4.436 \times 10^6\ mm^4}$	1M

c i) for an equilateral triangle of side 400mm. show that MI about the horizontal and vertical centroidal axis are equal.



i) $\sin 60° = \frac{h}{400}$ $\therefore h = 400 \sin 60°$

$\boxed{h = 346.41 \text{ mm}}$ 01M

$I_{xx} = I_G = \frac{bh^3}{36} = \frac{400 \times (346.41)^3}{36}$

$I_{xx} = 461.88 \times 10^6 \text{ mm}^4$ 01M

ii) To find M.I about vertical centroidal axis ie I_{yy}

$I_{yy} = I_G = \frac{hb^3}{48} = \frac{346.41 \times 400^3}{48}$ 01M

$I_{yy} = 461.88 \times 10^6 \text{ mm}^4$ 01M c ii) A bar of c/s area 200 mm^2 is axially pulled by force P kN. if the maximum stress induced in the bar is 30 Mpa. determine 'P' if elongation of 1.2 mm is observed over a guage length 3m determine young's modulus

→

$A = 200\ mm^2$ $L = 3m$

$P = P$ $\delta L = 1.2mm$

$\sigma = 30\ N/mm^2$

$$E = \frac{\sigma}{e}$$

$$\therefore e = \frac{\delta L}{L} = \frac{1.2}{3000} = 4 \times 10^{-4}$$ 01M

$$\therefore E = \frac{\sigma}{e} = \frac{30}{4 \times 10^{-4}} \quad \therefore \boxed{E = 75 \times 10^{3}\ Mpa}$$ 01M

$$\delta L = \frac{P \cdot L}{A \cdot E}$$

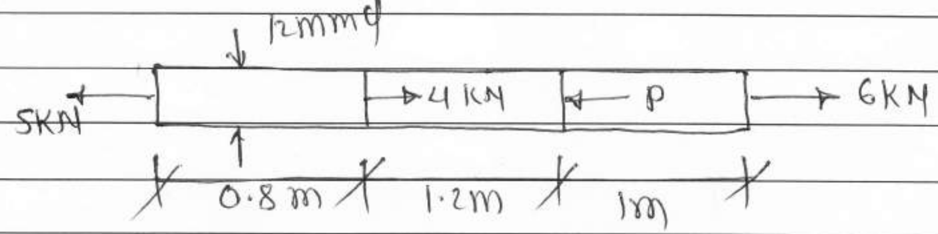
$$\therefore 1.2 = \frac{P \times 3000}{200 \times 75 \times 10^{3}}$$ 01M

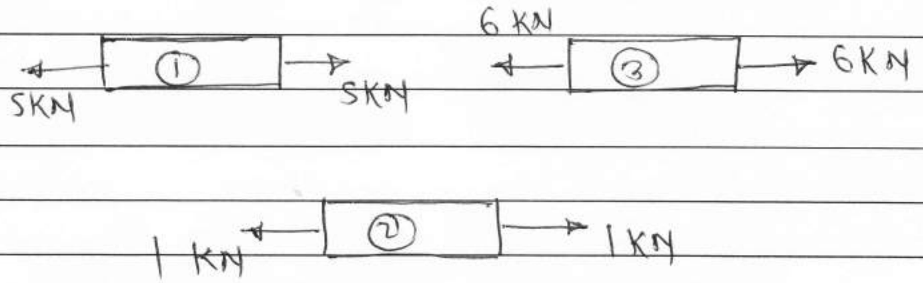
$$\therefore 1.2 \times 200 \times 75 \times 10^{3} = P \times 3000$$

$$\therefore P = \frac{1.2 \times 200 \times 10^{3} \times 75}{3000}$$

$$\therefore \boxed{P = 6\ kN}$$ 01M

Q-3 (a) Determine load P and total elongation in the bar shown in fig having 12mm diameter $E = 2\times10^5\ N/mm^2$





