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ESE 2024 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Civil Engineering

Test-4 : Design of Concrete and Masonry Structures [All Topics] Strength of Materials - 1+ Highway Engineering - 2 + Surveying and Geology-2 [Part Syllabus]

Name :

Roll No :

Test Centres			Student's Signature
Delhi ☑	Bhopal ☐	Jaipur ☐	
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Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. There are Eight questions divided in TWO sections.
3. Candidate has to attempt FIVE questions in all in English only.
4. Question no. 1 and 5 are compulsory and out of the remaining THREE are to be attempted choosing at least ONE question from each section.
5. Use only black/blue pen.
6. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
7. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
8. There are few rough work sheets at the end of this booklet. Strike off these pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	56
Q.2	55
Q.3	48
Q.4	—
Section-B	
Q.5	48
Q.6	—
Q.7	58
Q.8	—
Total Marks Obtained	265

Signature of Evaluator .... Cross Checked by ....

IMPORTANT INSTRUCTIONS

CANDIDATES SHOULD READ THE UNDERMENTIONED INSTRUCTIONS CAREFULLY. VIOLATION OF ANY OF THE INSTRUCTIONS MAY LEAD TO PENALTY.

DONT'S

1. Do not write your name or registration number anywhere inside this Question-cum-Answer Booklet (QCAB).
2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
3. Do not tear off any leaves from your QCAB, if you find any page missing do not fail to notify the supervisor/invigilator.
4. Do not leave behind your QCAB on your table unattended, it should be handed over to the invigilator after conclusion of the exam.

DO'S

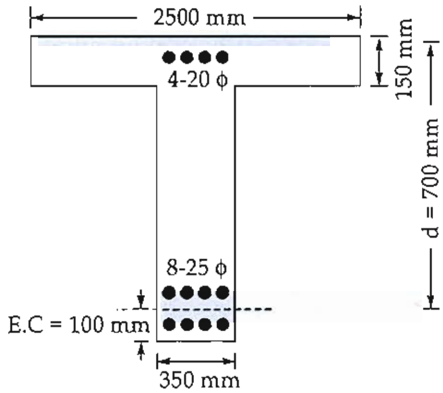
1. Read the Instructions on the cover page and strictly follow them.
2. Write your registration number and other particulars, in the space provided on the cover of QCAB.
3. Write legibly and neatly.
4. For rough notes or calculation, the last two blank pages of this booklet should be used. The rough notes should be crossed through afterwards.
5. If you wish to cancel any work, draw your pen through it or write "Cancelled" across it, otherwise it may be evaluated.
6. Handover your QCAB personally to the invigilator before leaving the examination hall.

Very Good, Keep it up.

(1) Accuracy is very good.
(2) Answer presentation & skills are also good
(3) Revise all the concepts & theory part.
(4) Practice more & more ques.

Section A : Design of Concrete and Masonry Structures

(a) A simply supported *T*-beam is as shown in figure below.



Clear span of *T*-beam = 10 m.
Live load on beam = 52 kN/m
Width of support = 500 mm
Grade of concrete and steel are M30 and Fe415 respectively.
Design the shear reinforcement of the beam using the table given below:

p_t%	1.25	1.50	1.75	2.00	2.25	2.5
τ_C(MPa)	0.71	0.76	0.80	0.84	0.88	0.91

Use LSM.

[12 marks]

$DL = 25(2.5)(0.15) + 25(0.8-0.15)(0.35)$

$= 9.375 kN/m + 5.6875$

$= 15.0625 kN/m$

$LL = 52 kN/m$

$W = DL + LL = 67.0625 kN/m$

$W_u = 1.5W = 1.5 \times 67.0625 = 100.6 kN$

since simply supported

$V_u = \frac{w_u l_{clear}}{2} = \frac{100.6 \times 10}{2} = 503 kN\text{-}m.$

$\tau_v = \frac{V_u}{b_w d} = \frac{503 \times 1000}{350 \times 700} = 2.05 < \tau_{cmax}$.

$\tau_{cmax} = 0.625\sqrt{f_{ck}} = 0.625\sqrt{30} = 3.4$

$P_t = \frac{100 A_{st}}{b_w d} = \frac{100 \times 8 \times \frac{\pi}{4}(25)^2}{350 \times 700} = 1.6\%$.

from table.

$\frac{1.75 - 1.5}{1.75 - 1.6} = \frac{0.8 - 0.76}{0.8 - \tau_c}$ $\tau_c = 0.776\ N/mm^2$.

$\therefore V_{uc} = \tau_c (b_w)(d)$

$= 0.776(350)(700) = 190120N = 190.12kN$

$V_{us} = V_u - V_{uc}$

$= 503 - 190.12$

$= 312.88kN$.

shear reinf

$V_{us} = \frac{0.87 f_y A_{sv} d}{S_v}$ provide 2leg 10mm.

$S_v = \frac{0.87 \times 415 \times \frac{\pi}{4}(10)^2 \times 2 \times 700}{312.88 \times 10^3}$.

$S_v = 126.88mm$

provide 2L-10mm @ 120mm c/c

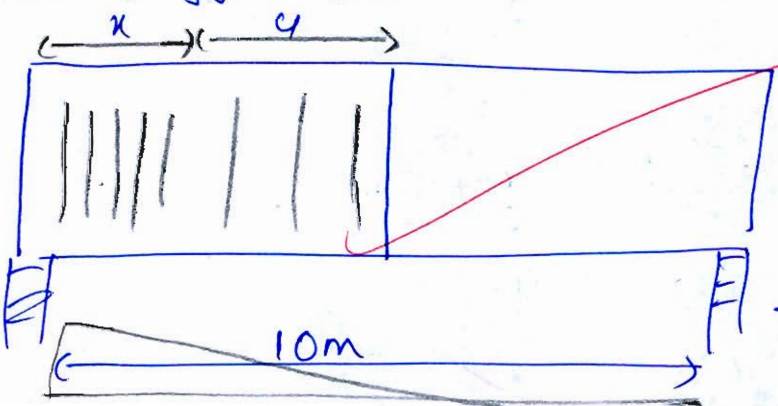
min shear reinf $\frac{A_{sv}}{bS_v} = \frac{0.4}{0.87f_y} \Rightarrow S_v = \frac{2 \times \frac{\pi}{4}(10)^2 \times 0.87 \times 415}{0.4 \times 350}$

$S_v = 405.09mm$.

$S_v = 0.75(700) = 525mm$.

300mm

∴ provide 2 legged 300 mm at center.



5 → 2.05
4 → 0.776

y = 1.89m
x = 3.11m

12

b) What are the assumptions made in limit state method as per IS : 456 – 2000? Also, show that limiting depth of neutral axis is 0.48 times of effective depth of the beam if Fe415 steel is used.

[12 marks]

Assumptions

1) The normal plane perpendicular to longitudinal axis will remain plane before and after bending

2) The max strain in compression in concrete $= 0.0035$ (under flexure)

3) Tensile strength of concrete is neglected

4) max strain in tension steel $< 0.002 + \frac{0.87 f_y}{E_s}$

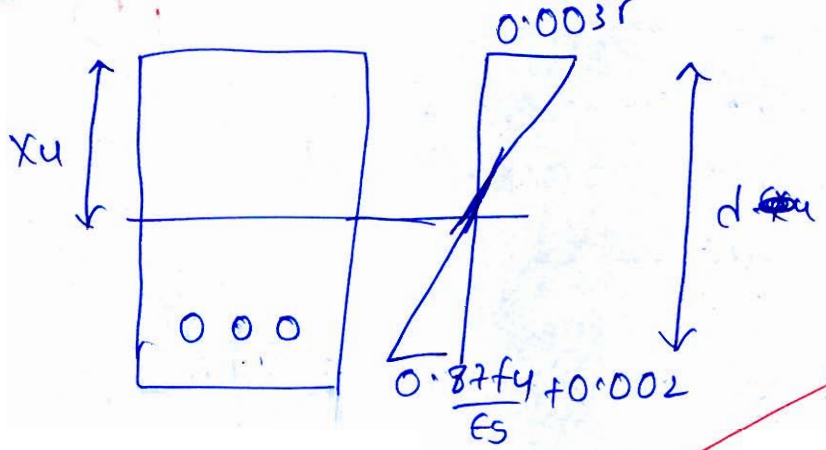
5) partial safety factor for concrete = 1.5
steel = 1.15

6) The stress strain diagram can be of any shape i.e trapezium, rectangle which give substantial test results.

06

7) compression strength is 0.67 times of characteristic strength of concrete.

Limiting depth



by similarity of Δle

$$\frac{x_u}{d-x_u} = \frac{0.0035}{0.002 + \frac{0.87f_y}{E_s}}$$

$$\frac{d-x_u}{x_u} = \frac{0.002 + 0.87f_y/E_s}{0.0035}$$

$$\frac{d}{x_u} = \frac{0.0055 + 0.87f_y/E_s}{0.0035}$$

$$x_u = \left(\frac{0.0035}{0.0055 + 0.87f_y/E_s}\right)d$$

At Fe 415 $f_y = 415$

E_s = constant 2×10^5

$$x_u = \left(\frac{0.0035}{0.0055 + \frac{0.87 \times 415}{2 \times 10^5}}\right) d$$

$$= \left(\frac{0.0035}{0.0055 + 0.001805}\right) d$$

$$x_u = 0.4799d$$

06

$$(x_u)_{limiting} = 0.48d \text{ for Fe-415}$$

(c) Find the working moment of resistance of a beam section 300 mm × 600 mm (overall depth) reinforced with 800 mm^2 compression steel and 2160 mm^2 tension steel. Use M25 grade of concrete and Fe415 grade of steel.

