CIVIL ENGINEERING
Paper – II

Time Allowed : **Three** Hours	Maximum Marks : **300**

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions divided in **TWO** sections.*

*Candidate has to attempt **FIVE** questions in all.*

*Questions No. **1** and **5** are **compulsory** and out of the remaining, **THREE** are to be attempted choosing at least **ONE** question from each section.*

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the question itself.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the Question-cum-Answer Booklet (QCA) must be clearly struck off.

*Answers must be written in **ENGLISH** only.*

SECTION A

**Q1.** **(a)** If the velocity components for two dimensional flow are given by

$$u = \frac{x}{x^2 + y^2} \quad \text{and} \quad v = \frac{y}{x^2 + y^2},$$

determine the acceleration components in X and Y direction and rotation in Z direction at two points in the flow field (i) 2, 3 and (ii) 4, 5. Coordinates are in metres.   *12*

(b) What are the different forces acting in a moving fluid ? Also discuss different similarity model laws used to study the dynamic similarity of a prototype.   *12*

(c) A stream has a width of 25 m, depth of 2·5 m and mean velocity of 1·5 m/sec. Find the height of weir to be constructed on the stream floor to raise the water level by 1 m. Assume value of discharge coefficient as 0·95.   *12*

(d) Define 'noise' and explain as to why and how it should be regarded as an environmental pollutant. Also explain briefly the major factors and actions that may help in noise abatement in a modern society.   *12*

(e) A wastewater treatment plant discharges 1·0 m³/sec of effluent having an ultimate BOD of 45·0 mg/L into a river flowing at 10·0 m³/sec. Just upstream from the discharge point, the river water has an ultimate BOD of 4·0 mg/L. The deoxygenation constant (k_d) is 0·22/day. Answer the following :

    (i) Assuming complete and instantaneous mixing, what would be the ultimate BOD of the mixture of waste and river just downstream from the outfall ?

    (ii) Assuming a constant cross-sectional area for the river equal to 60 m², what ultimate BOD would you expect to find at a point 10·0 km downstream ?   *12*

Q2. **(a)** A cylindrical gate of 3·0 m dia and having 4·0 m length is made of 60 mm thick steel sheet of 7·8 ton/m³ density. The gate has water on both its sides.

    (i) Water level is up to 2·0 m depth from bottom of gate on the left side and up to 1·5 m depth on the right side of the gate. Determine the magnitude, location and direction of the resultant hydrostatic force. Also determine whether the gate will float in this case or not.

    (ii) If the water level rises up to 3·0 m on the left of the gate (up to the top of the gate), determine whether the gate will float or not. If yes, what should be the thickness of the gate sheet to prevent it from floating ?   *20*

(b) A water softener has 0·05 m³ of ion exchange resin with an ion exchange capacity of 40 kg/m³. The water requirement of users is 1000 litres per day. If the water contains 230 mg/L of hardness as $CaCO_3$ and users want to soften it to 100 mg/L as $CaCO_3$, how much water should bypass the softener daily ? What is the time between regeneration cycles if it is assumed that the complete saturation of the resin occurs before regenerating ? *20*

(c) A homogeneous anisotropic embankment dam section is shown in the figure, the coefficient of permeability in the x and z directions being 5×10^{-8} m/s and 2×10^{-8} m/s respectively. Construct the flow net and determine the quantity of seepage through the dam. What is the pore water pressure at point 'P' ? *20*
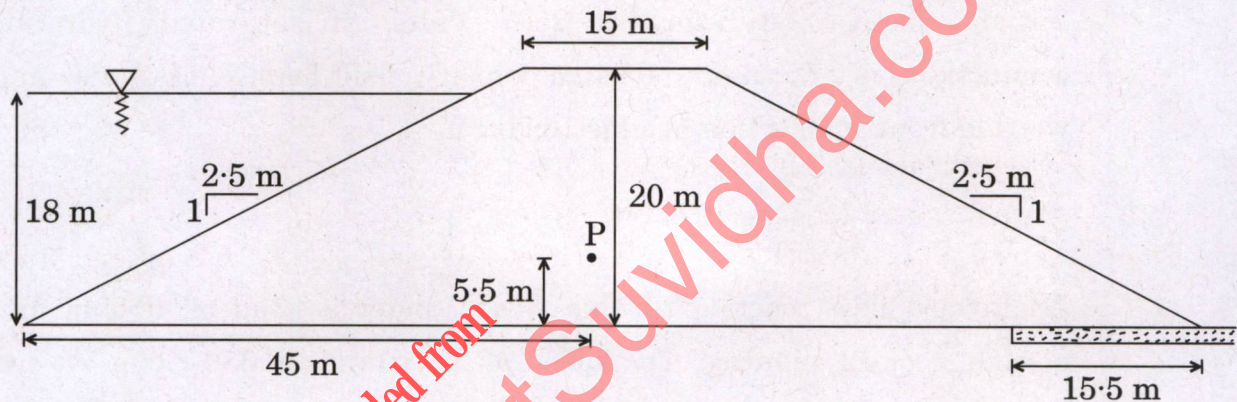
Q3. (a) Alignment of a water pipeline has been changed by 45° in horizontal plane using a reducing bend having 40 cm and 20 cm dia at the beginning and end of the bend respectively. A discharge of 400 lit/sec is flowing in the pipeline. The pressure in the pipeline at the starting end of the bend is 3000 bar. The frictional head loss due to the bend may be assumed as 5% of the kinetic energy at the exit of the bend. Determine the force exerted on the bend. Also determine the direction of resulting force. *20*

