Sl. No. 22350 A–DMHH–N–DFB

CIVIL ENGINEERING

Paper—II

(Conventional)

Time Allowed : Three Hours	Maximum Marks : 200

INSTRUCTIONS

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

Candidates should attempt FIVE questions in all.

Question No. 1 is compulsory.

Out of the remaining SIX questions, attempt any FOUR questions.

All questions carry equal marks. The number of marks carried by a part of a question is indicated against it.

Answers must be written in ENGLISH only.

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

Assume suitable data, if necessary, and indicate the same clearly.

Neat sketches may be drawn, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer-book.

Attempts of questions shall be counted in chronological 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 answer-book must be clearly struck off.

1. Answer *all* of the following :

(a) Prove that the scale ratio for discharge for a distorted model is given as

$$Q_p / Q_m = (L_r)_H \times [(L_r)_V]^{3/2}$$

where

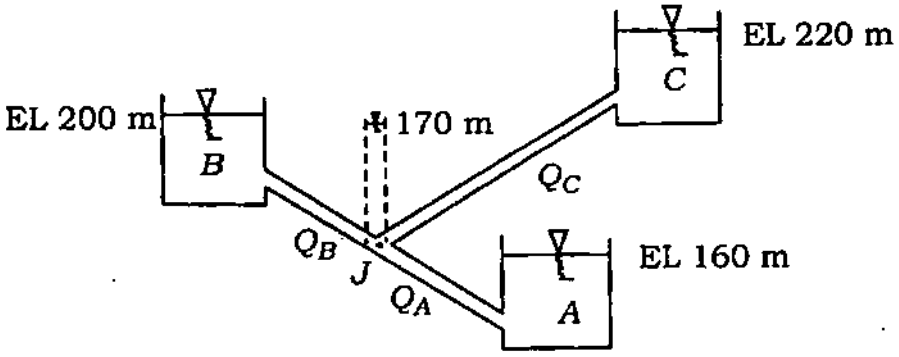
Q_p = discharge through prototype

Q_m = discharge through model

$(L_r)_H$ = horizontal scale ratio

$(L_r)_V$ = vertical scale ratio 4

(b) Three reservoirs *A*, *B*, *C* are inter-connected by pipes as shown in the figure



The water surface elevations in the reservoirs and the piezometric head at junction *J* are indicated in the figure. Write the mass balance equation at junction *J* and justify the answer. 4

(c) Determine the area required for a new landfill site with a projected life of 20 years for a population of 150000 generating 25 kg per household per

week. Assume that the density of waste is 500 kg / m^3. A planning restriction limits the height of the landfill to 10 m. 8

(d) A rectangular plate of 0·50 m × 0·50 m dimensions weighing 500 N slides down an inclined plane making 30° angle with the horizontal, at a velocity of 1·75 m/s. If the 2 mm gap between the plate and the inclined surface is filled with a lubricating oil, find its viscosity and express it in poise as well as in N s / m^2. 4

(e) The isohyets due to a storm in a catchment were drawn and the areas of the catchment bounded by the isohyets were tabulated as below :

Isohyets (cm)	*Areas* (km^2)
Station–12·0	30
12·0–10·0	140
10·0–8·0	80
8·0–6·0	180
6·0–4·0	20

Determine the uniform flow depth over the catchment. 4

(f) A soil deposit has a void ratio of 0·9. Its void ratio is reduced to 0·6 by compaction. Determine the percent reduction of volume by this compaction. 4

(g) When an unconfined compression test was conducted on a cylindrical soil sample, it failed under an axial stress of $120\ kN/m^2$. The failure plane makes an angle of 50° with the horizontal. Determine the cohesion and the angle of internal friction of the soil. 4

(h) An exit taxiway is to be designed for Boeing 707 with turnoff speed of 65 km/hr. Calculate the turning radius of the exit taxiway using the following data : 8