Assume stress in compression steel as 350 N/mm^2 and take effective cover as 50 mm in both tension and compression.

[12 marks]

$A_{st} = 2160 mm^2$ $A_{sc} = 800 mm^2$

$d = 550 mm = 600 - 50 = 550 mm$

Actual neutral axis

$$0.36 f_{ck} b x_u + (f_{sc} - 0.45 f_{ck}) A_{sc} = 0.87 f_y A_{st}$$

$$\Rightarrow 0.36 \times 25 \times 300 x_u + (350 - 0.45 \times 25) \times 800$$

$$= 0.87 \times 415 \times 2160$$

$$2700 x_u = 779868 - 271000$$

$$x_u = 188.47 mm.$$

$X_{u\,limit} = 0.48d$
$= 0.48(550)$
$= 264mm$

$\therefore X_u < X_{u\,limit}$ (URS)

$\therefore MOR = 0.36 f_{ck} b X_u (d - 0.42 X_u) + (f_{sc} - 0.45 f_{ck}) A_{sc} (d - d')$

$= 0.36 \times 25 \times 300 \times 188.47 (550 - 0.42 \times 188.47) + (350 - 0.45 \times 25)(800)(500)$

$= 239.59 + 135.5$

$= 375.09$ KN-m.

$M_{ultimate} = 375.09$ KN-m

$M_w = \frac{M_u}{1.5} = \frac{375.09}{1.5}$

$M_{work} = 250.06$ KN-m.

12

d) Briefly, explain the systems of prestressing.

[12 marks]

prestressing can be done by two methods

1) pretensioning

2) post tensioning.

1) pretensioning

In this the cables are anchored and concrete is directly poured on cables so that prestressing forces are transferred by bond action.

-> Generally it is used for smaller spans.

-> losses are high

-> Hoyer line (long line) method uses pretensioning.

② posttensioning

In this the concrete is poured first around the duct and lates cables are anchored in duct

→ forces transfer is through duct no direct bond

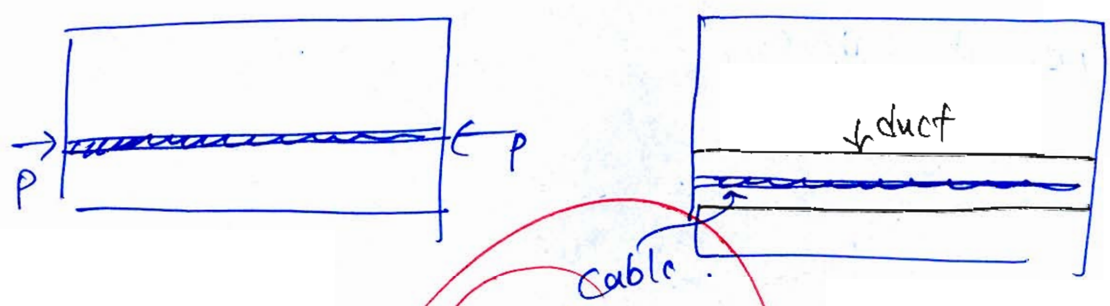
→ losses are less

→ used in high/longer span

→ Ex Grifford, magnel, Gccmel uses post tensioning.

Pretensioning

post tensioning



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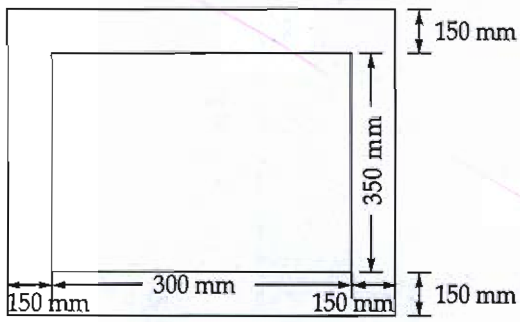
(e) A box section is as shown in figure below.



Design the beam as shown in figure for a working bending moment of 285 kN-m using M25 concrete and Fe415 steel and using limit state method. Consider effective cover for all reinforcement as 50 mm.

[12 marks]

$M_u = 1.5 \times 285$

$= 427.5$ kN-m.

Assume it as 2L beams.

since Length is not given consider whole as effective width

$b_f = 600$mm

Assuming $x_u < D_f$ $D_f = 150$mm.

$MOR = 0.36 f_{ck} b_f x_u (d - 0.42 x_u)$

$d = 150 + 350 + 150 - 50$

$= 600$mm.

$427.5 \times 10^6 = 0.36 \times 25 \times 600 x_u (600 - 0.42 x_u)$

$79166.67 = 600 x_u - 0.42 x_u^2$

$0.42 x_u^2 - 600 x_u + 79166.67 = 0$

$x_u = 147$mm.

$x_{u limit} = 0.48(600) = 288$ $x_u < x_{u limit}$

Hence our assumption is correct $x_u < D_f$.

$\therefore$ $C = T$.

$0.36 f_{ck} b_f x_u = 0.87 \times f_y p A_{st}$

$0.36 \times 600 \times 25 \times (147) = 0.87 \times 415 \times A_{st}$

$A_{st} = 2198.5 mm^2$

$(A_{st})_{at\ bottom} = 2199 mm^2$

provide 5-24mm bars.

12

$(A_{st})_{min} = \frac{0.85}{415}(b_w d)$

$= \frac{0.85}{415}(150)(600)$

$= 184 mm^2$

$A_{st} > A_{st\,min}$

$\therefore$ provide 5-24mm bars.

Spacing $= \frac{600}{5} = 120mm$ c/c

(a) (i) Design a circular column with helical reinforcement for an axial load of 3600 kN under service condition. The unsupported length of column is 5 m and the column is held in position and restrained against rotation at both the ends. Use LSM. (Use M30 concrete and Fe415 grade of steel)

(ii) What are the differences between working stress method and limit state method of design?

[15 + 5 = 20 marks]

(i) $P_u = 3600 \times 1.5 = 5400 kN$.

$l_{xo} = 5000 m$

For short colum $\quad$ SR < 12

$$\frac{L_{xe}}{D} < 12 \quad = \frac{0.65 \times 5000}{D} < 12$$

$\Rightarrow D \geq 270.8 mm.$

$e_{min} < 0.05 LLD$

$$\frac{L_{xo}}{500} + \frac{D}{30} \leq D/20 \Rightarrow \frac{5000}{500} \leq D/60.$$

$D \geq 600mm.$

provide D = 650 mm.

$P_u = 1.05(0.4 f_{ck} A_g + 0.67 f_y A_{sc})$

circular section

$5400 \times 10^3 = 1.05[0.4 \times 30 \times (650 \times 650 - A_{sc}) + 0.67 \times 415 A_{sc}]$

$5142857.143 = 5070 \times 10^3 + 266.05 A_{sc}$

$A_{sc} = 273.84 \text{ mm}^2$

$P_{sc}\% = \frac{A_{sc} \times 100}{\frac{\pi}{4}(650)^2} = \frac{274 \times 100}{\frac{\pi}{4}(650)^2} = 0.082\%$

∴ percentage of steel is should be 0.8 to 6%.
Hence not ok.

∴ provide 1% steel

$A_{sc} = \frac{1}{100} \times \frac{\pi}{4}(650)^2 = 3318.3 \text{ mm}^2$

provide 8-20mm bars + 4-16mm bars

$\therefore A_{sc} = \frac{\pi}{4}(20)^2 \times 8 + \frac{\pi}{4}(16)^2 \times 4$

$= 3318 \text{ mm}^2$

For helical reinforcement

gross dia = 650 mm

core dia = $D_g - 2N_c$ assume $N_c = 40$

$= 650 - 2(40) = 570 \text{ mm}$

helical dia = $D_h = 570 - \phi_h$

$= 560 mm$ $\phi_h = \frac{\phi_m}{4} = \frac{20}{4} = 5 mm$

(Assuming helix dia = 10 mm) for safety

$\frac{V_h}{V_c} \geq 0.36 \frac{f_{ck}}{f_y}\left(\frac{A_g}{A_c} - 1\right)$

$$\frac{\frac{\pi}{4}(\phi_h)^2 \times \frac{1000}{pitch} \times \pi(D_h)}{\frac{\pi}{4}(D_c)^2 \times 1000} \geq \frac{0.36 \times 30}{415}\left(\frac{650^2}{570^2} - 1\right)$$

$$\frac{10^2 \times \pi(560)}{(570)^2} \times \frac{1}{pitch} \geq \frac{0.36 \times 30}{415}\left(\frac{650^2}{570^2} - 1\right)$$

pitch < 69.26 mm

10

providing pitch = 65 mm

pitch

$> 3\phi_h = 3(10) > 30 mm$

$> 25 mm$ $> 25 mm$

$< \frac{1}{6}(D_c) = \frac{1}{6}(570) = 95$

$< 75 mm$ $< 75 mm$

} All satisfied

∴ conclusion Dia = 650 mm

Asc = 8-20 mm + 4-16 mm.

pitch of helical reinforce = 65 mm

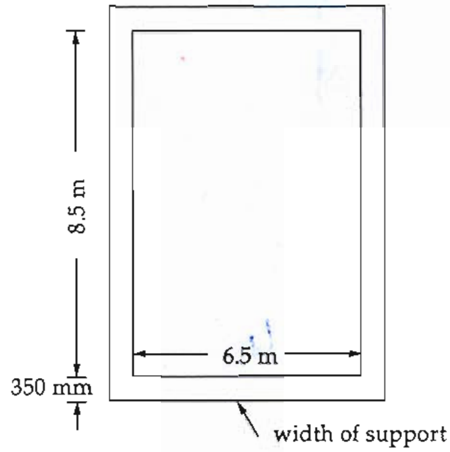
helical wire dia = 10 mm.

