188/300

- overall attempt of paper is good.
- Take care of calculation.
- Improve Answer representation

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ESE 2023 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Civil Engineering

Test-5

Flow of fluids, Hydraulic machines and Hydro power [All Topics]
Design of Concrete and Masonry Structures-1 [Part Syllabus]
+ Geo-technical & Foundation Engineering-2 [Part Syllabus]

Name : ....

Roll No :

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

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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.

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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.
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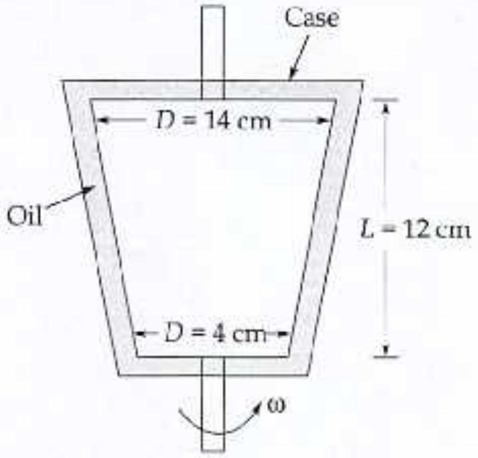
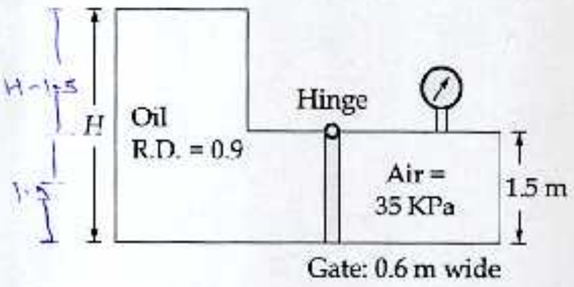
Section A : Flow of fluids, Hydraulic machines and Hydro power

Q.1 (a) A frustum-shaped body is rotating at a constant angular speed of 100 rad/s in a container filled with an oil of viscosity 0.099 Pa.s, as shown in figure. If the thickness of the oil film on all sides is 1.4 mm, determine the power required to maintain this motion.



[12 marks]

Q.1 (b) For the system shown in figure, calculate the height *H* of oil at which the rectangular hinged gate will just being to rotate counterclockwise.



[12 marks]

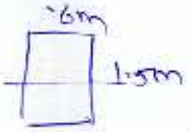
Force on gate :- due to oil

$F = \rho g A \bar{h} = 900 \times 9.81 \times (.6 \times 1.5)\left(H - 1.5 + \frac{1.5}{2}\right)$

$F = 7946.1\,(H - .75)$

$\bar{h}_{cp} = \bar{h} + \frac{\cancel{I_G}\sin^2\theta}{A\bar{h}} = H - .75 + \frac{(0.6)(1.5)^3}{12 \times .6 \times 1.5 \times (H - .75)}$

⑤



$\bar{h}_{cp} = H - .75 + \frac{.1875}{H - .75}$

force on gate due to Air :-

$F = P.A = 35 \times 10^3 \times .6 \times 1.5 = 31500\ N$

~~$\bar{h} = \frac{2h}{3} = \frac{2 \times 1.5}{3} = 1$~~

~~$h_{cp} = .75 + \frac{(2)(1.5)^3}{12 \times .6 \times 1.5 \times .75} = 1$~~

$\bar{h}_1 = \frac{1.5}{2} = 0.75m$

Cal. mistake

So, now $M@H = 0$

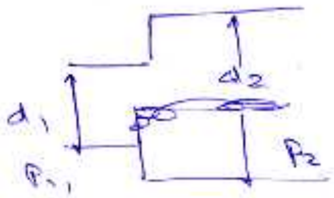
$7946.1\,(H - .75)\left[H - .75 + \frac{.1875}{H - .75}\right] = 31500 \times .75$

$7946.1\left[(H - .75)^2 + .1875\right] = 23625.$

$H = 2.42m$ //

Q.1 (c) Determine the optimum ratio between the diameter of the pipe before expansion and the diameter of the pipe after expansion so that pressure rise may be maximum for sudden expansion in pipe flow. What will be the corresponding pressure rise?

[12 marks]



Apply bernoulli's eqⁿ :-

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + \frac{(v_1 - v_2)^2}{2g}.$$

$$\frac{P_2 - P_1}{\rho g} = \frac{v_1^2 - v_2^2 - (v_1 - v_2)^2}{2g}$$

$$\frac{P_2 - P_1}{\rho g} = \frac{\cancel{v_1^2} - v_2^2 - \cancel{v_1^2} - v_2^2 + 2v_1v_2}{2g}$$

$$\frac{P_2 - P_1}{\rho g} = \frac{\cancel{2}v_2(v_1 - v_2)}{\cancel{2}g}.$$

$$\frac{P_2 - P_1}{\rho g} = \frac{\frac{Q}{\frac{\pi}{4}d_2^2}\left[\frac{Q}{\frac{\pi}{4}d_1^2} - \frac{Q}{\frac{\pi}{4}d_2^2}\right]}{g}.$$

$$\left\{ \because v_1 = Q/A_1 \quad v_2 = Q/A_2 \right\}$$

$$\frac{P_2 - P_1}{\rho g} = \frac{Q^2}{(\pi/4)^2 g} \times \frac{1}{d_2^2}\left[\frac{1}{d_1^2} - \frac{1}{d_2^2}\right]$$

$$\left\{ \text{Assume } c = \frac{Q^2}{(\pi/4)^2 g} \right\}$$

$$\frac{P_2 - P_1}{\rho g} = c\left[\frac{1}{d_1^2 d_2^2} - \frac{1}{d_2^4}\right]$$

$$\frac{P_2 - P_1}{\rho g} = \frac{c\,\cancel{d}}{d_1^4}\left[\left(\frac{d_1}{d_2}\right)^2 - \left(\frac{d_1}{d_2}\right)^4\right]$$

$$\left\{ \text{Now } r = \frac{d_1}{d_2} \right\}$$

$$\frac{P_2-P_1}{\rho g} = \frac{C\cancel{16}}{d_1^4}\left[r^2-r^4\right]$$

For pressure rise to be maximum,

$$\frac{\partial P}{\partial r} = 0 \qquad 2r - 4r^3 = 0$$

$$2r = 4r^3 \qquad r = \frac{1}{\sqrt{2}}$$

12

$$\text{So} \quad \frac{d_1}{d_2} = \frac{1}{\sqrt{2}} //$$

$$\frac{P_2-P_1}{\rho g} = \frac{Q^2}{(\pi/4)^2 g} \times \frac{\cancel{16}}{d_1^4}\left[\frac{1}{2} - \frac{1}{4}\right]$$

$$\frac{P_2-P_1}{\rho g} = \frac{1}{4}\frac{Q^2}{A_1^2 g} \rightarrow \frac{P_2-P_1}{\rho g} = \frac{1}{2}\left[\frac{V_1^2}{2g}\right]$$

Q.1 (d) **(i)** Explain cavitation in reaction turbine. What is Thoma's cavitation factor?

(ii) A conical draft tube having inlet and outlet diameters 0.8 m and 1.2 m respectively discharges water at outlet with a velocity of 3 m/sec. The total length of the draft tube is 8 m and 2 m of the length of draft tube is immersed in water. If the atmospheric pressure head is 10.3 m of water and loss of head due to friction in the draft tube is equal to 0.25 times the velocity head at outlet of the tube then find:

1. Pressure head at inlet.
2. Efficiency of the draft tube.

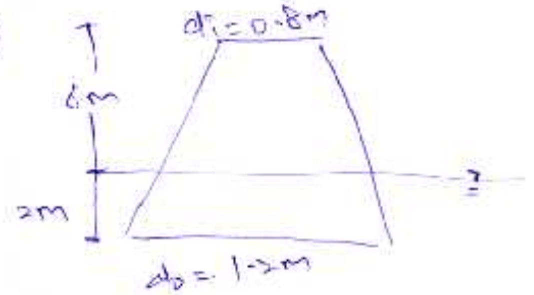
[4 + 8 marks]

ii)

$d_i = \cdot 8m \quad d_o = 1.2m \quad V_o = 3m/s \quad L = 8m$

$H_{atm} = 10.3m \quad h_f = \frac{\cdot 25 V_o^2}{2g}.$

1)



Apply Bernoulli eqn.

$$\frac{P_i}{\rho g} + \frac{V_i^2}{2g} + z_1 = \frac{P_o}{\rho g} + \frac{V_o^2}{2g} + z_2 + \frac{0.25 V_o^2}{2g}. \quad \text{—i)}$$

Apply continuity eqn

$$V_i\left(\frac{\pi}{4}(\cdot 8)^2\right) = 3 \times \frac{\pi}{4}(1.2)^2$$

$$V_i = 6.75 m/s.$$

from eqn i)

$$\frac{P_i}{\rho g} + \frac{(6.75)^2}{2 \times 9.81} + 8 = 10.3 + 2 + \frac{(3)^2 \times 1.25}{2 \times 9.81}.$$

$$\frac{P_i}{\rho g} - 2.55m \;//.$$

8

2) $$\eta = \frac{v_i^2/2g - v_0^2/2g - h_f}{v_i^2/2g} \times 100$$

$$\eta = \frac{v_i^2/2g - 1.25\, v_0^2/2g}{v_i^2/2g} \times 100$$

$$\eta = \frac{(6.75)^2 - 1.25 \times (3)^2}{(6.75)^2} \times 100 = \underline{\underline{75.3\%}}$$

i)

→ When water is flowing through a pipe and if the pressure reduces to less than vapour pressure of liquid then liquid starts converting into air bubbles.