Coefficient of lateral friction = 0·13

Wheel base = 18·0 m

Tread of main landing gear = 7·0 m

Width of taxiway = 22·5 m

2. (a) Two pipelines have been connected to a large water reservoir. One of the pipes is 15 cm × 300 m length with an outlet 4 m below the reservoir water level, while the other pipe is 20 cm × 600 m length. Both the pipes have free discharge at outlet end and the total discharge rate is 50 L/s. Calculate the difference of elevation between the reservoir water level and the outlet of 20 cm pipe. Neglect entrance losses, and for all pipes $f = 0{\cdot}08$ in Darcy's formula

$$h_f = \frac{flv^2}{2gd}$$

8

(b) An open cylindrical tank, 0·50 m in diameter and 1·0 m in height, is completely filled with water and rotated about its axis at 240 r.p.m. Find the radius up to which bottom will be exposed and the volume of water spilled out of the tank. 8

(c) While aligning a highway in a built-up area, it was necessary to provide a horizontal circular curve of radius 300 metres. Design the following geometric features : 8

(i) Superelevation

(ii) Extra widening of pavements

(iii) Length of transition curve

(d) A layer of sand 8·0 m thick lies above a layer of clay. The water table is at a depth of 1·0 m below the ground surface. The saturated unit weight of the sand is 20·0 kN/m^3 and its dry unit weight is 17·0 kN/m^3. Plot the total stress, neutral stress and effective stress diagram with depth up to 8·0 m. If the sand above the water table gets saturated due to capillary moisture, what will be the changes in stress diagram? 8

(e) A square filter box is to be designed for a filtration rate of 2·8 L / m^2 s. What are the required surface area and side dimension of the unit if the flow rate is 6 ML/d? If the filter is backwashed once a day for 12 minutes at a rate of 10 L / m^2 s, what percentage of the total flow rate is used for cleaning the filter? 8

3. (a) (i) A storm with a 15·0 cm precipitation produced a direct runoff 8·7 cm. The time distribution of the storm is as follows :

Time from start (in hour)	1	2	3	4	5	6	7	8
Incremental rainfall in each hour (in cm)	0·6	1·35	2·25	3·45	2·7	2·4	1·5	0·75

Estimate the ϕ index of the storm. 6

(ii) What is the difference in ϕ index and w index? 2

(b) The intensity of irrigation is 20% for wheat and 10% for rice, where cultural commanded area of a distributary is 6000 ha. The Kor period for wheat is 3 weeks and for rice 2 weeks. Find the total outlet discharge required excluding losses in the channel. Assume depth for Kor watering as 9 cm and 25 cm for wheat and rice respectively. 8

(c) A water treatment plant is designed to treat a flow of 20000 m^3/day. The chlorine dosage is 1 mg/L. What size of containers should be used in this plant? What is the minimum weight of chlorine which should be kept in hand? 8

(d) A wall footing carrying a load of 152 kN/metre length of wall is to be constructed at a depth of 1·2 m. Subsoil consists of a uniform deposit stiff clay with unit weight, $\gamma = 18{\cdot}8\ kN/m^3$ and unconfined compressive strength, $q_u = 150\ kN/m^2$. Determine the width of the footing using a factor of safety of 3. 8

(e) Determine the equilibrium speed and cant to be provided on a BG curve of 3 degree if the speeds of several trains running on the line are as follows : 8

15 trains at a speed of 50 km/hr
12 trains at a speed of 60 km/hr
8 trains at a speed of 70 km/hr
3 trains at a speed of 80 km/hr

4. (a) A 300 mm diameter pipe of mild steel having 6 mm thickness carries water at the rate of 200 litres/s. What will be the rise in pressure if the valve at the downstream end is closed instantaneously? Compare the results assuming the pipe to be rigid as well as elastic. What should be the maximum closing

time for the computed results to be valid? Take pipe length as 8·0 km. The ratio of modulus of elasticity and bulk modulus of water may be taken as 100. Assume any other data only if required and state the same clearly. 8

(b) If $\phi = \frac{-A}{2\pi} \log r$, where A is a positive constant, determine ψ and plot the typical equipotential lines and stream-lines. Identify the flow pattern. 8

(c) Define BOD. Explain how BOD is determined for wastewater. For a BOD test carried out in the laboratory, 5 mL of wastewater having no initial DO was taken in a 300 mL BOD bottle and mixed with dilution water of 9·2 mg/L DO concentration. After incubating the bottle for 5 days at 20 °C, the DO of the mixture was found to be 5·0 mg/L. Compute the BOD_5 (at 20 °C) of wastewater. 8

(d) A square pile group consists of nine friction piles driven in cohesive soil. The diameter of each pile is 0·3 m and centre-to-centre spacing is 1·2 m. The ultimate capacity of each pile is 300 kN. Estimate the design capacity of the pile group. 8

