Q. No. 1

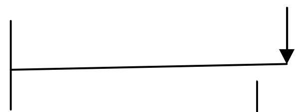
(a) Creep.:- Continuous deformation of the material which undergoes with time due to application of external steady load is called as creep.

Example : concrete beam gets permanently deflected after some years due to continuous loading.(01 mark for definition & 01 mark for example.)

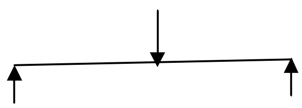
(b) Double Shear :-When shear force coming on the section is resisted by two shearing planes then it is said that the member is subjected to double shear. (02 marks).

(c) Types of beams

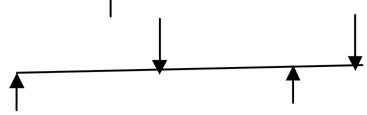
(i) Cantilever beam



(ii) Simply Supported beam



(iii) Overhanging beam



½ mark for each type of beam + ½ mark for fig.

(d) Hooks Law :Within elastic limit stress is directly proportional to the strain.02 marks

(e) Parallel axis theorems : If I_G be the M.I. of a lamina about its own centroidal axis then the M.I. of the lamina about an axis AB parallel to controidal axis is given by

$I_{AB} = I_G + Ah^2$ Where

A = Area of lamina

h = Dist. Between axis centroidal axis and axis AB

I_{AB} = M.I. of Lamina @ axis AB

I_G = M.I. of lamina @ centroidal axis

(01 mark for statement & 01 mark for formule)

(f) $I_P = \frac{\pi}{32}(d)^4$ -01

$= \frac{\pi}{32}(50)^4 = 613592.32\ mm^4$ -01

(g) (i) The material of the beam is homogenorous and isotropic.

(ii) The material obeys Hook's Law.

(iii) The transverse section of the beam which is plane before bending remain plane after bending.

(iv) Young's Modulus of beam material will be same in tension and compression.

(v) Each layer is free to expand or contract independently w.r.t. a layer above or below it.

(vi) The beam is initially straight & of uniform c/s section.

(vii) The radius of curvature after bending is large as compared to the dimensions of the cross section.

(One mark each for any two assumptions)

(h) Uniformly Distributed Load (UDL)

The load which is acting with uniform intensity over length of beam then such load is called as uniformly distributed load . - 02 marks

(i) Eccentric load :

The load which is acting at some distance away from the centroidal axis (i.e. eccentricity) is called as eccentric load. – 02 marks

(j) e $\leq \frac{Z}{A}$

Z = $\frac{\pi}{32} d^3$ A = $\frac{\pi}{4} d^2$ - ½ mark

e $\leq \frac{\pi}{32} d^3 . \frac{4}{\pi d^2}$ - ½ mark

e ≤ d/8 -01 mark

(k) $T = \frac{\sigma_s}{R} I_P = \frac{\sigma_s}{R} \cdot \frac{\pi}{32} [(d_o)^4 - (d_i)^4]$ - 02

OR

$T = \frac{G\theta}{l} I_P = \frac{G\theta}{l} \cdot \frac{\pi}{32} [(d_o)^4 - (d_i)^4]$ 02 mark

(l) $P = \frac{2\pi N\ Tav}{60} Watts.$ OR $P = \frac{2\pi N\ Tav}{4500} H.P.$ (01 mark)

P = Power, N = Speed of shaft in RPM Tav = Mean or average. Torque(.01 mark)

Q.2

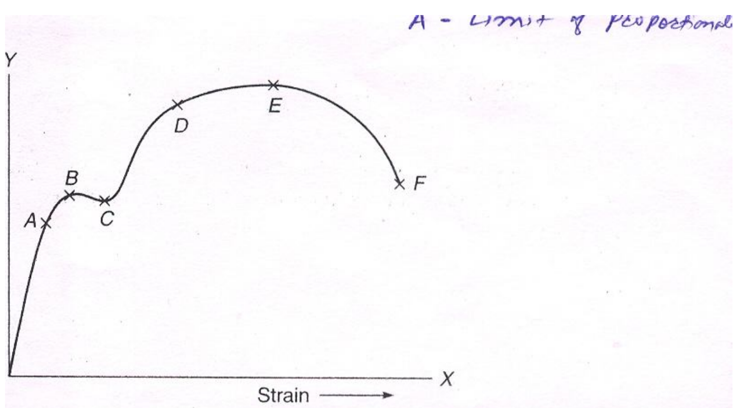
a) (i) Young's Modulus : Within the elastic limit the ratio of stress and strain is constant and this constant is called as young's modulus and it is denoted by E. – 01

$E = \frac{Stress}{Strain}$ $E = \frac{6}{E}$ - 01 mark

(ii) Modulus of Rigidity : Ratio of shear stress to the shear strain is called as modulus of rigidity. Generally denoted by C, G. or N. – 01

Mod. Of Rigidity. = $\frac{Shear\ Stress}{Shear\ Strain}$ $C = G = N = \frac{\tau}{\emptyset}$ -01 mark

b)



A= Limit of proportanility , B = Yield point
C= Lower yield point E= Ultimate Load, F = Failure load

Ultimate stress : The maximum stress induced in a member before failure is called as ultimate stress.