→ At another section when pressure increases then these bubbles collapse due to which a cavity is formed which gets filled by the water surrounding it. Because of these, noises come out & is known as cavitation.

→ In Reaction turbine cavitation occur at outlet of runner or inlet of draft tube because pressure energy is also used to rotate turbine due to which pressure reduces at outlet.

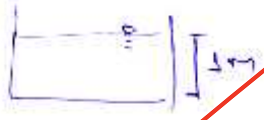
②

Q.1 (e) (i) Write the assumptions made in the derivation of depth of hydraulic jump.

(ii) A sluice gate discharges water into a horizontal rectangular channel with a velocity of 10 m/s and depth of flow of 1 m. Determine the depth of flow after the jump and consequent loss in total head.

[12 marks]

ii)



$V = 10 m/s$

$q = 10 m^3/s/m$

$y_1 = 1m$. $F_{r1}^2 = \frac{q^2}{g y^3} = \frac{(10)^2}{9.81 \times (1)^3} = 10.193$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1+8F_r^2}\right]$$

$y_2 = 4.04m$ //.

$$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2} = \frac{(4.04-1)^3}{4 \times 4.04 \times 1} = 1.738m //$$

9

i) Assumptions

1) Pressure throughout the jump is atmospheric

2) frictional losses are neglected during jump.

3) floor over which hydraulic jump occur is consider as horizontal means no weight component used.

InComplete

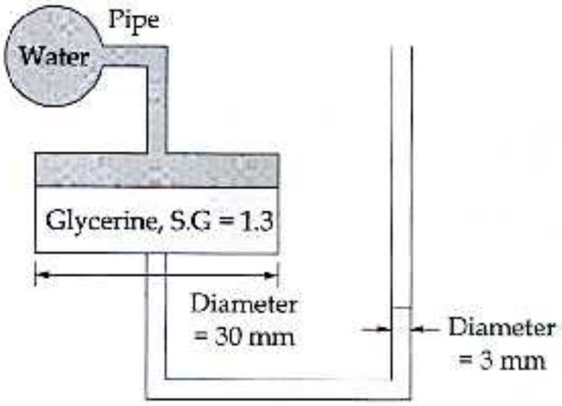
Q.2 (a) **(i)** A siphon consisting of a pipe of 20 cm diameter is used to empty oil of relative density 0.85 from tank *A*. The siphon discharges to the atmosphere at an elevation of 2.00 m. The oil surface in the tank is at an elevation of 5.00 m. The centreline of the siphon pipe at its highest point C is at an elevation of 6.50 m. Estimate:

1. the discharge in pipe.
2. pressure at point *C*.

The losses in the pipe can be assumed to be 0.4 m up to the summit and 1.2 m from the summit to the outlet.

[12 marks]

Q.2 (a) (ii) The system shown in the figure is used to accurately measure the pressure changes when the pressure is increased by ΔP in the water pipe. Corresponding to a rise of 70 mm in the level of glycerin in the vertical pipe, what will be the change in the pipe pressure?



[8 marks]

Q.2 (b) Given the velocity distribution in a laminar boundary layer on a flat plate as

$$\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^3 + \left(\frac{y}{\delta}\right)^4$$

Obtain expressions for the boundary layer thickness, shear intensity and force on one side of the plate.

[20 marks]

~~$\tau = \mu \frac{du}{dy}$~~

~~$\tau = \mu\left[\frac{2}{\delta} - \frac{6y^2}{\delta^3} + \frac{4y^3}{\delta^4}\right] \Rightarrow \tau = \frac{\mu}{\delta}\left[2 - 6\left(\frac{y}{\delta}\right)^2 + 4\left(\frac{y}{\delta}\right)^3\right]$~~

~~Now Boundary layer thickness:-~~

~~$\frac{\tau_0}{\rho U_\infty^2} = \frac{\partial \theta}{\partial x}$~~

~~$\theta = \int_0^\delta \frac{u}{U_\infty}\left[1 - \frac{u}{U_\infty}\right]dy = \int_0^\delta \left(\frac{u}{U_\infty} - \left(\frac{u}{U_\infty}\right)^2\right)dy$~~

~~$\int 2\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^3 + \left(\frac{y}{\delta}\right)^4 - \left(2\right.$~~

Q.2 (c) (i) A rectangular channel is 3 m wide and conveys a discharge of 15 m^3/sec at a depth of 2.5 m. It is proposed to reduce the width of the channel at hydraulic structure. Assuming the transition to be horizontal and the flow to be frictionless, determine the water surface elevations upstream and downstream of the constriction when the constricted width is 1.8 m.

[12 marks]

Q.2 (c) (ii) A 3.5 m wide rectangular channel carries a discharge of 15 m^3/sec at a depth of 2 m. Calculate the height and velocity of a surge produced when the flow is suddenly stopped completely by the full closure of a sluice gate at the downstream end.

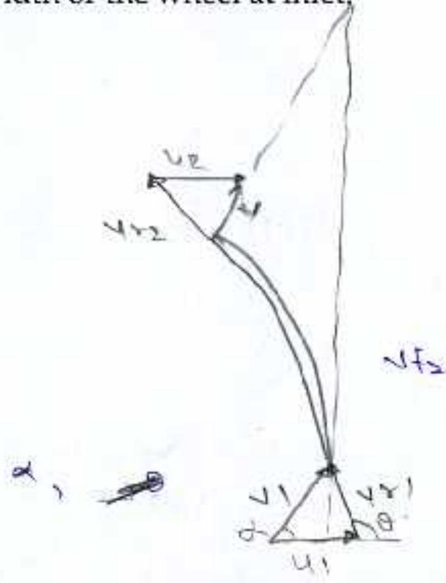
[8 marks]

Q.3 (a) **(i)** An inward flow turbine (reaction type with radial discharge) with an overall efficiency of 85% is required to develop 160 kW power. The head is 8 m; peripheral velocity of the wheel is $0.96\sqrt{2gH}$; the radial velocity of the flow is $0.36\sqrt{2gH}$. The wheel is to make 160 rpm and the hydraulic losses in the turbine are 24% of the available energy.

Determine:

1. The angle of the guide blade at inlet.
2. The wheel vane angle at inlet.
3. The diameter of the wheel.
4. The width or the wheel at inlet.

[15 marks]



$\eta_o = .85$ S.P = 160 kW.

H = 8 m

$u_1 = .96\sqrt{2gH} = 12.03$ m/s.

$V_{f2} = V_{f1} = ~~.96~~ .36\sqrt{2gH} = 4.51$ m/s.

N = 160 rpm.

$\eta_h = .76$.

$W.P = \frac{S.P}{\eta_o} = 188.235\ kW = \dot{m}gH$

$188.235 \times 10^3 = (10^3)(Q)(9.81)(8)$

$Q = 2.39\ m^3/s$.

$\eta_h = \frac{R.P}{W.P}$ — $R.P = 143.06\ kW$.

$R.P = \dot{m}\ V_{w1} u_1$

$143.06 \times 10^3 = (10^3)(2.39) \times V_{w1} \times 12.03$

$V_{w1} = 4.975$ m/s.

i) $\tan\alpha = \frac{V_{f1}}{V_{w1}} = \frac{4.51}{4.975} = 42.19°$.

Guide blade angle = 42.19° //

ii) Vane angle $\tan(180-\theta) = \frac{4.51}{7.055} = 32.59°$ //

$\underline{\underline{\theta = 147.41°}}$. / 5

⑫

(iii) $u_1 = \frac{\pi D_1 N}{60}$

$12.03 = \frac{\pi \times D \times 160}{60} \rightarrow D = 1.436m$

(iv) $Q = u_{f1}(\pi D B)$

$2.39 = 4.51 \times \pi \times 1.436 \times B$

$B = 11.747\,cm$ //

OK

Do calculation stepwise and clear

write about the steps which you do clearly

Do not write in this margin

Q.3 (a) (ii) What is an air vessel? Describe the function of the air vessel for reciprocating pumps.
[5 marks]

→ Air vessel is extra tank provided at both delivery and suction pipe.