1M

$E = 200\ Gpa$

$L_1 = 0.8m = 800mm$

$L_2 = 1.2m = 1200mm$

$L_3 = 1.2m = 1000mm$

$\Sigma fx = 6 - P + 4 - 5$

$\Sigma fx = 0$

$\therefore\ 6 - P + 4 - 5 = 0$

$\boxed{P = 5\ KN}$ 2M

$\therefore\ A = \frac{\pi}{4} \times 12^2 = 113.09\ mm^2$

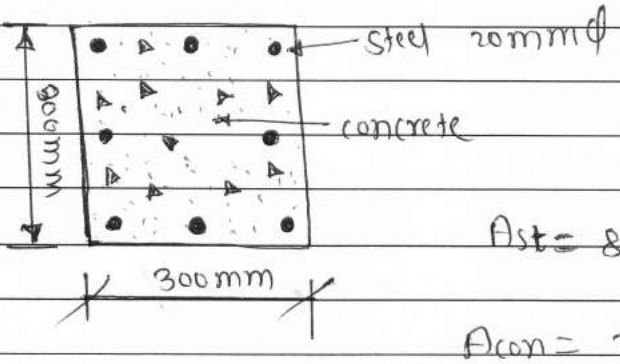
$\delta L = \delta L_1 + \delta L_2 + \delta L_3$ 1M

$\delta L = \frac{P_1L_1}{AE} + \frac{P_2L_2}{AE} + \frac{P_3L_3}{AE} = \frac{1}{AE}(P_1L_1 + P_2L_2 + P_3L_3)$ 02M

$\delta l = \frac{1}{113.09 \times 200}[(5\times800) + (1\times1200) + (6\times1000)]$ 01M

$\boxed{\delta L = 0.495\ mm}$ 01M

b) A reinforced concrete column is 300x300mm in section reinforced with 8 bars of 20 mm dia.
the column carries a load of 360 kN. find the stresses in concrete and steel bars
Take $E_s = 2.1 \times 10^5$ N/mm^2 $E_c = 1.4 \times 10^4$ N/mm^2



σ_{st} = stress in steel
σ_{con} = stress in concrete

$A_{st} = 8 \times \frac{\pi}{4} \times 20^2 = 2513.27$ mm^2

$A_{con} = 300^2 - 2513.27$

$A_{con} = 87486.726$ mm^2 — 01M

we know

$\sigma_{st} = m\, \sigma_{con}$ — 01M

$\sigma_{st} = 15 \times \sigma_{con}$

$P = P_{st} + P_{con}$

$\therefore P = \sigma_{st} A_{st} + \sigma_{con} A_{con}$ — 01M

$360 \times 10^3 = \sigma_{st} \times 2513.27 + \sigma_{con}\, 87486.726$

$360 \times 10^3 = 15\, \sigma_{con} \times 2513.27 + \sigma_{con} \times 87486.726$ — 01M

$360 \times 10^3 = \sigma_{con} (15 \times 2513.27 + 87486.726)$

$360 \times 10^3 = \sigma_{con} (125.185 \times 10^3)$

$\sigma_{con} = \frac{360 \times 10^3}{125.185 \times 10^3}$ — 02M

$\boxed{\sigma_{con} = 2.87 \text{ N/mm}}$ — 01M

$\sigma_{st} = 15 \times \sigma_{con}$

$\sigma_{st} = 15 \times 2.87$

$\boxed{\sigma_{st} = 43.05 \text{ N/mm}^2}$ — 01M

Q-3 (c) A steel rod 4 m long and 20 mm diameter is subjected to an axial tensile load of 45 KN. Find the change in length and diameter of the rod. $E_s = 2\times10^5$ N/mm². poissons ratio $\left(\frac{1}{m}\right) = \frac{1}{4}$

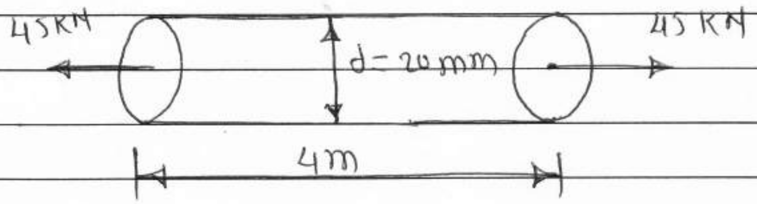
→ $L = 4\,m = 4000\,mm$

$d = 20\,mm$

$P = 45\,KN$

$E_s = 2\times10^5\,N/mm^2$

$\frac{1}{m} = \frac{1}{4} = \mu = 0.25$



i) To find change in length (δL)

we know

$$\delta L = \frac{PL}{AE} = \frac{45\times10^3\times4000}{\frac{\pi}{4}\times20^2\times2\times10^5}$$ 01M

$\delta L = 2.86\,mm$ (increase due to tensile load) 01M

ii) To find change in diameter (δd)

