Good

203/300

· Attempt of paper is good
· Improve answer representation
· Do in ~~effective~~ manner of design problem

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ESE 2023 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Civil Engineering

Test-4

Design of Concrete and Masonry Structures [All Topics]
Geo-technical & Foundation Engineering-1 [Part Syllabus]
+ Highway Engineering-2 + Surveying and Geology-2 [Part Syllabus]

Name : ....

Roll No :

Test Centres	Student's Signature
Delhi ☐ Bhopal ☐ Jaipur ☑ Pune ☐ Kolkata ☐ Bhubaneswar ☐ Hyderabad ☐	

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	
Q.2	
Q.3	
Q.4	
Section-B	
Q.5	
Q.6	
Q.7	
Q.8	
Total Marks Obtained	

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.

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Section A : Design of Concrete and Masonry Structure

Q.1 (a) What are the assumptions for the design of a reinforced concrete section for limit state of collapse in bending? Calculate the limiting percentage of tensile reinforcement in a flexural RC member for M30 grade concrete and Fe500 grade steel.

[12 marks]

Assumptions :-

1) Concrete in tension section is ignored.

2) Plane section before bending remains plane after bending.

3) The shape of stress strain curve for concrete can be triangular, rectangular or of any shape but the result of stain from it must match with test result.

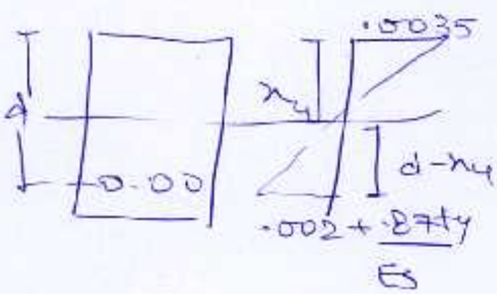
4) Maximum strain in compressive fibre should be 0.0035

5) ~~Minimum~~ strain in tensile ~~strain~~ reinforcement should be more than $0.002 + \frac{0.87 f_y}{E_s}$

6) Partial factor of safety for concrete is 1.5

7) ~~Part~~ factor of safety for steel is 1.15.

$F_{ck} - 30\ N/mm^2 \quad Fe - 500$



$$\frac{.0035}{x_u} = \frac{.002 + .87 f_y/E_s}{d - x_u} \rightarrow \left(\frac{d}{x_u} - 1\right) = \frac{.002 + \frac{.87 f_y}{E_s}}{.0035}$$

$$\frac{d}{x_u} = \frac{.0055 + .87 f_y/E_s}{.0035}$$

So $x_u = \left(\frac{.0035}{.0055 + \frac{.87 f_y}{E_s}} \right) \times d$

For Fe 500

$x_u = \left(\frac{0.0035}{.0055 + \frac{.87 \times 500}{2 \times 10^5}} \right) d$

So $x_u = 0.456 d$.

Now Comp. = Tension

$0.36 f_{ck} b x_u = .87 f_y A_{st}$

$0.36 \times 30 \times b \times .456 d = .87 \times 500 \times A_{st}$

$\frac{A_{st}}{bd} \times 100 = 1.132 \%$

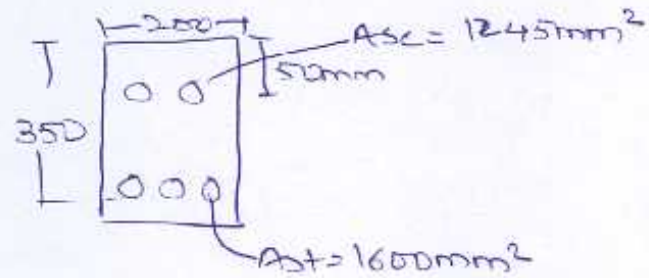
So $(P_t)_{lim} = 1.132 \%$

8

Q.1 (b) A doubly reinforced beam is 200 mm wide and 350 mm deep to centre of the tensile reinforcement. The areas of the compression and tensile steel are 1245 mm^2 and 1600 mm^2 respectively. The effective cover to the compression reinforcement is 50 mm. Find the ultimate moment of resistance of the beam section. Use M20 concrete and Fe250 steel.

[12 marks]

Fe 250 M20 $M_u = ?$



C = T

$0.36 f_{ck} b x_u + (f_{sc} - .45 f_{ck}) A_{sc} = .87 f_y A_{st}$.

consider $f_{sc} = .87 f_y$ for Fe 250

$.36 \times 20 \times 200 \times x_u + (.87 \times 250 - .45 \times 20) \times 1245 = .87 \times 250 \times 1600$

$x_u = 61.4$ mm.

$x_{u lim} = .58d = 203$ mm So – URS –

Now $M_u = .36 f_{ck} b x_u (d - .42 x_u) + (f_{sc} - .45 f_{ck}) A_{sc} (d - d')$

$M_u = .36 \times 20 \times 200 \times 61.4 \times (350 - .42 \times 61.4) +$
$(.87 \times 250 - .45 \times 20) \times 1245 \times (300)$

$M_u = 106.54$ kNm

(P)

Applied formula and Concept o.k

Approach wrong –

Do not write in this margin

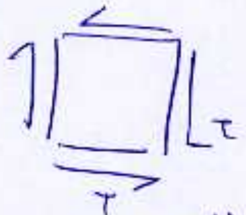
Q.1 (c) **(i)** Discuss the importance of diagonal tension in RCC beams.

(ii) Explain advantages of limit state method of design as compared to working stress method, for reinforced concrete flexural members.

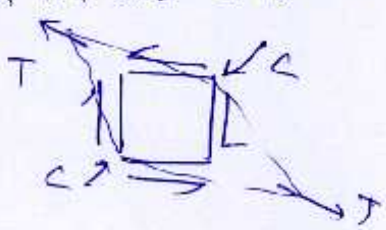
[6 + 6 marks]

i) Tension in diagonal direction occurs where Bending moment is zero and shear force is max^m generally at support.

— If we consider a element at support then only shear stress will act on it and no normal stress.



→ Due to this there is tension developed in diagonal direction in one side and compression on other side



— If this tensile stress become more than comp. stress then cracks occur. Due to which we provide shear stirrups which reduces cracks.

(2)

Elaborate it more

Do not write in this margin

ii)

Advantages.

1) LSM consider failure occur when max^m strain reaches in the fibre.

2) For same ~~section~~ load section designed by LSM is small ~~a~~ as compared to WSM

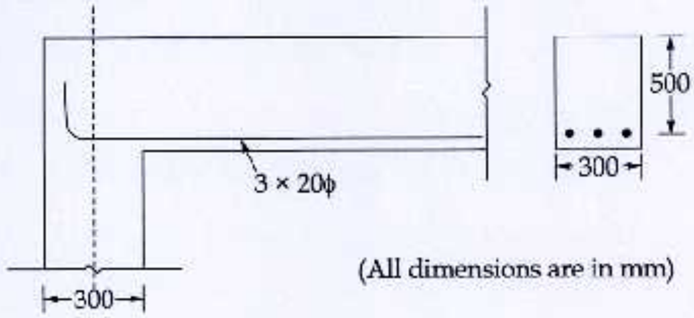
3) Use of LSM is economical.

4) LSM takes into account both collapse and serviceability criteria.

5) FOS for material is more in LSM as compared to WSM.

2

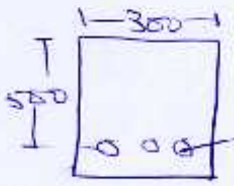
Q.1 (d) Determine the anchorage length of bars at the simply supported end of a reinforced concrete beam as shown below, if it is subjected to an ultimate shear force of 300 kN at the centre of support. Assume M20 grade concrete and steel of grade as Fe415.
[Take τ_{bd} = 1.92 N/mm^2]



(All dimensions are in mm)

[12 marks]

$L_o = ?$ $V_u = 300kN$ M20 Fe415.



3-20φ. $A_{st} = 942.47 mm^2$

$C = T$

$.36 f_{ck} b x_u = .87 f_y A_{st}$

$.36 \times 20 \times 300 \times x_u = .87 \times 415 \times 942.47$

$x_u = 157.54 mm.$

$x_{ulim} = .48d = 240mm$

∴ —URS— as $x_u < x_{ulim}$.

now $M_u = .36 f_{ck} b x_u (d - .42 x_u)$

$M_u = .36 \times 20 \times 300 \times 157.54 \times (500 - .42 \times 157.54)$

$M_u = 147.63 kNm.$

At support for checking Bond.

$\frac{1.3 M_u}{V_u} + L_o \geq L_d$ —— i)

Calculation of Development length (Ld)

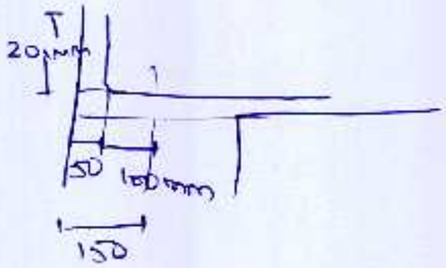
$$L_d = \frac{.87 f_y \phi}{4 \tau_{bd}} = \frac{.87 \times 415 \times 20}{4 \times 1.92} = 940.23\,mm.$$

Now use eqn i)

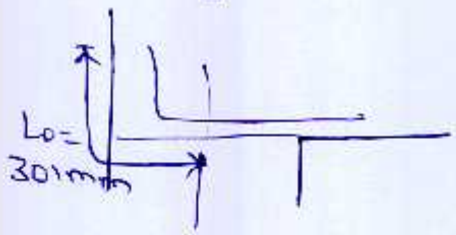
$$\frac{1.3 \times 147.63 \times 10^3}{300} + L_0 \geq 940.23$$

$$L_0 \geq 300.5\,mm.$$

Lo provided:-



Assume 50mm effective cover



12

Q.1 (e) A simply supported prestressed concrete beam of rectangular section 300 mm wide and 600 mm deep has a span of 12 m. The effective prestressing force is 980 kN at an eccentricity of 120 mm. The dead load of the beam is 4.50 kN/m and the beam has to carry a live load of 7.50 kN/m. Determine the extremes stresses.

(i) at the end section.

(ii) at the midsection without the action of live load.

(iii) at the midsection considering the action of live load.

[12 marks]

$P = 980 kN$.