(02 mark for diagram & 02 mark for definition)

c) d = 28mm l = 700 mm P = 52 x 10^3 N

A = $\pi/4$ $(28)^2$ = 615.75 mm^2, E = 2004 N/m^2 = 2004 x 10^{-6} N/mm^2.

δl.due to fore $\delta l_1 = \frac{Pl}{AE}$, $\delta l1 = \frac{52\times10^3\times700}{615.75\times2004\times10^{-6}} = 29498.45mm$ 1½

δl due to lateral pressure = δl_2 36 MPa = 36 N/mm^2.

$\delta l_2 = \frac{pr}{E}$ x μ x l = $\frac{36}{2004\times10^{-6}} \times 0.28 \times 700$ = 3520.96 mm 1½

Total Change in length $\delta l = \delta l_1 + \delta l_2$

= 29,498.45 + 3520.96

= 33019.41 mm 01

- If we consider E = 200 Mpa instead of 2004 Pa

  E = 200 x 10^6 N/m^2 = 200 N/mm^2.

$\delta l_1 = \frac{52\times10^3\times700}{615.75\times200} = 295.58mm$ ½ + 1

$\delta l_2 = \frac{36}{200} \times 0.28 \times 700 = 35.28mm$ ½ + 1

$\delta l = \delta l1 + \delta l2$ = 295.58 + 35.28 = 330.86 mm. 1

- if we consider E = 200 GPa instead of 2004 Pa,

  E = 200 x 10^9 N/m^2 = 2×10^5 N/mm^2.

$\delta l_1 = \frac{52\times10^3\times700}{615.75\times2\times10^5} = 0.2955 = 0.30mm$ ½ + 1

$\delta l_2 = \frac{36}{2\times10^5} \times 0.28 \times 700 = 0.0353mm$ ½ + 1

δl = 0.30 + 0.035 = 0.335 mm. 1

(d) E = 3k (1-2μ) 2 ½

E= Modulus of elasticity ½

K = Bulk Modulus ½

μ = Poisson's ratio ½

(e) E = 204 GPa

$= 204 \times 10^3$ N/mm^2.

$\mu = 0.27$

$e_x = \frac{6x}{E} - \mu.\frac{6y}{E}$

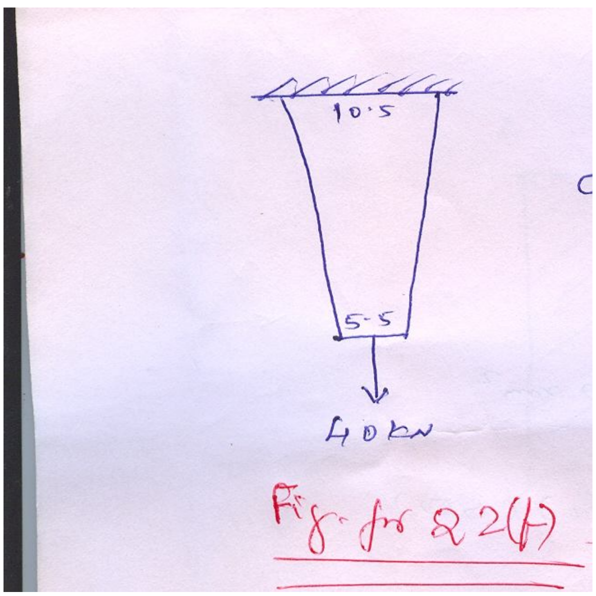
$= \frac{1}{E}(6_x - \mu\, 6y)$

$= \frac{1}{204\times10^3}[140 - 0.27(140)] = 5.01 \times 10^{-4}$ 02 marks

K= E/3(1-2μ)

$= \frac{204\times10^3}{3(1-2\times0.27)} = 147826$ N/mm^2 02 marks

f)



D = 105 mm d = 55 mm, 1 = 2000 mm.