Linear strain $(e) = \frac{\delta L}{L}$ 01M

$$e = \frac{2.86}{4000}$$

$e = 7.15\times10^{-4}$ 01M

	Lateral strain $(e_{ba}) = -\mu \cdot e$	01M
	$= -0.25 \times 7.15 \times 10^{-4}$	
	$= -1.7875 \times 10^{-4}$	01M
	But lateral strain $= \frac{\delta d}{d}$	
	$-1.7875 \times 10^{-4} = \frac{\delta d}{d}$	01M
	$\therefore \delta d = -1.7875 \times 10^{-4} \times d$	
	$\delta d = -1.7875 \times 10^{-4} \times 20$	
	$\boxed{\delta d = -3.575 \times 10^{-3}\ mm}$	01M

Q4a) Given

$L - 200\,mm$ $\quad \sigma_x = 120\,MPa$ $\quad \delta V = 140\,mm^3$

$b - 40\,mm$ $\quad \sigma_y = 40\,MPa$ $\quad E = 200\,GPa.$

$t - 40\,mm$ $\quad \sigma_z = 40\,MPa$

→ Volumetric strain of a rectangular body subjected to tri-axial loading is given by.

$$\frac{\delta V}{V} = \left[\frac{\sigma_x + \sigma_y + \sigma_z}{E}\right](1-2\mu) \quad \text{—(i)}$$ 3M

$V = b \times t \times L = 40 \times 40 \times 200 = 320 \times 10^3\,mm^3$

$\delta V = 140\,mm^3$

$\sigma_x = 120\,MPa$

$\sigma_y = \sigma_z = 40\,MPa.$

$E = 200\,GPa = 200 \times 10^3\,N/mm^2$

$$\therefore \quad \frac{140}{320 \times 10^3} = \left[\frac{120+40+40}{200 \times 10^3}\right](1-2\mu)$$ 1M

$$4.375 \times 10^{-4} = 1 \times 10^{-3}\,(1-2\mu)$$ 1M

$$\frac{4.375 \times 10^{-4}}{1 \times 10^{-3}} = 1-2\mu$$

$$0.4375 = 1-2\mu$$

$$0.4375 - 1 = -2\mu$$ 1M

$$-0.5625 = -2\mu$$

$$\therefore \mu = \frac{0.5625}{2}$$

$$\therefore \mu = 0.28125 \cong 0.28$$

$\therefore$ Poisson's ratio $\mu = 0.28$ 2M

Q4 b) Given

$d = 20\,mm\,\phi$ $\quad \delta L = 0.32\,mm$

$L = 200\,mm$ $\quad \delta d = 0.0085\,mm$

$P = 100\,KN$

1) Stress $\sigma = \frac{P}{A} = \frac{100\times10^3}{\frac{\pi}{4}\times20^2} = 318.309\,N/mm^2$ 1M

2) Strain $e = \frac{\delta L}{L} = \frac{0.32}{200} = 1.6\times10^{-3}$ 1M

3) Youngs Modulus $E = \frac{\sigma}{e} = \frac{318.309}{1.6\times10^{-3}} = 198.94\times10^3\,N/mm^2$

$E = 198.94\times10^3\,N/mm^2$ 1M

4) Poissons ratio $\mu = \frac{\text{lateral strain}}{\text{linear strain}}\ \frac{e_L}{e}$

lateral strain $e_L = \frac{\delta d}{d} = \frac{0.0085}{20} = 4.25\times10^{-4}$ 1M

$\therefore\ \mu = \frac{4.25\times10^{-4}}{1.6\times10^{-3}} = 0.2656 \cong 0.266$