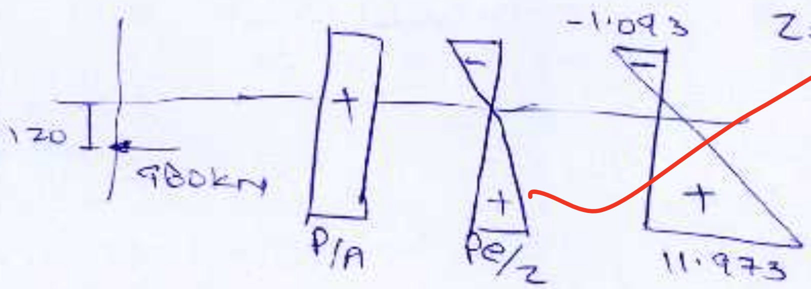
$w_{dl} = 4.5 kN/m$ $w_{LL} = 7.5 kN/m$

$M_{dl} = \frac{(w_{dl})(l)^2}{8}$ $M_{LL} = \frac{(w_{LL})(l)^2}{8}$

$M_d = \frac{4.5 \times (12)^2}{8} = 81 kNm$ $M_{LL} = \frac{7.5(12)^2}{8} = 135 kNm$

i) At end section.

→ stresses due to moment = 0.

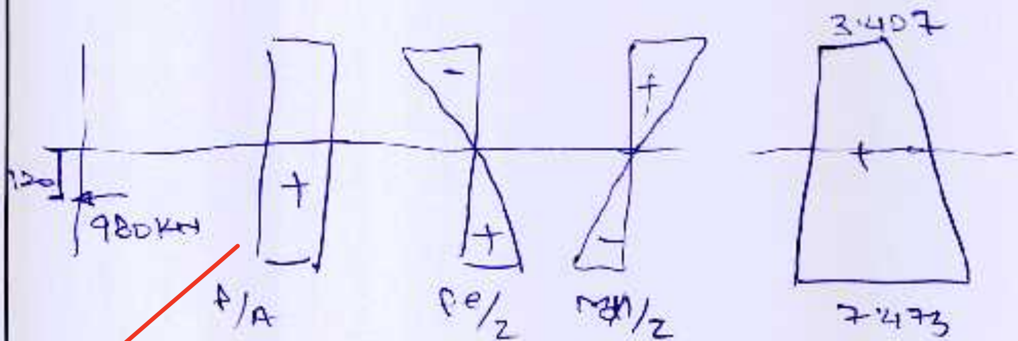


$Z = \frac{bd^2}{6} = 18 \times 10^6 mm^3$

$\frac{P}{A} = \frac{980 \times 10^3}{300 \times 600} = 5.44 N/mm^2$

$\frac{Pe}{Z} = \frac{980 \times 10^3 \times 120}{18 \times 10^6} = 6.533 N/mm^2$

ii) At mid section without L.L :-

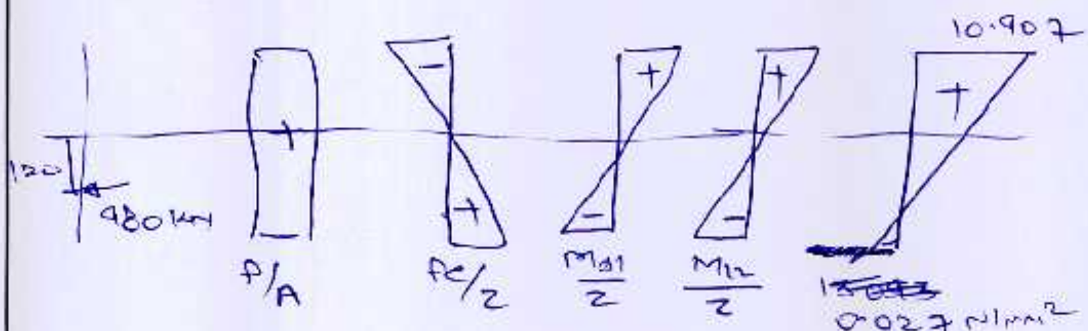


$\frac{P}{A} = 5.44\ N/mm^2$

$\frac{Pe}{Z} = 6.533\ N/mm^2$

$\frac{M_{dl}}{Z} = \frac{81 \times 10^6}{18 \times 10^6} = 4.5\ N/mm^2$

iii) Consider L.L



$\frac{P}{A} = 5.44\ N/mm^2$

$\frac{Pe}{Z} = 6.533\ N/mm^2$

$\frac{M_{dl}}{Z} = 4.5\ N/mm^2$

$\frac{M_{LL}}{Z} = \frac{135 \times 10^6}{18 \times 10^6} = 7.5\ N/mm^2$

10

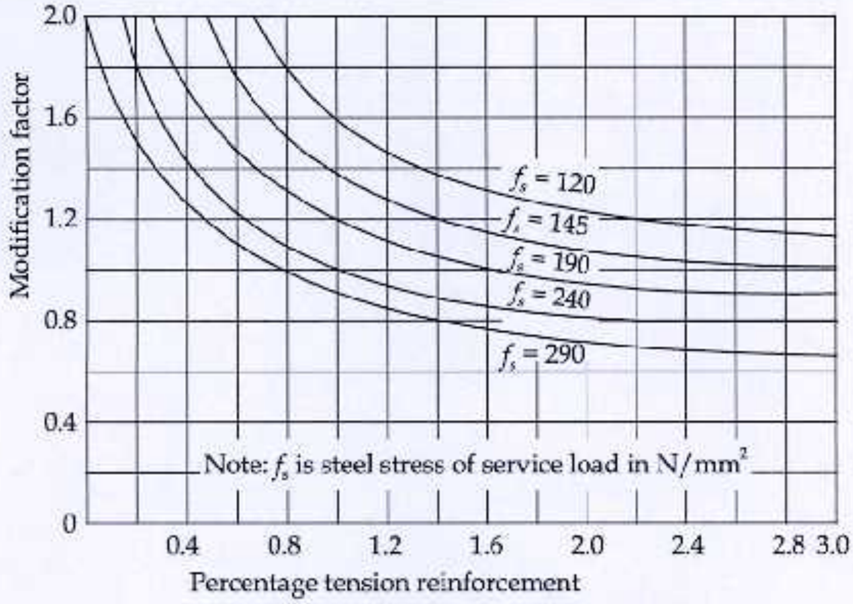
Show calculation details also

Q.2 (a) Design a 5.0 m × 7.5 m (clear spans) interior panel of a slab for flexure using the following data, by limit state method.

Width of supports = 400 mm
Live load over slab = 8 kN/m^2
Finishing load = 1.5 kN/m^2

Use M25 grade concrete and Fe415 steel. Check the slab for shear and deflection. Also sketch the reinforcement details.

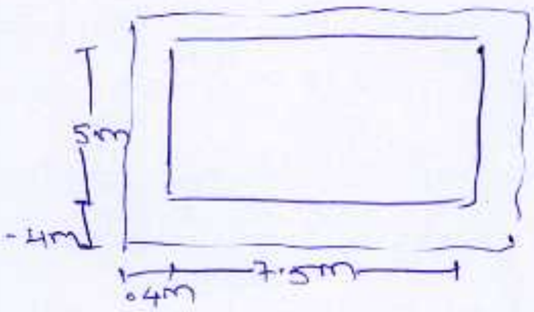
Interior panels	Short span coefficients α_x (values of l_y/l_x)								Long span coefficient α_y
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Negative moment at continous edge	0.032	0.037	0.043	0.047	0.051	0.053	0.060	0.065	0.032
Positive moment at mid span	0.024	0.028	0.032	0.036	0.039	0.041	0.045	0.049	0.024



$$f_s = 0.58 f_y \frac{\text{Area of cross-section of steel required}}{\text{Area of cross-section of steel provided}}$$

[20 marks]

$l_y = 7.5\text{m}$ $l_x = 5\text{m}$.



1) Depth of slab.

$D = \frac{L}{B} = \frac{5000}{32} = 156.25\text{mm}$ ($\because B = 32$ for HYSD)

So consider the effect of shear increase the depth to 200mm at initial stage only.

Provide effective cover of 30mm.

$l_{ex} = l_c + d = 5.17$
$l_c + w \quad 5.4$ } Min^m

$l_{ex} = 5.17m$.

$l_{ey} = 7.67m$.

2) Calculate Loading on 1m strip.

$LL = 8 \times 1 = 8$

$FF = 1.5 \times 1 = 1.5$

$DL = 25 \times 1 \times .2 = 5$

$w = 14.5 \, kN/m$

So $w_u = 1.5w = 21.75 \, kN/m$.

$\gamma = \frac{l_y}{l_x} = \frac{7.5}{5} = 1.5$

$\alpha_x^+ = 0.041$

$\alpha_x^- = 0.053$

$\alpha_y^+ = 0.024$

$\alpha_y^- = 0.032$

3) Calculate B.M

$M_{ux}^+ = \alpha_x^+ w_u l_{ex}^2 = .041 \times 21.75 \times (5.17)^2 = 22.84 \, kNm$.

$M_{ux}^- = \alpha_x^- w_u l_{ex}^2 = .053 \times 21.75 \times (5.17)^2 = 30.82 \, kNm$.

$M_{uy}^+ = \alpha_y^+ w_u l_{ex}^2 = .024 \times 21.75 \times (5.17)^2 = 13.96 \, kNm$.

$M_{uy}^- = \alpha_y^- w_u l_{ey}^2 = .032 \times 21.75 \times (5.17)^2 = 18.61 \, kNm$.

Mulim of section

$M_{ulim} = .138 f_{ck} b d^2$

$= 0.138 \times 25 \times 1000 \times (170)^2$

$M_{ulim} = 99.7 \, kNm$

As $M_{ulim} > M_{un}^-$ is — URS — .