→ These vessels acts as surge tank which provide water and store it as and when required.

functions -

→ Due to air vessels chances of cavitation reduces and pressure won't less than vapour pressure. ①

→ It helps to maintain constant discharge.

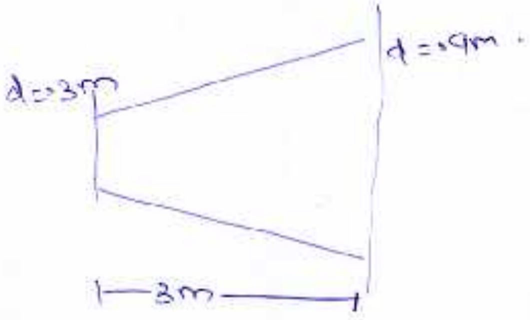
→ Because of it the speed of pump can also be increase without chances of negative slip.

Elaborate it more

Q.3 (b) **(i)** A 3.0 long conical diffuser 30 cm in diameter at the upstream end has 90 cm diameter at the downstream end. At a certain instant the discharge through the diffuser is observed to be 300 L/s of water and is found to increase uniformly at the rate of 60 L/s per second. Estimate the local, convective and total acceleration at a section 1.5 m from the upstream end.

[12 marks]

i)



$Q_t = 300 + 60t$

$(Q_t = .3 + .06t)\ m^3/s$.

$d_x = .3 + .2x$.

Local acceleration.

$a_t = \frac{\partial u}{\partial t}$ $\quad u = \frac{Q}{A_x} = \frac{Q_t}{\pi/4 (d_x)^2} =$

$u = \frac{.3 + .06t}{\pi/4 (d_x)^2}$

Now $a_x = \frac{\partial u}{\partial t} = \frac{.06}{\pi/4 (d_x)^2}$ $\quad$ At $x = 1.5m$ $d_x =$ ~~[illegible]~~ .6m.

$a_x = \frac{.06}{\pi/4 (.6)^2} = .2122 M^2/s$ //

Convective accel^n.

$a_x = u\frac{\partial u}{\partial x} + \cancel{v\frac{\partial u}{\partial y}}^{0} + \cancel{w\frac{\partial u}{\partial z}}^{0}$

$a_x = \frac{(.3 + .06t)}{\pi/4 (d_x)^2} \times \frac{.3 + .06t}{\pi/4} \frac{\partial}{\partial (.3 + .2x)^2}$

$a_x = \frac{(.3 + .06t)^2}{(\pi/4)^2 (d_x)^2} \times \frac{-.4}{(d_x)^3}$

$a_x = \frac{(.3)^2 \times .4}{(\pi/4)^2 \times (.6)^5} = -.75 M^3/s$ $\quad$ At $(t = 0 s)$

Total accl^n .

10

$$a = u\frac{\partial u}{\partial x} + \frac{\partial u}{\partial t}$$

$$a = .538 m^3/s$$

Q.3 (b) **(ii)** A proposed model of a river stretch of 20 km is to have a horizontal scale of $\frac{1}{250}$ and vertical scale of $\frac{1}{50}$. If the normal discharge, width and depth of the river are 150 m³/s, 100 m and 4 m respectively, estimate the corresponding model quantities. Also calculate the Manning's roughness '*n*' to be provided in the model to represent a prototype roughness value of 0.030.

[8 marks]

$(L_r)_H = \frac{1}{250}$ $L_v = \frac{1}{50}$ $Q_p = 150 m^3/s$ $B_p = 100m$ $D_p = 4m$.

$B_r = L_r \rightarrow \frac{B_m}{100} = \frac{1}{250} - B_m = \cdot 4m$.

$D_r = L_v = \frac{D_m}{4} = \frac{1}{50} - D_m = 0.08m$.

$Q = AV = (L_r)_H (L_r)_v \sqrt{(L_r)_v} = (L_r)_H (L_{rv})^{1.5}$

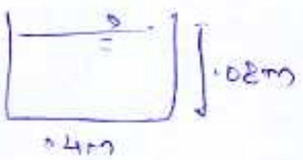
$\frac{Q_m}{150} = \frac{1}{250} \left(\frac{1}{50}\right)^{1.5}$

⑤

$Q_m = 1.697$ lit/s //.

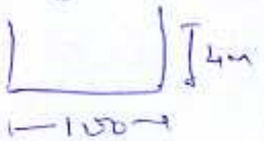
$Q = \frac{A}{n} (R)^{2/3} \sqrt{S_f}$

Model.



$R_m = \frac{\cdot 4 \times \cdot 08}{\cdot 4 + 2(0.08)} = \cdot 0571m$ $A_m = \cdot 032 m^2$

Prototype

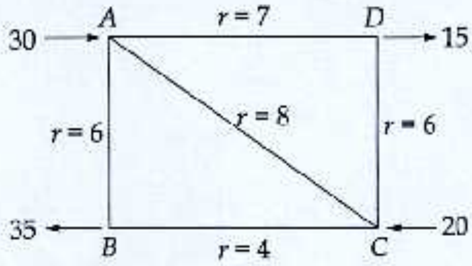


$R_p = \frac{100 \times 4}{100 + 8} = 3.7m$ $A_p = 400 m^2$

$n_r = \frac{A_r}{Q_r} (R_r)^{2/3} - \frac{n_m}{\cancel{n_p} \cdot 03} = \frac{\cdot 032}{400} \times \frac{150 \times 10^3}{1.697} \times \left(\frac{\cdot 0571}{3.7}\right)^{2/3}$

$n_m = 0.013$ //

Q.3 (c) For the network shown in figure, the head loss is given by $h_f = rQ^2$. The values of r for each pipe, and the discharge into or out of various nodes are shown in the sketch. The discharges are in arbitrary unit. Obtain the distribution of discharge in the network.

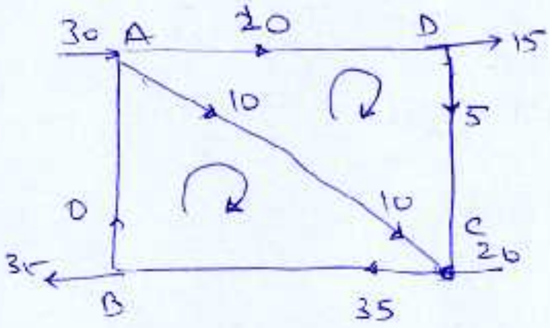


[20 marks]

$\Sigma \cancel{r}(Q+\Delta Q)^2 = 0 \quad - \Sigma rQ^2 + r\cancel{\Delta Q^2}^{0} + 2rQ\Delta Q = 0$

$$\Delta Q = -\frac{\Sigma rQ^2}{\Sigma |2rQ|}$$

Trial-1



Loop ACB.

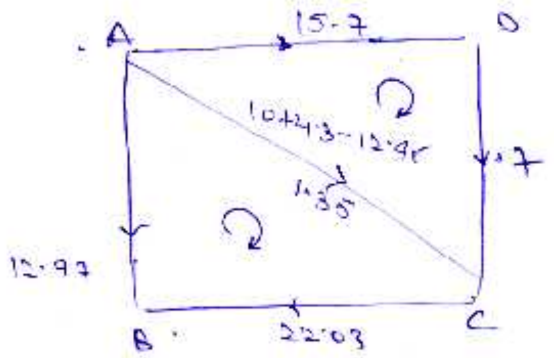
Pipe	r	Q^2	rQ^2	$\|2rQ\|$
AC	8	100	800	1600
CB	4	1225	4900	280
BA	6	0	0	
			5700	440

$\Delta Q = \frac{-5700}{440} = -12.95\ m^3/s$.

Loop ADC.

Pipe	r	Q	Q^2	rQ^2	$\|2rQ\|$
AD	7	20	400	2800	280
DC	6	5	25	150	60
CA	8	-10	-100	-800	160
				2150	500

$\Delta Q = -4.3\ m^3/s$.



Loop ACB

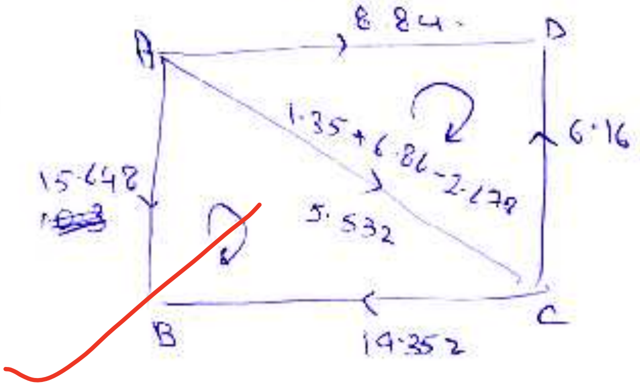
Pipe	r	Q	rQ^2	$\lvert 2rQ \rvert$
AC	8	1.35	14.58	21.6
CB	4	22.03	1941.2836	176.24
BA	6	-12.97	-1009.32	155.64
			946.54	353.48

$$\Delta Q = \frac{-rQ^2}{\Sigma\lvert 2rQ\rvert} = -2.678\,m^3/s$$

Loop ADC.