$\mu = 0.266$ 1M

5) Modulus of rigidity G

$E = 2G(1+\mu)$ ½M

$\therefore\ G = \frac{E}{2(1+\mu)} = \frac{198.94\times10^3}{2(1+0.266)}$

$\therefore\ G = 78.57\times10^3\ N/mm^2$ 1M

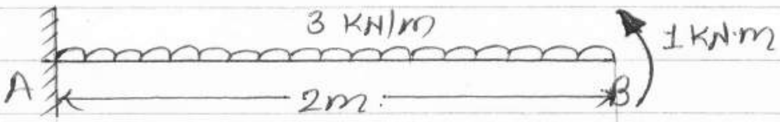
6) Bulk Modulus K

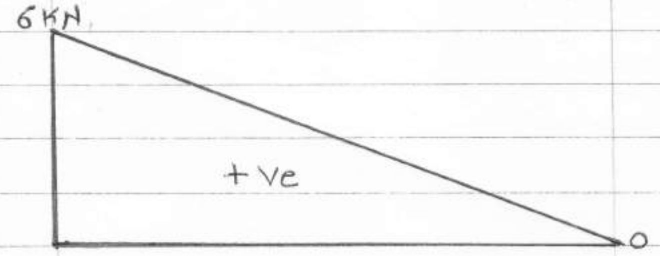
$E = 3K(1-2\mu)$ ½M

$K = \frac{E}{3(1-2\mu)} = \frac{198.94\times10^3}{3(1-2\times0.266)}$

$\therefore\ K = 141.69\times10^3\ N/mm^2$ 1M

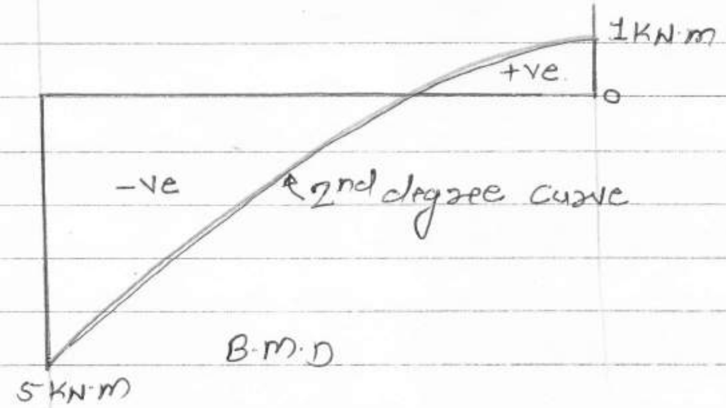
Q4 c)





S.F.D

1½ M



B.M.D

1½ M

1) Support Reaction

i) $\Sigma F_y = 0$ $R_A - (3 \times 2) = 0$ $\therefore R_A = 6$ KN. — 1M

2) S.F. Calculation

S.F at just left of A = 0 KN.

S.F at just right of A = R_A = 6 KN — 2M

S.F at B = $R_A - (3 \times 2) = 6 - (3 \times 2) = 0$ KN

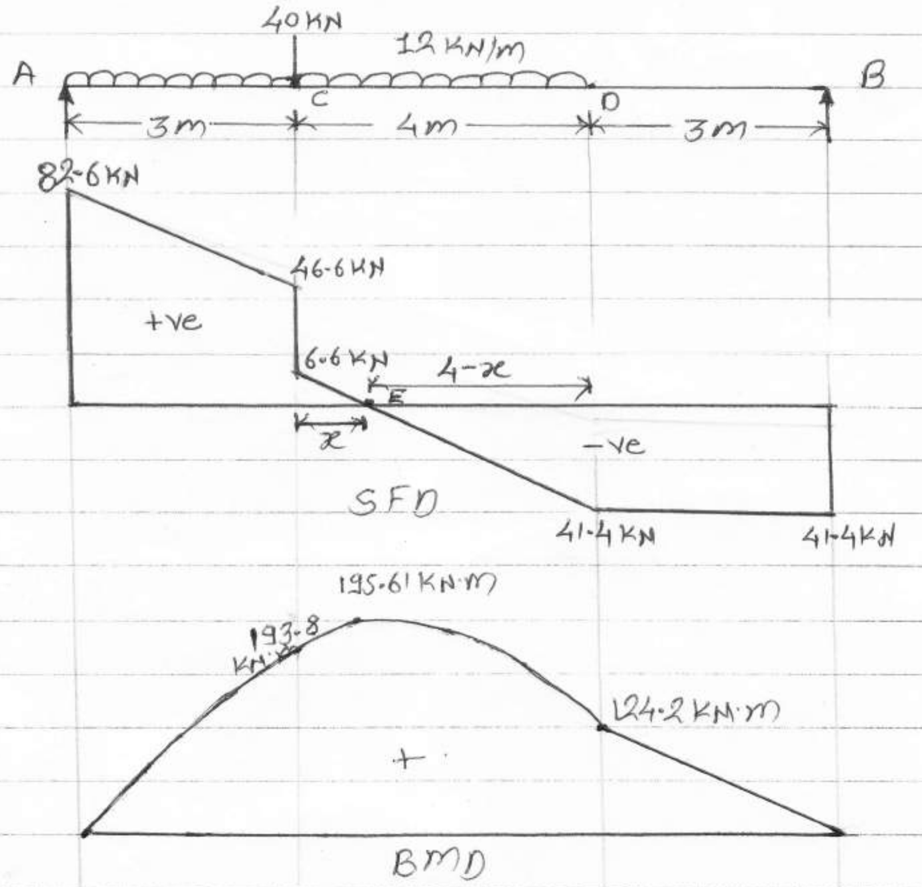
3) B.M. Calculation

B.M at just right of B = 0 KN·m.