4) Calculate Steel :-

$d_x = 170mm$

$d_y = 160mm$ (consider 10ϕ bars $\therefore d_y = d_x - 10 = 160MM$)

Moment	Value	d (MM)	$(A_{st})_{req}$	$(A_{st})_{prov.}$
M_{ux}^+	22.84	170	387	10ϕ @ 200 c/c.
M_{ux}^-	30.82	170	530	10ϕ @ 530 c/c
M_{uy}^+	13.96	160	249	10ϕ @ 300 c/c.
M_{uy}^-	18.61	160	334	10ϕ @ 230 c/c.

$$A_{st} = \frac{.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{f_{ck} bd^2}}\right] bd.$$

Put value of M_{ux}^+ in this

$$A_{stx}^+ = \frac{.5 \times 25}{415}\left[1 - \sqrt{1 - \frac{4.6 \times 22.84 \times 10^6}{25 \times 1000 \times (170)^2}}\right] \times 1000 \times 170$$

$A_{stx}^+ = 387mm^2$ Provide - 10ϕ.

$A_{st min} = 0.12\% BD = \frac{.12}{100} \times 1000 \times 200 = 240MM^2$ — OK —

$S_v = \begin{cases} 3d = 510MM \\ 300MM \\ S_v = 204.5MM \end{cases}$ So provide 10ϕ @ 200 c/c.

Similarly

$A_{stx}^- = 530mm^2$ Provide 10ϕ @ 140 c/c.

for Long span.

$$A_{sty}^{+} = \frac{.5\times25}{415}\left[1-\sqrt{1-\frac{4.6\times13.96\times10^{6}}{25\times1000\times(160)^{2}}}\right]\times1000\times160$$

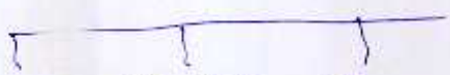
$A_{sty}^{+} = 249mm^2$ Provide 10ϕ @ 300 mm c/c.

$$S_v = \begin{cases} 3d = 3\times160 = 480mm \\ 300 \\ S_v = 315mm \end{cases}$$

similarly

$A_{sty}^{-} = 334mm^2$ Provide 10ϕ @ 230mm c/c.

5) Check for shear



DL	.4r	.6	.55	.5
LL	.45	.6	.6	.6

So $V_{dl} = .55\times1.5\times6.5\times5.17$ ($\because$ DL = 5 + 1.5 = 6.5 kN/m)

$V_{LL} = .6\times1.5\times8\times5.17$ ($\because$ LL = 8 kN/m)

$V_{dl} = 27.73$ kN.

$V_{LL} = 37.72$ kN

So $V_T = 65$ kN.

How this shear is resist by $A_{st}n^{-}$

So $pt\% = \frac{\frac{1000}{530}\times\frac{\pi}{4}\times(10)^2}{1000\times170} = .87 N/mm^2$

$\tau_c = .59 + \frac{.07}{.25}\times.12 = .623 N/mm^2$

$\tau_v = \frac{V_u}{bd} = \frac{65}{130} = .38 N/mm^2$

$\tau_v < \tau_c$

$\therefore$ —OK—

Do not write in this margin

~~No need to calcd~~
~~For y dirⁿ.~~

~~Vdl = .55×1.5×26.5~~ ×

for Deflection at Mid-span.

$$f_s = 0.58 \times 415 \times \frac{387}{\frac{1000}{202} \times \frac{\pi}{4} \times (10)^2} = 237.2 \text{ N/mm}^2$$

$$pt\% = \frac{392.7 \times 100}{1000 \times 170} = .231\%$$

MF₁ = 2.

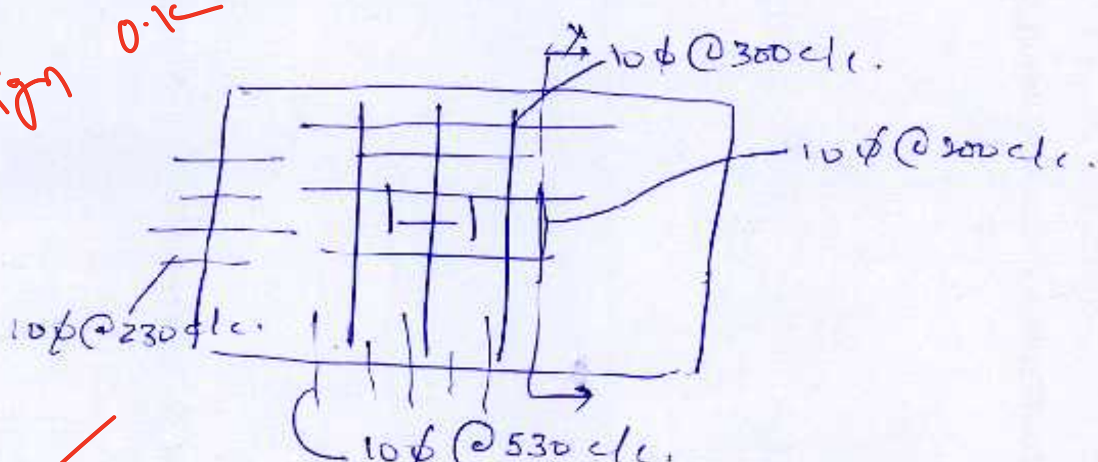
$$d = \frac{len}{A \times MF_1} \qquad A = 26 \text{ (Continuous slab)}$$

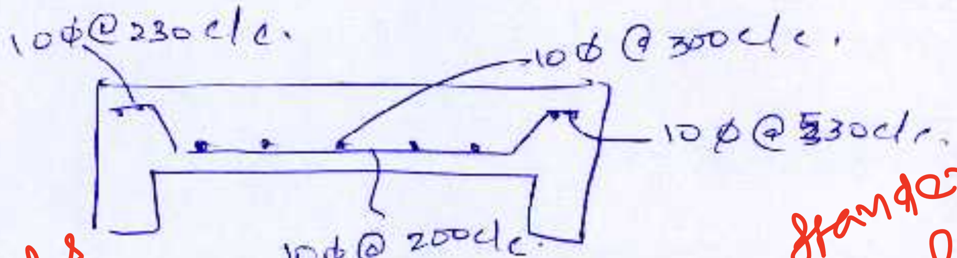
$$d = \frac{5170}{26 \times 2} = 99.42 \text{ mm}$$

As dprov > dreq ∴ Safe in deflⁿ.

(16)

Approach of design o.k





Section x-x

Design steps not o.k

Use standard values for design purpose

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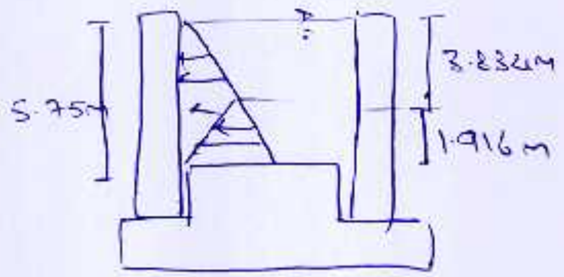
Q.2 (b) Design a cylindrical water tank of capacity 6.5 lakh litre. The diameter of the tank is 12 m and the wall is fixed with the base. Following parameters may be used for the design.

1. $\sigma_{cbc} = 11.5\ \text{N/mm}^2$
2. $\sigma_{cbt} = 2.21\ \text{N/mm}^2$
3. $\sigma_{ct} = 1.6\ \text{N/mm}^2$
4. $\sigma_{st} = 130\ \text{N/mm}^2$
5. $\gamma_w = 10\ \text{N/mm}^3$
6. $m = 8.11$

[20 marks]

D = 12m. V = 650 m³

$V = \frac{\pi}{4} D^2 H \rightarrow 650 = \frac{\pi}{4}(12)^2 (H) \rightarrow H = 5.75$ m.



T = 30H + 50 = 222.5 mm

So provide T = 250mm.

& eff. cover = 50mm

∴ d = 200mm.

Now $\frac{H^2}{Dt} = \frac{(5.75)^2}{12 \times .25} = 11$ (6 – 12) so H/3 or 1m. } max^m

h = 1.91 m.

1) Hoop Tension.

$T_H = \frac{\gamma_w (H-h) D}{2} = \frac{10 \times 3.834 \times 12}{2} = 231$ kN.

Now $T_H = f_{st} A_{st}$

$231 \times 10^3 = 130\ A_{st}$

$A_{st}' = 1777\ mm^2$

~~So provide~~ 16ϕ ~~@ 110 mm~~ c/c.

as T > 225mm ∴ Provide reinf. in two layers

$A_{st} = \frac{A_{st}'}{2} = 888.5\ mm^2$

Provide 16ϕ @ 220mm c/c.

$A_{st\,min} = .24\%$ Surface zone $= \frac{.24}{100} \times 1000 \times 125 = 300\,mm^2$

∴ — OK —

Now check tension

$T_{th} = \sigma_{ct} A_{ct} + \sigma_{st} A_{st}$

$T_{th} = \sigma_{ct} (A_g + (m-1) A_{st})$

$\sigma_{ct} = \frac{231 \times 10^3}{(1000 \times 250 + 7.11 \times 1827.8)} = .878\,N/mm^2$

$\sigma_{ct} < 1.2$ ∴ OK —

2) For B.M.

$M = \frac{1}{2} \gamma_w H \times h \times \frac{h}{3} = \frac{\gamma_w H h^2}{6} = \frac{10 \times 5.75 \times (1.916)^2}{6}$

$M = 35.2\,kNm$

Design for balanced sect^n.

$k = .4$

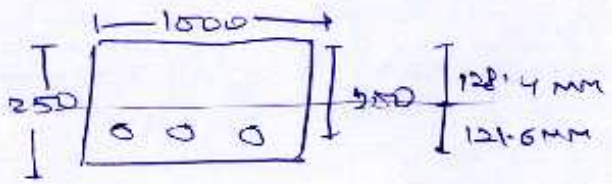
$M = \sigma_{st} A_{st} \left(d - \frac{x_a}{3}\right)$

$35.2 \times 10^6 = 130\, A_{st} \times 200 \left(1 - \frac{.4}{3}\right)$

$A_{st} = 1562.13\,mm^2$ Provide 16ϕ @ 120 mm c/c.

$A_{st\,prov} = 1675\,mm^2$

check for bending.



$\bar{y} = \frac{1000 \times 250 \times 125 + 7.11 \times 1675 \times 200}{1000 \times 250 + 7.11 \times 1675} = 128.4\,mm$

$I = \frac{1000(250)^3}{12} + 1000 \times 250 \times (3.41)^2 + 7.11(1675 \times (71.6)^2)$

$I = 1366 \times 10^6 \, mm^4$

$\sigma = \frac{My}{I} = \frac{35.2 \times 10^6 \times 121.6}{1366 \times 10^6}$ ($\because y_t = 121.6 \, mm$)

$\sigma_{cbt} = 3.13 \, N/mm^2$

As this value is more than $2.21 \, N/mm^2$

$\therefore$ Increase the depth to 350 mm.

