ESE (Mains), 2019

CIVIL ENGINEERING Paper-II

SECTION 'A'

1. (a) The velocity vector in an incompressible flow is given by

$V = (6xt + yz^2)i + (3t + xy^2)\,j + (xy - 2xyz - 6tz)k$

(i) Verify whether the continuity equation is satisfied.

(ii) Determine the acceleration in x direction at point A (1, 1, 1) and t = 1.0. 12

(b) Three tube wells of 25 cm diameter each are located at the three vertices of an equilateral triangle of side 100 m. Each tube well penetrates fully in a confined aquifer of thickness 25 m. Assume the radius of influence for these wells and the coefficient of permeability of the aquifer as 300 m and 40 m/day respectively.

(i) Calculate the discharge when only one well is pumping with a drawdown of 3 m. 12

(ii) What will be the percent change in discharge of this well if all the three wells were to pump such that the drawdown is 3 m in all the wells? 12

(c) Draw the schematic diagram of a gravity dam and indicate the major forces acting on it. Draw the diagram of the uplift force when (i) drain is not provided and (ii) drain is provided. 12

(d) A city has the following recorded population:

Year 1971: 60000

Year 1991 : 120000

Year 2011: 180000

Estimate (i) the saturation population and (ii) expected population in the year 2031 by logistic curve method. 12

(e) A water contains 110 mg/L carbonate ion and 80 mg/L bicarbonate ion at a pH of 10. Calculate the alkalinity exactly at 25 °C. Approximate the alkalinity by ignoring hydroxide and hydrogen ion. What is the percentage error in approximation? 12

2. (a) A trapezoidal channel is to be designed to convey a discharge of 50 m^3/sec at a velocity of 2 m/sec. The bed width to depth ratio is 0.8. The side slopes are 1 H : 1 V. Calculate the bed width, depth of flow and bed slope of the channel. Assume Manning's coefficient, n = 0.02. 20

(b) Define a unit hydrograph. Explain two basic assumptions made in the derivation of unit hydrograph. Following are the ordinates of a 4-hr unit hydrograph. Using this, derive the ordinates of a 12-hr unit hydrograph (do not plot the graph) :

Time (hr)	0	4	8	12	16	20	24	28	32	36	40	44
Ordinate of 4-hr UH	0	20	80	130	150	130	90	52	27	15	05	0

What are the uses and limitations of unit hydrograph? 20

(c) (i) How will you estimate the total storage capacity of a distribution reservoir? Support your answer with suitable sketches and formulae. 15

(ii) Compute the average sound pressure level from the following sound pressure readings: 5

(1) 39 dBA
(2) 52 dBA
(3) 67 dBA
(4) 77 dBA

3. (a) Estimate the hydraulic gradient in a 2.2 m diameter smooth concrete pipe carrying a discharge of 3.4 cumecs at 20 °C temperature by using (i) Darcy-Weisbach formula, (ii) Manning's formula and (iii) Hazen-Williams formula. The kinematic viscosity of water at 20 °C = 1.004 × 10.6 m^2/sec, Hazen-Williams coefficient of hydraulic capacity of the smooth pipe = 130 and Manning's coefficient = 0.013.

(b) A wastewater treatment plant consists of primary treatment clarifier followed by an activated sludge treatment unit. The primary and secondary sludge are mixed, thickened in a gravity thickener and sent to further treatment. Wastewater, treatment plant and sludge characteristics are as follows :

- Influent SS = 220 mg/L; primary clarifier diameter = 25 m
- Influent BOD = 250 mg/L; aerator volume = 3000 m^3
- Effluent BOD = 30 mg/L; MLSS in aerator = 3000 mg/L
- Flow = 20000 m3/day; solids in thickener supernatant negligible
- Primary sludge 5% solids; secondary sludge = 0.75% solids and thickened sludge = 4% solids
- Efficiency of primary clarifier for SS and BOD removal are 58% and 32% respectively
- Biomass conversion factor in aerator = 0.35

Determine-

(i) solids loading in kg/day to the sludge disposal facilities; 20

(ii) $\frac{F}{M}$ ratio in aerator;

(iii) percent volume reduction by the thickener.

(c) Explain geometric similarity, kinematic similarity and dynamic similarity. Two homologous pumps are to run at the same speed of 600 r.p.m. Pump A has an impeller of 50 cm diameter and discharges 0.4 m^3/sec of water under a head of 50 m. Determine the size of pump B and its net head if it is to discharge 0.3 m^3/sec. 20

4. (a) Explain the terms initial regime' and 'final regime' as explained in Lacey's regime theory of stable channels. Design a stable channel for carrying a discharge of 30 m3/sec using Lacey's method assuming a silt factor equal to 1.0. 20

(b) (i) Define field capacity, permanent wilting point and average moisture content. Explain how these will be useful in deciding the frequency of irrigation. (A schematic diagram showing less and more frequent irrigation is to be drawn for clarity) 3+ 4 + 3 = 10

(ii) In a hydraulic jump occurring in a horizontal channel, the Froude's number before the jump is 100 and energy loss is 3.2 m. Estimate sequent depths, discharge intensity and Froude's number after the jump. 10

(c) (i) Explain in detail the various process parameters required to control the aerobic composting of solid waste. Discuss the relevance of each parameter also. 10

(ii) Discuss the isokinetic sampling process of flue gas stack sampling and explain with the help of diagram, how the results will be affected if the sampling is not done isokinetically. 10