P = 40 x 10^3 N E = 2 x 10^8 kN/m^2

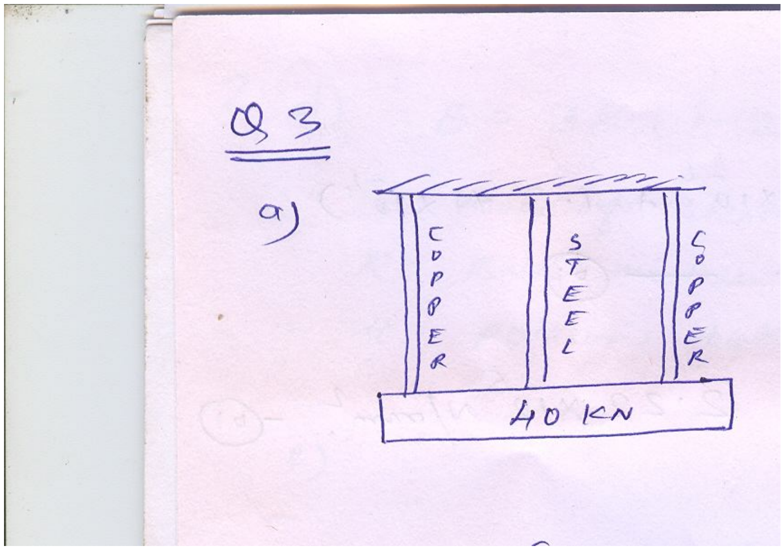
= 2 x 10^8 x 10^3 x 10^{-6} = 2 x 10^5 N/mm^2.

$\delta l = \frac{4PL}{\pi E D d}$ 02

$= \frac{4 \times 40 \times 10^3 \times 2000}{\pi E (105)(55)}$ 01

$= 0.088$ mm. 01

Q. No. 3 a)



$E_S = 210$ GPa $= 210 \times 10^3$ N/mm^2.

$E_C = 120$ GPa $= 120 \times 10^3$ N/m^2.

$A = 250$ mm^2.

$\delta l_s = \delta l_c$

$E_S\, l = E_C\, l$

$$\frac{6_S}{E_S} = \frac{6_C}{E_C}$$

$6S = \frac{E_S}{E_C} . 6_c = \frac{210 \times 10^3}{120 \times 10^3} = 6_S = 1.75\ 6_C$ 01 mark

$P = P_s + P_c$.

$P = 6_S . A_S + 6_C . A_C$ 01 mark

$A_S = 250$ mm^2 $A_C = 2 \times 250 = 500$ mm^2.

$40 \times 10^3 = (1.75\ 6_C)(250) + (6c)(500)$

$40 \times 10^3 = 937.5\ 6_C$.

$6_C = 42.67$ N/mm^2.

$6s = 1.75\ 6_C = 1.75\ (42.67) = 74.67\ N/mm^2$. 01 mark

$P_C = 6_C.A_C = 42.67\ (500)$

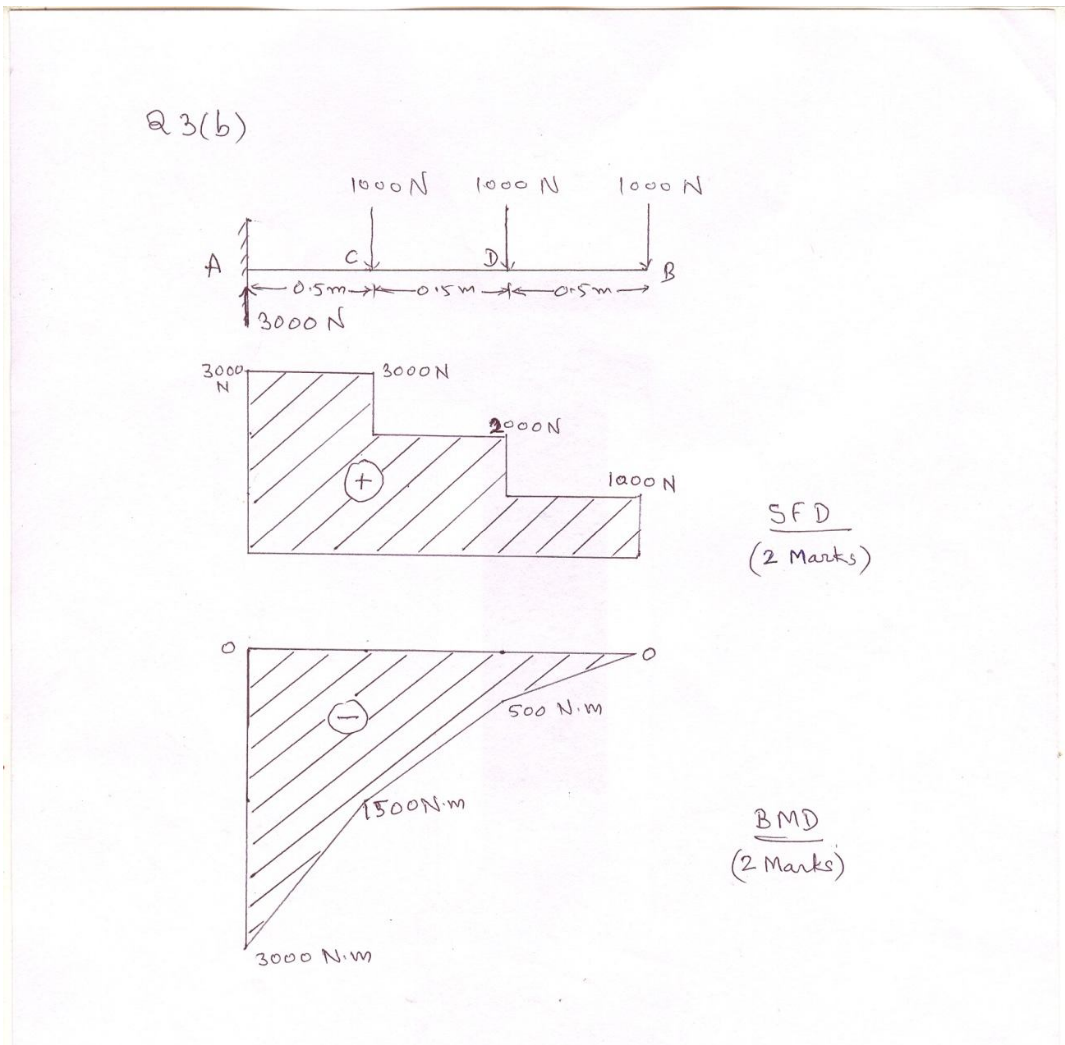
$= 21335$ N.