Now d = 300 mm.

$\frac{H^2}{Dt} = \frac{(5.75)^2}{12 \times .35} = 7.87 \in (6-12)$ $H/3$ or 1m)

So Hoop tension design same

2) for BM.

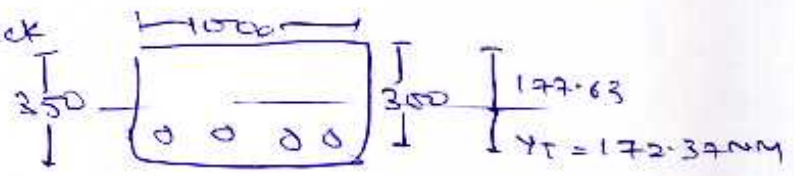
BM = 35.2 kN.

$10^6 \times 35.2 = 130 \times Ast \times 300 \left(1 - \frac{.4}{3}\right)$

$Ast = 1041.6 \, mm^2$ provide 16 ϕ @ 190 c/c.

$Ast_{prov} = 1058 \, mm^2$

Check



$\bar{y} = \frac{1000 \times 350 \times 175 + 7.11 \times 1058 \times 300}{1000 \times 350 + 7.11 \times 1058} = 177.63 \, mm.$

$I = \frac{1000(350)^3}{12} + 1000 \times 350 \times (2.63)^2 + 7.11 \times 1058 \times (122.37)^2$

$I = 3687 \times 10^6 \, mm^4$

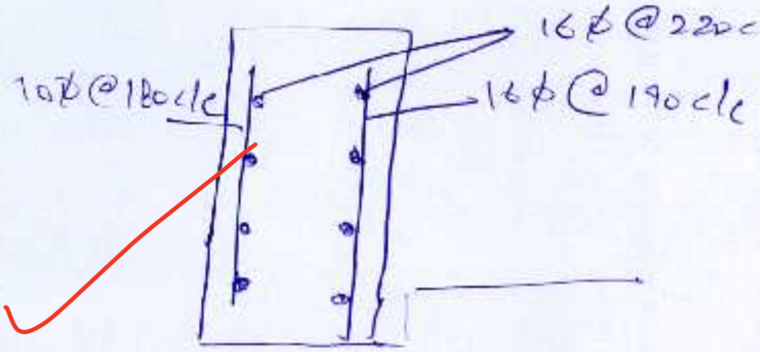
$\sigma = \frac{My}{I} = \frac{35.2 \times 10^6 \times 172.37}{3687 \times 10^6} = 1.64 < 2.21$

— OK —

$A_{st\,min} = \frac{.24}{100} \times 1000 \times 175 = 420\ mm^2$ ~~Provide~~

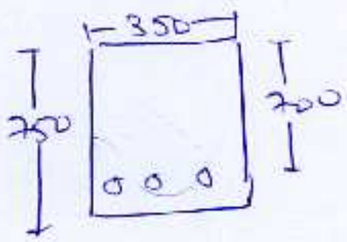
For distribution bar 10 ϕ @ 180 mm c/c.

18



Q.2 (c) Design the torsional reinforcement in a rectangular beam section, 350 mm wide and 750 mm deep, subjected to an ultimate twisting moment of 140 kN-m combined with an ultimate (hogging) bending moment of 200 kN-m and an ultimate shear force of 110 kN. Assume M25 concrete and Fe415 steel. Consider an effective cover of 50 mm.

[20 marks]



$T_u = 140\ kNm$

$M_u = -200\ kNm.$

$V_u = 110\ kNm.$

1) Calculate eq. shear force.

$$V_{u\,eq} = V_u + 1.6\frac{T_u}{b} = 110 + \frac{1.6 \times 140}{0.35} = 750\ kN$$

$$\tau_v = \frac{V_{ueq}}{bd} = \frac{750 \times 10^3}{350 \times 700} = 3.06\ N/mm^2 < \tau_{cm}(3.1)\ N/mm^2$$

∴ Safe.

2) Calculate eq^n M_{ue}.

$$M_{ue} = \frac{T_u}{1.7}\left(1 + \frac{D}{b}\right) = \frac{140}{1.7}\left(1 + \frac{750}{350}\right) = 258.82\ kNm.$$

$M_{u1} = M_u + M_{ue} = 58.82\ kNm.$

$M_{u2} = M_u - M_{ue} = -458.82\ kNm.$

So

$M_{ulim} = .138 \times 25 \times (350)(700)^2$

$M_{ulim} = 591.6$ kNm.

∴ — URS —.

for Sagging $M = 58.82$ kNm

Hogg $M = -458.82$ kNm.

$A_{st} = \frac{.5 \times 25}{415}\left[1 - \sqrt{1 - \frac{4.6 \times 458.82 \times 10^6}{25 \times 350 \times (700)^2}}\right] \times 350 \times 700$

$A_{st} = 2122\ mm^2$

Provide $= 4-28\phi$

for Sogg.

$A_{st} = \frac{.5 \times 25}{415}\left[1 - \sqrt{1 - \frac{4.6 \times 58.82 \times 10^6}{25 \times 350 \times (700)^2}}\right] \times 350 \times 700$

$A_{st} = 237\ mm^2$

$(A_{st\,min} f_y) = .85bd$

$415\ A_{st\,min} = .85 \times 350 \times 700$

$A_{st\,min} = 502\ mm^2$

So provide $A_{st} = 502\ mm^2$ — $3-16\phi$.

Now Design for shear for 4

$\tau_v = 3.06\ N/mm^2$

$A_{st} = 4 \times \frac{\pi}{4}(28)^2 = 2463\ mm^2$

$p_t\% = 1\%$ so $\tau_c = .66\ N/mm^2$

$V_u = (\tau_v - \tau_c)bd = 588$ kN

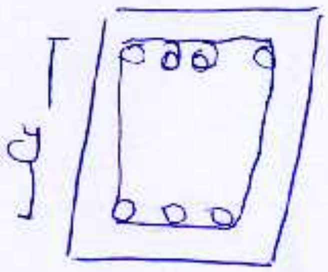
Now provide 2L-10φ $A_{sv} = 157\,mm^2$

$$\frac{T_u}{b_1} + \frac{V_u}{2.5} = .87 f_y A_{sv}\left(\frac{d}{s_v}\right)$$

$$\left(\frac{140}{.35} + \frac{588}{2.5}\right)\times 10^3 = .87\times 415\times 157\times \frac{700}{s_v}$$

$S_v = 62.46\,mm.$

S_v { $x = 288\,mm.$; $\frac{x+y}{4} = 242\,mm$; 300 }



So provide 2L-10φ @60 c/c.

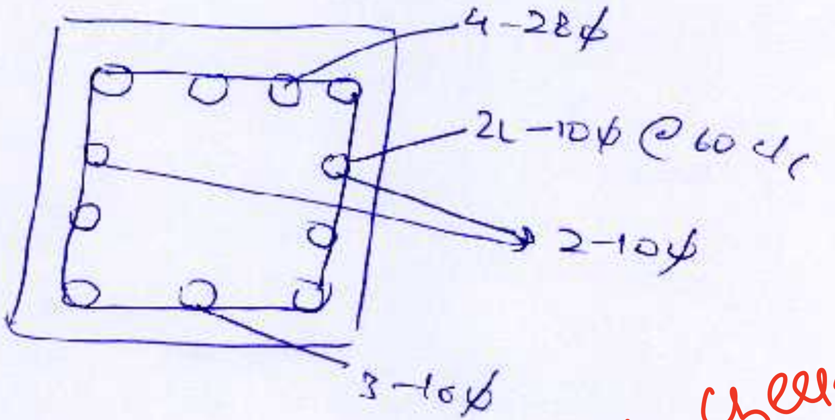
$y = 750-100+14+8+10$
$y = 682\,mm$
$x = 350-100+28+10$
$x = 288\,mm.$

Provide side Reinf. equally on both side.

$A_{st} = .1\%\,BD = \frac{0.1}{100}\times 350\times 750 = 262.5\,mm^2$

18

$A_{st1} = A_{st2} = 131.25\,mm^2$ 2-10φ.



Apply all necessary check

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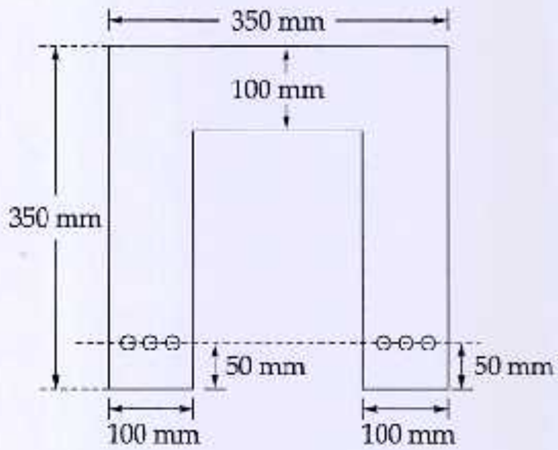
Q.3 (a) A rectangular column 600 mm × 400 mm carry an axial load of 800 kN. Design a rectangular footing of width 2 m to support the column. The safe bearing capacity of the soil is 200 kN/m^2. Use M20 grade concrete and Fe415 grade steel. Consider self weight of footing as 10% of column load and neglect the weight of soil above the footing.

[20 marks]

Q.3 (b) The section of a precast slab unit is shown in the figure. Each slab unit is supported on a span of 8 m. The section is pretensioned by 6 wires of 5 mm diameter, with three wires in each rib. The wires are provided at a distance of 50 mm from the bottom of the ribs. The wires are subjected to an initial stress of 1250 N/mm^2, the total loss of prestress is 15% of the initial stress. The permissible stress in concrete are 14 N/mm^2 in compression and 0.75 N/mm^2 in tension. Determine the safe uniformly distributed load on the slab unit.