(e) *ABCD* is a traverse. The included angles are measured as angle $A = 110°$, angle $B = 54°$, angle $C = 125°$, angle $D = 71°$. Calculate the bearings of the traverse lines with *A* as origin and *AB* line as an arbitrary meridian. 8

5. (a) In a laboratory experiment, an orifice of diameter 15 mm is installed in a 25 mm diameter pipe and two pressure tappings, one before and one after the orifice, are connected to a vertical mercury manometer. The discharge is obtained by measuring the rise of water level in a 30 cm × 30 cm square tank collecting the outflow from the pipe. For a particular experiment, the difference in manometer readings was 130 mm of Hg and the rise of water level was 120 mm in 15 seconds. Estimate the coefficient of discharge. 8

(b) A hydraulic jump takes place in a horizontal, frictionless triangular channel with a bottom angle of 90°. Find the discharge if the pre-jump and post-jump depths are 5 cm and 15 cm respectively. 8

(c) A family of four people generates solid waste at the rate of 0·45 kg/cap/day and the bulk density of refuse in a typical garbage can is about 120 kg/m^3. If collection is once a week, how many 120 litres garbage cans will be needed for the household? 8

(d) (i) Determine the axial stress at failure for a dry dense sand in triaxial loading if $\sigma_3 = 300\ kN/m^2$. A previous test had given

$\sigma_3 = 150\ kN/m^2$; $\sigma_1 = 735\ kN/m^2$

at failure. 4

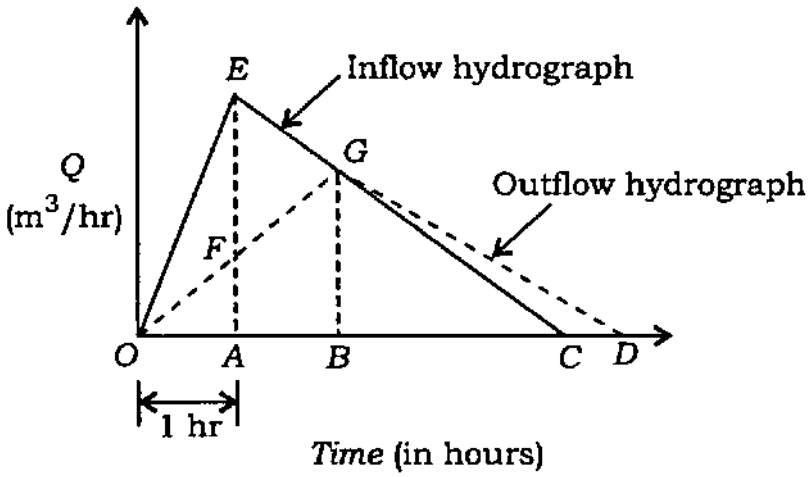
(ii) To estimate the seepage loss through a cofferdam foundation, the flow nets were constructed. The results of the flow net study gave $N_f = 7$, $N_d = 17$. The head of the water lost during seepage was 6 m. If $k = 5 \times 10^{-5}$ m / minute, compute the seepage loss per metre length of dam per day. 4

(e) During a compass traverse surveying of a closed traverse *PQRS*, the following readings were obtained :

Line	*Length* (m)	*Whole circle bearing*
PQ	Could not be measured	89°
QR	98·0	178°
RS	202·0	Roughly west local attraction
SP	86·4	1°

Determine the exact bearing of *RS* and length of *PQ*. 8

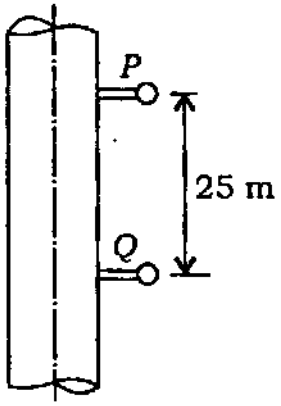
6. *(a)* Inflow and outflow hydrographs of a channel reach are triangular in shape and are plotted simultaneously as shown in the figure. The peak of inflow hydrograph is 10000 m^3/hr and occurs after one hour from the starting. The base is 96 hours. Similarly the peak of the outflow hydrograph is 8000 m^3/hr and falls on recession of inflow hydrograph.