(ii)

LSM	WSM
→ stresses can be taken beyond elastic limit	→ stresses should be within elastic limit
→ FOS is used for materials and stresses	→ FOS is only for stress
→ strain governing	→ stress governing
→ results in high steel and less c/s	→ results in low steel and more c/s
→ less dead load	→ more dead load.
→ Economical	→ uneconomical.
→ it has limit state of collapse & serviceability	→ (linear elastic or modular method

OS

b) A simply supported slab is provided as shown in figure. The edges and corners are not prevented from lifting. Design the slab using I.S. code method.



Live load = 6 kN/m^2.

Flooring thickness = 80 mm.

Unit weight of flooring = 24 kN/m^3.

Grade of concrete and steel are M30 and Fe500 respectively.

$r = \frac{l_y}{l_x}$	1.2	1.30	1.40
α_x	0.084	0.093	0.099
α_y	0.059	0.055	0.051

Also, check the slab for shear. [Given $\tau_{c(min)}$ = 0.29 MPa for M30 concrete]

[25 marks]

since SSB A = 20

$l_y/l_x = \frac{8.5}{6.5} < 2$ → two way slab.

$\frac{l_{eff}}{A \times mf_t} = d$.

$\frac{6500 + d}{A \times mf_t} = d$

Assuming $Mf_t = 1.2$ for Fe-500

$6500 + d = (20 \times 1.2) d$

$d = 282.60$ mm

provide d = 300 mm   D = d + EC.

provide total depth = 350 mm (EC=50mm)

Leff = 6.5+d or 6.5+w (min).

= 6.8m.

$(L_{eff})_y = 8.8 \quad (L_{eff})_x = 6.8$

$r = \frac{(l_y)_e}{(l_x)_e} = \frac{8.8}{6.6} = 1.34$

Rounding r = 1.35

$\alpha_x = 0.096$

$\alpha_y = 0.053$

1) LOADS

DL = γ(D) = 25(0.35) = 8.75 kN/m²

LL = 6 kN/m²

Flooring load = 24(0.08) = 1.92

w = 16.67 kN/m²

wu = 1.5w = 25 kN/m².

$M_u = w_u l_{eff}^2 \alpha_x$

$M_{ux} = \alpha_x w_u l_{eff}^2 = 0.096 \times 25 \times 6.8^2$

= 110.976 kN-m

$M_{uy} = \alpha_y w_u l_{eff}^2 = 0.053 \times 25 \times 6.8^2$

= 61.268 kN-m

$$d_{required} = \sqrt{\frac{M_{max}}{0.133 f_{ck} b}} \quad \text{since Fe-500}$$

$$= \sqrt{\frac{110.976\times10^6}{0.133\times30\times10^3}}$$

$d = 167mm < d_{provided}$ Hence safe.

$d_x = 300mm$.

$$A_{stx} = \frac{0.5 f_{ck}}{f_y}\left(1-\sqrt{1-\frac{4.6 M_{ux}}{f_{ck} B d_x^2}}\right) B d_x$$

$$= \frac{0.5\times30}{500}\left(1-\sqrt{1-\frac{4.6\times110.976\times10^6}{30\times1000\times300^2}}\right)\times1000\times300$$

$= 895.35mm^2 > (A_{st})_{min}$.

$(A_{st})_{min} = 0.12\% BD = \frac{0.12}{100}\times1000\times350$

$= 420mm^2$.

provide 12mm bars of spacing $= \frac{1000\times\frac{\pi}{4}(12)^2}{895.35}$

$= 126mm$

provide 12mm @ 120mm c/c.

provide 12mm @ 240mm c/c in $A_{st}(-)$ portion.

$d_y = d_x - \phi = 300 - 12 = 288.$

$$A_{sty} = \frac{0.5 \times 30}{500}\left(1 - \sqrt{1 - \frac{4.6 \times 61.268 \times 10^6}{30 \times 1000 \times 288^2}}\right) \times 1000 \times 288$$

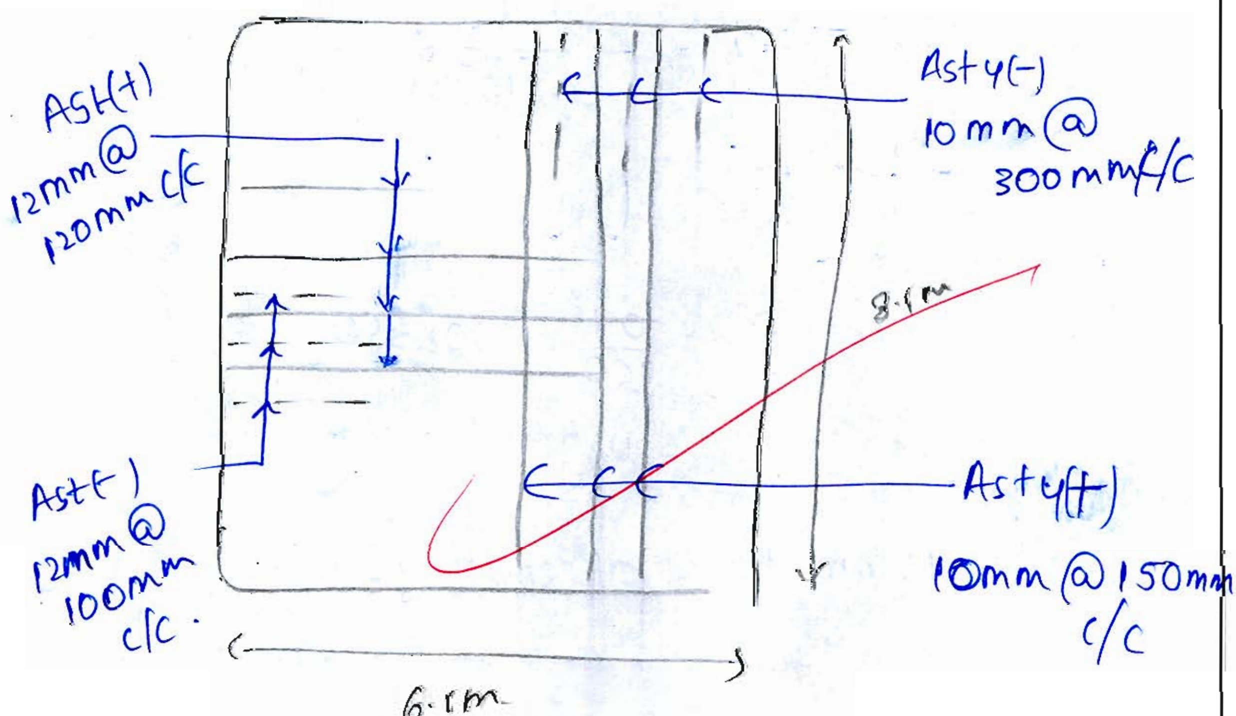
$= 504 mm^2.$

provide 10mm bars of spacing $= \frac{1000}{504} \frac{\pi}{4}(10)^2$

$= 155.8 mm$

$A_{sty(+)}$ → provide 10mm @ 150mm c/c

$A_{sty(-)}$ provide 10mm @ 300mm c/c.



Check for shear

In x direction $V_{ux} = w_u L_{x} \times \frac{r}{r+2}$

$= 25 \times 6.5 \times \frac{1.34}{3.34}$

$= 65.21 (kN)$

$$\tau_{vx} = \frac{V_u}{B d_x} = \frac{65.2 \times 10^3}{1000 \times 300}$$

$$= 0.217 \, N/mm^2 < (\tau_{c\,min} = 0.29)$$

Hence safe in shear in x dir^n.

y dir^n

$$\tau_{vy} = \frac{V_{uy}}{B d_y} = \qquad V_u = \frac{w_u l_{c1}}{3} = \frac{25 \times 6.5}{3}$$

$$= 54.17 \, kN.$$

$$\frac{V_{uy}}{B d_y} = \frac{54.17 \times 10^3}{10^3 \times 288}$$

$$= 0.188 \, N/mm^2 < \tau_{c\,min}$$

$\tau_{vy} < 0.29 \, N/mm^2$

Hence safe in y dir^n.

25

Q.2 (c) A continuous *T*-beam is used for an effective span of 15 m. Given below are its properties.

- Flange width = 2000 mm
- Flange thickness = 150 mm
- Overall depth = 1000 mm
- Effective cover = 100 mm
- Width of web = 500 mm
- 10 bars of 32 mm diameter are provided as tension reforcement
- M25 concrete and Fe500 steel used.

Calculate the ultimate moment of resistance of the *T*-beam section using LSM.