[20 marks]

Q.3 (c) A reinforced concrete column of unsupported length 6 m is 340 mm × 500 mm in section and is reinforced with 10 bars of 20 mm diameter, consisting of 3 bars along each short edge and the remaining 4 bars equally distributed along the long faces with 2 bars per face as shown in figure. The column is held in position and restrained against rotation at both the ends. The column is subjected to an ultimate load of 1490 kN whose eccentricities are 80 mm about x-x axis and 60 mm about the y-y axis. M20 grade concrete and Fe415 grade steel are used. Check the adequacy of this column under the above loading conditions.

Chart - 44, SP : 16

Compression with bending. Reinforcement distributed equally on four sides.

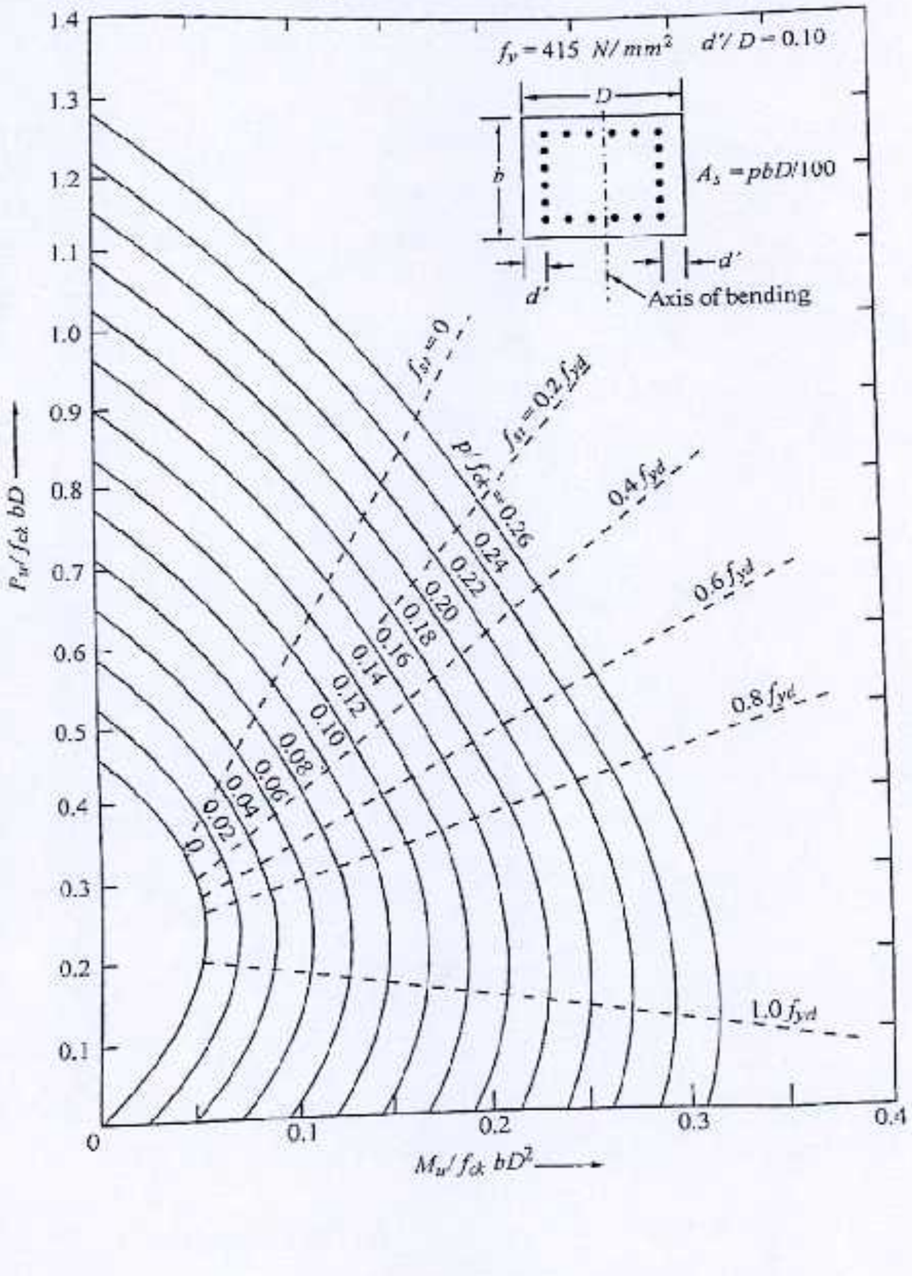
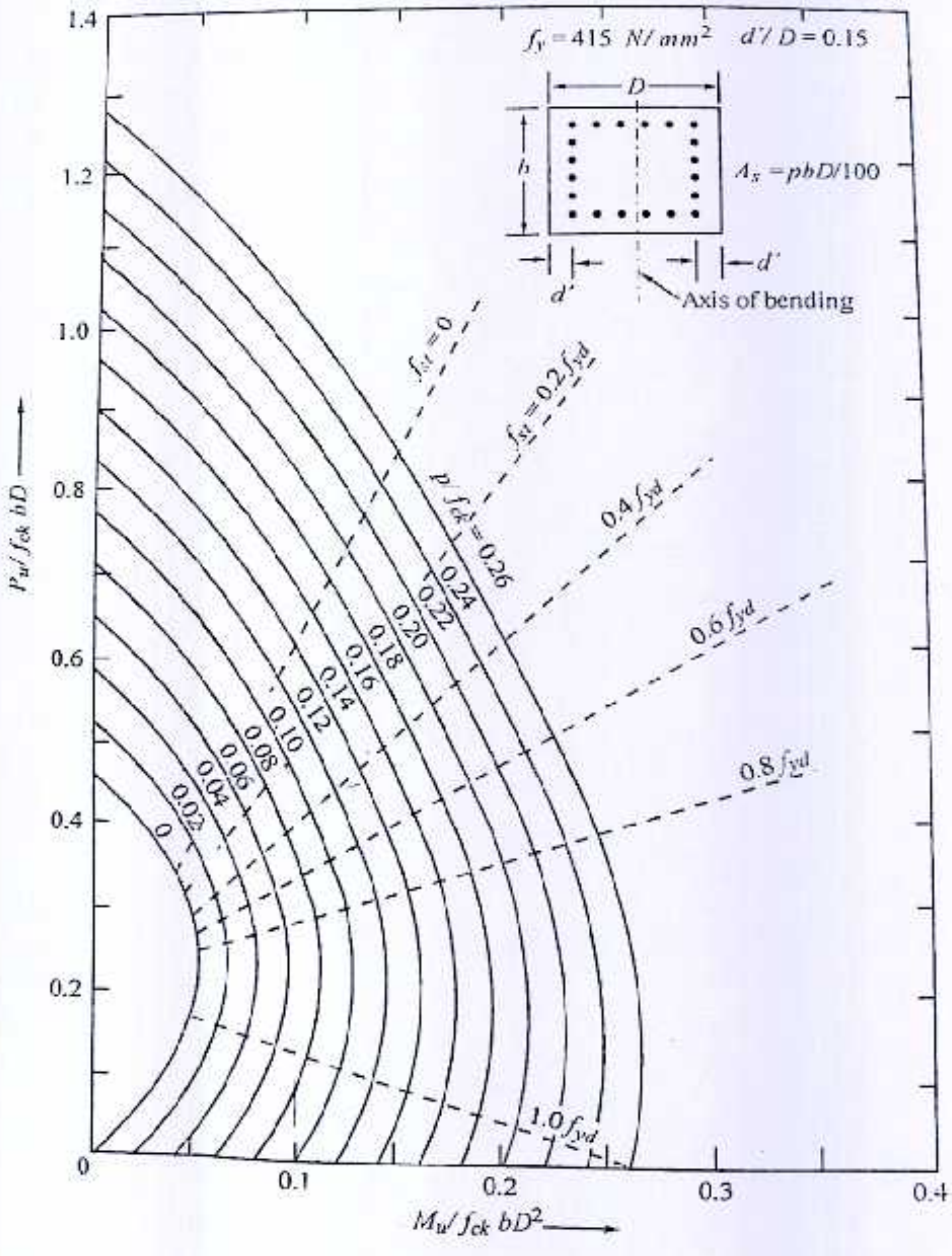
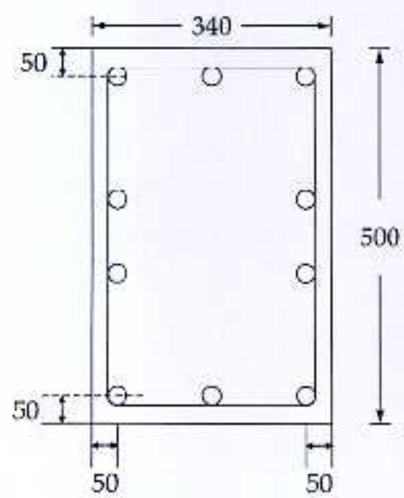


Chart - 45, SP : 16

Compression with bending. Reinforcement distributed equally on four sides.

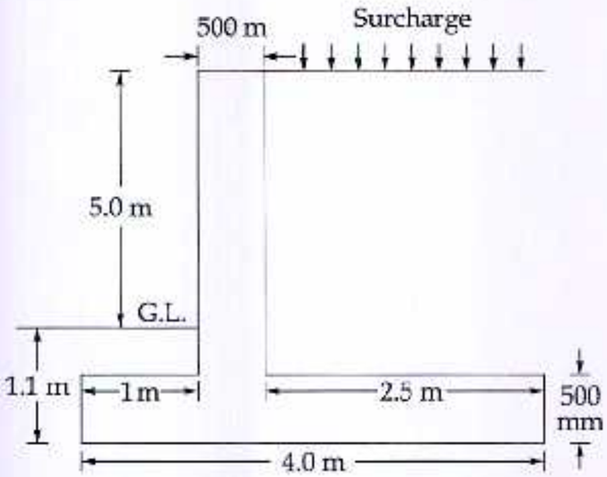




(All dimensions in mm)

[20 marks]

Q.4 (a) An RCC retaining wall is used to retain a level earth-fill 5.0 m above the ground level. Due to construction of a building, there is a surcharge of 30 kN/m^2 on the earth-fill. A good soil for foundation is existing at a depth of 1.1 m below the ground level with a safe bearing capacity of 280 kN/m^2. The unit weight and the angle of repose of the soil are 19 kN/m^3 and 30° respectively. Assume the coefficient of friction between soil and concrete to be 0.50. The initial proportioning of the retaining wall is shown in the figure below:



$\frac{100 A_s}{bd}$	τ_c for M - 30 N/mm^2
0.25	0.37
0.50	0.50
0.75	0.59
1.00	0.66

(i) Check the safety of retaining wall against overturning.