(b) Determine the size and depth of a high rate single stage trickling filter for treating the following domestic and industrial wastewater of a town of 50,000 population. Also determine the efficiency of filter and BOD_5 of the effluent. *20*

- Domestic sewage @ 150 litres per capita per day having 225 mg/L of BOD_5, and

- Industrial wastewater @ 2,00,000 litres per day having 650 mg/L of BOD_5.

Assume the following data :

- BOD$_5$ removal in primary clarifier = 35%
- Permissible organic loading of trickling filter = 900 g/day/m^3 (excluding recirculated sewage)
- Recirculation ratio = 1·0
- Permissible hydraulic loading = 20 m^3/day/m^2 (including recirculated sewage)

(c) Calculate the infiltration rate and cumulative infiltration after 1·50 hours of rainfall of 4·0 cm/hr intensity on a silt loam soil with an initial effective saturation of 25%. Value of saturated hydraulic conductivity is 0·65 cm/hr, effective porosity of silt loam soil is 0·486, and wetting front soil suction head is 16·70 cm.   *20*

Q4. (a) An inward flow reaction turbine works under a head of 40·0 m and discharge of 12 cu.m/sec. The speed of the runner is 350 r.p.m. At the inlet tip of runner vane, the peripheral velocity of wheel is 25·20 m/s and the radial velocity of flow is 8·40 m/s. If the overall efficiency and hydraulic efficiency of the turbine are 80% and 90% respectively, determine
(i) power developed by the turbine in kW, (ii) diameter and width of runner at inlet, (iii) guide blade angle at inlet, (iv) inlet angle at runner vane, and (v) diameter of runner at outlet.

Assume flow is radial at outlet. Also assume no blade friction and radial velocities at inlet and outlet are equal.   *20*

(b) (i) The depth of flow of water at a certain section of a rectangular channel 3 m wide is 0·45 m. The discharge through the channel is 3·1 m^3/s. Determine whether a hydraulic jump will occur, and if so, determine its height and loss of energy per kg of water.   *10*

(ii) The inflow hydrograph to a river reach is given in the table below. Determine the outflow hydrograph from this reach if coefficient $K = 2.4$ h, $X = 0.15$. Initial outflow in the reach is 85 m^3/s. Routing time step $\Delta t = 1$ h. *10*

S.No.	Routing Period (hr)	Inflow (m^3/s)
1	1	93
2	2	137
3	3	208
4	4	320
5	5	442
6	6	546
7	7	630
8	8	678
9	9	691
10	10	675
11	11	634
12	12	571
13	13	477
14	14	390
15	15	329
16	16	247
17	17	184
18	18	134
19	19	108
20	20	90

(c) (i) A city has its catchment area of 7500 hectares. If the population density of the city is 200 persons per hectare and the water is supplied at the rate of 175 litres per capita per day, what would be the design flow for a combined sewer ? Take intensity of rainfall equal to 30 mm/hour, average runoff coefficient equal to 0·50 and only 75% of water supplied contributes to the sewage. Also, peak discharge factor should be taken as 3·0. *10*

(ii) What do you understand by aerobic digestion ? What are its advantages and disadvantages ? *10*

SECTION B

Q5. (a) A concrete pile 450 mm in diameter and 20 m long is driven through a system of layered cohesive soil. The top layer is 8 m thick and comprises of soft clay with cohesion of 30 kN/m² and adhesion factor of 0·90. The middle layer which is medium stiff clay has a thickness of 6 m and undrained cohesion of 50 kN/m² with adhesion factor of 0·75. The bottom-most layer which is stiff strata extends to a great depth with undrained cohesion of 105 kN/m² and adhesion of 0·50. Compute the ultimate and allowable capacity of pile if the factor of safety assumed is 3·0. The water table is observed to be at ground level. *12*