Pipe	r	Q	rQ^2	$\lvert 2rQ \rvert$
AD	7	15.7	1725.43	219.8
DC	6	.7	2.94	8.4
CA	8	-1.35	-14.58	21.6
			1713.79	249.8

$$\Delta Q = -6.86\,m^3/s$$



Loop ACB.

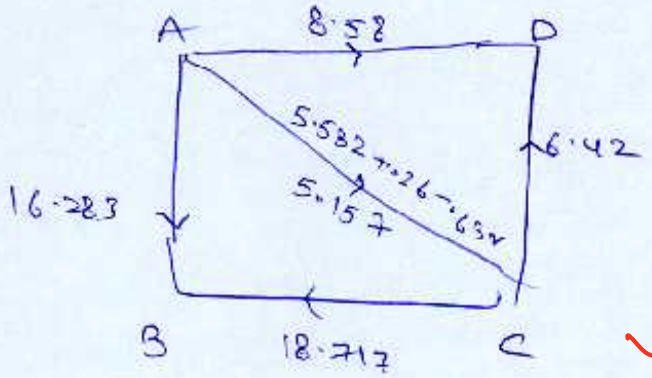
Pipe	r	Q	rQ^2	$\lvert 2rQ \rvert$
AC	8	5.532	244.83	88.51
CB	4	19.352	1498	154.816
BA	6	-15.648	-1469.16	187.77
			273.67	431.1

$\Delta Q = -.635 \, m^3/s$.

Loop ADC.

Pipe	r	Q	rQ^2	$\lvert 2rQ \rvert$
AD	7	8.84	547	123.76
DC	6	-6.16	-227.7	73.92
CA	8	-5.532	-244.82	88.512
			74.48	286.192

$\Delta Q = -.26 \, m^2/s$.



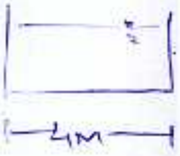
18

Q.4 (a) **(i)** A 4 m wide rectangular channel has a Manning's coefficient of 0.025. For a discharge of 6 m^3/sec, identify and draw the possible types of GVF profiles produced in the following break in grades:

1. $S_{01} = 0.0004$ to $S_{02} = 0.005$.
2. $S_{01} = 0.015$ to $S_{02} = 0.0045$.

[12 marks]

1)



$n = .025 \quad Q = 6m^3/s.$

$$Q = \frac{A}{n}(R)^{2/3}\sqrt{S_f}.$$

$$6 = \frac{4 \times y}{.025}\left(\frac{4 \times y}{4+2y}\right)^{2/3}\sqrt{.0004}.$$

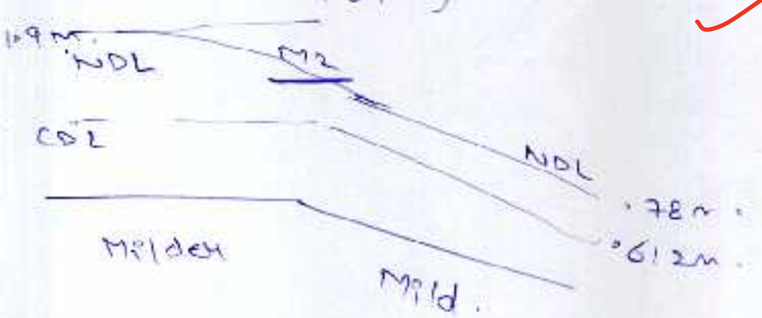
$$(4+2y)^{2/3}\, 7.5 = (4y)^{5/3} \qquad y_{n_1} = 1.9m.$$

for $S_{02} = .005$

$$6 = \frac{(4y)^{5/3}}{(4+2y)^{2/3}} \times \frac{\sqrt{.005}}{.025} \rightarrow 6 4+2y)^{2/3}(2.12) = (4y)^{5/3}$$

$$y_{n_2} = .78m.$$

$$y_c = \left(q^2/g\right)^{1/3} = \left(\frac{(6/4)^2}{9.81}\right)^{1/3} = .612m.$$



2) $\theta = \frac{A}{n}(R)^{2/3}\sqrt{S_{0_1}}$

⑨

$$6 = \frac{(4y)^{5/3}}{(4+2y)^{2/3}} \times \frac{\sqrt{\cdot 015}}{\cdot 025}$$

~~y~~ $(4+2y)^{2/3} \times 1.2247 = (4y)^{5/3}$

$y_{n_1} = 0.524m.$

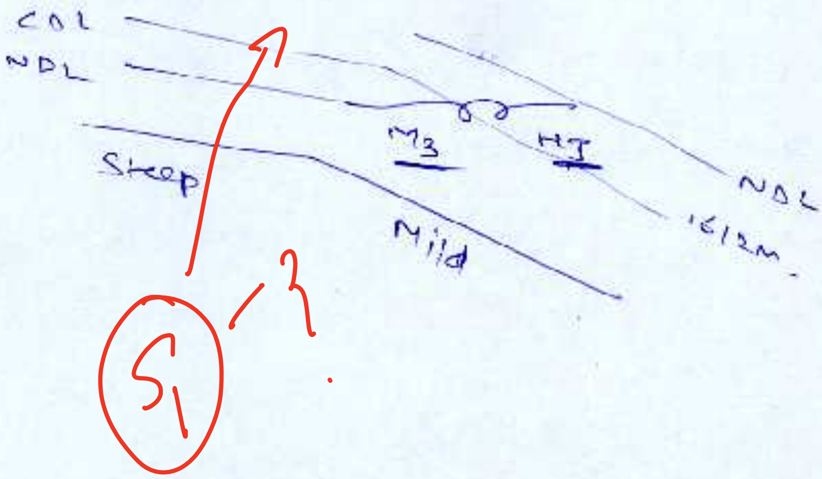
✓

for $S_{0_2} = \cdot 0045$

$$6 = \frac{(4y)^{5/3}}{(4+2y)^{2/3}} \times \frac{\sqrt{\cdot 0045}}{\cdot 025}$$

~~y_{n_2}~~ $(4+2y)^{2/3}\left(\boxed{2.236}\right) = (4y)^{5/3}$ ✓

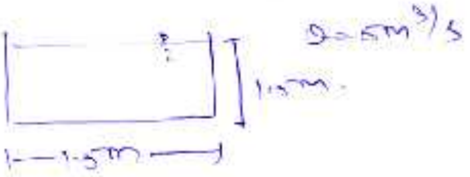
$y_{n_2} = \cdot 808m.$

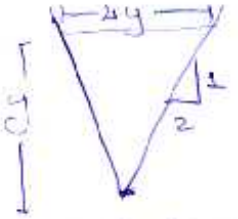


Q.4 (a) **(ii)** A 1.5 m wide rectangular channel carries a discharge of 5.0 m^3/s at a depth of 1.5 m. At a section the channel undergoes transition to a triangular section of side slopes 2 H : 1 V. If the flow in the triangular section is to be critical without changing the upstream water surface, find the location of the vertex of triangular section relative to the bed of rectangular channel. What is the drop/rise in the water surface at the transition? (Assume zero energy loss at the transition)

[8 marks]

(ii)





$A = \frac{1}{2} \times 4y \times y = 2y^2$

$Fr_1^2 = \frac{q^2}{gy^3} = \frac{(5/1.5)^2}{9.81 \times (1.5)^3}$

$Fr_1 = .58 < 1$

subcritical

$E_1 = y_1 + \frac{V_1^2}{2g}$

$\left\{ V_1 = \frac{5}{(1.5)^2} = 2.22 m/s \right\}$

$= 1.5 + \frac{(2.22)^2}{2 \times 9.81}$

$E_1 = 1.75m$

now flow in triangle to be critical

$E_2 = E_c = 1.75m.$

y_c $Fr_c^2 = \frac{Q^2 T}{gA^3} = 1 \rightarrow \frac{Q^2 (my2)}{g(my^2)^3} = 1$

$\frac{Q^2 \times 2m}{g m^3 y_c^5} = 1$ $\quad y_c = \left(\frac{2Q^2}{gm^2}\right)^{1/5}$

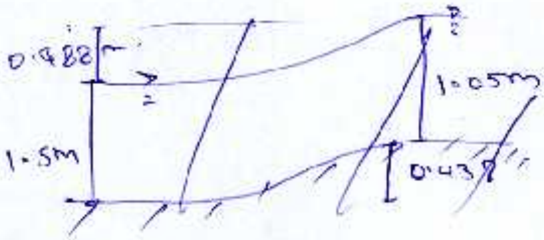
$E_c = \frac{5}{4} y_c$. $\quad y_c = \left(\frac{2 \times (5)^2}{9.81 \times (2)^2}\right)^{1/5} = 1.05m$

⑥

So $E_c = \frac{5}{4}\left(\frac{2\times(5)^2}{9.81\times(2)^2}\right)^{1/3} = 1.312m.$

$E_1 = E_c + \Delta z$

So $\Delta z = E_1 - E_c = 0.438m$.