[15 marks]

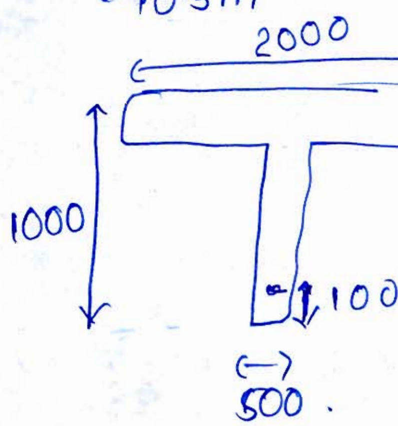
since continous isolated case.

$$b_f = \frac{l_o}{\left(\frac{l_o}{b_f} + 4\right)} + b_w \qquad l_o = 0.7 \times 15 = 10.5\,m$$

$$b_f = \frac{10.5}{\left(\frac{10.5}{2} + 4\right)} + 0.5$$

$= 1.635 m$

$b_f = 1635 mm$.



① Assume NA within flange

$$0.36 f_{ck} b_f x_u = 0.87 f_y A_{st}$$

$$A_{st} = 10 \times \frac{\pi}{4}(32)^2 = 8042.47\,mm^2$$

$$0.36 \times 25 \times 1635 x_u = 0.87 \times 500 \times 8042.47$$

$x_u = 238 mm > D_f$

∴ case Assume $D_f / x_u > 0.43$

$$y_f = 0.15 x_u + 0.65 D_f$$

$$= 0.15 x_u + 0.65(150) = 0.15 + 97.5$$

Do not write in this margin

NA

$0.36 f_{ck} b_w x_u + 0.45 f_{ck} (b_f - b_w) y_f = 0.87 f_y A_{st}$

$0.36 \times 25 \times 500 x_u + 0.45 \times 20 (1635 - 500)(0.15 x_u + 97.5)$
$= 0.87 \times 500 \times 8042.47$

$4500 x_u + 1532.25 x_u = 3498474.45$
$- 995962.5$

$6032.25 x_u = 2502511.95$

$x_u = 414.85 mm.$

$\frac{D_f}{x_u} = \frac{150}{414.85} = 0.36 < 0.4$

Case-3 Assume $\frac{D_f}{x_u} < 0.43$.

$0.36 f_{ck} b_w x_u + 0.45 f_{ck} (b_f - b_w) D_f = 0.87 f_y A_{st}$

$0.36 \times 25 \times 500 x_u + 0.45 \times 25 (1135)(150) = 0.87 \times 500 \times 8042.47$

$x_u = ~~352 mm~~ 351.81 mm.$

$\frac{D_f}{x_u} = \frac{150}{351.81} = 0.426 < 0.43.$

$x_{u limit} = 0.46 \times 900 = 414 mm$

$\therefore MOR = 0.36 f_{ck} b_w x_u (d - 0.42 x_u)$
$+ 0.45 f_{ck} (b_f - b_w)(D_f)\left(d - \frac{D_f}{2}\right)$

$x_u < x_{ulim}$ (URS)

$= 0.36 \times 25 \times 500 \times 351.8 (900 - 0.42 \times 351.8)$
$+ 0.45 \times 25 (1135)(150)\left(900 - \frac{150}{2}\right)$

$= 1190.87 + 1580.132$
$= 2771 kN\text{-}m.$

Do not write this

$M_{ultimate} = 2771 \text{ kN-m}$

$M_{working} = \frac{M_u}{1.5} = 1847.33 \text{ kN-m}.$

15

Q.3 (a) An unsymmetrical I-section is required to support an imposed load of 2 kN/m over a span of 8 m. Top flange is 300 mm wide and 50 mm thick, bottom flange is 100 mm wide and 50 mm thick, web thickness is 80 mm with overall depth of I-section as 450 mm. An effective prestressing force of 200 kN is applied at 40 mm from soffit of beam at mid-span. What are the stresses at the centre of span for

(i) prestress + self weight?

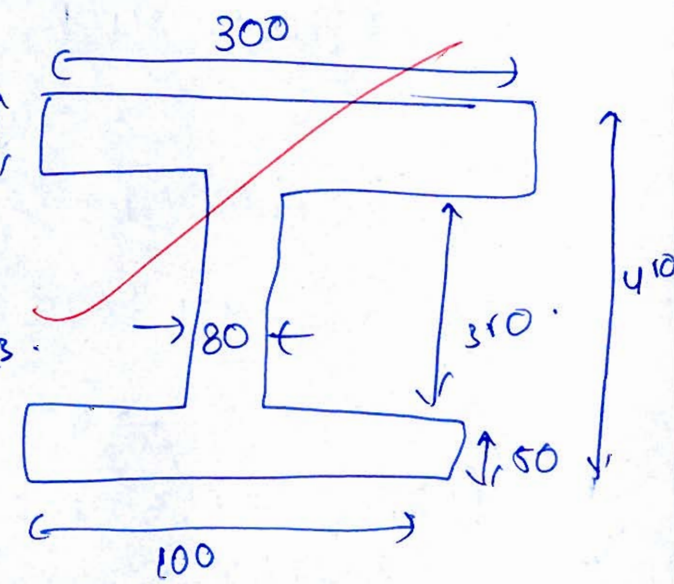
(ii) prestress + self weight + imposed load?

[20 marks]

LL = 2 kN/m.

P = 200 kN.

Assume $\gamma = 25 \text{ kN/m}^3$.



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$DL = 25(0.3)(0.05) + 25(0.1)(0.05) + 25(0.08)(0.35)$

$= 0.36 + 0.12 + 0.672$

$= ~~1.152~~ \; 1.2$

$\bar{y}$ from top

$$\bar{y} = \frac{300 \times 50 \times 25 + 350 \times 80 \left(\frac{350}{2} + 50\right) + 100 \times 50 (350 + 50 + 25)}{300 \times 50 + 350 \times 80 + 100 \times 50}$$

$$= \frac{375 \times 10^3 + 6300 \times 10^3 + 2125 \times 10^3}{48000}$$

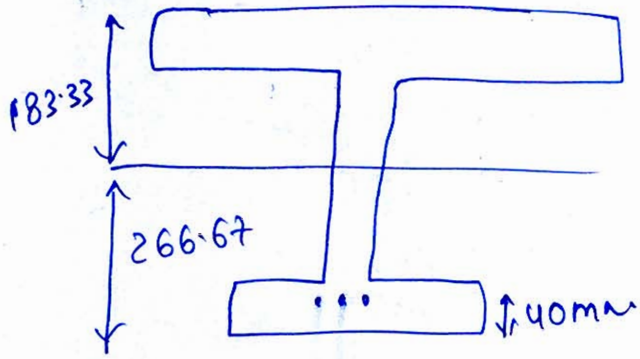
$= 183.33 mm$

$$I = \frac{300 \times 50^3}{12} + 300 \times 50 \times (183.33 - 25)^2 + \frac{80 \times 350^3}{12} + 80 \times 350 (225 - 183.33)^2 + \frac{100 \times 50^3}{12} + 100 \times 50 (425 - 183.33)^2$$

$= 3.79 \times 10^8 + 3.344 \times 10^8 + 2.93 \times 10^8$

$= 10.064 \times 10^8 \; mm^4$.

(i)



$$M_D = \frac{w_D l^2}{8}$$

$$= \frac{1.2 \times 8^2}{8}$$

$$= 9.6 \text{ kN-m}$$

$$\text{Area} = 300 \times 50 + 100 \times 50 + 350 \times 80 = 48000$$

$$\frac{P}{A} = \frac{200 \times 10^3}{48000} = 4.167 \text{ N/mm}^2$$

$$\frac{Pe}{I}(y)_{top} = \frac{200 \times 10^3}{10.064 \times 10^8} \times 226.67 \times 183.33$$

$$= 8.258 \text{ N/mm}^2$$

$$\frac{Pe}{I}(y_{bottom}) = \frac{200 \times 10^3}{10.064 \times 10^8} \times 226.67 \times 266.67$$

$$= 12.01 \text{ N/mm}^2$$

$$\frac{M}{I}(y)_{top} = \frac{9.6 \times 10^6}{10.064 \times 10^8} \times 183.33 = 1.748 \text{ N/mm}^2$$

$$\frac{M}{I}(y_{bott}) = \frac{9.6 \times 10^6}{10.064 \times 10^8} \times 266.67 = 2.54 \text{ N/mm}^2$$

At top

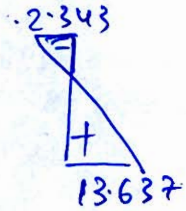
$$\frac{P}{A} - \frac{Pe}{I}(y_{top}) + \frac{M}{I}(y_{top}) = 4.167 - 8.258 + 1.748$$

$$= -2.343\ N/mm^2 = \sigma_1$$

At bottom

$$\frac{P}{A} + \frac{Pe}{I}(y_{bo}) - \frac{M}{I}(y_{bott}) = 4.167 + 12.01 - 2.54$$

$$= 13.637\ N/mm^2 = \sigma_2.$$



(ii) by imposed load

$M = \frac{2 \times l^2}{8} = 16\ kN\text{-}m.$

at top $= \frac{M}{I}(y_{top}) = \frac{16 \times 10^6}{10.064 \times 10^8} \times 183.33 = 2.91\ N/mm^2$