$P_S = 6_S.A_S = 74.67\ (250)$

$= 18667.50$ N. 01 mark

Load sheared by steel wire= 18.67 kN

Load sheared by copper wire = 10.67 kN.



Q. 3 (c) $\sum M_A = 1000x3-500-R_Bx5=0$

$\therefore R_B = 500$ N.

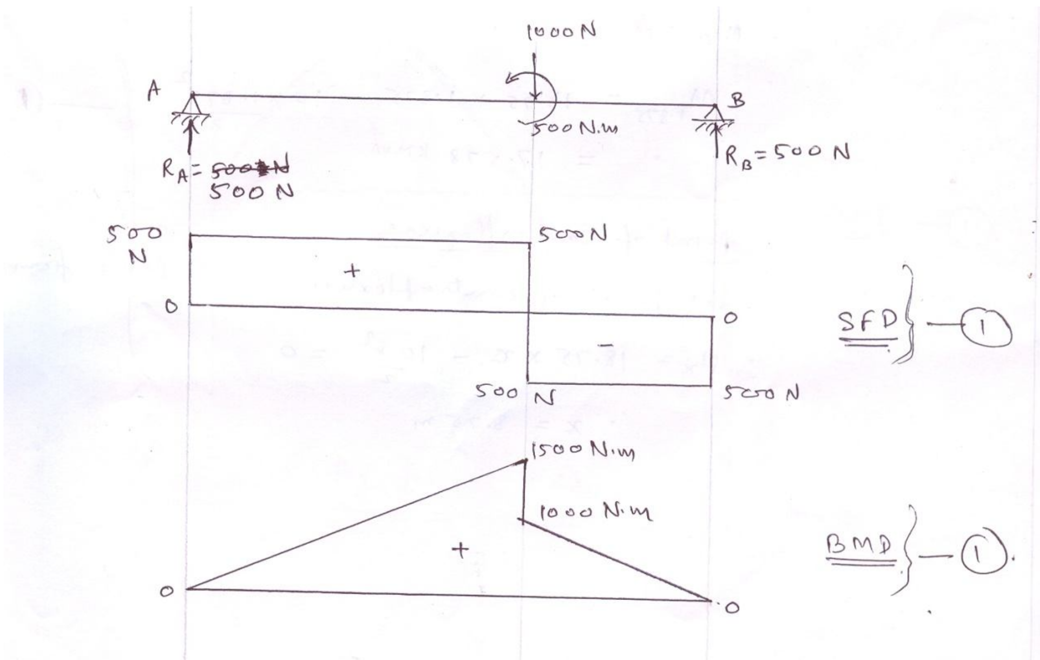
$R_A + R_B = 1000$

$R_A = 1000 - 500$

$\therefore R_A = 500$ N. 1

B.M. at $C_{Left} = 500 \times 3 = 1500$ N.m.

B.M. at $C_{Right} = 500 \times 2 = 1000$ N.m. 1



Q. 3 (d)

$\sum M_A = 10 \times 5 \times 2.5 - R_B \times 4 = 0$

$\therefore R_B = 31.25$ kN.

$R_A + R_B = 10 \times 5$

$R_A = 50 - 31.25$

$\therefore R_A = 18.75$ kN.