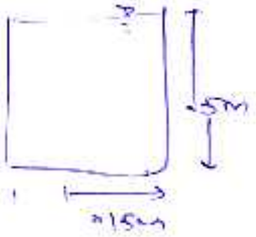
So ~~rise of 0.488m~~

So, Drop of .012m

Cal. mistake

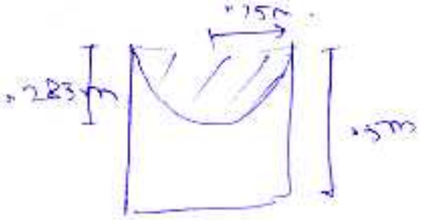
Q.4 (b) **(i)** An open cylinder 30 cm in diameter and 50 cm high is filled with water and rotated about its axis. Calculate the amount of water spilled when the speed of rotation is (*a*) 150 rpm and (*b*) 250 rpm.

[12 marks]



1) $N = 150$ rpm $\quad \omega = \frac{2\pi N}{60} = 15.7$ rad/s.

Now $z = \frac{\omega^2 r^2}{2g} = \frac{(15.7 \times .15)^2}{2 \times 9.81} = .283$m



V spilled = V initial − V final

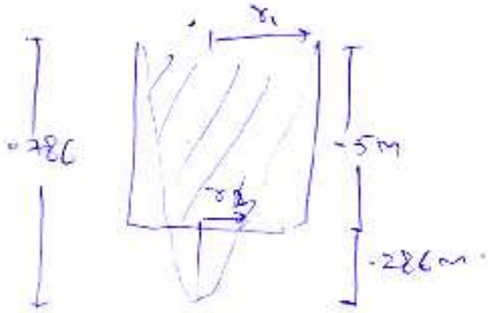
V spilled = V hatched portion

$V_{spilled} = \frac{\pi (0.15)^2 \times .283}{2} = .01\,m^3$ //

2) $N = 250$ rpm

$\omega = 26.18$ rad/s.

$z = \frac{\omega^2 r^2}{2g} = \frac{(26.18 \times .15)^2}{2 \times 9.21} = .786$m.



for r_2

$$z_2 = \frac{(\omega r_2)^2}{2g} \rightarrow .286 = \frac{(20.18 \times r_2)^2}{2 \times 9.81}$$

$r_2 = .09m.$

$$V_{parched} = \frac{\pi r_1^2 h_1}{2} - \frac{\pi r_2^2 h_2}{2}$$

$$= \frac{\pi (.15)^2 (.786)}{2} - \frac{\pi (.09)^2 \times .286}{2}$$

$V_{spilled} = .0241 m^3$

12

Q.4 (b) **(ii)** In a turbulent flow through a pipe of radius r_0, at what distance from the boundary would the local velocity

1. be equal to the mean velocity?
2. be equal to half the mean velocity if the shear velocity is 1/10 of the mean velocity?

[8 marks]

ii) $\frac{u-\bar{u}}{u_*} = 5.75 \log\left(\frac{y}{R}\right) + 3.75$

1) $u = \bar{u}$

$0 = 5.75 \log\left(\frac{y}{R}\right) + 3.75 \rightarrow -3.75 = 5.75 \log\left(\frac{y}{r_0}\right)$ ✓

$\underline{\underline{y = .223 r_0}}$

2) $u = \bar{u}/2$ $\quad u_* = \bar{u}/10$

$\frac{u-\bar{u}}{u_*} = \frac{\frac{1}{2} - 1}{1/16} = -5$ ✓

$-5 = 5.75 \log\left(\frac{y}{R}\right) + 3.75 \longrightarrow$

$\rightarrow -8.75 = 5.75 \log\left(y/r_0\right)$ ✓

⑧

$\underline{\underline{y = .03 r_0}}$

Q.4 (c) A centrifugal pump operates against a manometric head of 30 m with a manometric efficiency of 80%. The pressure rise through the impeller is 60% of the total head developed by the pump. The radial velocity of flow which is constant is 3.5 m/s. The outer diameter of the impeller is 450 mm and the width at outlet is 15 mm. The blades at inlet are curved backwards at 60° to the wheel tangent.

Calculate:

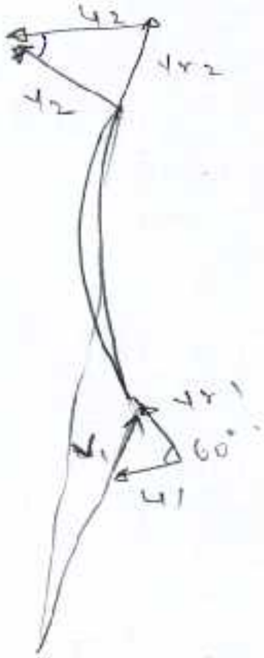
(i) the discharge in liters per minute.

(ii) speed of the pump.

(iii) blade angle at outlet.

(iv) diameter of impeller at inlet.

[20 marks]



$H_M = 30m$ $\eta_m = \cdot 8$

$\frac{P_o - P_i}{\rho g} = 18m.$

$V_f = 3.5 m/s.$

$D_o = \cdot 45M$ $B_o = \cdot 015m.$

i) $Q = V_{f_2}(\pi D_o B_o) = 3.5 \times \pi \times \cdot 45 \times \cdot 015 = 4453.2$ lit/min

ii) $\frac{I.P}{\dot{m}g} = 37.5m = \frac{V_{w_2} u_2}{g}.$ $\left\{ \because \eta_m = \frac{IP/\dot{m}g}{H_m} \right\}$

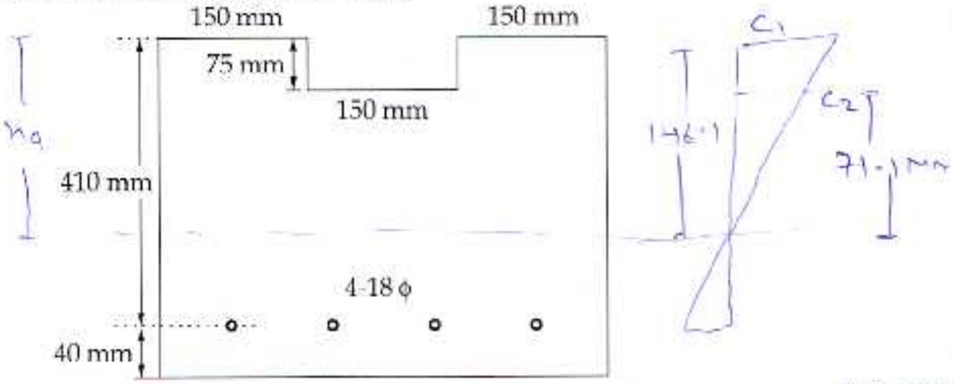
$\frac{P_i}{\rho g} + \frac{V_i^2}{2g} + \frac{I.P}{\dot{m}g} = \frac{P_o}{\rho g} + \frac{V_o^2}{2g}.$

$37.5 - 18 = \frac{-(3.5)^2 + V_o^2}{2g}$ $- V_2 = 17.87 m/s.$

Incomplete

Section B : Design of concrete and Masonry Structures-1 + Geo-technical & Foundation Engineering-2

Q.5 (a) The beam section shown in the figure is subjected to a bending moment of 50 kN-m. Determine the maximum compressive stress in concrete and the tensile stress in steel. (Take m = 13.33 and assume cracked section)



[12 marks]

$M = 50$ kN-m $\quad A_{st} = 1017.87\,\text{mm}^2$

Now, neutral axis,

$$B\frac{x_a^2}{2} - 75(150)(x_a - 37.5) = m A_{st}(d - x_a)$$

$$450\frac{x_a^2}{2} - 75\times150(x_a - 37.5) = 13.33\times1017.87(410 - x_a)$$

$$225x_a^2 + 2318.2x_a - 514189.9 = 0$$

$$x_a = 146.1\,\text{mm}$$

~~M = B E = My~~

$$M = Bx_a\left(\frac{C_1}{2}\right)\left(d - \frac{x_a}{3}\right) - 75\times150\times\left(\frac{C_1 + C_2}{2}\right)(d - \bar{C})$$

~~50×10^6 = 4~~

$$\frac{C_1}{146.1} = \frac{C_2}{71.1} \sim C_2 = .4867C_1$$

$$\bar{h} = \left(\frac{C_1 + 2C_2}{C_1 + C_2}\right)\left(\frac{75}{3}\right) = \left[\frac{1 + 2(.4867)}{1.4867}\right]\times\frac{75}{3} = 33.18\,\text{mm}$$

$$50\times10^6 = 450\times146.1\times\frac{C_1}{2}\left(410 - \frac{146.1}{3}\right) - 75\times150\times.7435C_1\times(376.82)$$

$$50 = 11.8768C_1 - 3.151C_1$$

$$C_1 = 5.73\,\text{MPa}//$$

from stress diagram.

