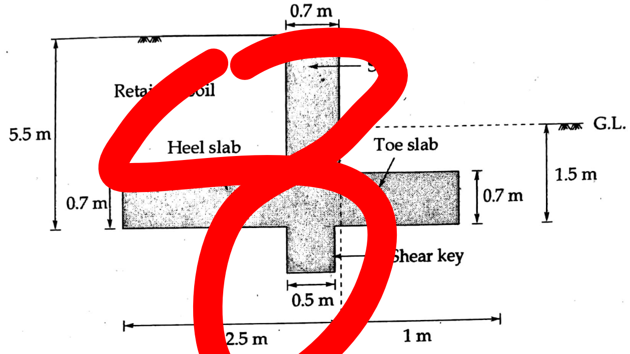
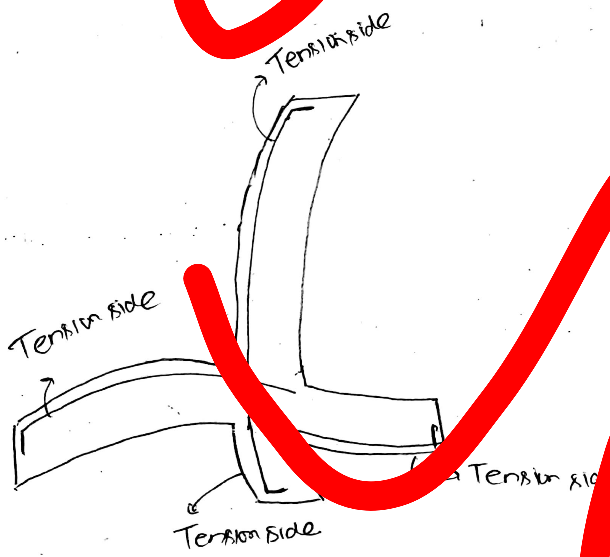
Section A : Design of concrete and Masonry Structures

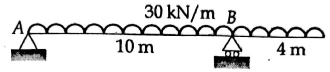
Q.1 (a) An RCC retaining wall has been constructed as shown in figure below. Draw the deflected shape of the retaining wall and sketch the position of main reinforcement in stem, heel slab and toe slab.



[12 marks]



Q.1 (b) A reinforced concrete beam of rectangular section 300 mm × 500 mm is reinforced in tensile zone by 4 bars of 16 mm diameter having an effective cover of 40 mm. The beam is loaded with a factored load including its self-weight as shown in the figure below. Design the vertical shear reinforcement for the beam at critical section for shear. Take M25 grade of concrete and Fe415 grade of steel.



Use the following data:

For M25 concrete, $\tau_{c,max} = 3.1\ N/mm^2$

$\frac{100A_{st}}{bd}$	0.25	0.5	0.75	1
$\tau_c (N/mm^2)$	0.36	0.49	0.57	0.64

[No need for detailing]

[12 marks]

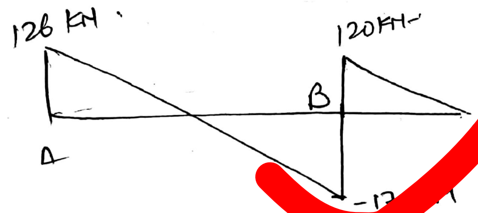
$d = 500 - 40 = 460\,mm$

$b = 300\,mm$

$A_{st} = 4 \times \frac{\pi}{4} \times 16^2 = 804.25\,mm^2$

$w = 30\,kN/m$

SFD of beam



Max shear force = 174 kN

$\frac{100A_{st}}{bd} = \frac{100 \times 804.25}{300 \times 460} = 0.5828 < \tau_c = 3.1\,MPa$ (OK) from interpolation

$\Rightarrow \tau_c = 0.5165 \text{ N/mm}^2$

$V_d = V - \tau_c \times bd$

$= 174 - \frac{0.5165 \times 300 \times 460}{1000}$

$V_d = 102.724 \text{ kN}$

using 10mm two legged stirrups

$\Rightarrow S = \frac{0.87 f_y \cdot A_{sv} \times d}{V_d}$

Spacing = 127mm $< \begin{cases} 0.75d = 345 \\ 300 \end{cases}$

provide 10mm stirrups at spacing of 120mm

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Q.1 (c) As per IS 456-2000, what information are required in specifying a particular grade of concrete?

[12 marks]

⇒ Grade of concrete is decieded by characterstic compressive strength of the stardard samples.

→ ~~In~~ As per IS 456-2000 standard sample size is 150×150×150 mm

⇒ for specifying the particular grade of concrete, these informations are required

1. Grade of cement
2. Type of sand
3. Type of aggregate (Crushed or Residual)
4. Quality characterstics water

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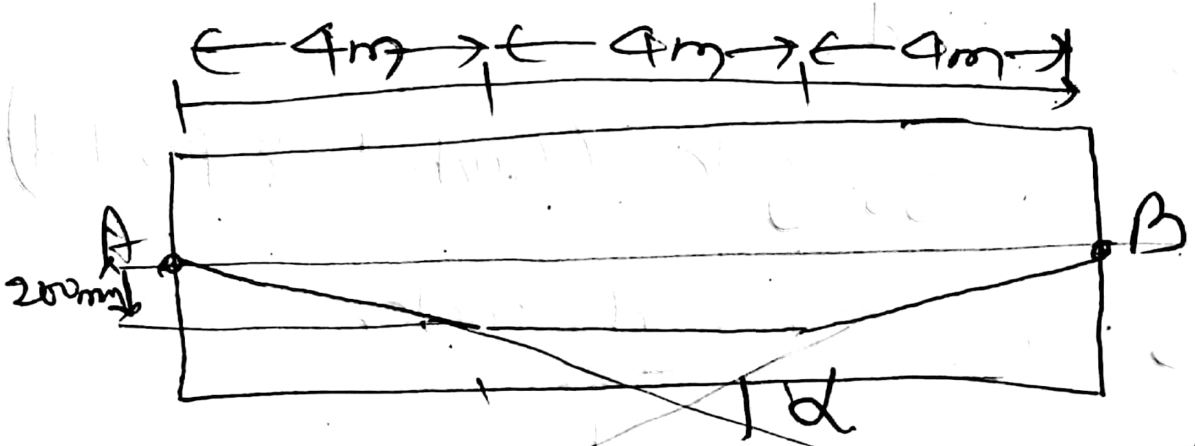
Q.1 (d) A concrete beam *AB* of span 12 m is post-tensioned by a cable which is concentric at supports *A* and *B* and has an eccentricity of 200 mm in the mid-third span with a linear variation towards the supports. If the cable is tensioned at the jacking end *A*, what should be the jacking stress in the wire if the stress at B is to be 1000 N/mm^2? Assume the coefficient of friction between the cable duct and concrete as 0.55 and the friction coefficient for the wave effect as 0.0015/m.