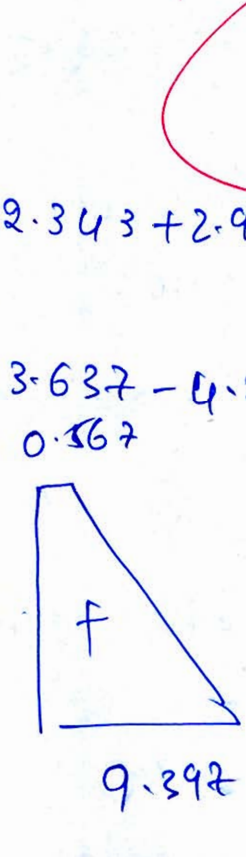
At bottom $= \frac{M}{I}(y_{bottom}) = \frac{16 \times 10^6}{10.064 \times 10^8} \times 266.67 = 4.24\ N/mm^2$

∴ stress at top

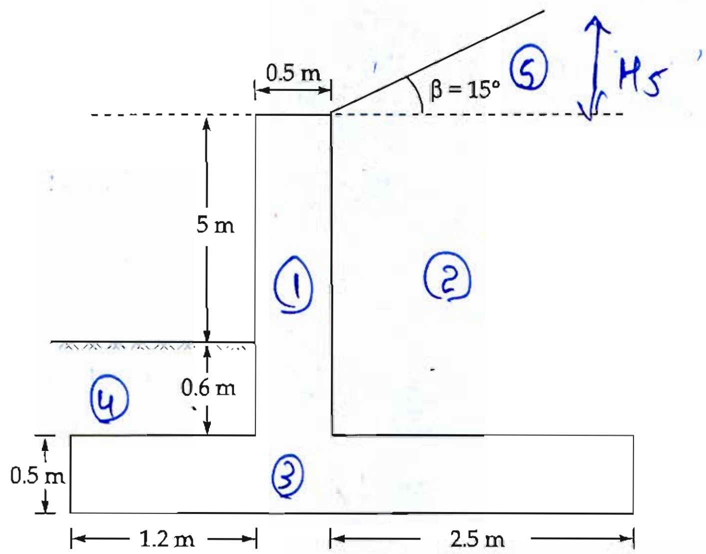
$\sigma_1' = \sigma_1 + 2.91 = -2.343 + 2.91 = 0.567\ N/mm^2.$

stress at bottom

$\sigma_2' = \sigma_2 - 4.24 = 13.637 - 4.24 = 9.397\ N/mm^2.$



Q.3 (b) A retaining wall is as shown in figure.



Unit weight of soil = 19 kN/m^3.

Angle of repose, $\phi = 32°$

Coefficient of friction between concrete and soil = 0.6

Safe bearing capacity of soil = 300 kN/m^2.

Use M30 concrete and Fe500 steel.

Check the stability of retaining wall and determine the minimum and maximum pressure at base of retaining wall.

[30 marks]

$H = 2.5 \tan 15 = 0.6698 \simeq 0.67$

$K_a = \cos\beta \left(\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}} \right)$

$K_a = \left(\frac{0.966 - 0.462}{0.966 + 0.462} \right) \times 0.966.$

$K_a = 0.34.$

$P_a = \frac{1}{2} K_a \gamma H_{total}^2$

$= \frac{1}{2}(0.34)(19)(0.67 + 5.6 + 0.5)^2$

$= 148 \text{ kN}$

$P_H = P_a \cos 15 = 142.99 = 143 kN$

$P_V = P_a \sin 15 = 38.32 kN$

Calculation error

SNO	wt	distance from toe	moment
①	25×5.6×0.5 = 70	1.45	101.5
②	19×5.6×2.5 = 266	2.95	748.7 → 784
③	25×4.2×0.5 = 52.5	2.1	110.25
④	19×0.6×1.2 = 13.68	0.6	8.208
⑤	½×19×2.5×0.67 = 15.92	3.367	53.597
⑥	P_V = 38.32	4.2	160.944
	ΣV = 456.42		1183.3

Stability against moment

$M_{OT} = P_H \times \frac{H}{3} = 143 \times \left(\frac{6.77}{3}\right)$

$= 322.7$

$(FOS)_{OT} = \frac{\Sigma M_R \times 0.9}{\Sigma M_{OT}} = \frac{1183.3 \times 0.9}{322.7} = 3.3 > 1.4$

Hence safe

$P_p = \frac{1}{2} K_p H^2$ $\quad K_p = \frac{1+\sin 32}{1-\sin 32}$

$= \frac{1}{2} \times (3.25)(19)(1.1)^2$ $\quad = 3.25$

$= 37.4\,kN$

$(FOS)_{sliding} = \frac{\mu \Sigma V + P_p}{P_H}$

$= \frac{0.6(456.42) + 37.2}{143}$

$= 2.175 > 1.4$ Hence ok.

Hence it is safe against OT & sliding

$x = \frac{\Sigma M_R - \Sigma M_{OT}}{\Sigma V}$

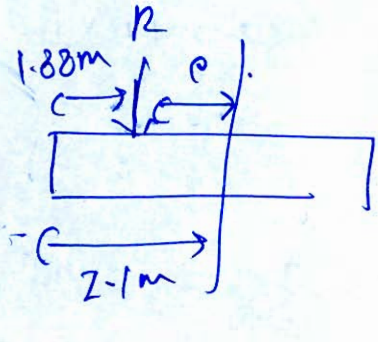
$= \frac{1183.33 - 322.7}{(456.42)}$

$= 1.88\,m$.

eccentricity $= B/2 - x$

$= \frac{4.2}{2} - 1.88$

$= 0.22$.



$$\sigma_{max} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{b}\right)$$

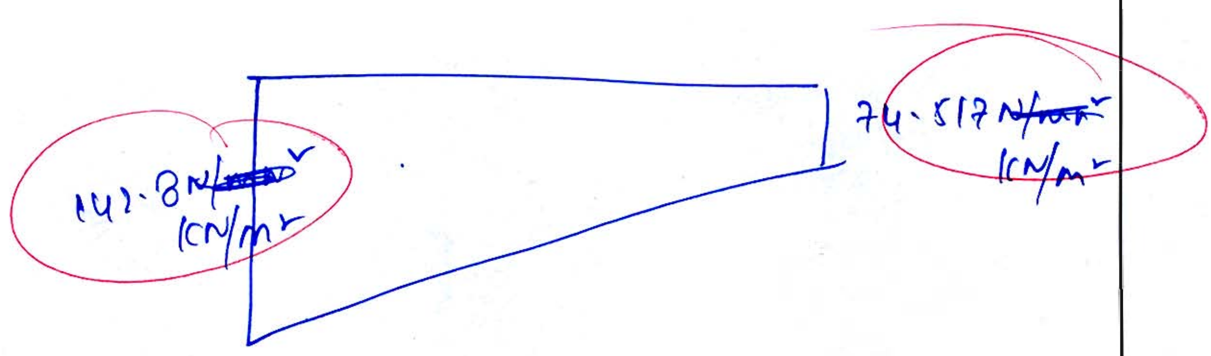
$$= \frac{456.42}{4.2}\left(1 + \frac{6(0.22)}{4.2}\right)$$

$$= 142.8 \text{ kN/m}^2$$

$$\sigma_{min} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{b}\right)$$

$$= \frac{456.42}{4.2}\left(1 - \frac{6(0.22)}{4.2}\right)$$

$$= 74.517 \text{ kN/m}^2$$



since $\sigma_{max} = 142.8 \text{ kN/m}^2$

SBC = 300 kN/m²

$\therefore \sigma_{max} < SBC$

Hence retaining wall is safe.

Q.3 (c) Explain the reasons for essentially using high tensile steel and high grade concrete in PSC structures.

[10 marks]

① the prestressing force is very high so in order to have high bearing stress we use high strength concrete

② The stress transfer will happen through bond so that bond stress should be also high

③ At corner after anchorage there will be bursting stresses so that to resist these stresses high strength concrete is reqd.

08

Also

④ for high strength concrete creep and shrinkage will be minimum.

⑤ the strength is high so we can reduce the dimensionsions so dead load gets decreased.

High strength steel

If we use mild steel the $f_y = 250$ mpa.

After considering the all losses the $\Delta f_{loss} = 200$ around so the strength remaining is negligible so we use high strength steel of $f_y = 1000$ to 1500 mpa.

→ In high strength steel the relaxation loss will also be less

-4) Design one of the flights of staircase of a school building spanning between landing beams to suit the following data:

Type of staircase: Waist slab type.

Number of steps in flight = 12

Tread, T = 300 mm

Riser, R = 150 mm

Width of landing beams = 400 mm

Finished load = 0.6 kN/m

Live load = 4 kN/m

Materials: M20 grade concrete and Fe415 HYSD bars.

[20 marks]

Q.4 (b) **(i)** What are the reasons due to which the cracks in concrete occurs? Also, explain the factors affecting the crack width.