B.M. at B = M_B = 10 x 1 x 0.5 = 5 k.N.m. 1/2 mark

Point of zero shear force –

18.25 – 10 x = 0

$\therefore$ x = 1.875 m

Max B.M. at x = 1.875 m 1/2 mark

$M_{1.875} = 18.75 \times 1.875 - 10 \times \frac{1.875^2}{2} = 17.578$ KN-m 1/2 mark

Point of contraflexure

Let point of contraflexure is at dist., x from A

$\therefore M_x = 18.75\,x - \frac{10x^2}{2} = 0$

$\therefore$ x =3.75 m 1/2 mark

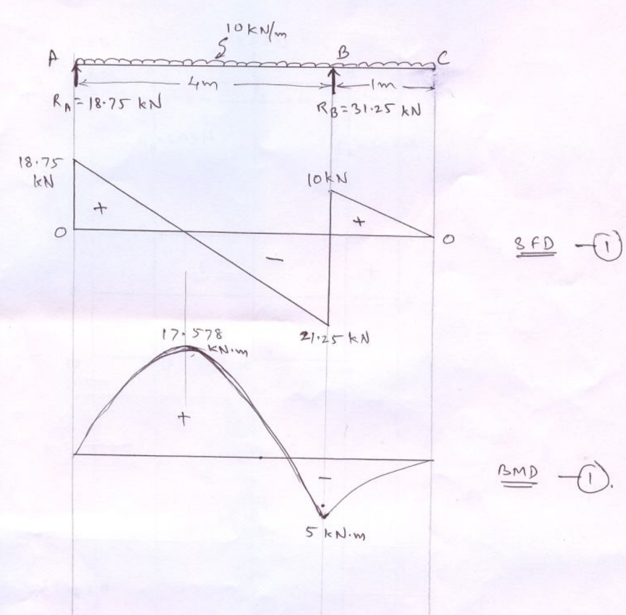


Fig for Q 3(d)

Q. 3 (e)

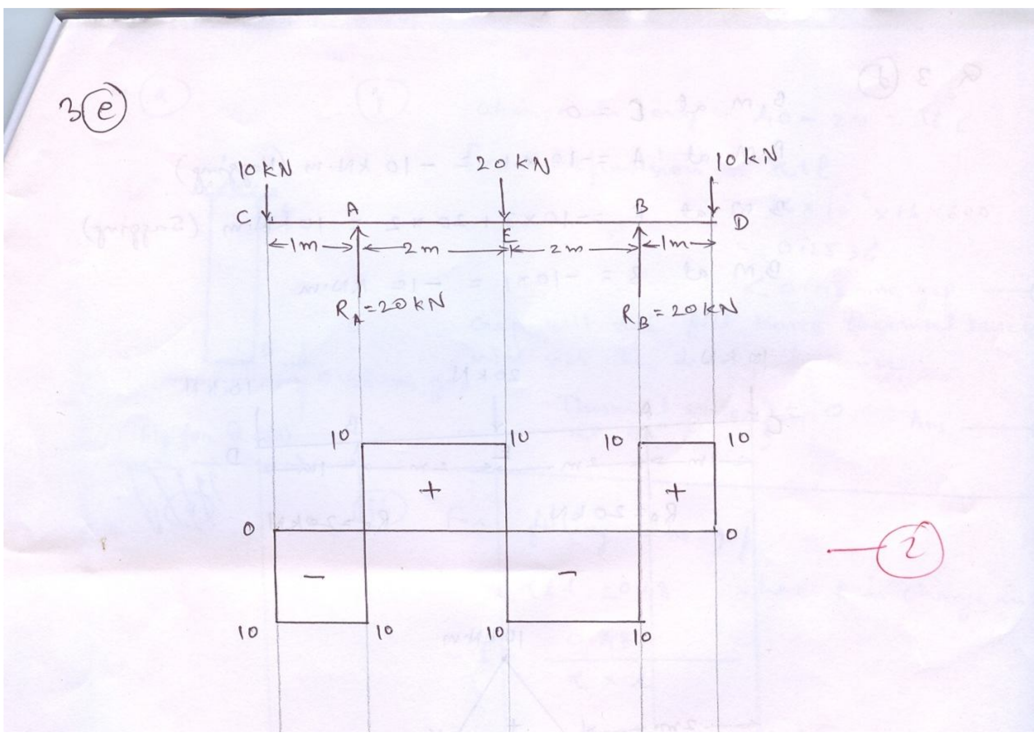
$\sum M_A = 0$

$-10 \times 1 + 20 \times 2 + 10 \times 5 - R_B \times 4 = 0$

$R_B = 20$ kN 01 mark

$R_A = (10 + 20 + 10) - R_B$

= 20 kN. 01 mark



3 (f)

B.M. at C = 0

B.M. at A = -10 x 1 = -10 kN. M (Hogging)