[12 marks]



$\mu = 0.55$, $K = 0.0015/m$

If jacked from one end

$\Rightarrow \alpha = 2 \times \frac{0.2}{4} = 0.1$

$x = 12m.$

$$\Delta P = P_0\left(1 - e^{-(\mu\alpha + kx)}\right)$$

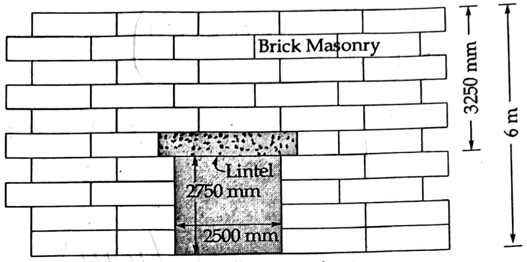
$$(P_0 - 1000) = P_0\left[1 - e^{-(0.55\times0.1 + 0.0015\times12)}\right]$$

$$\Rightarrow \boxed{P_0 = 1075.73\ \text{N/mm}^2}$$

→ prestressing force ~~Reqired~~. Required.

Q.1 (e) Design a lintel over a 2.5 m wide opening in an industrial shed wall as shown in figure below. The thickness of wall is 40 cm, height of opening is 2.75 m and eaves level is 6 m above the floor level. Use M20 mix and Fe415 steel. Unit weight of masonry = 19 kN/m^3. Check for shear and development length at support are not required detailing is also not required.

[Take base angle of imaginary triangle = 60°, unit weight of RCC = 25 kN/m^3]

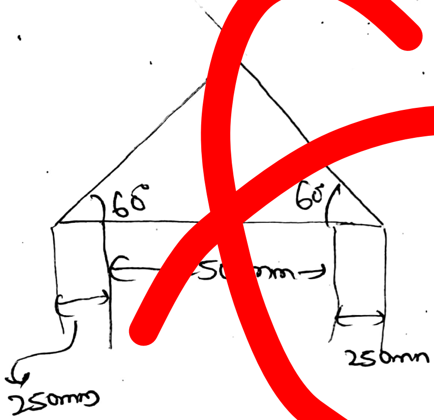


Lintel over door opening

[12 marks]

Assume d = 150 mm.

⇒ l_{eff} = 2500 + 150 = 2650 mm



load or brick = $\frac{\sqrt{3}}{4} \times 3^2 \times 0.4 \times 19$

= 29.62 KN

Q.4 (a) Design and detail a simply supported rectangular slab with effective dimensions of (4 m × 4.8 m). It carries a live load of 2.5 kN/m² and finish load of 1 kN/m² (Take the effective cover as 25 mm and 10 mm diameter bars as main reinforcement). Use the following table for bending moment coefficients for slab spanning in two directions at right angles, simply supported on four sides.

l_y/l_x	1	1.1	1.2	1.3	1.4	1.5	1.75	2
α_x	0.062	0.074	0.084	0.093	0.099	0.104	0.113	0.118
α_y	0.062	0.061	0.059	0.055	0.051	0.046	0.037	0.029

Assume that corner lifting is not restrained. Use M20 and Fe415 steel for design of slab.
[20 marks]

$l_x = 4m, \quad l_y = 4.8m$

$\lambda = \frac{l_y}{l_x} = 1.2$

from table

$\alpha_x = 0.084, \quad \alpha_y = 0.059$

$M_x = \alpha_x w l_x^2 \quad , M_y = \alpha_y w l_x^2$

$w_{Live} = 2.5 kN/m^2$

$w_{finish} = 1 kN/m^2$

Assume $D = 150mm$ $\left(\begin{array}{l} d = 150 - 25 \\ d = 125mm \end{array}\right)$

$w_{Dead} = 0.15 \times 1 \times 25 = 3.75 kN/m^2$

$w = w_{Live} + w_{finish} + w_{dead}$

$w = 7.25 kN/m^2$

factored load = $1.5w = 10.875 kN/m^2$

$\Rightarrow M_x = 0.084 \times 10.075 \times 4^2$

$$M_x = 14.616 \text{ KN-m}$$

$M_y = 0.055 \times 10.075 \times 4^2$

$$M_y = 10.266 \text{ KN-m}$$

for Fe 415 & M20

$$d = \sqrt{\frac{M_x}{0.138 \times f_{ck} \times b}}$$

$\Rightarrow d = 72.77 < 125 \text{ mm}$

(Hence OK)

$\Rightarrow$ for Reinforcement for x.

$$\Rightarrow A_{st} = \frac{0.5 \times f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_x}{bd^2 f_{ck}}}\right] \times bd$$

$A_{st} = 343.62 \text{ mm}^2/\text{m}$

$A_{st\,min} = \frac{0.12}{100} \times bd = 150 \text{ mm}^2/\text{m} < A_{st}$

using 10mm ϕ bar spacing $= \frac{1000}{\frac{343.62}{\frac{\pi}{4} \times 10^2}} = 220.57 \text{ mm}$

using 10mmϕ bar at spacing of 200mm

R/F of My.

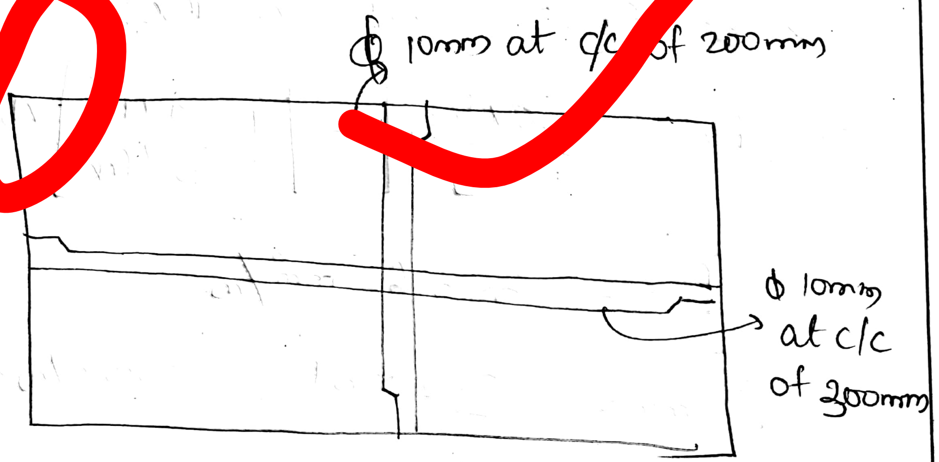
$$\Rightarrow A_{st} = \frac{0.5\times20}{415}\times1000\times125\left[1-\sqrt{1-\frac{4.6\times10.266\times10^{6}}{20\times1000\times125^{2}}}\right]$$

$$A_{st} = 236.9\ mm^2/m > A_{st,min}$$

Using 10mmϕ bar

$$\Rightarrow spacing = \frac{1000}{\frac{236.9}{\frac{\pi}{4}\times10^2}} = 331.532\ mm > 300mm$$

⇒ Using 10mmϕ bar @ c/c spacing of 300mm



Q.4 (b) Design a plain concrete footing for a column of 400 mm × 400 mm carrying an axial load of 400 kN under service loads. Assume safe bearing capacity of soil as 300 kN/m² at a depth of 1 m below the ground level. Use M20 and Fe415 for the design. Use limit state design.