(ii) A cantilever beam of span 6.5 m is having of cross-sections 250 mm × 550 mm. Check the beam for deflection and lateral stability.
[Use effective cover as 50 mm]

[10 + 10 = 20 marks]

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:) A simply supported lintel beam is to be designed for a clear span of 2.60 m.
Width of support on both sides is 300 mm.
Height of brick wall above lintel is 1.5 m and brick work is 250 mm wide.
Slab of 150 mm thickness is resting on top of brick work and is transferring a line load of 30 kN/m on the wall.
Consider 50 mm effective cover.
Design the lintel using M30 concrete and Fe500 steel.
Check the lintel for shear also and use LSM.
Take γ_{brick} = 20 kN/m^3 and γ_{RCC} = 25 kN/m^3

Design shear strength of M30 concrete	
p_t	τ_c (MPa)
0.75	0.59
1.0	0.66
1.25	0.71
1.5	0.76

[20 marks]

Section B : SOM - 1 + Highway Engineering - 2 + Surveying and Geology-2

.) Design a flexible pavement for a two-lane undivided carriage way using the following data:
Subgrade CBR value = 8%
Lane distribution factor = 0.5
Design life = 15 years
Planning and construction period = 1.5 years
Present commercial traffic is as under:

Vehicle type	Gross weight (kg)	No. of vehicles per day	Wheel configuration	Growth rate	Standard axle load
Bus	16000	250	Front axle-single rear axle -Dual	5%	8160 kg
Truck	22000	1200	Front axle-single rear axle-tendem	8%	14968 kg

As per IRC 37-2018 the following pavement composition is desired for CBR of 8% subgrade corresponding to different design traffic:

Design traffic (msa)	BC wearing course (mm)	DBM binder course (mm)	WMM base course (mm)	GSB sub-base course (mm)
5	30	50	250	150
10	30	60	250	200
20	30	90	250	200
30	40	95	250	200
40	40	105	250	200
50	40	115	250	200

[12 marks]

$N(SA) = \frac{365}{r}\left((1+r)^n - 1\right) \times A \times D \times F$.

(D = 0.5) for both two lane undivided

For bus

Vehicle Damage factor $= \frac{\Sigma N_i F_i}{\Sigma N_i}$

$F_i = \left(\frac{16000}{8160}\right)^4 = 14.781$

VDF = 14.781

$A = 250(1.05)^{1.5} = 268.982$

$N_1 = \frac{365}{0.05}\left[(1.05)^{15}-1\right] \times 268.982 \times 0.5 \times 14.781 / 10^6$

$N_1 = 15.657$ (CSA)

For truck

vehicle damage factor $= \left(\frac{22000}{14968}\right)^4$

$= 4.67$.

$A = P(1+r)^n$

$A = 1200(1.08)^{1.5}$

$= 1346.8427$.

$N_2 = \frac{365}{0.08}\left((1.08)^{15}-1\right) \times 1346.8427 \times 4.67 \times 0.5 / 10^6$

$= 31.167$ (CSA)

$N = N_1 + N_2$

$= 15.657 + 31.167$

$= 46.828$ (CSA)

∴ for N = 40 or 50

BC = 40mm, WMM = 250mm GSB = 200mm.

DBM ⇒ $\frac{50-40}{115-105} = \frac{50-46.825}{115-T}$ $T = 111.825$ mm.

(BC) = 40mm.

(DBM) = 111.825 ≈ 112mm.

WMM = 250mm.

GSB = 200mm.

12

b) Explain the importance of Engineering Geology and discuss various geological hazards. **[12 marks]**

Geology is important to find the

1) various stratification present in earth crest

2) various minerals present ~~at~~ in earth crest

3) Availability of water at different places.

4) many countries have RED on Geological survey to find the countries treasure beneath the surface.

Hazard

⇒ Excavating higher depth leads to high dust raise which cause pollution.

→ human health gets affected.

→ Improper work place may also leads to death of human

→ local (nearby) water bodies gets polluted.

06

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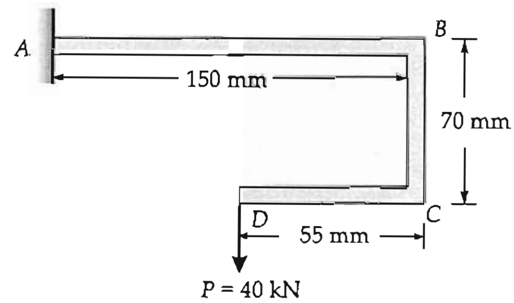
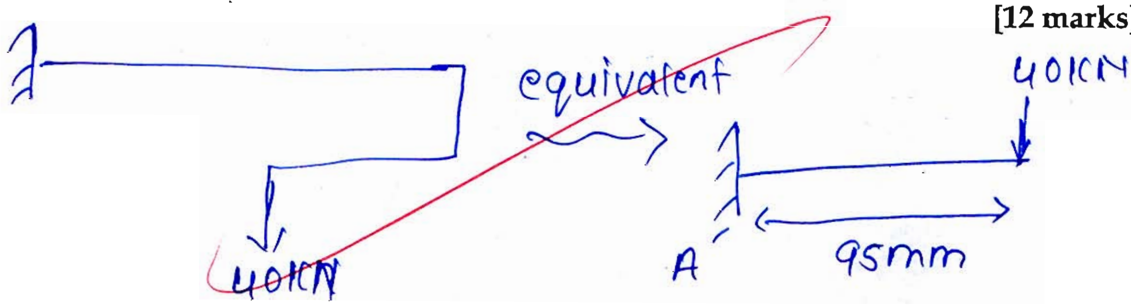
) A fiber glass bracket ABCD of solid circular cross-section is subjected to a vertical load $P = 40$ kN at its free end as shown in the figure. Determine the minimum permissible diameter of the bracket if the allowable bending stress in the material is 30 MPa.



[12 marks]



max $B.M = \frac{40(95)}{1000} = 3.8$ kN-m.

Given: $\sigma = 30$ Mpa.

12

$\therefore \frac{M}{I} = \frac{\sigma}{y}$.

$3.8 \times 10^6 = \sigma (I/y)$

$3.8 \times 10^6 = 30 \times \frac{\frac{\pi}{64}(D^4)}{D/2}$

$\frac{3.8 \times 10^6}{30} = \frac{\pi}{32}(D)^3$.

D = 108·86 mm

$\therefore$ min dia = 109 mm

Q.5 (d) What are different type of rocks? Explain briefly.

[12 marks]

→ Three types

1) Igneous

2) sedimentary

3) metamorphic.

Igneous rock

⇒ These are formed by molting of lava on the surface of earth

⇒ Generally when lava burst igneous rocks are formed

Ex Basalt.

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2) sedimentary rocks

these are formed by long time by applying high Temp and pressure condition upto shallow depth

Ex shale.

3) metamorphic rocks

It is the min of above two conditions ie rocks are formed by molting of lava and subjected high temp and pressure at a greater depth in earth crest.

Rocks are classified as

1) Intrunstic
2) Extrunsic.

0 6

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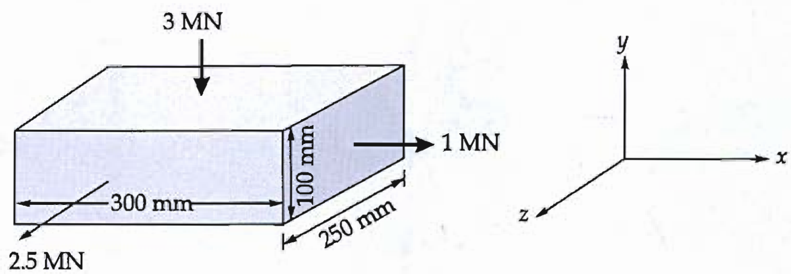
A metallic cuboid of size 300 mm × 250 mm × 100 mm is subjected to the loading as shown in the figure. Determine the change in the volume of cuboid. What additional load should be applied in direction of 2.5 MN load so that no volume change takes place? Assume $E = 2 \times 10^5$ N/mm² and $\mu = 0.25$.



[12 marks]

Volume change

$\epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z$.

$\epsilon_x = \frac{\sigma_x}{E} = \quad \sigma_x = \frac{P_x}{A_x} = \frac{1 \times 10^6}{250 \times 100} = 40 \text{ N/mm}^2 \text{ (T)}$

$\sigma_y = \frac{P_y}{A_y} = \frac{-3 \times 10^6}{300 \times 250} = -40 \text{ N/mm}^2 \text{ (C)}$

$\sigma_z = \frac{P_z}{A_z} = \frac{2.5 \times 10^6}{300 \times 100} = +83.33 \text{ N/mm}^2 \text{ (T)}$

$\epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z = \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1 - 2\mu)$

$= \frac{40 - 40 + 83.33}{2 \times 10^5}(1 - 2(0.25))$

12

$\epsilon_v = \frac{83.33}{2 \times 10^5} \times 0.5 = 2.0833 \times 10^{-4}$

$\Delta V = \frac{83.33}{4 \times 10^5} \times 300 \times 250 \times 100 = 1562.5 \text{ mm}^3$.

In second case

$\Delta V = 0$.

$\epsilon_V = 0 \Rightarrow \quad \sigma_x + \sigma_y + \sigma_z = 0$.

$$40 - 40 + (83.33 + x) = 0$$

$$x = -83.33 \text{ N/mm}^2$$

$\therefore$ Additional load $= -\frac{250}{3} \times (300)(100)$

$= -2.5 \text{ MN}$

$\therefore$ Apply 2.5MN compression in z direction

(i) What is forecasting of traffic and its importance. Enumerate the various factors that affect growth of traffic.

(ii) On an approach to a signalized intersection, the effective green time and the effective red time are 30 sec each. The arrival rate of vehicles on this approach is 360 vph between 0 to 120 sec, 1800 vph between 120 to 240 sec, and 0 vph between 240 to 420 sec. The saturation flow rate for this approach is 1440 vphgpl (Vehicles per hour of green per lane). The approach under consideration has one lane. Assume that at time, $t = 0$ sec the light for the approach has just turned red.