Determine the channel storage after one hour (i.e., under the peak of inflow hydrograph) and the maximum storage and the time at which it occurs along with the principle on which these are computed. 8

(b) *(i)* A 30 mm diameter vertical pipe conveys oil of dynamic viscosity of 1 poise and mass density of 0·85 gm/cc. The pressures measured at two points *P* and *Q*

located 25 m apart are 1882 cm and 4706 cm. If the flow is laminar, determine the direction of the flow and the discharge. 4



(ii) Obtain the diameter of the pipe outlet of a non-modular outlet : 4

Discharge through the outlet
$= 0{\cdot}02\ m^3\ s^{-1}$

Length of the outlet = 15 m

FSL of the distributary
= 200·00 m

Available working head = 5 cm

Coefficient of discharge = 0·51

(c) Given the following data :

Plant inflow = 9000 m^3/day

Recycle flow = 6000 m^3/day

Mixed liquid suspended solids
(MLSS) = 4000 mg/L

Sludge volume withdrawn
$= 580\ m^3$/day

Suspended solids = 3800 kg day

Solid loading rate of
150 kg/m^2-day at average flow

Obtain the final settling tank size for an extended aeration plant. 8

(d) For a general c-ϕ soil, the cohesion c is 50 kPa. The total unit weight is $20\ kN/m^3$ and the bearing capacity factors are $N_c = 8$, $N_q = 3$, $N_\gamma = 2$. Using Terzaghi's formula, calculate the net ultimate bearing capacity for a strip footing of width 2 m at a depth of 1 m. Considering shear failure only, estimate the safe total load on a 10 m long, 2 m wide strip footing using a factor of safety of 3. 8

(e) On a two-lane two-way highway, a car *A* was following a truck *B* and both were travelling at a speed of 40 kmph. While looking for an opportunity to overtake the truck, the driver of car *A* saw another car *C* coming from the opposite direction. At that moment, the distance between *A* and *C* was 450 m. After an initial hesitation period of 2 seconds, the driver of car *A* started the overtaking operation. The distance between *A* and *B* at that instant was 30 m. *A* overtook *B* by accelerating at a uniform rate of $1{\cdot}20\ m\,s^{-2}$. When the overtaking operation was completed, there was a distance of 25 m between *B* and *A*. Determine the distance between different vehicles given as measured from the front bumper of the one vehicle to the front bumper of the another vehicle. Design speed of the highway is 80 kmph. 8

7. *(a)* What is the difference between form drag and friction drag? For a flat plate kept perpendicular to the flow direction in a uniform flow field, the coefficient of pressure is constant at – 1·2 on the back face and varies parabolically on the front face from a value of 1·0 at the centre to – 1·2 at both edges. Find the drag coefficient. 8

(b) The pressure drop per unit length, $\Delta p / L$, in a pipe depends on the diameter D, velocity V, roughness height ε, density ρ and viscosity μ. The Moody's friction factor chart uses the non-dimensional parameters f, Re and ε / D, and is convenient in finding out the pressure drop in a pipe when the other parameters are known. However, it cannot be directly used to find the velocity for a given pressure drop. Obtain the set of non-dimensional parameters whose plot will directly provide the velocity if other parameters are known. 8

(c) A wastewater plant produces 1000 kg of dry solids/day at a moisture content of 95%. The solids are 65% volatile with a specific gravity of 1·05 and the specific gravity of the non-volatile portion is 2·5. Determine the sludge volume—

(i) as produced;

(ii) after digestion reduces the volatile solids by 50% and decreases moisture content by 90%;

(iii) after dewatering to 75% moisture;

(iv) after drying to 10% moisture;

(v) after incineration (only non-volatile solids remain). 8

(d) Water is flowing at the rate of 0·05 m s^{-1} in the upward direction through a fine sand sample whose $k = 2 \times 10^{-3}$ cm s^{-1}. The sample thickness is 12 cm and the area of cross-section is 50 cm^2. Determine the effective pressure at the middle and bottom sections of the sample if the saturated unit weight of the sand is 19·4 kN / m^3. 8

(e) Traffic noise data are given in the table below. Compute L_{eq}. 8

Time (in s)	10	20	30	40	50	60	70	80	90	100
Noise (dBA) *L(t)*	71	75	70	78	80	84	76	74	75	74

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