Permissible bearing stress in concrete is given as $\sigma_{br} = 0.45 f_{ck} \left(\frac{A_1}{A_2}\right)^{1/2}$.

[Take the weight of footing and backfill soil as 15% of axial load, unit weight of concrete and soil as 24 kN/m³ and 20 kN/m³ respectively]

[20 marks]

$W = 1.15 \times 400 = 460 \text{ kN}$

Area of footing $= \frac{460}{300} = 1.533 \text{ m}^2$

$B^2 = 1.533 \text{ m}^2$

$B = 1.24 \text{ m}$

adopting .

$B = 1.25 \text{ m}$

Bearing stress $= \frac{1.5 W}{B_c^2} = \frac{1.5 \times 400}{(0.4)^2}$

~~σ_{br} = 3094 kN/m²~~

$\sigma_{br} = 3750 \text{ kN/m}^2$

$\sigma_{br} = 3.75 \text{ MPa}$

3 ∴ $\sigma_{br} = 0.45 f_{ck} \sqrt{\left(\frac{A_1}{A_2}\right)}$

(Here $\sqrt{\frac{A_1}{A_2}} \ngtr 2$)

$3.75 = 0.45 \times 20 \sqrt{\frac{A_1}{0.4 \times 0.4}}$

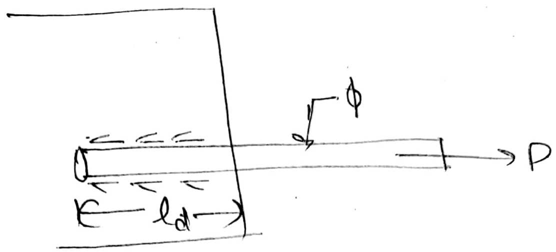
Q.4 (c) (i) Show that development length of a steel bar of diameter ϕ embedded in concrete is given by $L_d = \frac{0.87 f_y \phi}{4\tau_{bd}}$.

Also draw the variation of bond stress along the length of the bar.

(ii) Name with sketch five types of staircases based on geometrical configurations. Also draw a typical stair case flight and show:

(a) tread
(b) nosing
(c) riser
(d) waist
(e) going

[10 + 10 = 20 marks]



⇒ bond strength should be equal to strength of bar

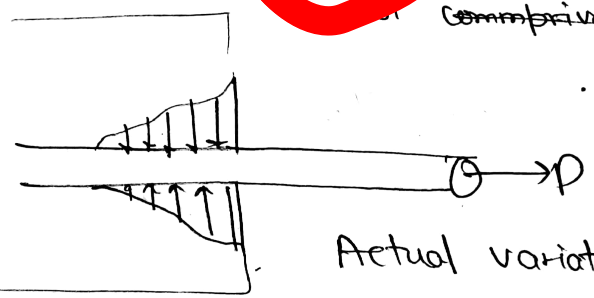
⇒ τ_{bd} (Area in bond) = $0.87 f_y \times \frac{\pi}{4} \times \phi^2$

$\tau_{bd} \times (\pi d\, l_d) = 0.87 f_y \times \frac{\pi}{4} \times \phi^2$

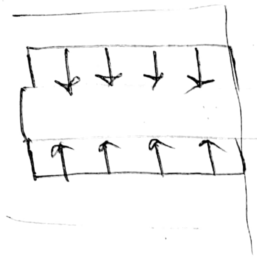
⇒ $$l_d = \frac{0.87 f_y \cdot \phi}{4 \tau_{bd}}$$

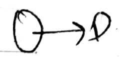
Increase τ_{bd} for 60% in case of HYSD bar due to its surface

& Increase τ_{bd} for 25% in case of compressive bars



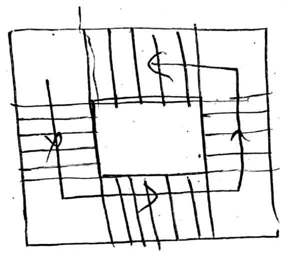
Actual variation of bond stress



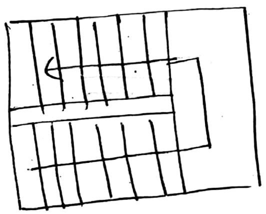


Assumed variation of bond stress

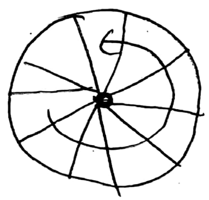
(iii)



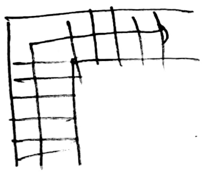
Open well staircase



dog legged staircase

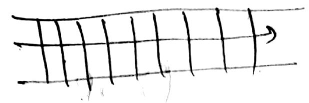


spiral staircase



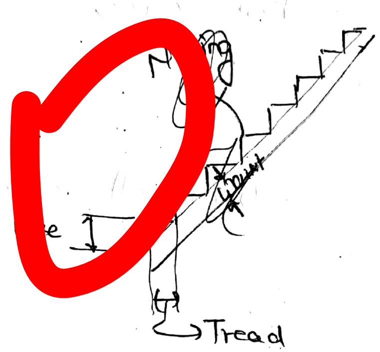
Quarter turn stair case

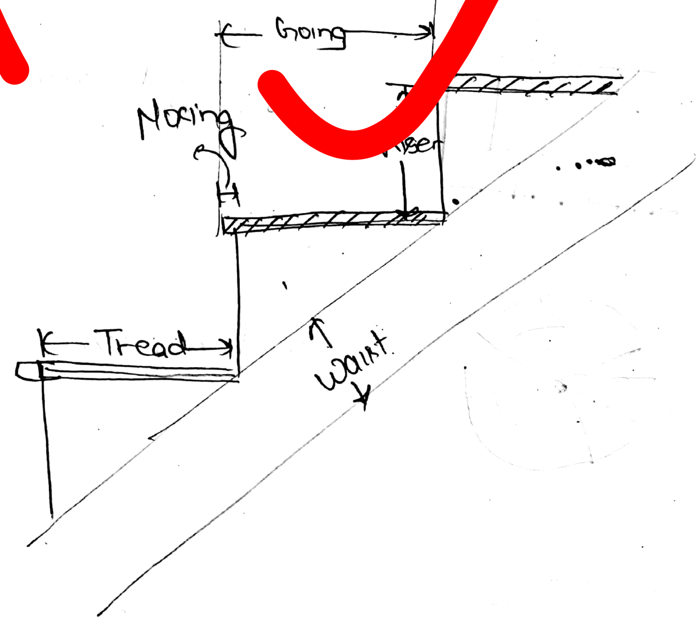
Q.5 (a)



straightway.