B.M. at E = -10 x 3 + 20 x 2 = 10 kN.m (sagging)

B.M. at B = -10 x 1 = -10 kN.m 01 mark

Let point of contraflexure be at dist. X from point C

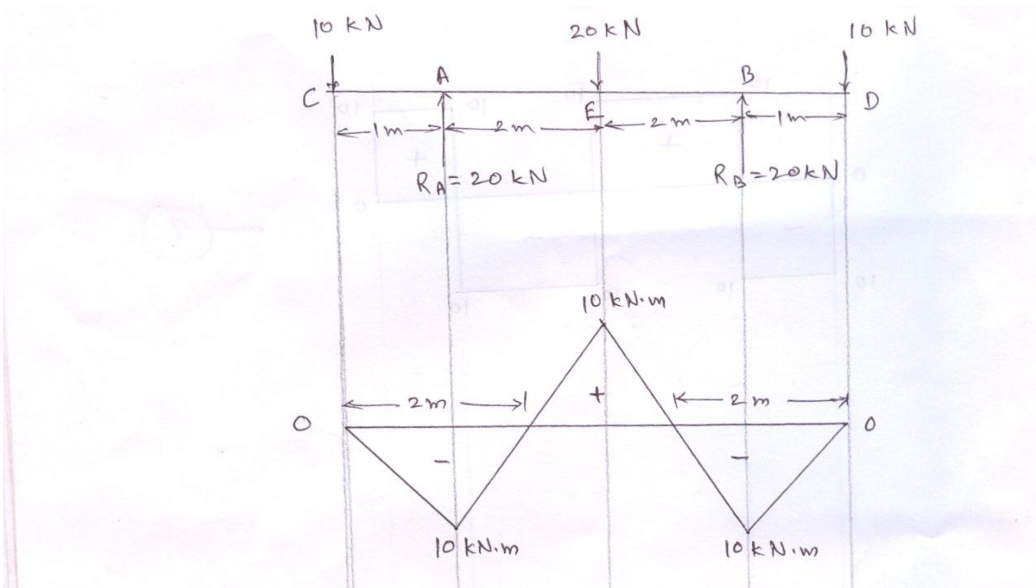
BM at dist x, M_x = -10x + 20 (x-1) = 0

-10x + 20x – 20 = 0

∴ x = 2m from point C. 01 mark

Due to symmetry other point of contraflexure lies at dist. 2m. from point D.

(02 marks for figure)



4(a) (i) Change in temp = 40 – 24 = 16^0 C.

Free expression = α.t.l

= 16 x 10^{-6} x 16 x 600

= 0.1536

< 0.48 mm gap

Gap will not close. Hence thermal stress will not be developed. 01 marks

Hence Thermal stress at 40^0 C = 0 01 mark

ii) For closing the gap

$\alpha\, t\, l = 0.48$ where t is change in temp.

$\therefore t = \frac{0.48}{\alpha \times l}$

$= \frac{0.48}{16 \times 10^{-6} \times 600}$

$= 50^0$ C 01 mark

$\therefore$ Final temperature required to close the gap = 24 + 50 = 74^0 C 01 marks

4(b) $A_1 = 200 \times 300 = 60000\ mm^2$

$y_1 = 150$ mm

$A_2 = \frac{\pi \times 150^2}{4} = 17671.46\ mm^2$

$y_2 = 300 – 100 = 200$ mm 01 mark

$\bar{Y} = \frac{60000 \times 150 - 17671.46 \times 200}{(60000 - 17671.46)}$

= 129.126 mm from bottom 01 mark

$I_{XXg} = \frac{200 \times 300^3}{12} + 200 \times 300 \times (150 – 129.126)^2$

$- \left[\frac{\pi \times 150^4}{64} + \frac{\pi \times 150^2}{4} \times (200 - 129.126)^2\right]$

= 476143432.60 – 113616415

= 362527018 mm^4 02 marks

4 (c) $I_{base} = \frac{bh^3}{12} = \frac{80 \times 60^3}{12} = 1440000\ mm^4$ 02 marks

$Ixx = \frac{bh^3}{36} = \frac{80 \times 60^3}{36} = 480000\ mm^4$ 02 marks

4 (d)

$A_1 = 150 \times 50 = 7500\ mm^2$

$y_1 = 150 + \frac{50}{2} = 175$ mm.