(ii) Check whether shear key is required.

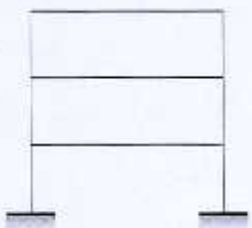
(iii) Design the stem of the retaining wall.

Use M30 grade concrete and Fe-415 grade steel.

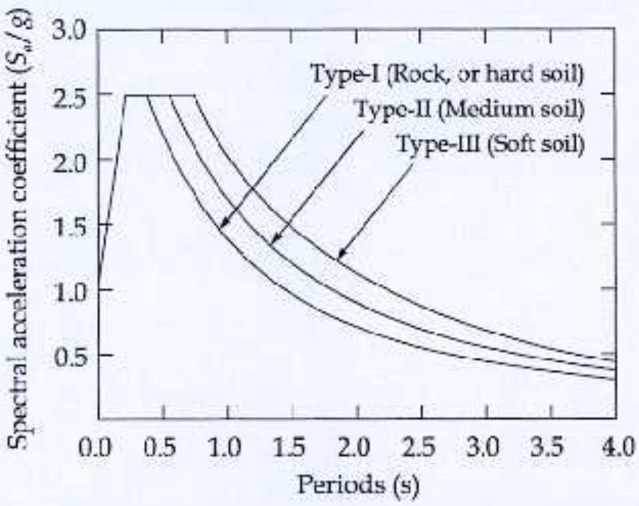
[20 marks]

Q.4 (b) A three storeyed symmetrical RC school building is situated at Bhuj (zone V) and the following details are available:

Plan dimension = 7 m
Storey height = 3.5 m
Total weight of beams in a storey = 130 kN
Total weight of slab in a storey = 250 kN
Total weight of columns in a storey = 50 kN
Total weight of walls in a storey = 530 kN
Live load on each floor = 130 kN
Live load on terrace = 0 kN
Weight of terrace floor = 655 kN



The structure is resting on hard rock and infill panels are provided. Determine the total base shear and lateral loads at each floor levels for 5% damping using seismic coefficient method. Also draw shear force diagram due to lateral forces only.



Response spectra for rock and soil sites for 5% damping.

[20 marks]

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

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

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

1. tread
2. nosing
3. riser
4. waist
5. going

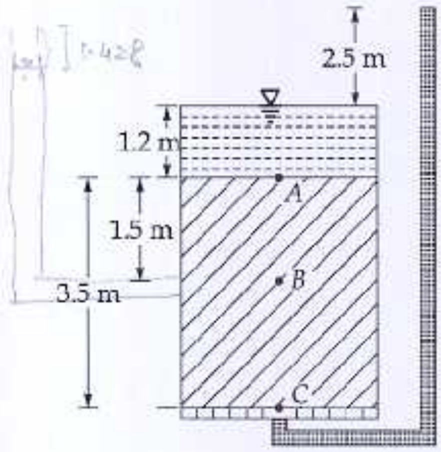
[8 + 12 marks]

Section B : Geo-technical & Foundation Engineering-1 + Highway Engineering-2 + Surveying and Geology-2

Q.5 (a) An upward flow of water is occurring through a layer of sand as shown in the figure below. Sand is having a specific gravity of 2.72 and void ratio of 0.61.

(i) Calculate the total stress, pore water pressure and effective stress at points *A*, *B* and *C*.

(ii) What is the upward seepage force per unit volume of soil?



[12 marks]

$G_s = 2.72 \quad e = 0.61 \quad S = 1$

$\gamma' = \left(\frac{G_s - 1}{1+e}\right)\gamma_w = \left(\frac{1.72}{1.61}\right) \times 9.81 = 10.48 \, kN/m^2$

$\gamma_{sat} = \gamma' + \gamma_w = 20.29 \, kN/m^2$

i) A

$\sigma = 1.2 \times 9.81 = 11.772 \, kN/m^2$

$u = 1.2 \times 9.81 = 11.772 \, kN/m^2$

$\bar{\sigma} = \sigma - u = 0$

$i = \frac{2.5}{3.5} = .714$

B

$\sigma = 1.2 \times 9.81 + 1.5 \times 20.29 = 42.207 \, kN/m^2$

$\bar{\sigma} = \gamma' z - i z \gamma_w = 10.48 \times 1.5 - .714 \times 1.5 \times 9.81 = 5.21 \, kN/m^2$

$u = \sigma - \bar{\sigma} = 42.207 - 5.21 = 36.997 \, kN/m^2$

c

$\sigma = 1.2 \times 9.81 + 3.5 \times 20.29 = 82.787 \text{ kN/m}^2$

$u = (7.2)(9.81) = 70.632 \text{ kN/m}^2$

$\bar{\sigma} = \sigma - u = 12.155 \text{ kN/m}^2$

ii) seepage Pressure $= iz\gamma_w$

seepage force in area 'A' $= izA\gamma_w$

seepage force/vol^m $= \dfrac{izA\gamma_w}{zA} = i\gamma_w$

$= 0.714 \times 9.81$

$= 7 \text{ kN/m}^3$

12

Do not write in this margin

Q.5 (b) The average normal flow of traffic on cross roads 1 and 2 during design period are 440 and 280 PCU per hour, the saturation flow values on these roads are estimated as 1300 and 1100 PCU per hour respectively. The all-red time required for pedestrian crossing is 12 sec. Design two phase traffic signal with pedestrian crossing by Webster's method. Also, sketch the phase diagram showing the cycle timings obtained.

[12 marks]

R = 12s. Phase 'n' = 2 Consider amber time = 2s.

So Lost time $L = 2n + R$

$L = 16s.$

Now $y = y_1 + y_2$ $y_1 = 0.338$

$y = \frac{440}{1300} + \frac{280}{1100} = 0.593$ $y_2 = 0.254$

Websters formula.

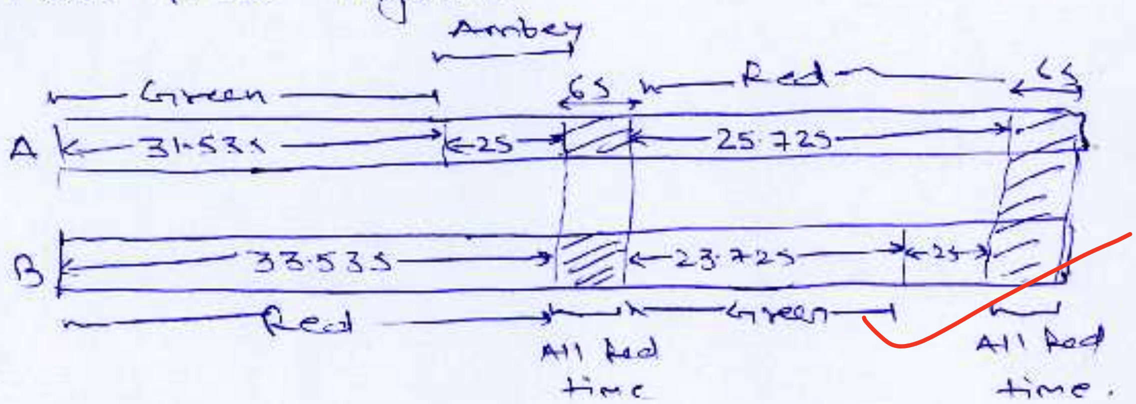
$C_o = \frac{1.5L + 5}{1 - Y} = \frac{1.5 \times 16 + 5}{1 - .593} = 71.255.$

Now, Green time for each phase.

$$G_1 = \frac{y_1}{Y}(C_o - L) = \frac{.338}{.593}(71.25-16) = 31.535.$$

$$G_2 = \frac{y_2}{Y}(C_o - L) = \frac{0.254}{.593}(71.25-16) = 23.725.$$

Now phase diagram.



12

Q.5 (c) (i) A mass of soil coated with a thin layer of paraffin weighs 5.23×10^{-3} kN. When immersed in water, it displaces 3.7×10^{-4} m^3 of water. The paraffin is peeled off and found to weigh 1.71×10^{-4} kN. The specific gravity of the soil particles is 2.72 and that of paraffin is 0.9. Determine the void ratio of the soil if its water content is 11%.

(ii) Write a short note on 'Quick sand condition'.

[8 + 4 marks]

i) $e = ?$

$W_s + W_{pw} = 5.23 \times 10^{-3}$ kN, $V_s + V_{pw} = 3.7 \times 10^{-4}$ m^3

$W_{pw} = 1.71 \times 10^{-4}$ kN $\quad G_s = 2.72 \quad \omega = .11$

$\gamma_{pw} = .9 \times 9.81 = 8.829$ kN/m^3

$\gamma_{pw} = \frac{W}{V} \rightarrow V = \frac{W}{\gamma} = \frac{1.71 \times 10^{-4}}{8.829} = 1.9368 \times 10^{-5}$ m^3

So $V_s = 3.5 \times 10^{-4}$ m^3

$W_s = 5.0586 \times 10^{-3}$ m^3

$\gamma_b = \frac{W_s}{V_s} = 14.453$ kN/m^3

Now $\gamma_b = \frac{(G_s + Se)\gamma_w}{1+e}$

$\gamma_b = \frac{(G_s + \omega G)\gamma_w}{1+e}$ $\quad (\because Se = \omega G)$

$14.453 = \frac{(1+.11) \times 2.72 \times 9.81}{1+e}$

$e = 1.05$

8

ii) Quick sand condition is a flow phenomenon in which the upward seepage head becomes more than sub. wt. of soil.

– Due to this the effective stress become zero and sand starts flowing like water.

→ This condition mostly seen in sand because it is cohesionless.

→ Care must be taken that hydraulic head cannot be more than critical hydraulic head.

Sub. wt. in seepage condition is given by.

$\bar{\sigma} = \gamma' z - i z \gamma_w$.

3

If $\bar{\sigma} = 0$ $\gamma' z = i_{cr} z \gamma_w$

so $i_{cr} = \frac{\gamma'}{\gamma_w}$ or $i_{cr} = \frac{G_s - 1}{1+e}$.