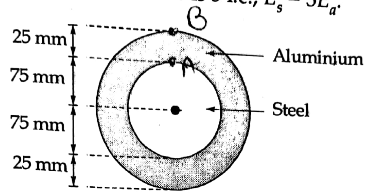
(a)





Section B : Strength of Mateials-1 + Transportation Engineering - 2 + Surveying and Geology-2

Q.5 (a) A 150 mm diameter solid steel rod is securely encased in a 200 mm outer diameter and 150 mm inner diameter aluminium tube to form a composite section of beam as shown in figure. There is no slip between the components. Determine the maximum stresses developed in each material when the beam is subjected to a bending moment of 85 kNm. The modular ratio of the two materials is 3 i.e., $E_s = 3E_a$.



Compostie section

[12 marks]

Transformed section in steel

$$\Rightarrow I = \frac{\pi}{64} \times 150^4 + \frac{1}{m}\frac{\pi}{64}(200^4 - 150^4)$$

$$I = \frac{\pi}{64} \times 150^4 + \frac{1}{3} \times \frac{\pi}{64}(200^4 - 150^4)$$

$$I = 42746931.29 \times 10^{-12} \text{ m}^4.$$

stress at A $\quad \sigma = \frac{M}{I}$

$$\sigma_A = \frac{85 \times 10^3}{42746931.29 \times 10^{-12}} \times 75 \times 10^{-3}$$

$$\sigma_A = 149.134 \times 10^6 \text{ Pa}$$

$$\boxed{\sigma_A = 149.134 \text{ MPa}}$$ Max. stress in steel

stress at B

$$\sigma_B = \frac{85 \times 10^3}{42746931.29 \times 10^{-12}} \times 100 \times 10^{-3}$$

$$\boxed{\sigma_B = 198.04 \times 10^6 \text{ Pa}}$$

Max. stress in Aluminium = $\frac{\sigma_B}{m}$

$(\sigma_{max})_{Al} = 56.20$ MPa

✓ 1/2 ✓

Q.5(b) A four-legged right angled intersection is to be signalised with a fixed time two phase signal.

The design hourly flow and saturation flow are as under:

	North (N)	South (S)	East (E)	West (W)
Design hourly flow	900	500	800	700
Saturation flow	2500	2000	3200	3000

The lost time may be taken as 2 seconds per arm. Determine the optimum cycle time and apportion the green times in the two phases. Sketch the timing diagram for each phase.

[12 marks]

$q_N = \frac{900}{2500} = 0.36$, $q_S = \frac{500}{2000} = 0.25$

$q_E = \frac{800}{3200} = 0.25$ $q_W = \frac{700}{3000} = 0.2333$

$q_1 = \max(q_N, q_S) = 0.36$

$q_2 = \max(q_E, q_W) = 0.25$

$\Rightarrow q = q_1 + q_2 = 0.61$

$L = 2 \times$ No. of Arms $= 8$ sec

$$C_0 = \frac{1.5L+5}{1-Y}$$

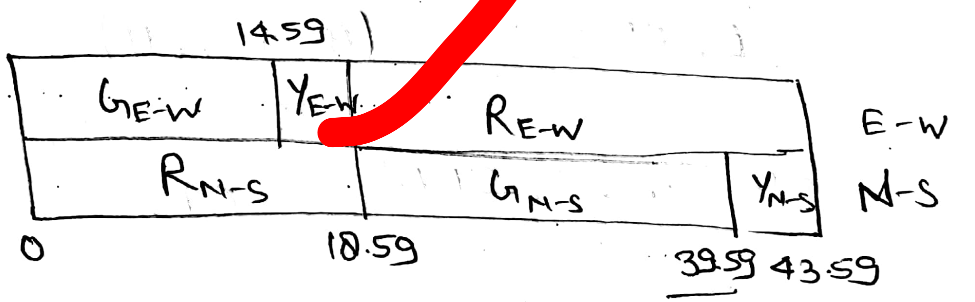
$$C_0 = \frac{1.5\times 8+5}{1-0.61} = 43.59\ sec$$

$$G_{N-S} = \frac{(C_0-L)}{Y} y_1 = \frac{(43.59-8)\times 0.36}{0.61}$$

$$G_{N-S} = 21\ sec$$

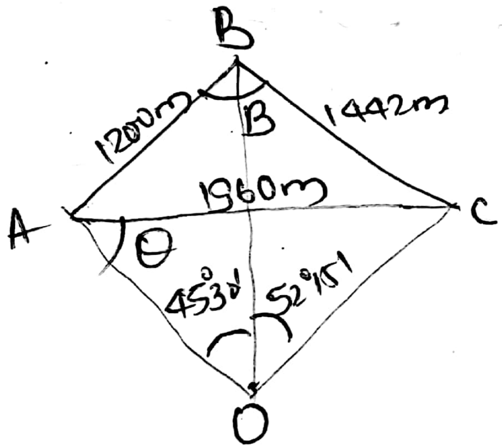
$$G_{E-W} = \frac{(C_0-L)}{Y} \cdot y_2 = \frac{(43.59-8)\times 0.25}{0.61}$$

$$G_{E-W} = 14.59\ sec$$



Q.5 (c) A, B and C are three visible stations in a hydrographic survey. The sides of the triangle ABC are AB = 1200 m, BC = 1442 m and CA = 1960 m. A station O is established outside the triangle and its position is to be determined by resection on A, B and C, the angle AOB and BOC being respectively 45° 30′ and 52° 15′. Determine distances of OA and OC, if O and B are on the opposite sides of line AC.

[12 marks]



$$\cos B = \frac{AB^2 + BC^2 - AC^2}{2 AB BC}$$

$$\Rightarrow \angle B = 95.3426°$$

$$\angle BCA = 37.5595°$$

$$\angle BAC = 47.0979°$$

$$\angle ACO = 180 - \theta - 45°30' - 52°15'$$

$$\angle ACO = 82°15' - \theta$$

$\angle BAO = 47.0979° + \theta$. [from △OAB]

$$\frac{OB}{\sin\angle BAO} = \frac{1200}{\sin\angle AOB}$$

$$OB = \sin(47.0979° + \theta) \times 1602.4305 \quad \text{---(i)}$$

from [△ OBC]

$$\frac{OB}{\sin\angle BCO} = \frac{1442}{\sin\angle BOC)}$$

$$\frac{OB}{\sin(119.00 - \theta)} = \frac{1442}{0.7906}$$

$$OB = ~~1442~~ \; 1823.946 \times \sin(119.00 - \theta) \quad \text{---(ii)}$$

from eqn (i) & (ii)

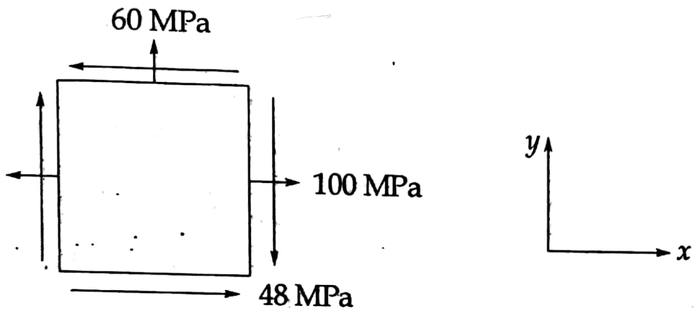
$$\boxed{\theta = 55.7048°}$$

$$\frac{OC}{\sin\theta} = \frac{OA}{\sin(82.25 - \theta)} = \frac{1960}{\sin(97.75°)}$$

$$\Rightarrow \boxed{OC = 1634.17\,m}$$

$$\boxed{OA = 884.006\,m}$$

Q.5(d) For the state of plane stress as shown below, determine the principal planes and the principal stresses by using Mohr's circle.