$A_2 = 150 \times 50 = 7500\ mm^2$

$y_2 = 75$ mm

$\bar{Y} = \frac{7500\times175+7500\times75}{7500+7500} = 125$ 02 marks

$I_{xx} = \frac{150\times50^3}{12} + 7500 \times (175-125)^2 + \frac{50\times150^3}{12} + 7500 \times (125-75)^2$

$Ixx = 53125000\ mm^4$ 02 marks

4 (e)

$A_1 = 80 \times 20 = 1600$ $X_1 = 40$ mm

$A_2 = 80 \times 20 = 1600$ $X_2 = 10$mm

X= (1600 x40 + 1600 x10)/3200 = 25 02 marks

$I_{yy} = \frac{80\times20^3}{12} + 1600 \times (25-10)^2 + \frac{20\times80^3}{12} + 1600 \times (40-25)^2$

$I_{yy} = 1626666.67\ mm^4$. 02 marks

4 (f)

$I_{base} = \frac{100\times90^3}{12} - \left(\frac{20\times30^3}{12} + 20 \times 30 \times 45^2\right) = 4815000\ mm^4$. 02 + 02 marks

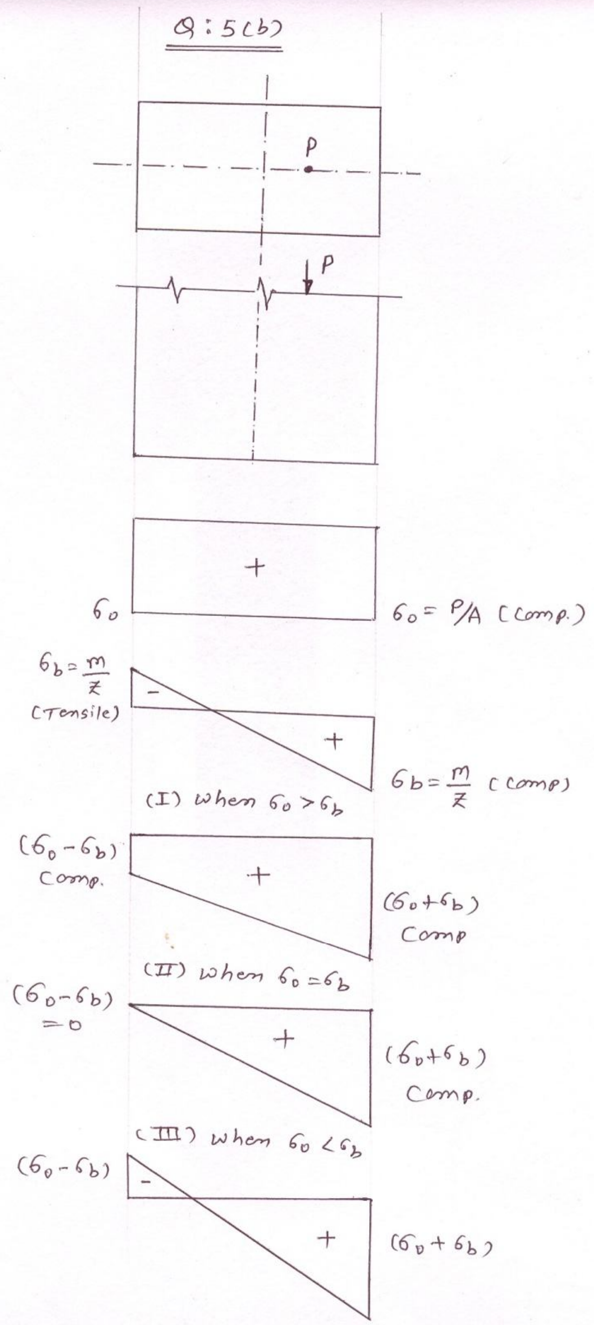
5 (a)

(i) Resistance offered by a flexural member against external bending moment is called as moment of resistance. 02 marks

(ii) A level within section of flexural member at which bending stress is zero is called as neutral axis. 02 marks

Q.5 b) Direct stress : Resistance offered by the material against direct normal load per unit cross sectional area is called as 'Direct Stress. 1/2 marks

Bending Stress : Stress developed in flexural member to resist external bending moment are called bending stresses. 1/2 marks



(01 mark for each case)

5 (c)

e= Z/A 01 mark

Z= π/ 32 d^3 01 mark

A= $\pi/4d^2$

e= d/8 01 mark

e= 50/8 = 6.25 mm 01 mark

5 (d)

$A = \frac{\pi}{4}(300^2 – 250^2) = 21598.45\ mm^2$

eccentricity ,e = 150 mm

$\sigma_0 = \frac{100000}{21598.45} = 4.63\ N/mm^2$. 01 marks

M = P.e. = 100000 x 150 = 1.5×10^7

$I = \frac{\pi}{64}(300^4 – 250^4) = 0.20586 \times 10^9$

y = 150

$\sigma_b = \frac{1.5\times10^7}{0.20586\times10^9} \times 150 = 10.93\ N/mm^2$. 02 marks

$\sigma_{max} = 4.63 + 10.93 = 15.56\ N/mm^2$. 1/2 marks

$\sigma_{min} = 4.63 - 10.93 = -6.3\ N/mm^2$. 1/2 marks

5 (e)

b=2t

$\sigma = 100\ N/mm^2$.