B.M at just left of B = 1 KN·m — 2M

B.M at A = $1 - (3 \times 2 \times 1) = -5$ KN·m.

Q5a) →



$1\frac{1}{2}$ M

$1\frac{1}{2}$ M

1) Support reactions

i) $\Sigma F_y = 0$; $R_A + R_B - 40 - (12 \times 7) = 0$ $\therefore R_A + R_B = 124$ KN

ii) $\Sigma M @ A = 0$; $(40 \times 3) + (12 \times 7 \times 3.5) - R_B \times 10 = 0$

$\therefore R_B = 41.4$ KN $\therefore R_A = 82.6$ KN 1M

2) S.F. Calculation.

S.F at just left of A = 0 KN

S.F at just right of A = R_A = 82.6 KN

S.F at just left of C = $82.6 - (12 \times 3) = 46.6$ KN

S.F at just right of C $= 46.6 - 40 = 6.6$ KN

S.F at D $= 6.6 - (12 \times 4) = -41.4$ KN 2M

S.F at just left of B = −41.4 KN

S.F at just right of B $= -41.4 + R_B = 0$ KN.

To locate point E i.e. Point of Contrashear

$$\frac{6.6}{x} = \frac{41.4}{4-x}$$

Q5a) cont...

$6.6(4-x) = 41.4x$

$26.4 - 6.6x = 41.4x$

$26.4 = 48x$

$\therefore x = 0.55\,m$ from C point.

3) B.M. Calculation.

B.M at A = B.M at B = 0 KN.m .... S.S. ends

B.M at C $= R_A \times 3 - (12\times3\times1.5) = (82.6\times3) - (12\times3\times1.5)$

$= 193.8$ KN.m

B.M at D $= R_A\times7 - (12\times7\times3.5) - (40\times4)$ 2M

$= 82.6\times7 - (12\times7\times3.5) - (40\times4)$

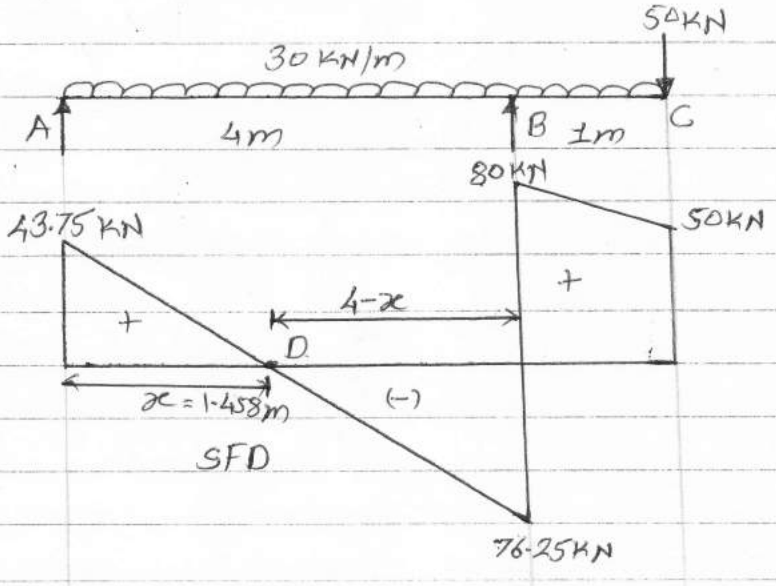
$= 124.2$ KN.m.

Maximum B.M at E $= (R_A\times3.55) - (12\times3.55\times\frac{3.55}{2}) - (40\times0.55)$

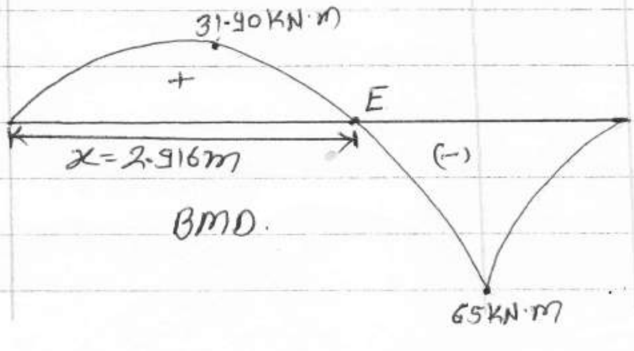
$= (82.6\times3.55) - (12\times3.55\times\frac{3.55}{2}) - (40\times0.55)$

$= 195.67$ KN.m

Q5b →



$1\frac{1}{2}$M



$1\frac{1}{2}$M

Q5b) Contn..