Determine:

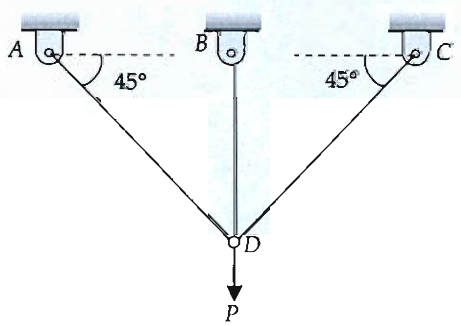
(i) the average delay to vehicles arriving between 0 - 120 sec.

(ii) the average delay to vehicles arriving between 120 - 420 sec.

(iii) the average delay to vehicles arriving between 0 - 420 sec.

[10 + 10 = 20 marks]

Q.6 (b) (i) A symmetrical framework system consisting of three pin-connected bars is loaded by a force P as shown in the figure. The angle between the inclined bars and the horizontal is 45°. The axial strain in the middle bar is measured as 0.0814. Determine the tensile stress in the outer bars if they are constructed of aluminium alloy having modulus of elasticity, $E = 70$ GPa.

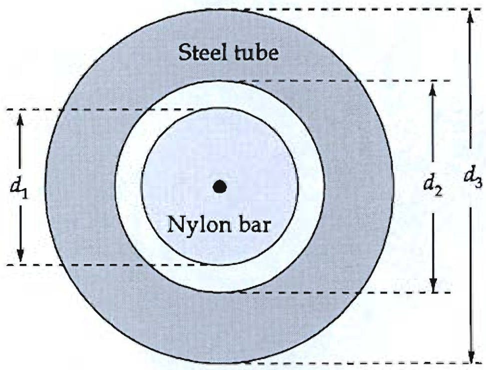


(ii) Explain the following properties of materials

1. Proof stress
2. Modulus of toughness

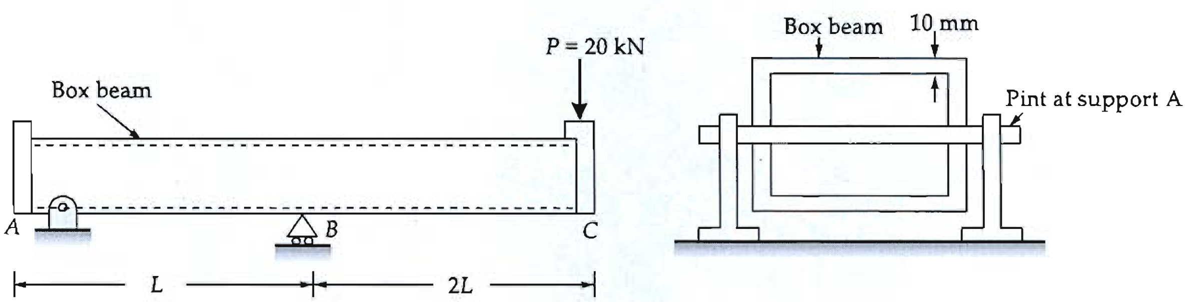
[14 + 6 = 20 marks]

Q.6 (c) (i) A nylon bar having diameter d_1 = 8.8 cm is placed inside a steel tube having inner diameter d_2 = 8.85 cm and outer diameter d_3 = 9.1 cm as shown in the figure. The nylon bar is then compressed by an axial force P. For what value of P, space between the nylon bar and steel tube will be closed so that no stress is developed in steel tube?



[For nylon, E = 2.7 GPa and μ = 0.4]

(ii) A hollow box beam *ABC* of length *L* is supported at end A by a 20 mm diameter pin that passes through the beam and its supporting pedestals as shown in the figure. Determine the average shear stress in the pin and average bearing stress between the pin and the box beam if wall thickness of the beam is 10 mm.



[12 + 8 = 20 marks]

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(i) Determine the number of photographs required to cover an area of 750 sq. km. Given the scale of the photograph is 1 in 10,000 and the photograph format is 250 mm × 250 mm. Consider the longitudinal overlap and side overlap as 65% and 35% respectively.

(ii) 1. What are the various laws of weights?

2. Explain types of errors.

[10 + 10 = 20 marks]

(i) Area $= 750 km^2$

$= 750 \times 10^6 m^2$.

$L = (1-P_L) \times \frac{l}{s} = (1-0.65) \times 250 \times 10^4$

$= 875 \times 10^3 mm = 875 m$

$B = (1-P_b) \times \frac{b}{s} = (1-0.35) \times 250 \times 10^4$

$= 1625 \times 10^3 mm = 1625 m$

$\therefore$ area $= L \times B = 875 \times 1625$

$\therefore$ No of photographs $= \frac{A}{a}$

$= \frac{750 \times 10^6}{875 \times 1625}$

$= 527.47$

$\therefore$ No of photographs $=$ 528 (number)

10

(ii) ② . ① Types of errors

① ~~Accidental~~ systematic errors

-> these are cumulative and follow the mathematical law.

-> we can apply the correction

Ex Temp increase so chain length ↑es.

② Random errors/ Accidental

-> These follow probabilistic laws.

-> these errors gets cancelled when large amount of data is surveyed.

③ Instrumental errors

-> This is due to wrong instrumental operations by human

Ex slip, parallax.

④ Human errors

This is because of human negligence.

Ex wrong measurements taken

⑤ Environmental errors

-> because of curvature and refraction.

(i) laws of wt

~~If the~~ A, B is measured value

A, B has wt → w_1, w_2

if $A \rightarrow w_1$

① $KA \rightarrow \frac{w_1}{K^2}$

② $\frac{A}{K} \rightarrow K^2 w_1$

③ $A+B = \frac{1}{\frac{1}{w_1}+\frac{1}{w_2}}$

④ $180-(A+B) = \frac{1}{\frac{1}{w_1}+\frac{1}{w_2}}$

These are some laws of weights.

08

Q.7 (b) An element of material in plane strain is subjected to strains $\in_x = 450 \times 10^{-6}$, $\in_y = 60 \times 10^{-6}$ and $\gamma_{xy} = 400 \times 10^{-6}$.

Determine the following quantities:

(a) the strains for an element oriented at an angle of 80° anticlockwise from horizontal.

(b) the principal strains.

Also, show the strain element in each case.

[20 marks]

(a) $\epsilon_x = 450 \times 10^{-6}$ $\epsilon_y = 60 \times 10^{-6}$ $\gamma_{xy} = 400 \times 10^{-6}$.

$\theta = 80°$

$\epsilon_\theta = \left(\frac{\epsilon_x + \epsilon_y}{2}\right) + \left(\frac{\epsilon_x - \epsilon_y}{2}\right)\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$.

$= \left[\left(\frac{450+60}{2}\right) + \left(\frac{450-60}{2}\right)\cos 160 + 200 \sin 160\right] \times 10^{-6}$

$= (255 + (-183.24) + 68.404) \times 10^{-6}$

$= 140.164 \times 10^{-6}$.

$\frac{\gamma_{xy}}{2} = -\left(\frac{\epsilon_x - \epsilon_y}{2}\right)\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta$.

$= \left[-\left(\frac{450-60}{2}\right)\sin 160 + 200 \cos 160\right] \times 10^{-6}$

$= (-66.7 - 187.93) \times 10^{-6}$

$\frac{\gamma_{xy}}{2} = -254.63 \times 10^{-6}$

$\gamma_{xy} = -509.27 \times 10^{-6}$

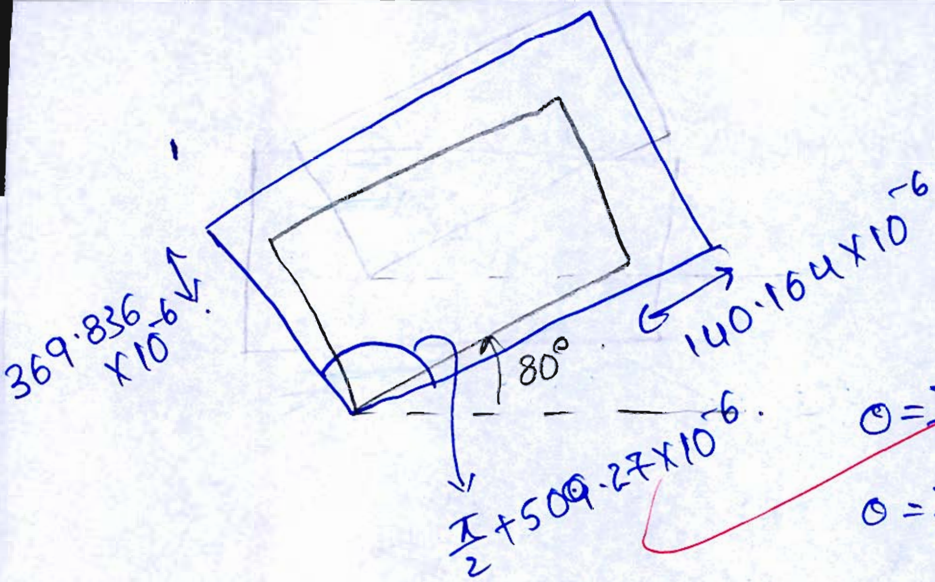
20

strain element

$\epsilon_x' = 140.164 \times 10^{-6}$

$\epsilon_y' = \epsilon_x + \epsilon_y - \epsilon_x' = (450 + 60 - 140.164) \times 10^{-6}$

$= +369.836 \times 10^{-6}$



$\theta = \frac{\pi}{2} - \gamma_{xy}$

$\theta = \frac{\pi}{2} - (-509{\cdot}27 \times 10^{-6})$

$\theta = \frac{\pi}{2} + 509{\cdot}27 \times 10^{-6}$

(b) for principal strain

$\epsilon_{P1}/\epsilon_{P2} = \frac{\epsilon_x + \epsilon_y}{2} \pm \sqrt{\left(\frac{\epsilon_x - \epsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$

$= \left[\frac{450+60}{2} \pm \sqrt{\left(\frac{450-60}{2}\right)^2 + \left(\frac{400}{2}\right)^2}\right] \times 10^{-6}$

$= \left(255 \pm \sqrt{195^2 + 200^2}\right) \times 10^{-6}$

$= (255 \pm 279{\cdot}32) \times 10^{-6}$

$\epsilon_{P1} = ~~474{\cdot}14\times10^{-6}~~ \; 534{\cdot}32 \times 10^{-6}$.