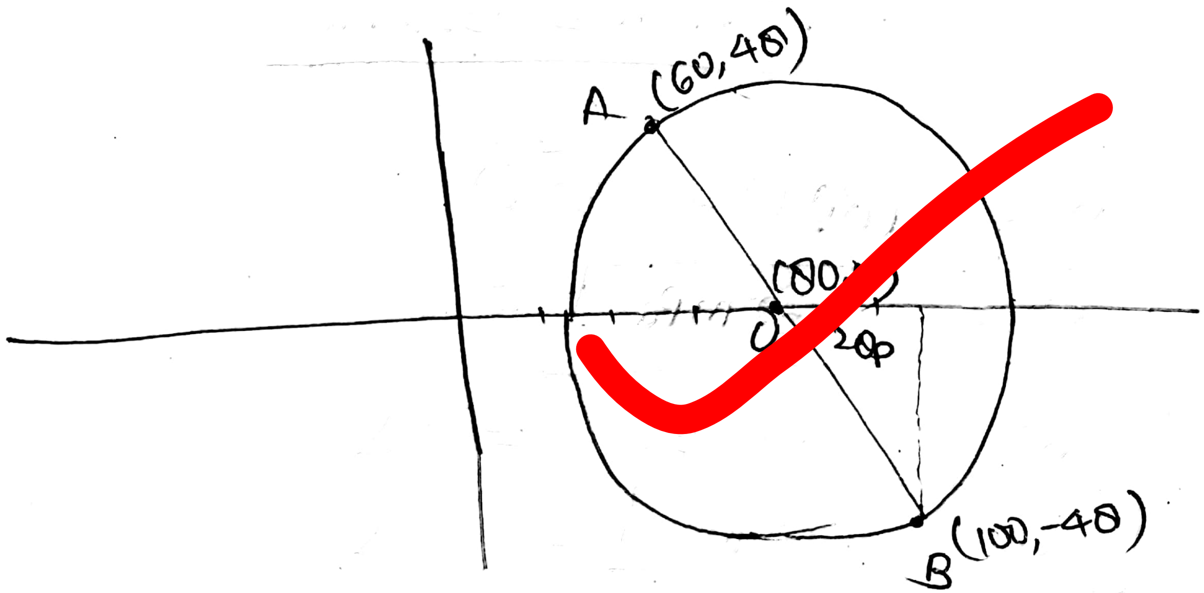


[12 marks]

$\sigma_x = 100 MPa$

$\sigma_y = 60 MPa$

$\tau_{xy} = -48 MPa$



Centre of Mohr circle = ~~80~~. $\frac{\sigma_x + \sigma_y}{2}$

$= (80, 0)$

$\tan 2\theta_p = \frac{+48}{100-80} = +67.38^\circ$

$\theta_p = 33.69^\circ$	Clockwise

8

principle stress ⇒

Radius of Circle = $\frac{AB}{2}$

$= \frac{\sqrt{(100-60)^2 + (-48-48)^2}}{2}$

$= 52 \text{ MPa}$

Max. shear stress = τ_{max} = Radius of circle

$\tau_{max} = 52 \text{ MPa}$

$\sigma_1 = (80, 0) + (52, 0)$

$\sigma_1 = 132 \text{ MPa}$

$\sigma_2 = 80 - 52$

$\sigma_2 = 28 \text{ MPa}$

Q.5 (e) Find the shortest distance between two places A and B, given that the latitudes of A and B are 14°N and 15°06′N and their longitudes are 70°10′E and 76°E, respectively. Radius of earth is 6372 km.

[12 marks]

Difference btw latitudes ⇒ $15°06' - 14$
$= 1°06'$

Difference btw longitude ⇒ $76° - 70°10'$
$= 5°50'$

∴ $1°$ in km $= \dfrac{2\pi \times 6372}{360}$

$= 111.212$ Km.

⇒ $\Delta L = 1.1 \times 111.212 = 122.334$ Km

Δ longitude $= \left(5 + \frac{5}{6}\right) \times 111.212 = 648.737$ Km shortest distance $= \sqrt{(648.737)^2 + (122.334)^2}$

shortest distance = 660.170 Km

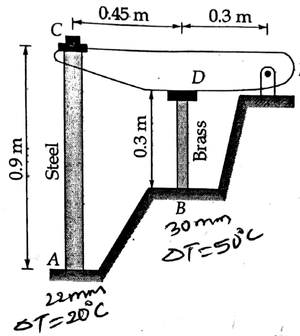
Neglecting Curvature of the earth

10

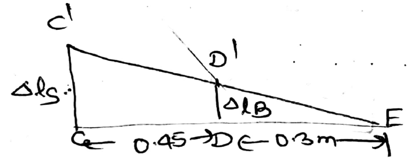
Q.6 (a) The rigid bar *CDE* is attached to a pin support at *E* and rests on the 30 mm diameter brass cylinder *BD*. A 22 mm diameter steel rod *AC* passes through a hole in the bar and is secured by a nut which is snugly fitted when the temperature of entire assembly is 20°C. The temperature of the brass cylinder is then raised to 50°C while that of the steel rod remains at 20°C. Assuming that no stresses were present before the temperature change, determine the stress in the cylinder.

Rod *AC*: Steel
$E = 200$ GPa
$\alpha = 11.7 \times 10^{-6}/°C$

Cylinder *BD*: Brass
$E = 105$ GPa
$\alpha = 20.9 \times 10^{-6}/°C$



[20 marks]



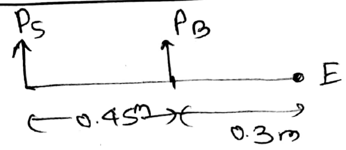
from properties of triangle

$$\frac{\Delta l_S}{0.75} = \frac{\Delta l_B}{0.3}$$

$$\boxed{\Delta l_S = 2.5\Delta l_B} \quad \text{—(i)}$$

let the steel bar is in tension & the Brass bar is in compression due to unequal extension of bars.