1) Support reaction

i) $\Sigma F_y = 0$; $R_A + R_B - (30\times5) - 50 = 0$ $\therefore R_A + R_B = 200$ KN

ii) $\Sigma M@A = 0$; $(30\times5\times2.5) + (50\times5) - R_B\times4 = 0$

$625 = 4R_B$

$\therefore R_B = 156.25$ KN

$\therefore R_A = 200 - 156.25 = 43.75$ KN — 1M

2) S.F Calculation

SF at just left of $A = 0$ KN

SF at just right of $A = R_A = 43.75$ KN

SF at just left of $B = 43.75 - (30\times4) = -76.25$ KN — 1M

SF at just right of $B = -76.25 + 156.25 = 80$ KN

S.F at just left of $C = 80 - (30\times1) = 50$ KN

SF at just right of $C = 50 - 50 = 0$ KN.

To locate point D i.e. point of Contrashear/zeroshear

$$\frac{43.75}{x} = \frac{76.25}{4-x}$$

$43.75(4-x) = 76.25x$

$\therefore x = 1.458$ m from A.

3) B.M. Calculation

B.M at $A = 0$ KN.m S.S. end

BM at $C = 0$ KN.m free end of overhang.

BM at $B = R_A\times4 - 30\times4\times2 = 43.75\times4 - 30\times4\times2 = -65$ KN.m

BM at $D = (43.75\times1.458) - (30\times1.458\times1.458/2) = 31.90$ KN.m — 2M

*To locate point E i.e. point of Contraflexure.

Take section xx at x from A in portion AB

$M_x = R_A\cdot x - 30\cdot x\cdot\frac{x}{2} = 43.75x - \frac{30x^2}{2}$

But at point E, $M_x = 0$.

$\therefore 0 = 43.75x - 30x^2/2$

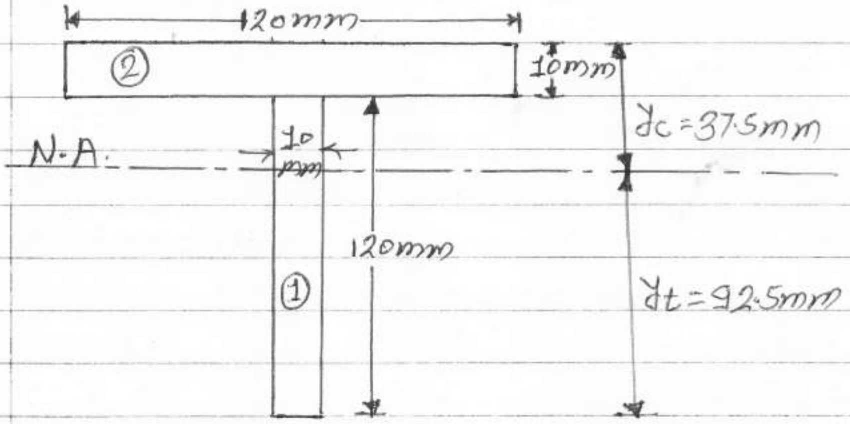
$30x^2 = 2\times43.75x$

$\therefore x = 2.916$ m from A. — 1M

Q5 c)

→ $\sigma_{bt} = 160\ MPa$ $E = 210\ GPa$

$\sigma_{bc} = 100\ MPa$



As the beam is simply supported beam, the sagging B.M will produced in beam & these will be Comp. at top.

1) Position of N.A

$\bar{x} = \frac{120}{2} = 60mm$

$\bar{y} = \frac{a_1y_1 + a_2y_2}{a_1+a_2} = \frac{(120\times10\times60) + (120\times10\times125)}{(120\times10)+(120\times10)}$

$\bar{y} = 92.5\ mm$ from bottom

$\therefore\ y_t = 92.5\ mm$ 1M

$y_c = 37.5\ mm$

2) M.I about N.A.

$I_{xx} = I_{xx_1} + I_{xx_2}$

$= \left[I_{G_1} + A_1h_1^2\right] + \left[I_{G_2} + A_2h_2^2\right]$

$= \left[\frac{10\times120^3}{12} + 1200\,(92.5-60)^2\right] + \left[\frac{120\times10^3}{12} + 1200\,(92.5-125)^2\right]$

$= 2.70\times10^6 + 1.277\times10^6$

$I_{xx} = 3.977\times10^6\ mm^4$ 2M

Q5C Contd... 3) Moment of Resistance.