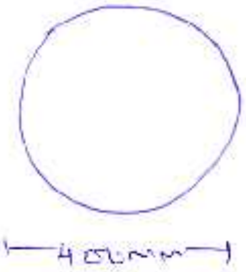
$$\frac{c_1}{146.1} = \frac{t}{m \times 267.9}$$

$$t = \frac{5.73 \times 13.33 \times 263.9}{146.1} = 137.96\ \text{MPa}$$ //

⑫

Q.5 (b) A circular column of 400 mm diameter is subjected to a factored load of 1500 kN. The column has an unsupported length of 3.2 m. The column is held in position but not restrained against rotation at both ends. Design the helical reinforcement. Use M25 grade concrete and Fe415 grade steel.

[12 marks]



$P_u = 1500\,kN$.

$L_0 = 3.2\,m$.

$L_{eff} = 3.2\,m$.

$e_{min} = \left(\frac{L_0}{500} + \frac{D}{30}\right)$ or $20\,mm = 19.73$ or $20\,mm = 20\,mm$

$e_{max} = .05\,D = 20\,mm$ — ok —

$\lambda = \frac{l_{eff}}{D} = \frac{3200}{400} = 8 < 12$ short column.

Now

$P_u = 1.05\,(.4 f_{ck} A_c + .67 f_y A_{sc})$

~~Assume Asc 2% Ag So, Asc =~~

$P_u = 1.05\,[.4 f_{ck} A_g + (.67 f_y - .4 f_{ck}) A_{sc}]$

$1500 \times 10^3 = 1.05\,(.4 \times 25 \times \frac{\pi}{4} \times (400)^2 + (.67 \times 415 - .4 \times 25) A_{sc}]$

$A_{sc} = 641.43\,mm^2$ //

Now $\frac{A_{sc}\,\%}{A} = \frac{641.43}{\pi/4\,(400)^2} \times 100 = .51\,\%$

As $A_{sc} < .8\,\%\,A_g$ ∴ Provide Min^m Reinf

$A_{sc} = \frac{.8}{100} \times \frac{\pi}{4} \times (400)^2 = 1006\,mm^2$ //

Provide - 5-16 ϕ //.

Pitch of ties.

Assume $\phi_h = 10mm$ clear cover = 40mm.

So, $D_g = 400mm$ $D_c = 320mm$ $D_h = 310mm$.

$$.36\frac{f_{ck}}{f_y}\left[\frac{A_g}{A_c} - 1\right] \geq \frac{V_h}{V_c}$$

$$V_h = \left(\frac{1000}{p}\right)\left(\frac{\pi}{4}\phi_h^2\right)(\pi D_h) = \frac{1000}{p} \times \frac{\pi}{4} \times (10)^2 \times \pi \times 310$$

$$V_h = \frac{76489434.11}{p}$$

$$V_c = 1000 \times \frac{\pi}{4} \times (D_c)^2 = 1000 \times \frac{\pi}{4} \times (320)^2 = 80424771.93$$

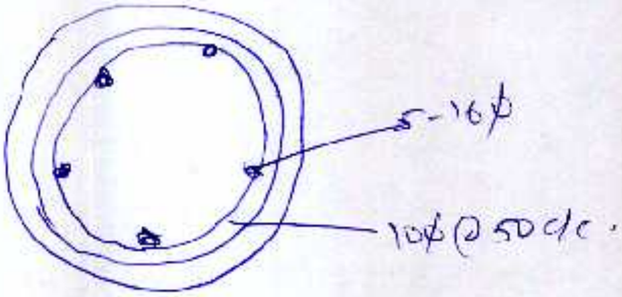
$$.36 \times \frac{25}{415}\left[\left(\frac{400}{320}\right)^2 - 1\right] \geq \frac{76489434.11}{p \times 80424771.93}$$

$$.012198 \geq \frac{.951}{p}$$

$$p \geq 77.96mm.$$

$$p = \begin{cases} < 75mm & > 3\phi_h = 30mm. \\ < D_c/6 = 53.33mm & > 25mm \end{cases}$$

So provide 10ϕ @ 50mm c/c.



⑩

Q.5 (c) Explain the following terms:

(i) Arching effect in sand.

(ii) Anchored bulkhead.

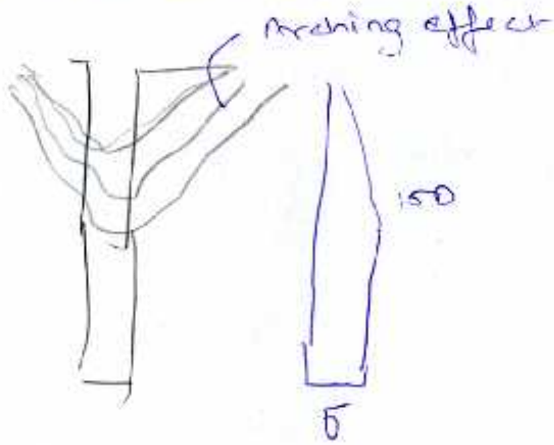
(iii) Coffer dams.

(iv) Geocells and Geogrids.

[3 + 3 + 3 + 3 marks]

i) When the pile is driven in the ground it produces vibrations. These vibrations will compact the soil surrounding to it as it goes deeper into the ground.

→ Now because of this upto a certain depth only the unit weight of soil is increased and after that it remains constant.



iv) Geocells are provided ~~in~~ mainly in road works because it stablise /confined the aggregates. which are poured in it.

Geogrids ~~a~~ have grid like shape which has high tensile strength due to which they are used to provide protection from soil erosion.

ii) Anchored bulkhead :

→ Anchored bulkhead are provided in retaining walls which provide extra horizontal force to stabilise the R.C wall.

→ Bcz of this the required depth of R.C wall decreases and it become economical.

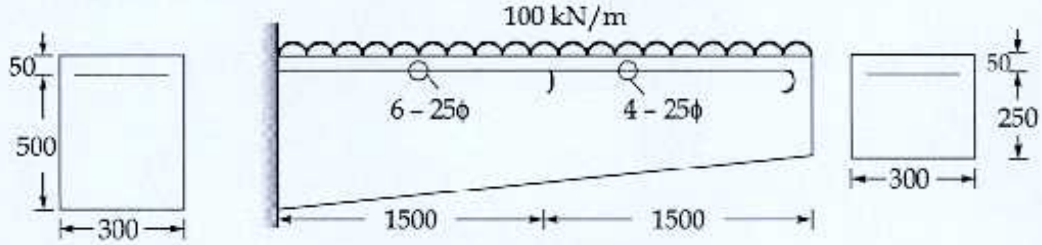
iii) Coffer dam :

→ Cofferdams are provided when well foundation are to be provided in flowing water.

→ The main purpose of cofferdam is to provide working space ~~to~~ for workers and deflect water from the working area.

5

Q.5 (d) Design shear reinforcement for a tapered cantilever beam of span 3 m, having a section of 250 mm effective depth and 300 mm width at the free end, and 500 mm effective depth and 300 mm width at the support as shown in figure. The beam has to support a factored uniform load of 100 kN/m, including its self weight. Assume an effective cover of 50 mm, Fe415 steel and M20 concrete. Use 2-legged 8 mm-ϕ stirrups.



(All dimension in mm)

Design shear stress of M20 concrete is given in table below:

$\%P_t = \frac{A_{st}}{bd} \times 100$	$\tau_c\left(\text{N/mm}^2\right)$
≤ 0.15	0.28
0.25	0.36
0.50	0.48
0.75	0.56
1.00	0.62
1.25	0.67
1.50	0.72
1.75	0.75
2.00	0.79

[12 marks]

$V_u = 100 \times 3 = 300$ kN.

$\tau_v = \frac{V_u}{bd} = \frac{300 \times 10^3}{500 \times 300} = 2$ N/mm^2

At support

$p_t\% = \frac{6 \times \pi/4 (25)^2 \times 100}{300 \times 500} = 1.963\%$ ✓

So $\tau_c = .75 + \frac{.04}{.25} \times .2135 = .784$ N/mm^2 ✓

force for which stirrups are designed.

$V_u = (\tau_v - \tau_c)bd = (2 - .784) \times 300 \times 500 = 182.370$ kN.

$V_u = .87 f_y A_{sv} \left(\frac{d}{S_v}\right)$

$182.376 \times 10^3 = .87 \times 415 \times 2 \times \frac{\pi}{4} (8)^2 \left(\frac{500}{S_v}\right)$

$S_v = 99.5 mm$.