$$\Rightarrow \left.\begin{aligned} \Delta l_S &= (\Delta l_{Temp})_{steel} + \Delta l_{P_S} \\ \Delta l_B &= (\Delta l_{Temp})_{Brass} + \Delta l_{P_B} \end{aligned}\right\} \quad \text{—(ii)}$$



taking Moment about E

$\Rightarrow P_S \times 0.75 = -P_B \times 0.3$

$2.5 P_S = -P_B$

$$\boxed{P_B = -2.5 P_S} \quad -(iii)$$

from eqn (i) (ii) & (iii)

$$(\Delta l_{temp})_{steel} + \Delta l_{P_S} = 2.5\left[(\Delta l_{temp})_{Brass} + \Delta l_{P_B}\right]$$

$$0.9 \times 11.7 \times 10^{-6} \times (20-20) + \frac{P_S\, 0.9}{\frac{\pi}{4} \times (0.022)^2 \times 200 \times 10^9}$$

$$= 2.5\left[0.3 \times 20.9 \times 10^{-6}(50-20) + \frac{P_B \times 0.3}{\frac{\pi}{4} \times (0.030)^2 \times 105 \times 10^9}\right]$$

$$P_S(0.01103797 \times 10^{-6}) = 2.5\left[188.1 + \frac{(-2.5P_S) \times 0.3}{\frac{\pi}{4} \times (0.030)^2 \times 105 \times 10^3}\right]$$

$$P_S(0.01103797) = 470.25 - 0.02526269 P_S \times 10^{-6}$$

$P_S = 12674.90$ N

or

$\boxed{P_S = 12.67 \text{ KN}}$ (Tensile)

$\boxed{P_B = -31.69 \text{ KN}}$ (compressive)

$$\sigma_{steel} = \frac{12674.98}{\frac{\pi}{4} \times (0.022)^2} = 33.34 \text{ MPa}$$

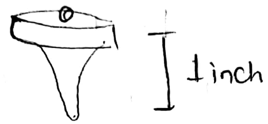
$$\sigma_{Brass} = \frac{31.69 \times 10^3}{\frac{\pi}{4} \times (0.030)^2} = 44.83 \text{ MPa}$$

20

Q.6 (b) What are the various physical tests which should be done on bitumen to judge its suitability as a binding material for pavement construction?

[20 marks]

① Ring ball Test →



Temp increament by 5°C/minute

This test is done to find out the softening point of the bitumen.

In this test we make a sample of bitumen In the Ring & then a steel ball is placed at the centre of it & the entire setub is submerged in the water & the Temp of water is then Increased ~~at~~ at Rate of 5°C/min

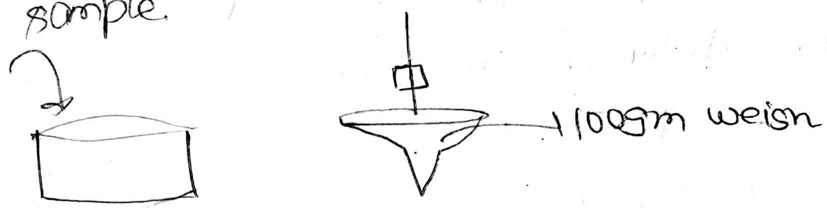
→ by this test we can find out the suitabity of bitumen at different locations with different Temp

⇒ Temp low ⇒ Use Bitumen with low softening point

→ Hot places ⇒ Use Bitumen ~~with~~ of High Softening point

② penetration test -

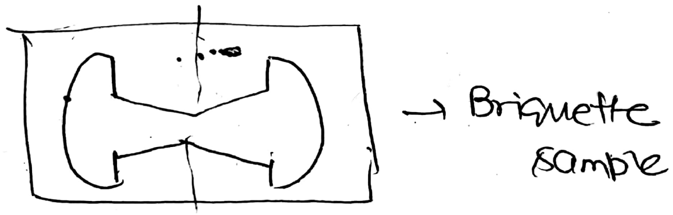
sample.



⇒ 100 gm weight with pointed cone is allowed to penetrate in the bitumen for 5 sec.

by this test we can check the consistency of the Bitumen.

③ Ductility Test



sample ⇒ at 27°C

& streched at the Rate of 50mm/min

④ flash & fire point Test → Flash point means that temp. when a spark occurs & If spark/fire is for min 5 sec then it is called fire point

This [illegible] is done because (flash point - 50°C) is allowed for the use bitumen in the [illegible] mixture.

(5) Float Test

(6) Sp [illegible] Test

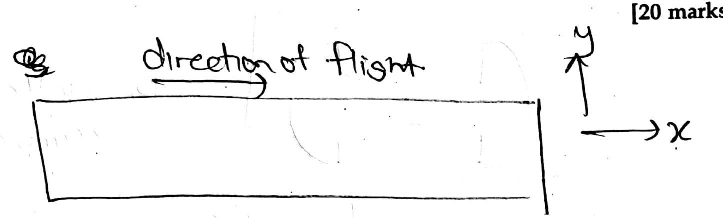
(7) loss on Ignition Test

(8) Residual Test

Q.6 (c) An area of 150 km × 15 km is to be surveyed using aerial photogrammetry. Determine the total number of photographs required to cover the whole area with the following details:

Size of photograph = 23 cm × 23 cm
Average scale of photograph = 1 : 25000
Average elevation of terrain = 335 m
Longitudinal overlap = 65%
Side overlap = 28%
Ground speed of aircraft = 270 km/hr
Focal length of camera = 200 mm
Least count of intervalometer = 0.5 sec

[20 marks]



~~[illegible]~~

length covered in one photograph

$\Rightarrow (1-S_l) \times \frac{S}{\text{Scale}} = 0.35 \times \frac{0.23}{\frac{1}{25000}}$

$\Rightarrow l = 2012.5\,m.$

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Interval between two Images =

$$\frac{2012.5}{270 \times \frac{5}{18}} = 26.833 \text{ sec}$$

Assuming $t = ~~27~~ 26.5$ sec

2) [illegible] covered by one photograph

$$= ~~27~~\,26 \times 270 \times \frac{5}{18}$$

$$= ~~2~~1987.5 \text{ m}$$

No. of photographs in x direction

$$= \frac{150 \times 10^3}{1987.5} + 1 = 76.[illegible]$$

≈ 77 photographs

No. of photographs in y-direction

$$N_y = \frac{15 \times 10^3}{(1-[illegible]) \times 0.23} \times \text{Scale} + 1$$

$$= \frac{15000 \times \frac{1}{25000}}{0.72 \times 0.23} + 1$$

$N_y = 4.62 \approx 5$ photographs

Total photographs $= 77 \times 5 = 385$ Ans

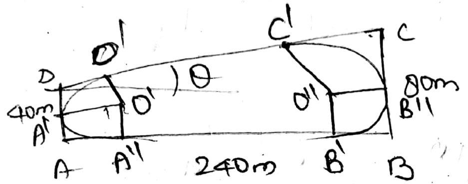
20

Q.7 (a) In order to layout a pond as a public park, two perpendiculars AD and BC of 40 m and 80 m length respectively were erected on same side of a line AB of length 240 m. If the pond is to have sides along AB and DC, the ends being formed of circular arcs to which AB, DC and end perpendiculars AD and BC are tangential then, calculate