Using relation.

$$\frac{Mr}{I} = \frac{\sigma b}{y}$$ 1m

$$\sigma b = \frac{Mr}{I} \times y$$

$$\therefore \quad Mr = \frac{\sigma b}{y} \times I$$

$$\therefore \quad Mr_c = \frac{\sigma bc}{y_c} \times I \quad \text{and} \quad Mr_t = \frac{\sigma bt}{y_t} \times I$$ 1m

$$\therefore \quad Mr_c = \frac{100}{37.5} \times 3.977 \times 10^6 = 10.60 \times 10^6 \text{ N·mm}$$ 1m

$$Mr_t = \frac{160}{92.5} \times 3.977 \times 10^6 = 6.87 \times 10^6 \text{ N·mm}$$ 1m

Consider least of above two values

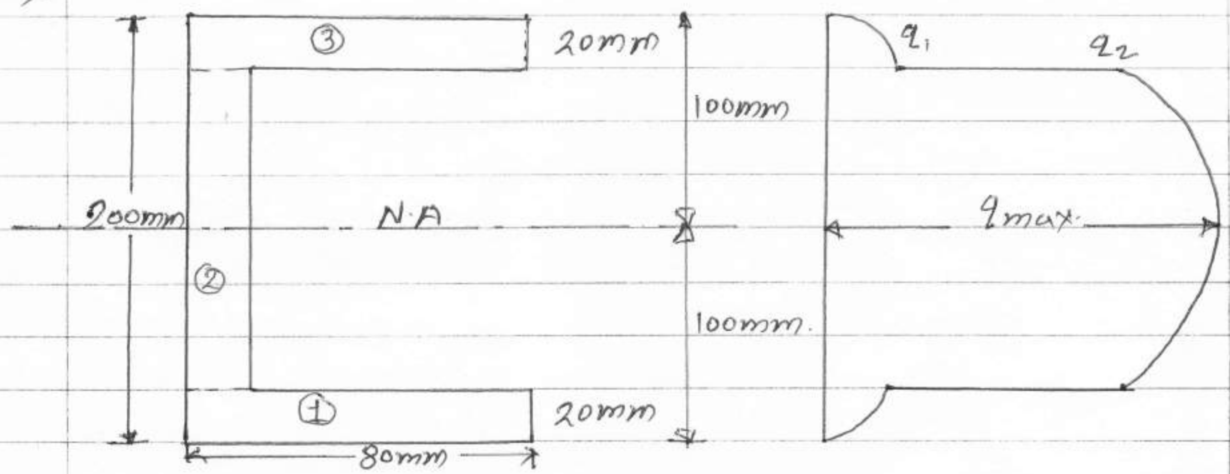
Hence, Moment of resistance = 6.87×10^6 N·mm

OR 1m

$$Mr = 6.87 \text{ KN·m}.$$

Q6a)

→



1) since section is symmetrical about x-axis.

$\therefore \bar{y} = \frac{200}{2} = 100mm$ 1M

2) M.I. about N.A.

$I_{xx} = I_{xx_1} + I_{xx_2} + I_{xx_3}$

$= [I_{G_1} + A_1 h_1^2] + [I_{G_2} + A_2 h_2^2] + [I_{G_3} + A_3 h_3^2]$

$= \left[\frac{80 \times 20^3}{12} + 1600(100-10)^2\right] + \left[\frac{20 \times 160^3}{12} + 3200(100-100)^2\right]$

$+ \left[\frac{80 \times 20^3}{12} + 1600(100-190)^2\right]$

$= 13.01 \times 10^6 + 6.82 \times 10^6 + 13.01 \times 10^6$

$I_{xx} = 32.846 \times 10^6 \; mm^4$ 2M

OR OR

$I_{xx} = \frac{BD^3}{12} - \frac{bd^3}{12} = \frac{80 \times 200^3}{12} - \frac{60 \times 160^3}{12}$

$I_{xx} = 32.85 \times 10^6 \, mm^4$ 2M

3) shear stress;

Let us consider the portion of the beam above N.A.