$S_v = \begin{cases} .75d = 375 mm \\ 300 mm \\ 50 mm \end{cases}$

Min^m spacing :

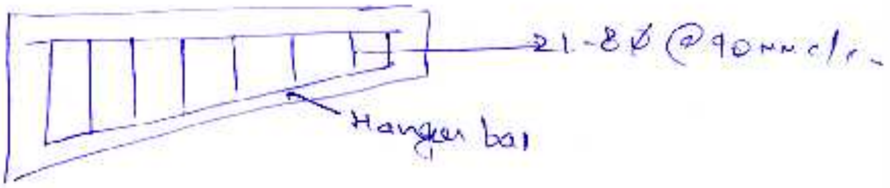
$.87 f_y A_{sv} = .4 b S_v$

$.87 \times 415 \times 2 \times \frac{\pi}{4} \times (8)^2 = .4 \times 300 \times S_v$

⑤

$S_{v\,min} = 302 mm$.

So provide 2L-8ϕ @90mm c/c.



Approach O.K

mistake in calculating

(Tv)

Q.5 (e) Determine the immediate settlement beneath the centre of (i) 5 m size square flexible footing (ii) 4.5 m size square rigid footing, resting at 1 m depth and applying a stress of 125 kN/m² in dry dense sand with an average E value of 30×10^3 kN/m² upto a depth of 10 m and an average value of 60×10^3 kN/m² for a depth between 10 m and 25 m. The soil is having a Poisson's ratio of 0.35.

(Consider Influence factor, I_f for $\frac{L}{B} = 1$ at centre as 1.12 for flexible footing)

[12 marks]

i) B = 5m It = 1.12 E = 30×10^3 kN/m² μ = .35.

$$St = \frac{qB(1-\mu^2)}{E} \times It$$

$$= \frac{125 \times 5(1-(.35)^2) \times 1.12}{30 \times 10^3}$$

$$= 20.475mm //$$

ii) B = 4.5m

$$St = \frac{125 \times 4.5 \times (1-(.35)^2)}{30 \times 10^3} = 16.45mm //$$

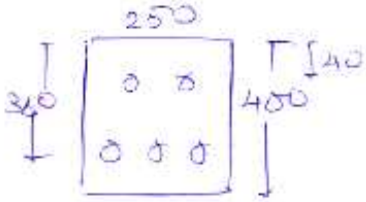
mistake in calculating E. value

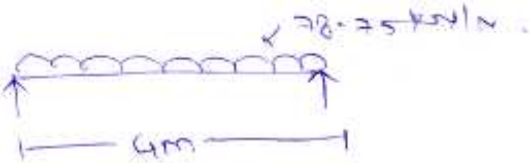
Q.6 (a) A rectangular RC beam is 25 cm wide and 40 cm deep (overall). The beam is simply supported over an effective span of 4 m. The superimposed load over the beam is 50 kN/m. Using M20 grade concrete and Fe415 grade steel, design the beam for flexure only. Consider an effective cover of 40 mm.

Stress-strain values for Fe415

Maximum Design stress	Total strain
$0.8 \times 0.87 f_y$	0.00144
$0.925 \times 0.87 f_y$	0.00217
$0.950 \times 0.87 f_y$	0.00241
$0.9625 \times 0.87 f_y$	0.00259
$0.975 \times 0.87 f_y$	0.00276
$0.9875 \times 0.87 f_y$	0.00328
$1.0 \times 0.87 f_y$	0.00380

[20 marks]





Load Calⁿ.

LL = 50 × 1 = 50

DL = 25 × .25 × .4 = 2.5

w = 52.5

Wu = 1.5w = 78.75 kN/m.

~~Ne~~ Now effective length.

l_{eff} = ~~[illegible]~~ 4m

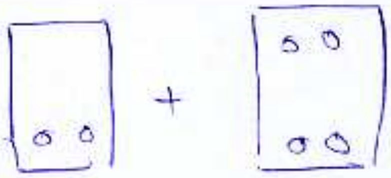
$M_u = \frac{w_u l_{eff}^2}{8} = \frac{78.75 \times (4)^2}{8} = 157.5$ kNm.

$M_{ulim} = .138 f_{ck} b d^2 = .138 \times 20 \times 250 \times (360)^2$

M_{ulim} = 89.424 kNm.

As $M_u < M_{ulim}$.

∴ Design Doubly Reinf. section.



$M_{ulim} = 89.424$ $M_u - M_{ulim} = 68.076\,kNm$.

$x_{ulim} = .48d = 172.8\,mm$.

$M_{ulim} = .87 f_y A_{st1} (d - .42 x_{ulim})$

$89.424 \times 10^6 = .87 \times 415 \times A_{st1} \times (360 - .42 \times 172.8)$

$A_{st1} = 861.71\,mm^2$

$M_u - M_{ulim} = .87 f_y A_{st2} (d - d')$

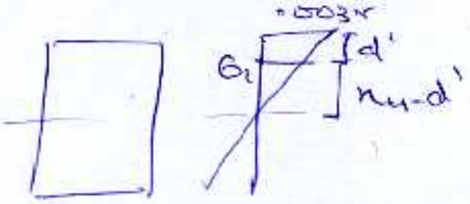
$68.076 \times 10^6 = .87 \times 415 \times A_{st2} (360 - 40)$

$A_{st2} = 589.22\,mm^2$

$(A_{st})_t = A_{st1} + A_{st2} = 1451\,mm^2$.

So Provide - 5-20φ bar.

Now Compression Steel.



$$\frac{.0035}{x_u} = \frac{\epsilon_c}{x_u - d'}$$

$$\frac{.0035 \times (172.8 - 40)}{172.8} = \epsilon_{sc}$$

$\epsilon_c = .00269$

From table.

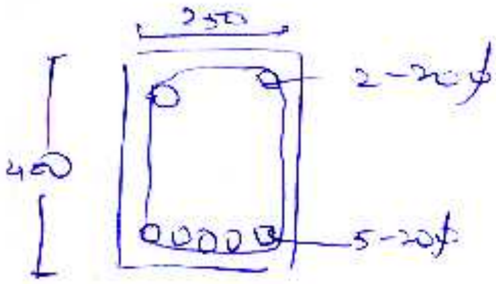
$$f_{sc} = 347.51 + \frac{4.513}{1.7 \times 10^{-4}} \times 1 \times 10^{-4} = 350.16\,N/mm^2$$

$M_u - M_{ulim} = (f_{sc} - .45 f_{ck}) A_{sc} (d - d')$

$68.076 \times 10^6 = (350.16 - .45 \times 20) \times A_{sc} \times (360 - 40)$

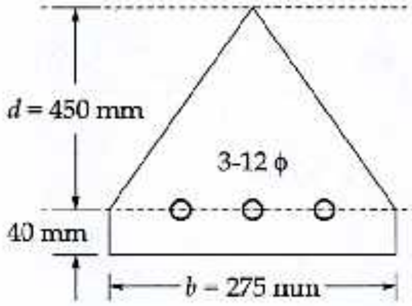
$A_{sc} = 623.57\,mm^2$

Provide - 2-20φ

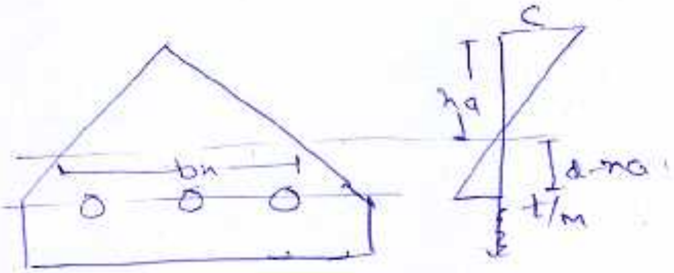


⑳

Q.6 (b) A triangular reinforced concrete beam section is as shown in the figure. Find the depth of neutral axis and the moment of resistance of the beam section. Safe stresses in concrete and steel are 7 N/mm² and 230 N/mm² respectively. (Take m = 13.33)



[20 marks]



$$\frac{c}{x_a} = \frac{t}{m(d-x_a)} \rightarrow \frac{7}{x_a} = \frac{230}{13.33(450-x_a)}$$

$450 - x_a = 2.465 x_a$

$x_a = 129.87$ mm. $A_{st} = 339.3$ mm²
bal.

for ~~N.A~~

~~Comp =~~ Tension.

$\cancel{\left(\frac{C_a}{2}\right)\left(\frac{1}{2} b_x h_x\right) = m}$

$\frac{b_x}{275} = \frac{d\, x_a}{450} - b_x = .611 x_a$

for N.A.