(b) With a neat labelled sketch of stress conditions and failure envelope in a triaxial compression test, derive the relation between major and minor principal stress in terms of cohesion and angle of internal friction. *12*

$$\sigma_1 = \sigma_3\, N_\phi + 2c\sqrt{N_\phi}$$

σ_1 : Major principal stress

σ_3 : Minor principal stress

c : Cohesion

ϕ : Angle of internal friction

(c) Write a note on ten requirements of track drainage system for a typical B.G. railway line. *12*

(d) Clearly state the nine goals and objectives of National Transport Plan of India. *12*

(e) A star of declination 42°30'30" S is to be observed at lower and upper transit at a place of latitude 75°30'30" S. Draw a neat labelled figure depicting declination, latitude, altitude in upper transit, altitude in lower transit and find the approximate apparent altitude at which the star should be sought. *12*

Q6. (a) A square footing 2 m wide is resting on soft saturated clay. The depth of foundation is 1·5 m from existing ground level. The thickness of clay layer is 4·0 m and is underlain by a firm sand stratum. The properties of clay are as under : Liquid limit 30%, natural moisture content 40%, specific gravity 2·7, angle of internal friction zero and undrained cohesion 0·5 kg/cm². The clay stratum is normally consolidated. Determine the net safe bearing capacity using the Vesic equation. Compute the settlement that would result if the load intensity were allowed to act on the footing. Natural water table is at ground level. Assume load spread 2 : 1.   20

(b) List the five traffic surveys and elaborate all of them.   20

(c) (i) With a neat labelled sketch, derive the relation between superelevation (e), for a broad gauge railway with a speed 'V' (km/h) and radius of curvature (R).   10

(ii) If the wheel base of a vehicle moving on B.G. track is 6 m, the diameter of wheel is 1·50 m and the depth of flanges below the top of rail is 3·20 cm, determine the extra width required to be provided on gauge if the radius of the curve is 150 m.   10

Q7. (a) Soft saturated clay has a thickness of 6 m. After one year, when the clay consolidated by 50%, the observed settlement was to the tune of 10 cm. For an identical clay and loading condition, what will be the magnitude of settlement at the end of one year and five years if the thickness of the clay layer was 25 m ?   20

(b) (i) How do the methods of tunnel construction in hard rock differ from the methods of tunnel construction in soft ground ? State the various operations involved in hard rock tunnelling and soft ground tunnelling.   10

(ii) List the ten typical features of a harbour. Elaborate any three at length.   10

(c) Write a detailed note on ideal and real remote-sensing system by highlighting their six components as well as their six shortcomings.   20

Q8. (a) Two sets of tacheometric readings were taken from an instrument station A (R.L. = 100·50 m) to a staff station B as given below :

Instrument	P	Q
Multiplying constant	95	90
Additive constant	0·25	0·35
Height of instrument	1·35 m	1·40 m
Staff held	Vertical	Normal

Instrument	Instrument station	Staff station	Vertical angle	Stadia readings (m)		
P	A	B	8°12′	0·905	1·305	1·555
Q	A	B	8°12′	?	?	?

Determine :

(i) The distance between instrument station and staff station.

(ii) The reduced level of staff station B.

(iii) The stadia readings with instrument Q. *20*

(b) (i) The mass specific gravity of a fully saturated specimen of clay having a water content of 29% is 2·00. On oven drying, the mass specific gravity drops to 1·60. Calculate the specific gravity of clay assuming the void ratio to remain unchanged. *10*

(ii) A footing 2 m × 2 m in plan, transmits a pressure of 100 kN/m² on a cohesive soil layer having $E = 6 \times 10^4$ kN/m² and $\mu = 0.50$. Determine the immediate settlement of the footing at the centre, assuming it to be (I) a flexible footing, and (II) a rigid footing. *10*

Influence Factor I_f for Vertical Displacement

Shape	I_f Flexible Foundation			I_f Rigid Foundation
	Centre	Corner	Average	
Circular	1·00	0·64	0·85	0·86
Square	1·12	0·56	0·95	0·82
Rectangular				
L/B = 1·5	1·36	0·68	1·20	1·06
L/B = 2	1·52	0·76	1·30	1·20
L/B = 5	2·10	1·05	1·83	1·70
L/B = 10	2·52	1·26	2·25	2·10
L/B = 100	3·38	1·69	2·96	3·40

(c) Design a summit curve for a National Highway for a stopping sight distance of 200 m at the junction of a rising gradient of 1 in 60 and a falling gradient of 1 in 60. Set out the curve with a chord 25 m long. Determine the R.L. of the point immediately below the intersection point of the grade line and also the R.L. of the highest point on the curve. Assume sight distance is less than the length of vertical curve, R.L. at the start of the curve as 10·0, h_1 and h_2 as per current Indian practice IRC 66-1976.

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