Q6a) Contn...

q_1 = Shear stress at junction of flange & web by Considering width of flange, b = 80mm.

$$q_1 = \frac{SA\bar{Y}}{bI} = \frac{150\times10^3 \times 80\times20\times(100-5)}{80\times32.85\times10^6}$$

$$q_1 = 8.675\ N/mm^2$$ 1m

q_2 = Shear stress at junction of flange & web by Considering width of web, b = 20mm.

$$q_2 = \frac{SA\bar{Y}}{bI} = \frac{150\times10^3\times80\times20\times(100-5)}{20\times32.85\times10^6}$$

$$q_2 = 34.70\ N/mm^2$$ 1m

$q_{max} = q_{N.A} = q_2 + q_{additional}$

$q_{additional}$ = Additional shear stress due to web area above N.A taking b = 20mm.

$$= \frac{SA\bar{Y}}{bI} = \frac{150\times10^3\times80\times20\times(\frac{80}{2})}{20\times32.85\times10^6}$$

$$q_{addi} = 14.61\ N/mm^2$$

$$\therefore q_{max} = 34.70 + 14.61 = 49.31\ N/mm^2$$ 1M

4) Average shear stresses.

$$q_{avg} = \frac{S}{A} = \frac{150\times10^3}{(2\times80\times20)+(160\times20)} = 23.43\ N/mm^2$$ 1m

5) Ratio of q_{avg} to q_{max}

$$\frac{q_{avg}}{q_{max}} = \frac{23.43}{49.31} = 0.475$$ 1m

Q6b)

→ $L = 2.5m$ with both end hinged.

$D = 40mm$ $\alpha = \frac{1}{7500}$

$d = 30mm$

$E = 200GPa$ $\sigma c = 320$ MPa.

1) Geometrical Properties

i) Area $A = \frac{\pi}{4}(D^2-d^2) = \frac{\pi}{4}(40^2-30^2) = 549.778\ mm^2$

ii) M.I $I = \frac{\pi}{64}(D^4-d^4) = \frac{\pi}{64}\times(40^4-30^4) = 85.90\times10^3\ mm^4$ 1M

iii) Radius of Gyration $r = \sqrt{\frac{I}{A}} = \sqrt{\frac{85.90\times10^3}{549.778}} = 12.50\ mm$ 1M

iv) Effective length $Le = L = 2500\ mm$. 1M

2) Crippling load by Eulers formula.

$$Pe = \frac{\pi^2 EI}{(Le)^2}$$ 1M

$$= \frac{\pi^2\times200\times10^3\times85.90\times10^3}{(2500)^2}$$

$$Pe = 27.129\times10^3\ N$$

$$Pe = 27.129\ KN.$$ 1M

3) Crippling load by Rankins formula.

$$P_R = \frac{\sigma c.A}{1+\alpha\left(\frac{Le}{r}\right)^2}$$ 1M

$$= \frac{320\times549.778}{1+\frac{1}{7500}\left(\frac{2500}{12.50}\right)^2}$$

$$P_R = 27.778\times10^3\ N$$

$$P_R = 27.778\ KN$$ 1M

The crippling load given by Eulers & Rankinges is approximately equal. 1M

$$\frac{P_e}{P_R} = \frac{27.129}{27.778} = 0.976.$$

Q6c

→ Given

$P = 1000N$

$L = 5m = 5000mm$

$h = 200mm$

$\sigma = 80MPa$

$E = 210\ GPa.$

1) In case of Impact load, the stress produced is given by.

$$\sigma = \frac{P}{A} + \sqrt{\left(\frac{P}{A}\right)^2 + \frac{2PhE}{AL}}$$ 2M

$$\therefore \sigma = \frac{P}{A} + \sqrt{\left(\frac{P}{A}\right)^2 + \frac{2hE}{L}\left(\frac{P}{A}\right)}$$

Let $\frac{P}{A} = x$ 1M

$$\therefore \sigma = x + \sqrt{x^2 + \frac{2hE}{L}x}$$

$$80 = x + \sqrt{x^2 + \frac{2 \times 200 \times 210 \times 10^3}{5000}x}$$

$$(80 - x) = \sqrt{x^2 + 16800x}$$

$$(80 - x)^2 = x^2 + 16800x$$

$$6400 - 160x + \cancel{x^2} = \cancel{x^2} + 16800x$$ 1M

$$6400 = 16800x + 160x$$

$$6400 = 16960x$$

$$\therefore x = 0.3773$$ 1M

Q6c) Contd...	But $x = \frac{P}{A}$	
	$\therefore 0.3773 = \frac{1000}{A}$	
	$\therefore A = 2650.41 \; mm^2$	1M
	But Area of Circular section $A = \frac{\pi}{4} d^2$	
	$\therefore \frac{\pi}{4} d^2 = 2650.41$	1M
	$d^2 = \frac{4 \times 2650.41}{\pi} = 3374.60$	
	$\therefore d = \sqrt{3374.60}$	
	$\therefore d = 58.09 \; mm.$	1M