$\frac{1}{2} \times b_x \times x \times \frac{x}{3} = m A_{st} (d - x_a)$

$\frac{1}{2} \times .611 \frac{x_a^3}{3} = 13.33 \times 339.3 (450 - x_a)$

$2.251 \times 10^{-5} x_a^3 + x_a - 450 = 0$

$x_a = 217.7$ mm As $x_a > x_{bal}$
∴ ORS //.

9

Now MoR.

$$MoR = \left(\frac{f_{cr}}{2}\right)\left(\frac{1}{2} b_n x\right)\left(d - \frac{x_u}{3}\right)$$

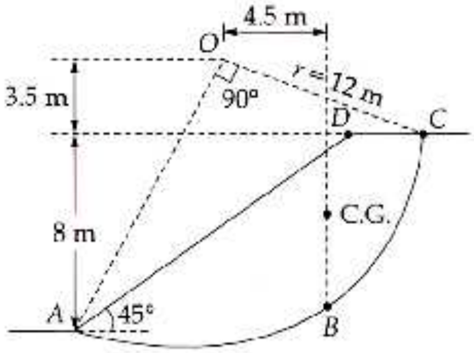
$$= \left(\frac{7}{2}\right)\left(\frac{1}{2}\times .611 \times (217.7)^2\right)\left(450 - \frac{217.7}{3}\right)$$

$$MoR = \underline{\underline{19.12 \text{ kNm}}}$$

Wrong approach

Q.6 (c) (i) A 45° slope has been excavated to a depth of 8 m in a saturated clay having cohesion of 60 kN/m^2, angle of internal friction as zero and unit weight of 20 kN/m^3. Area of the failure wedge (*ABCD*) is taken as 70 m^2. Determine (*a*) the factor of safety for the trial failure surface specified in the figure. (*b*) The minimum value of factor of safety for the given slope.

(Assuming that the depth factor is zero)



[14 marks]

(b) Min^n FOS = $\frac{M_R}{M_D}$ occur when sudden drawdown occurs.

$M_R = C_u \times L \times r = C_u r^2 \theta$ $(\because L = r\theta)$

$M_R = 60 \times (12)^2 \times 90 \times \frac{\pi}{180} = 13571.68$ kNm

$M_D = Wt \cdot \times d$

Wt = 20×70 = 1400 kN/m (γ_{sat} is used for min^m FOS)

$M_D = 1400 \times 4.5 = 6300$ kNm.

So FOS = $\frac{13571.68}{6300} = \underline{\underline{2.15}}$.

7

(a) FOS occur for saturated soil

Wt = 10.19 × 70 = 713.3 kN/m. $(\because \gamma' = 20 - 9.81 = 10.19)$

$M_D = 3209.85$ kNm

$M_R = 13571.68$ kNm.

FOS = ~~3200~~ $\frac{13571.68}{3209.85} = \underline{\underline{4.23}}$.

Q.6 (c) **(ii)** Briefly explain the assumptions of Rankine's earth pressure theory and Coulomb's earth pressure theory.

[6 marks]

Rankine's Earth Pressure theory:-

→ Failure surface is planer

→ Wall face is vertical and smooth.

→ Soil is cohesionless, dry and homogenous.

→ Elemental failure occur.

→ Backfill is horizontal.

3

Coulomb's theory:-

→ Wall face is vertical and rough.

→ Wedge failure occurs at the time of failure.

→ Rupture surface is planer.

→ Backfill is inclined with horizontal.

→ Resultant of earth pressure act at $H/3$ from base at inclination of 'i' From horizontal.

→ Soil is cohesionless and homogenous.

Q.7 (a) Design a wall of a rectangular water tank to resist a pull of 60 kN and a bending moment of 7.5 kN-m/m width. Use M30 concrete and Fe 415 grade steel.

Effective cover = 30 mm.

Permissible stress in direct tension in concrete = 1.5 MPa.

Permissible stress in bending tension in concrete = 2 MPa.

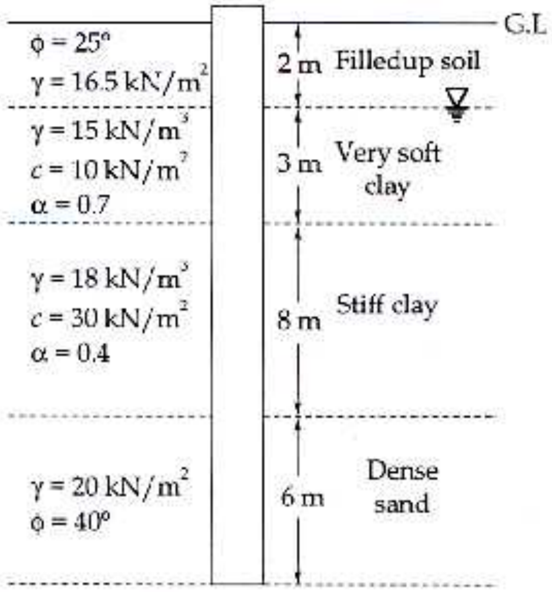
Permissible stress in bending compression in concrete = 10 MPa.

Modular ratio, $m = 9.33$.

Permissible stress in steel = 130 MPa.

[20 marks]

Q.7 (b) At a particular site, the soil profile consists of four different layers as shown in the figure below with respective soil properties. The water table is at 2 m below the ground level.



A pile of diameter 600 mm and length 19 m is bored through the soil. Calculate the safe load that can be carried by the pile with a factor of safety of 2.5.
(Take, $N_q = 140$ and $N_\gamma = 152$)

[20 marks]

Q.7 (c) A retaining wall of 8 m height has backfill soil in three different layers. Top 1 m and bottom 3 m clay layer has unconfined compressive strengths equal to 50 kN/m^2 and 75 kN/m^2 respectively. The void ratio of top and bottom-most clay is 0.7 and 0.5 respectively. Middle 4 m sand layer has a void ratio of 0.45 and when tested in tri-axial test the confining pressure comes out to be 300 kN/m^2 and deviator pressure comes out to be 350 kN/m^2.

Calculate the line of action of the total active earth pressure force from the bottom of wall, if water table exists at a depth of 3 m from the top of wall and a surcharge of 40 kN/m^2 is applied at the ground level.

(Take specific gravity of clay, G_{clay} = 2.7, Specific gravity of sand, G_{sand} = 2.68, Water content of clay above water table = 8%, Water content of sand above water table = 8%)

[20 marks]

Do not write in this margin

Q.8 (a) Design a waist slab type dog-legged staircase for a building given the following data:

Height between floors = 2.7 m

Riser = 150 mm

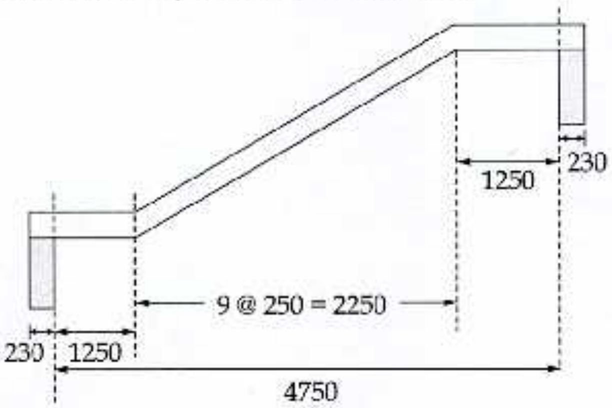
Tread = 250 mm

Width of flight and landing width = 1.25 m

Imposed load = 4.0 kN/m^2

Floor finishes = 0.6 kN/m^2

Assume that the stair is to be supported on 230 mm wide beam at the outer edges of the landing, parallel to the risers as shown in figure. Use M20 concrete and Fe415 grade steel. Assume any other data suitably.



(All dimension in 'mm')

[20 marks]

Q.8 (b) A square footing, placed at a depth of 1.4 m below the ground surface, carrying a safe load of 1050 kN. The soil beneath the footing is having void ratio of 0.64, specific gravity of 2.67, cohesion as 12 kN/m^2 and angle of internal friction of 30°. The soil upto 1.4 m depth is having void ratio of 0.55, degree of saturation 50% (above water table) specific gravity 2.79, cohesion as 10 kN/m^2 and angle of internal friction 32°. The bearing capacity factors for respective friction angles are given as :

ϕ	N_c	N_q	N_γ
30°	37.2	22.5	19.7
32°	44.14	28.5	27.5

Find the size of the footing if the desired factor of safety is 3. (Water table is present at 0.5 m depth from the ground level).

[20 marks]

Q.8 (c) **(i)** Discuss in brief about the various types of soil samplers.

(ii) Write a short note on pressuremeter test.

[12 + 8 marks]

OOOO

Space for Rough Work

Space for Rough Work

$= \cancel{(3+2x)}^{-2-1}$

$-2\times 2(3+2x)^{-3}$

~~$-4(3$~~

$\frac{-4}{(3+2x)^3}$ $\frac{-4}{(dx)^3}$

navneet@