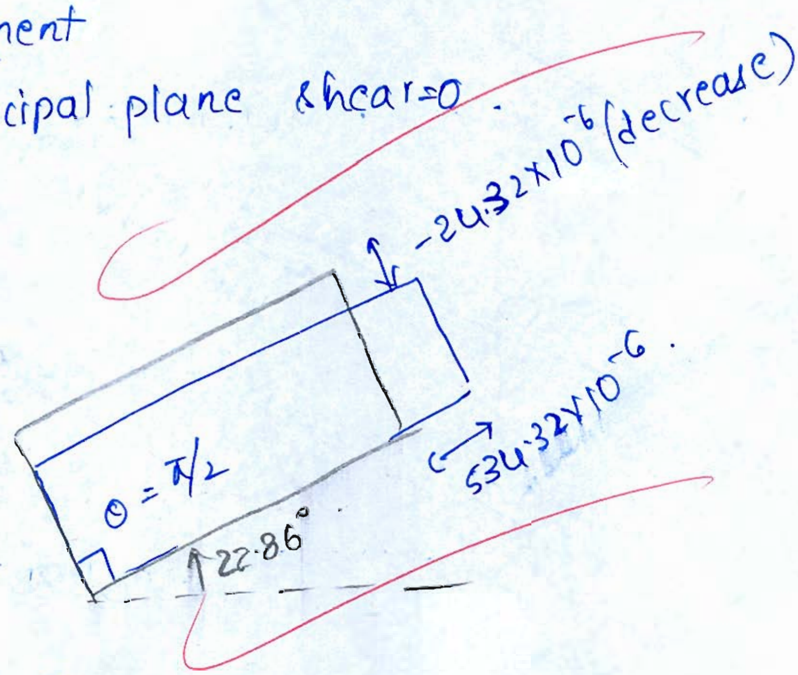
$\epsilon_{P2} = ~~35{\cdot}86\times10^{-6}~~ \; -24{\cdot}32 \times 10^{-6}$.

$\tan 2\theta_p = \frac{2\left(\frac{\gamma_{xy}}{2}\right)}{\epsilon_x - \epsilon_y} = \frac{400}{450-60} = 1{\cdot}02$

$\theta_p = 22{\cdot}86$.

strain element

on principal plane shear=0.



$\gamma_{xy} = 0$.

Q.7 (c) (i) A road intersection has five legs designated as 1, 2, 3, 4 and 5. Leg 1 is in N-S direction and others are marked clockwise. The traffic volumes in terms of PCU(V_{ij}) per hour during peak period are given below:

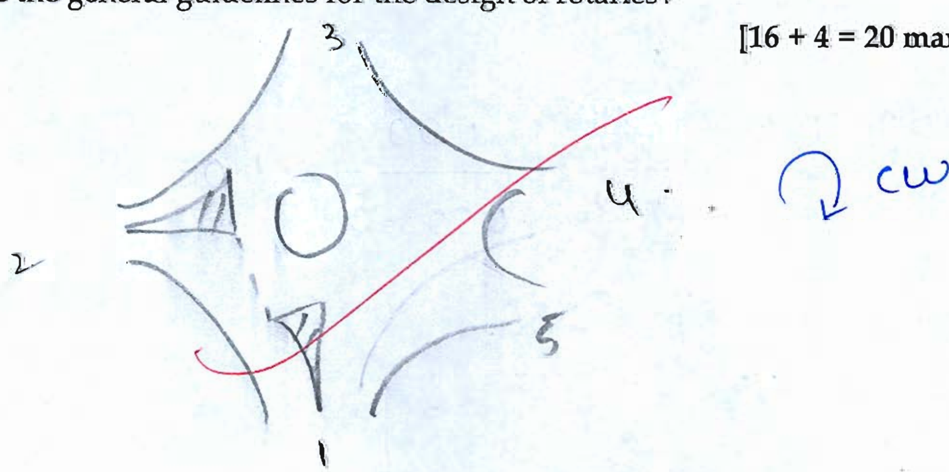
v_{12}	37	v_{31}	466	v_{41}	182	v_{51}	45
v_{13}	303	v_{32}	122	v_{42}	54	v_{52}	132
v_{14}	64	v_{34}	47	v_{43}	18	v_{53}	62
v_{15}	52	v_{35}	657	v_{45}	116	v_{54}	15

Width of carriage way at entry and exit is 10 m.
Weaving length is 50 m.
Find the weaving ratio between the legs 1 and 2, also calculate the practical capacity of rotary corresponding to this weaving ratio.

(ii) What are the general guidelines for the design of rotaries?

[16 + 4 = 20 marks]

(i)



Do not write in this margin

$a = V_{12} = 37$

$b = V_{13} + V_{14} + V_{15} = 303 + 64 + 52 = 419$

$c = V_{32} + V_{42} + V_{52} = 122 + 54 + 132 = 308$

$d = V_{43} + V_{54} + V_{53} = 18 + 15 + 62 = 95$

weaving ratio $P = \frac{b+c}{a+b+c+d} = \frac{419+308}{37+419+308+95}$

$= \frac{727}{859}$

$= 0.846$

$$Q_p = \frac{280w\left(1+\frac{e}{w}\right)\left(1-\frac{P}{3}\right)}{1+w/L}$$

16

$e = \frac{e_1+e_2}{2} = \frac{10+10}{2} = 10\,m$

$w = \frac{e_1+e_2}{2} + 3.5 = 10 + 3.5 = 13.5$

$L = 50m$ given

$$Q_p = \frac{280 \times 13.5\left(1+\frac{10}{13.5}\right)\left(1-\frac{0.846}{3}\right)}{\left(1+\frac{13.5}{50}\right)}$$

$= \frac{4724.44}{63.5} \times 50 = 3720$ veh/hr

(ii) Guidelines

→ the speed at rotary in urban areas = 30 kmph
rural areas = 40 kmph

→ $R_{central} = 1.33 R_{entry}$

→ $R_{exit} = 2 R_{entry}$

→ super elevation = 0 at rotary

→ min right turning traffic = 50% of total ~~fast~~ traffic moving

→ fast right moving traffic = 30% of total traffic

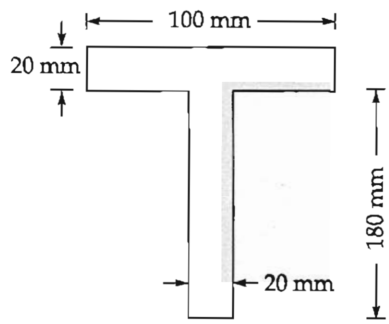
→ min capacity = 500 veh/hr
max capacity = 3000 veh/hr.

04

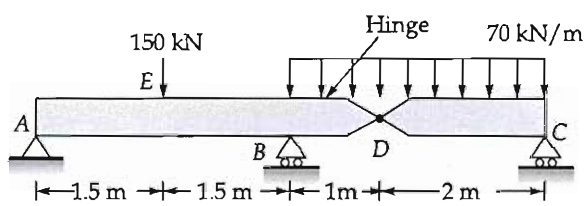
Two straight lines intersect at a chainage of 40 chains and 60 links with a deflection angle of 48°. Calculate the necessary data for setting out the curve of radius 380 m using Rankine's method. Use 30 m chain length with 100 links.

[20 marks]

(i) A simply supported beam of T-section (as shown in figure) of span 3 m carries a load of 4 kN at midspan inclined at 20° to the vertical, passing through the centroid of the section. Determine the maximum tensile stress induced in the section.



(ii) Draw the shear force diagram for the beam loading as shown in figure.



[12 + 8 = 20 marks]

Q.8 (c) (i) Consider the following data:

Wheel load, $P = 5000$ kg

Modulus of elasticity of cement concrete, $E = 3 \times 10^5$ kg/cm^2.

Pavement thickness, $h = 20$ cm.

Poisson's ratio of concrete, $\mu = 0.15$.

Modulus of subgrade reaction, $k = 6.0$ kg/cm^3.

Radius of contact area, $a = 15$ cm.

Calculate:

(a) The edge load stresses using modified equation of Teller and Sutherland.

(b) Corner load stress using modified equation of Kelley.

(ii) Write down the construction steps for water bound macadam road?

[12 + 8 = 20 marks]

■■■■

Space for Rough Work