A = b x t

= 2t x t = $2t^2$

$\sigma_0 = \frac{25000}{2t^2}$

M = 25000 x 150 = 3750000 01 marks

$Z = \frac{t \times (2t)^2}{6} = \frac{2}{3}t^3$

$\sigma_b = \frac{M}{Z} = \frac{3750000}{\frac{2}{3}t3}$ 01 marks

$\sigma_{max} = \sigma_0 + \sigma_b = \frac{25000}{2t^2} + \frac{3750000}{\frac{2}{3}t^3} = 100$

$12500t + 5625000 = 100t^3$

$t^3 - 56250 - 125\,t = 0$

$t^3 - 125t - 56250 = 0$

t=39.40 mm say 40 mm 1 1/2 marks

b=78.805 mm say 80 mm 1/2 marks

5(f) $A = t \times 3t = 3t^2$ 01 marks

$\sigma = \frac{P}{A} = \frac{80000}{3t^2} = 70$ 01 marks

t=19.518 mm 02 marks

6(a)

$M = BM = wl^2/8 = 16w/8 = 2w$ 01 marks

$Y = \frac{300}{2} = 150$

$\frac{M}{I}.y = \sigma$ 01 marks

$\frac{2w \times 10^6}{8 \times 10^6} \times 150 = 120$

W=3.2 N/mm = 3.2 kN/m. 02 marks

Q.6 b)

I = $\frac{150\times340^3}{12} - \frac{140\times300^3}{12}$

=491300000-315000000

=176300000 01 marks

S=50000 N

A$\bar{y}$=150 x 20 x 160 + 150 x 10 x 75 = 592500 mm^3 01 marks

$\tau = \frac{SA\bar{y}}{Ib} = \frac{50000\times592500}{176300000\times10}$ = 16.803 N/mm^2. 1 + 1 marks

6(c) P = $\frac{2\pi NT}{60}$ 01 marks

100 x 10^3 = $\frac{2\pi\times150\times T}{60}$

T = 6366.197 N.m.

T_{max} = 1.4 x 6366.197 = 8912.68 01 marks

$I_P = \frac{\pi d4}{32} = \frac{\pi\times120^4}{32}$=20357520.4 mm^4

$\frac{T}{I_P} = \frac{\tau}{r}$ 01 marks

$\frac{8912.58\times10^3}{20357520.4} = \frac{\tau}{60}$

τ=26.268 N/mm^2 01 marks

Q.6 d)

d=50mm, N=120 rpm, τ=80 MPa

$I_p = \frac{\pi d^4}{32} = = \frac{\pi\times50^4}{32}$ = 613592.315 01 marks

Using $\frac{T}{I_P} = \frac{\tau}{r}$

Torque T=$\frac{\tau}{r}$ x I_P = $\frac{80}{25} \times 613592.315$

= 1963495.41 N.mm.

= 1963.495 N.m. 01 marks

Power transmitted, P = $\frac{2\pi NT}{60} = \frac{2\pi \times 120 \times 1963.495}{60}$

$\approx 24674\, W$

$\approx 24.674\, KW$ 1+1 marks

Q.6 (e)

P = 375 kW, N = 210 rpm τ_{max} = 50 Mpa

$\theta = 1^0 \approx \frac{\pi}{180}$ radians l_1 = 3000 mm, $I_p = \frac{\pi d^4}{32} = \frac{\pi \times d^4}{32} = 0.098175 d^4 mm^4$ ½ + ½

G = 80 Gpa ≈ 80000 Mpa

Using P = $\frac{2\pi NT}{60}$ 01 marks

375 x 10^3 = $\frac{2\pi \times 210 \times T}{60}$

∴ T = 17052.31 N.m. 01 marks

Using $\frac{T}{I_P} = \frac{\tau}{r} = \frac{G\theta}{l}$ 01 marks

$$\frac{17052.31 \times 10^3}{0.098175 d^4} = \frac{50}{\left(\frac{d}{2}\right)} = \frac{80000 \times \pi/180}{3000}$$

^{d3} = 1736947

d = 120.206 mm

d=214.85 mm

∴ Provide d = 214.55 mm 01 marks

Q. 6 (f)

D = 120 mm, d = 90 mm, r = 60mm

T = 18 kNm

= 18 x 10^6 N mm

Polar M.I. = $I_P = \frac{\pi}{32}(120^4 - 90^4)$ 1 + 1 marks

= 13916273.71 mm^4

Using $\frac{T}{I_P} = \frac{\tau}{r}$

$$\frac{18 \times 10^6}{13916273.71} = \frac{\tau}{60}$$

$\tau = 77.61$ N/mm^2. 1 + 1 marks

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