So $FOS = \frac{i_{cr}}{i}$

Do not write in this margin

Q.5 (d) (i) Find the shortest distance between two places A and B, given that the latitudes of A and B are 15° N and 16°10′ N and their longitudes are 70°30′ E and 75° E, respectively. Take radius of earth as 6400 km.

(ii) Write a short note on signal propagation errors.

[8 + 4 marks]

Q.5 (e) Briefly discuss about the suitability of igneous rocks for building and foundation works.
[12 marks]

→ Igneous rocks are the rocks which are obtained from below the earth crust.

– When lava comes out of earth it solidifies and known as igneous rocks. Eg. Basalt.

– These rocks are of high strength and has good suitability for foundation.

– The permeability and compressibility is also less. and hence chances of seepage reduces.

– In high rise building we can use shallow foundⁿ instead of deep foundⁿ.

1

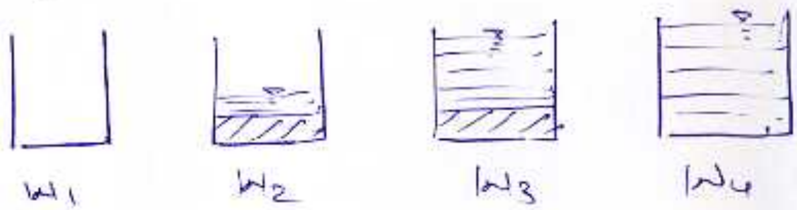
elaborate it more

Q.6 (a) (i) Derive an expression for determination of water content in soil by pycnometer method.

(ii) A clay layer 5 m thick has double drainage. It was consolidated under a load of 127.5 kN/m^2. The load is increased to 197.5 kN/m^2. The coefficient of volume compressibility is 5.79×10^{-4} m^2/kN and value of permeability is 1.6×10^{-8} m/min. Find ultimate settlement and settlement at 50% consolidation. Also, determine probable period of time required for clay stratum to undergo 90% of ultimate settlement under the given increment of load.

[10 + 10 marks]

i) To determine w.c wet soil is taken and not dry soil.



W_1 :- Weight of empty pycnometer

W_2 :- Weight of pcynometer + moist soil

W_3 :- Wt. of pcycnometer + moist soil + extra water

W_4 :- Wt. of pcynometer + Wt. of water completely filled.

now $\omega = \dfrac{W_w}{W_s}$.

$W_4 = W_3 - W_s + V_s \gamma_w$ $\left(\because \gamma_s = \dfrac{m_s}{V_s} - V_s = \dfrac{W_s}{\gamma_s} \right)$

So,

$W_4 = W_3 - W_s + \dfrac{W_s}{G_s}$ $\left(\because G_s = \dfrac{\gamma_s}{\gamma_w} \right)$

$W_4 = W_3 - \left(1 - \dfrac{1}{G_s}\right) W_s$

$W_s = \dfrac{W_3 - W_4}{\left(1 - 1/G_s\right)}$

~~$W_w = W_4 - W_1$~~

$W_N = W_2 - W_1 - W_3$

So $\omega = \frac{W_w}{W_3} = \frac{W_2 - W_1 - W_3}{W_3} = \frac{W_2 - W_1}{W_3} - 1$

Put eqn of W_3 in above eqn.

$$\omega = \frac{W_2 - W_1}{W_3 - W_4}\left(1 - \frac{1}{G}\right) - 1$$

(8)

ii) $d = 2.5m$ $\sigma_1 = 127.5 kN/m^2$ $\sigma_2 = 197.5 kN/m^2$

$m_v = 5.79 \times 10^{-4} m^2/kN$ $k = 1.6 \times 10^{-8} \frac{m}{min}$ $H = 5m$.

$\Delta\sigma = \sigma_2 - \sigma_1 = 70 kN/m^2$

$\Delta H = H m_v \Delta\sigma = 5 \times 5.79 \times 10^{-4} \times 70 = 202.65mm$.

$k = C_v m_v \gamma_w$

$\frac{1.6 \times 10^{-8}}{60} = 5.79 \times 10^{-4} \times C_v \times 9.81 \rightarrow C_v = 4.69 \times 10^{-8} m^2/s$

for $U_z = 50\%$.

$T_v = \frac{\pi}{4}(U_z)^2 = \frac{\pi}{4}(0.5)^2 = 0.1963$

$T_v = \frac{C_v t}{d^2} \rightarrow .1963 = \frac{4.69 \times 10^{-8} \times t}{(2.5)^2}$

$t = 302.85 days$ //.

Extra

for $U_z = 50\%$.

$\frac{\Delta h}{H} = .5 \rightarrow \Delta h = 101.325mm$.

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$U_z = 90\%$

$T_v = 1.781 - .933 \log(100 - U_z)$

$= 1.781 - .933 \log(10)$

$T_v = 0.848$

10

$T_v = \frac{C_v t}{d^2}$

$.848 = \frac{4.69 \times 10^{-8} \times t}{(2.5)^2}$

$t = 3.583$ yrs.

Avoid extra calculation

Read question carefully

Q.6 (b) **(i)** Determine the total thickness of flexible pavement assuming single layer elastic theory and using the following data:

Design wheel load = 5100 kg,
Tyre pressure = 7.0 kg/cm^2,
Elastic modulus = 180 kg/cm^2,
Permissible deflection = 0.25 cm.

(ii) The spacing between the contraction joints of a CC pavement is 4.5 m. Determine the tensile stress developed in CC pavement due to contraction if the coefficient of friction between the bottom of the pavement and the supporting layer is 1.3 and the unit weight of CC is 2400 kg/m^3.

(iii) A rigid pavement of 15 cm thickness is supported over a subgrade having modulus of subgrade reaction as 7.5 kg/cm^3. If dowel bars are placed at every 30 cm, calculate the maximum load carried by a single dowel which is just below the wheel. Assume the wheel load as 4100 kg, participation of dowel bars in load distribution upto 1.8 times radius of relative stiffness and load to be transferred by the joint as 50%. Poissons' ratio and modulus of elasticity of cement concrete may be taken as 0.15 and 2.1 × 10^5 kg/cm^2 respectively.

[4 + 4 + 12 marks]

i) $P = 5100$ kg $\quad p = 7$ kg/cm^2 $\quad E_s = 180$ kg/cm^2 $\quad \Delta = .25$ cm.

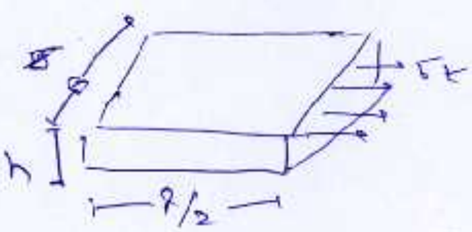
$$T = \sqrt{\left(\frac{3PXY}{2\pi E \Delta}\right)^2 - \frac{P}{\pi p}} \quad (\text{Assume } X = Y = 1)$$

$$T = \sqrt{\left(\frac{3 \times 5100}{2\pi \times 180 \times .25}\right)^2 - \frac{5100}{\pi(7)}}$$

$T = 51.92$ cm

(4)

ii) $l = 4.5$ m $\quad f = 1.3$ $\quad \gamma = 2400 \frac{kg}{m^3}$ $\quad \sigma_t = ?$



Equating forces:-

$(\sigma_t)(Bh) = f\gamma \frac{l}{2} Bh \rightarrow \sigma_t = \frac{f\gamma l}{2}$

So, $\sigma_t = 1.3 \times 2400 \times \frac{4.5}{2} = 7020$ kg/m^2

(4)

iii)

Q.6 (c) **(i)** An area of 150 km × 100 km is to be surveyed using aerial photogrammetry. From the data given below:

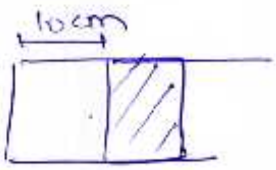
Size of photograph = 25 cm × 25 cm
Average scale of photograph = 1 : 25000
Average elevation of terrain = 330 m
Longitudinal overlap = 60%
Side overlap = 40%
Ground speed of aircraft = 270 km/hr
Focal length of camera = 200 mm
Least count of intervalometer = 0.5 seconds

Determine:

1. Number of photographs required to cover the complete area.
2. Height of flight
3. Spacing of flight lines
4. Ground exposure distance and
5. Exposure interval.

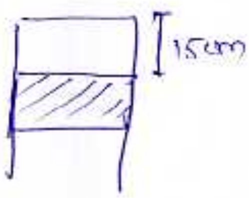
[15 marks]

1)



$l = 2.5\,km$

$N_1 = \left(\frac{L}{l} + 1\right) = \left(\frac{150}{2.5} + 1\right) = 61$



$b = \frac{15 \times 25000}{10^5} = 3.75\,km.$

$N_2 = \left(\frac{B}{b} + 1\right) = \left(\frac{100}{3.75} + 1\right) = 28$

So $N = N_1 \times N_2 = 1708$

2)

$\frac{x}{X} = \frac{y}{Y} = \frac{f}{H-h} = \text{Scale}$

$\frac{1}{25000} = \frac{.2}{H-330} \Rightarrow H = 5330\,m.$

5

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5) Interval.

$$t = \frac{l}{v} = \frac{2.5}{270} = 9.25 \times 10^{-3} \text{ hr} = 33.33s$$

6)

Incomplete solution

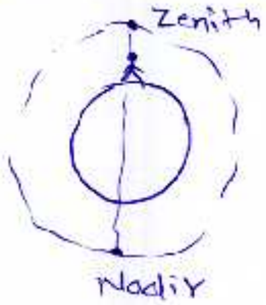
Q.6 (c) **(ii)** Define the following terms briefly:

1. Zenith and nadir
2. Azimuth
3. Prime vertical
4. Declination.

[5 marks]

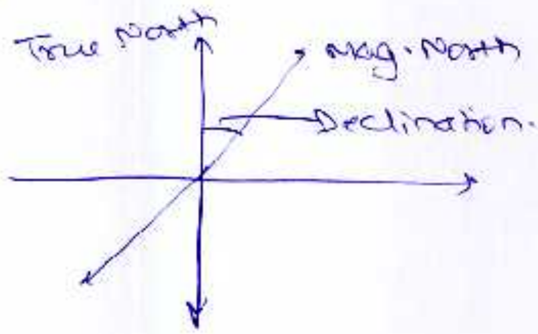
1) Zenith :- It is the point on celestial sphere which is just above the observer's head.