(i) the radii of sub-circular curves

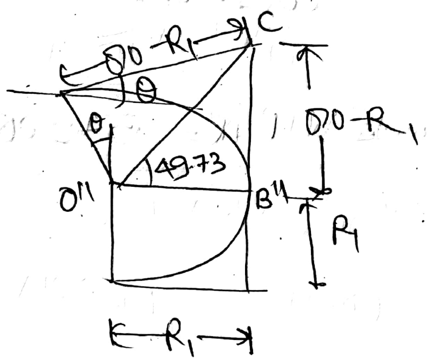
(ii) the perimeter of the park

[20 marks]



$$\tan\theta = \frac{40}{240}$$

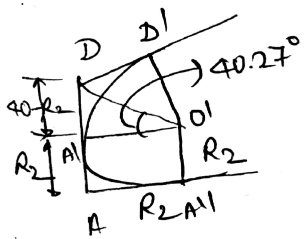
$$\theta = 9.4623^\circ$$



In Δ O''CB''

$$\Rightarrow \tan 49.73^\circ = \frac{80 - R_1}{R_1} = \frac{80}{R_1} - 1$$

$$R_1 = 36.689\ m$$



In Δ O'A'D'

$$\tan 40.27^\circ = \frac{40 - R_2}{R_2}$$

$$R_2 = 21.655\ m$$

$$\text{Perimeter of Park} = (240 - R_1 - R_2) + \frac{(180 - 9.4623)}{180} \times \pi \times R_2$$

$$+ \left((CD + R_1 + R_2) - 80 - 40 \right)$$

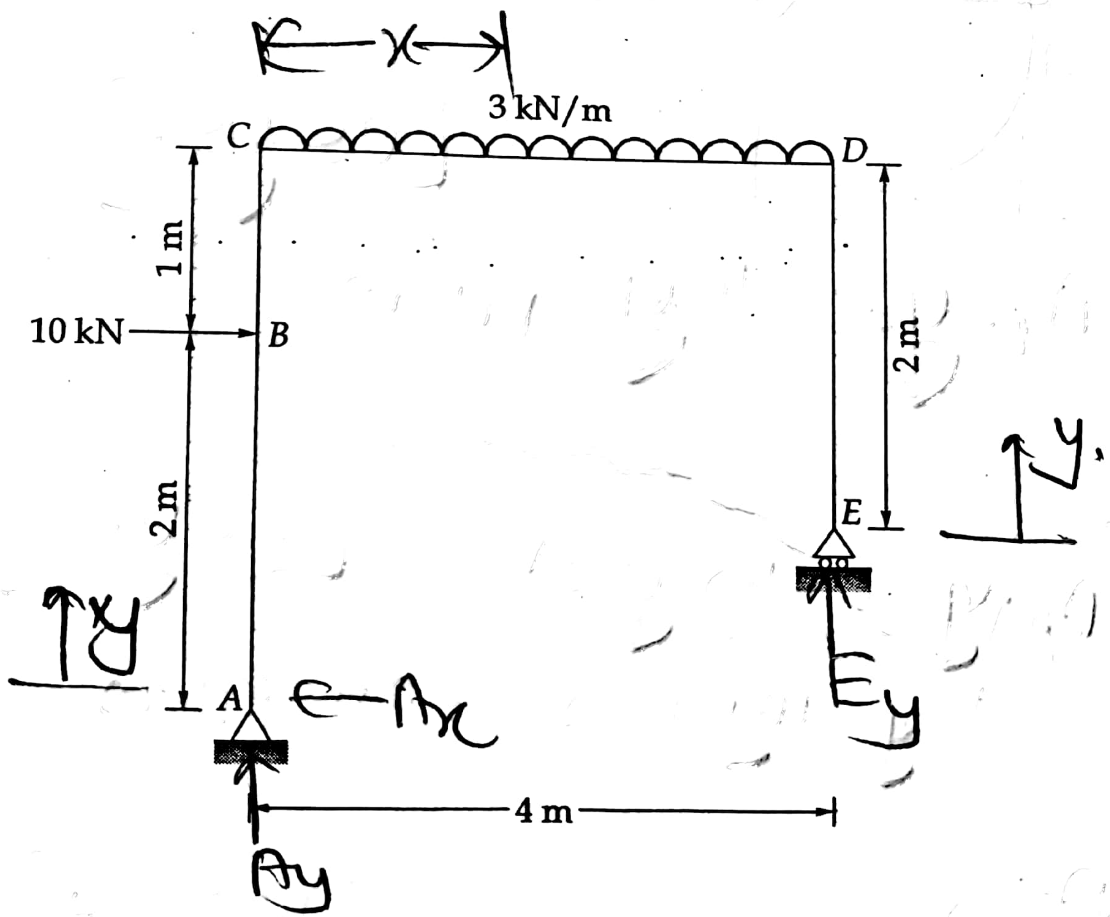
$$+ \frac{(180 + 9.4623)}{180} \times \pi R_1$$

$$CD = \frac{240}{\cos 9.4623} = 243.[illegible]05\ m$$

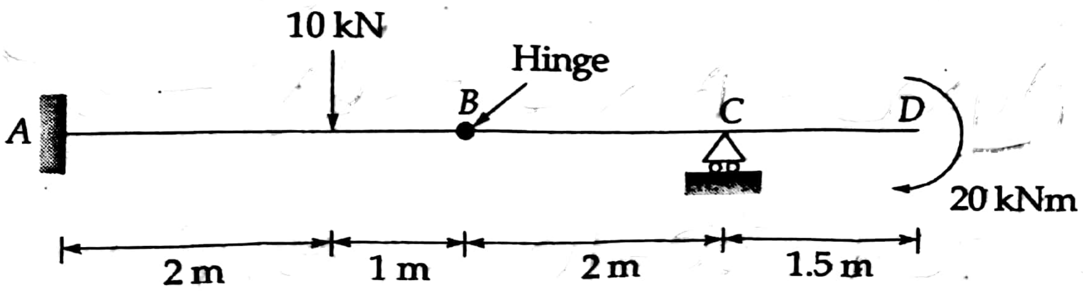
$\Rightarrow$ **Perimeter of Park = 5[illegible]9.006 m**

Q.7 (b) Workout and sketch the bending moment diagram in the following case shown in figure below.

(i)



(ii)



[20 marks]

(i) $\Sigma F_x = 0$

$\Rightarrow A_x = 10 kN$

$\Sigma F_y = 0$

$A_y + E_y = 12$

Taking Moment about A

$10 \times 2 + (3 \times 4 \times 2) = E_y \times 4$

$E_y = 11 kN$

$\Rightarrow A_y = 1 kN$

for span AB. $[0 \le y \le 2]$

$M_x = A_x \cdot y = 10y$ kN-m

for span BC

$M_x = A_x \cdot y - 10(y-2)$ $[2 \le y < 3]$

$= 10y - 10y + 20 = 20$ kN-m

for span CD $[0 \le x \le 4]$

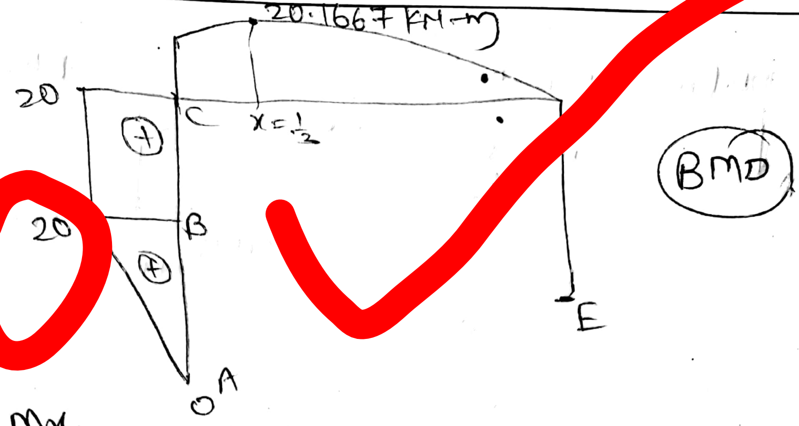
$M_x = A_y \times x + A_x \times 3 - 10 \times 1 - 3x \cdot \frac{x}{2}$

$M_x = x + 30 - 10 - 1.5x^2$

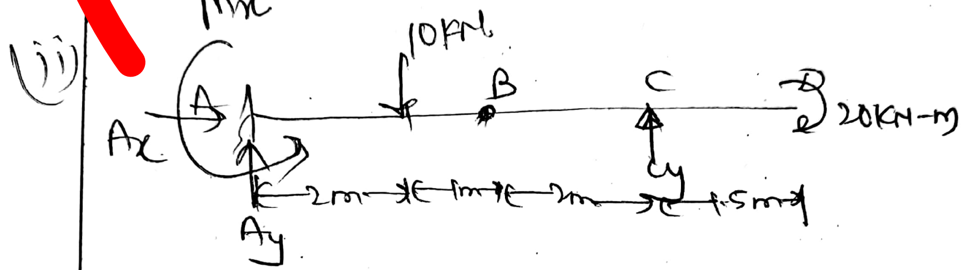
$M_x = -1.5x^2 + x + 20$

for span DE

$M_x = 0$



(ii)



Taking Moment about B ⇒ (Right side)

$20 = C_y \times 2$

$C_y = 10\ KN$

$\Sigma F_x = 0$

$\Rightarrow A_x = 0$

$\Sigma F_y = 0$

$A_y + C_y = 10$

$\Rightarrow A_y = 0$

$M_x = 10 \times 2 + 20 - 10 \times 5$

$M_x = -10\ KN\text{-}m$

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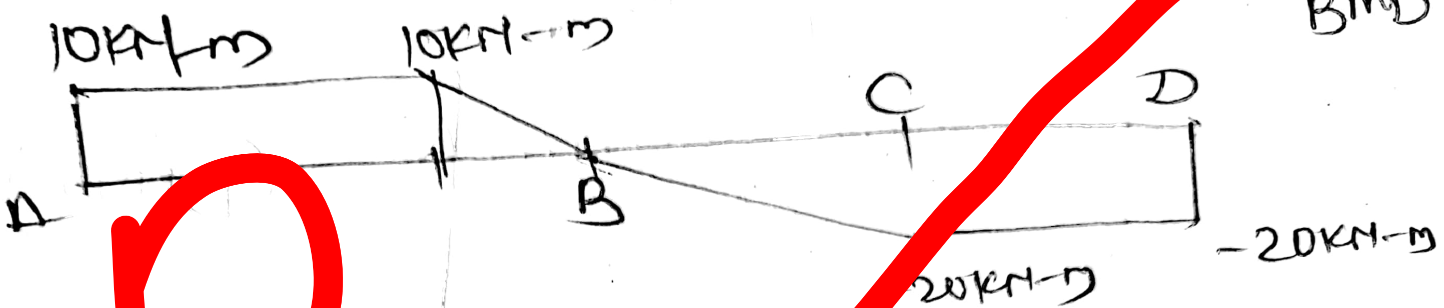
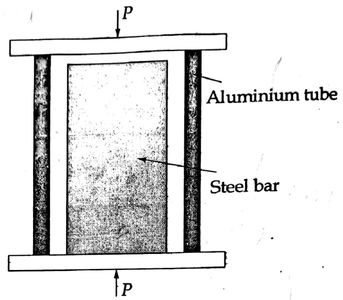
BMD



10

Q.7 (c) (i) A solid steel bar 50 cm long and 7 cm in diameter is placed inside an aluminium tube having 7.5 cm inside diameter and 10 cm outside diameter. The aluminium tube is 0.015 cm longer than the steel cylinder. An axial compressive load of 60,000 kg is applied to the bar and the tube through rigid cover plates as shown in figure. Find the stresses developed in the steel bar and the aluminium tube. Assume $E_s = 2.2 \times 10^6$ kg/cm^2 and $E_{al} = 0.7 \times 10^6$ kg/cm^2.



(ii) Determine the specific gravity of combined aggregates in a bituminous mix having maximum theoretical specific gravity of 2.4. The bitumen content is 8 percent by weight of the mix and its specific gravity is 1.00.

[15 + 5 = 20 marks]

P = 60000 kg

P = $P_{Al} + P_{Steel}$

⇒ P_{st} = 60000 − P_{Al} —(i)

from given data

Δl_{Al} = Δl_{steel} + 0.015 × 10^{-2} —(ii)

from eqn (i) & (ii)

$$\frac{P_{Al} \times l_{Al}}{A_{Al} \times E_{Al}} = \frac{P_{st} \times l_{st}}{A_{st} \times E_{st}} + 0.015 \times 10^{-2}$$

$$\frac{P_{Al} \times (0.50 + 0.00015)}{\frac{\pi}{4} \times (0.1^2 - 0.075^2) \times 0.7 \times 10^6 \times 10^4} = \frac{(60000 - P_{Al}) \times (0.50)}{\frac{\pi}{4} \times (0.07)^2 \times 2.2 \times 10^{10}} + 0.015 \times 10^{-2}$$

$\Rightarrow P_{A1} = 18889.34$ Kg.

$P_{st} = 41110.66$ Kg.

$\sigma_{A1} = \frac{18889.34}{\frac{\pi}{4} \times (10^2 - 7^2)}$

$\sigma_{st} = \frac{41110.66}{\frac{\pi}{4} \times 7^2}$

$\boxed{\sigma_{A1} = 549.73 \text{ kg/cm}^2}$

$\boxed{\sigma_{st} = 1068.24 \text{ kg/cm}^2}$

15

(ii)

$G_{theoretical} = 2.4$

$G_T = \frac{100}{\frac{(100-8)}{G_A} + \frac{8}{G_B}}$

$2.4 = \frac{100}{\frac{92}{G_A} + \frac{8}{1}}$

$\boxed{G_A = 2.733}$ → ~~Combined~~ S.G of combined Aggregates

5