Nadir :- It is the point on celestial sphere which is at diametrically opposite end of zenith



2) Azimuth :- It is the bearing of any line with respect to true north and south meridian.

4) Declination :- It is defined as the angle made between Magnetic north and true north.



3

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Q.7 (a) Pore pressure measurement were made during undrained triaxial tests on samples of compacted fill material from an earthen dam after saturating them in the laboratory. The results were as follows:

Property measured (kN/m^2)	Test-1	Test-2
Lateral pressure (σ_3)	150	450
Total vertical pressure (σ_1)	400	1000
Pore water pressure (u)	30	125

Determine the apparent cohesion and the angle of shearing resistance with respect to (i) total stress (ii) effective stress.

[20 marks]

i) Total stress

$\sigma_1 = 400 \quad \sigma_3 = 150$ | $\sigma_1 = 1000 \quad \sigma_3 = 450$

Now, use shear equation of triaxial test.

$\sigma_1 = \sigma_3 \tan^2(45+\phi/2) + 2c\tan(45+\phi/2)$

$400 = 150 \tan^2(45+\phi/2) + 2c\tan(45+\phi/2)$ — i)

$1000 = 450 \tan^2(45+\phi/2) + 2c\tan(45+\phi/2)$ — ii)

Subtract eq^n ii) − i)

$600 = 300 \tan^2(45+\phi/2)$

$\phi = 19.47°$

Put this value in eq^n i)

$400 = 150(2) + 2c\sqrt{2}$

So $c = 35.35$ kN/m^2

ii) Effective stress

$\bar{\sigma}_1 = 400-30 = 370\ kN/m^2$ | $\bar{\sigma}_1 = 1000 - 125 = 875\ kN/m^2$

$\bar{\sigma}_3 = 150-30 = 120\ kN/m^2$ | $\bar{\sigma}_3 = 450 - 125 = 325\ kN/m^2$

Eq^n for triaxial test:-

$$\bar{\sigma}_1 = \bar{\sigma}_3 \tan^2(45+\phi'/2) + 2c'\tan(45+\phi'/2)$$

$$370 = 120\tan^2(45+\phi'/2) + 2c'\tan(45+\phi'/2) \quad \text{— iii)}$$

$$875 = 325\tan^2(45+\phi'/2) + 2c'\tan(45+\phi'/2) \quad \text{— iv)}$$

Subtract eq^n iv) − iii)

$$505 = 205\tan^2(45+\phi'/2)$$

$$\phi' = 24.99^\circ$$

Put ϕ' in eq^n iii)

$$370 = 120(2.463) + 2c'(1.569)$$

So, $c' = 23.722\ kN/m^2$

20

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Q.7 (b) The consolidated data collected from speed and delay studies by floating car method on a stretch of urban road of length 3.5 km, are given below. Determine the average values of (i) traffic volume, (ii) journey speed and (iii) running speed of the traffic stream along both the directions.

Trip no.	Direction of trip	Journey time, min-sec	Total stopped delay, min-sec	No. of vehicles overtaking	No. of vehicles overtaken	No. of vehicles from opposite direction
1	N-S	6 - 48	1 - 50	3	7	270
2	S-N	7 - 20	1 - 40	4	3	190
3	N-S	7 - 10	1 - 30	5	3	290
4	S-N	7 - 40	2 - 00	3	1	220
5	N-S	6 - 10	1 - 30	3	6	270
6	S-N	8 - 00	2 - 30	2	2	190
7	N-S	6 - 32	1 - 50	2	5	320
8	S-N	7 - 40	1 - 30	3	2	190

[20 marks]

Direction	Journey time	Delay	Overtaking	Overtaken	Opposite
N-S	6.8	1.833	3	7	270
N-S	7.167	1.5	5	3	290
N-S	6.167	1.5	3	6	270
N-S	6.533	1.833	2	5	320
	6.67	1.67	3.25	5.25	287.5

For Volume

$q t_w - V t = n_y$

$q t_a + V t = n_a$

$q(t_a + t_w) = n_y + n_a$

$q = \frac{n_y + n_a}{t_a + t_w}$

For Journey time.

$q t_w - \frac{q}{V} \times V \bar{t} = n_y \rightarrow q t_w - q \bar{t} = n_y$

~~$q t$~~ $\bar{t} = t_w - \frac{n_y}{q}$

Direction	Journey time	Delay	Overtaking	Overtaken	Opposite
S–N	7.33	1.67	4	3	190
S–N	7.67	2	3	1	220
S–N	8	2.5	2	2	190
S–N	7.67	1.5	3	2	190
	7.67	1.9175	3	2	197.5

for N-S.

i)

n_y = overtaken − overtaking

$n_y = 2$ $n_a = 197.5$ $t_w = 6.67$ $t_a = 7.67$ min.

$$q = \frac{2 + 197.5}{6.67 + 7.67} = 13.91 \text{ veh/min.}$$

ii)

Journey time

$$\bar{t} = 6.67 - \frac{2}{13.91} = 6.526 \text{ min.}$$

So Journey speed $= \frac{L}{t} = \frac{3500}{6.526 \times 60} = 8.94$ m/s

iii) Running time = $\bar{t}$ − delay

$= 6.526 - 1.67$

$= 4.856$ min.

So Running speed $= \frac{L}{t} = \frac{3500}{4.856 \times 60} = 12.01$ m/s for S – N.

$t_w = 7.67 min$ $t_a = 6.67 min$ $n_a = 287.5$ $n_y = -1$

i) $q = \frac{n_y + n_a}{t_a + t_w} = \frac{287.5 - 1}{7.67 + 6.67} = 19.98 veh/min.$

ii) Journey time.

$\bar{t} = t_w - \frac{n_y}{q} = 7.67 + \frac{1}{19.98} = 7.72 min.$

So, $speed = \frac{L}{\bar{t}} = \frac{3500}{7.72 \times 60} = 7.55 m/s.$

iii) Running time $= \bar{t} - delay$

$= 7.72 - 1.9175$

$= 5.8025 min.$

So, $Speed = \frac{L}{t} = \frac{3500}{5.8025 \times 60} = 10.05 m/s$

18

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Q.7 (c) (i) What do you mean by the term 'Metamorphism'? Describe the various agents associated with it.

[10 marks]

→ Metamorphism in rocks ~~[illegible]~~ means the wheather of rocks due to high temperature and pressure.

→ Due to these adverse condition ~~the rocks~~ the structural shape of rocks are changed. and are called as metamorphic rock.

→ These rocks generally formed by igneous and ~~[illegible]~~ sedimentary rocks. only.

1

Q.7 (c) (ii) Briefly explain the igneous formations viz. dykes and sills. Also state the importance of dykes from civil engineering point of view.

[10 marks]

Q.8 (a) (i) Define the following terms:

1. Coefficient of compressibility
2. Coefficient of volume change
3. Compression index
4. Expansion index
5. Recompression index

[10 marks]

Q.8 (a) (ii) A wall with smooth vertical back 5 m high retains a mass of dry cohesionless sand that has a horizontal surface. The sand behind the wall is having specific gravity of 2.65, void ratio of 0.65 and angle of shearing resistance of 20°. The water level behind the wall is at an elevation of 1 m below the crest. The backfill carries a uniformly distributed load of 14.6 kN/m^2. If the deformation condition for active Rankine state is satisfied, then what is the total horizontal pressure on the back of the wall?

[10 marks]

Q.8 (b) (i) Briefly discuss about the angular methods commonly employed for curve setting.

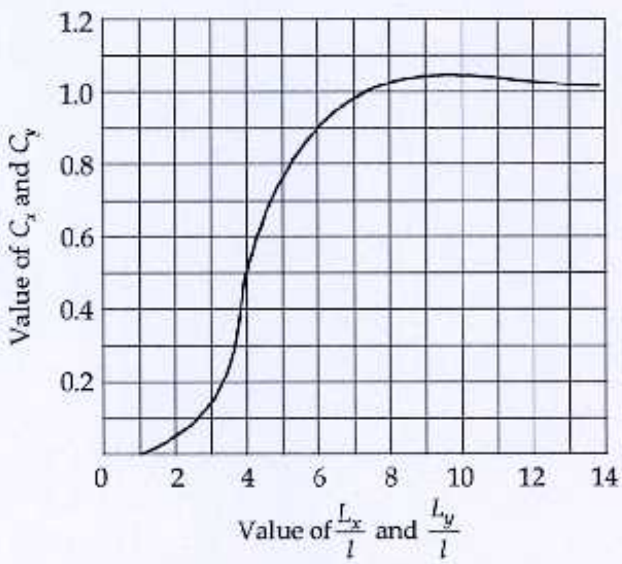
(ii) Two straights *AB* and *BC* intersect at a chainage of 4274.0 m. The angle of intersection is 150°. It is required to set out a 3° simple circular curve to connect the straights. Calculate all the data necessary to set out the curve by the method of offsets from the chord produced with an interval of 30 m.

(iii) Discuss briefly about the terms 'Drift' and 'Crab'.

[6 + 10 + 4 marks]

Q.8 (c) (i) Determine the warping stresses at interior, edge and corner of a 26 cm thick cement concrete pavement with transverse joints at 4.5 m interval and longitudinal joints at 3.5 m intervals. The modulus of subgrade reaction is 15 kg/cm³ and radius of loaded area is 15 cm. Assume maximum temperature differential during day to be 0.6° C per cm slab thickness and maximum temperature differential of 0.4° C per cm slab thickness during the night. Additional data are given below:

$\alpha = 10 \times 10^{-6}$ per °C, $E = 3 \times 10^5$ kg/cm², $\mu = 0.15$



Warping stress coefficient chart (by Bradbury)

[15 marks]

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Q.8 (c) **(ii)** What is prime coat and what purpose does it serve in the construction of bituminous pavement?

[5 marks]

OOOO

Space for Rough Work

Space for Rough Work

Space for Rough Work

Space for Rough Work

$$\omega = \frac{W_2 - W_1}{W_3 - W_4}\left(1 - \frac{1}{G_s}\right) - 1$$

4
35 28
40 32