SECTION-B

5. (a) A pit of 6.4 m deep is to be excavated in a fine sand stratum completely saturated up to the ground surface. The saturated unit weight of the sand was obtained as 20.3 kN/m^3. To stabilize the bottom of the excavation (prevent boiling), it was decided to drive steel sheet piles to act as cutoff walls that encircle the excavation. Determine the total length of sheet pile wall to provide a factor of safety of 1.5 against sand boiling. Assume specific gravity of soil, G_S = 2.7 and unit weight of water, γ_wY 9.81 kN/m^3. 12

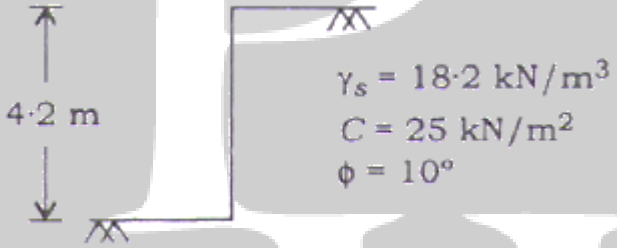
(b) An unsupported cut as shown in the figure below was made at a site for which unit weight of soil, γ_s = 18.2 kN/m^3, cohesion, C = 25 kN/m^2 and angle of internal friction, ϕ = 10°. Determine the lateral stress at-

(i) the top of the excavation;

(ii) the bottom of the excavation;

(iii) the maximum depth of potential tension crack for the excavation.

What is the maximum depth up to which the excavation can be carried out safely without any support? 12



(c) How are runways oriented? Explain the terms 'wind coverage' and 'crosswind component'. 12

(d) Calculate equilibrium cant on an MG curve of 6 degree for an average speed of 50 km/hr. Also find out the maximum permissible speed after allowing maximum cant deficiency. 12

(e) (i) What is repetition method in theodolite surveying? What are different instrumental errors which can be eliminated by the repetition method? 6

(ii) A level was set up between two stations A and B. The distance of level from station A was 520 m and the reading on the staff held at A was 1.620 m. The distance of level from station B was 780 m and the reading on the staff held at B was 2-120 m. The reduced level (RL) of point A was 100.000 m. What is the RL of point B? Assume that there is no error in the instrument. 6

6. (a) Liquid limit (LL) and plastic limit (PL) tests were carried out on a soil sample as per Indian Standard method. The values were 60% and 36% respectively for LL and PL. What is the type of soil based on the above test data as per Indian Standard Classification System? Justify your answer.

(b) Two square footings with equal contact pressure of 250 kPa are at 5 m apart (centre-to-centre). The size of the one footing (A) is 2 m × 2 m and the other one (B) is 2.5 m × 2.5 m. Determine the vertical stress at 2 m vertically below (i) the footing (A), (ii) the footing (B) and (iii) the midpoint between the footings. Use Boussinesq's point load formula. 10

(c) A plate bearing test with a 0-3 m diameter plate was carried out on a thick deposit of sand. The shearing failure of the plate was occurred when a load of 3·5 kN was applied. The unit weight of the sand was 19.2 kN/m3 and water table was found to be at a depth of 1.0 m below the ground surface. If a square foundation of size 1.5 m x 1.5 m is planned in the same sand deposit but placed at a depth of 1.0 m below the ground surface, what will be the allowable bearing capacity of the footing? Assume saturated unit weight of sand also as 19.2 kN/m3 and unit weight of water as 9.81 kN/m3. The chart given below may be used:

ϕ°	0°	Nc	Ny
0	5.70	1.00	000
2	6.30	1.22	0.18
4	6.97	1.49	0.38
6	7.73	1.81	0.62
8	8.60	2.21	0.91
10	9.61	2.69	1.25
12	10.76	3.29	1.70
14	12.11	4.02	2.23
16	13.68	4.92	2.94
18	15.52	6.04	3.87
20	17.69	7.44	4.97
22	20.27	9.19	6.61
24	23.36	11.40	8.58
26	2709	14.21	11.35
28	31.61	17.81	15.15
30	37.16	22.46	19.73
32	44.04	28.52	27.49
34	52.64	36.51	36.96
36	63.53	47.16	51.70
38	77.50	61.55	73.47
40	95.67	81.27	100.39
42	119.67	108.75	165.69
44	151.95	147.74	248.29
46	196.22	204.20	426.96
48	258.29	287.86	742.61
50	347.52	415.16	1153.15

(d) Write down the construction steps for Water Bound Macadam road. Also compare WBM construction with WMM construction. 20

7. (a) A rigid pavement of 25 cm thickness of M40 grade of concrete is supported over a subgrade having modulus of subgrade reaction as 8.0 kg/cm^3. If dowel bars are placed at centre-to-centre spacing of 30 cm, calculate the maximum load carried by a single dowel which is just below the wheel. Assume wheel load as 4100 kg, participation of dowel bars in load distribution up to 1.0 × radius of relative stiffness and load to be transferred by joint as 50%. Poisson's ratio of the concrete may be taken as 0.15.

(b) A pile group consists of four friction piles in cohesive soil. The unit weight and unconfined compressive strength of the soil are respectively 20-2 kN/m3 and 200 kPa. The diameter of each pile is 300 mm, length is 12.0 m and centre-to- centre spacing between the piles is 750 mm. Assuming an adhesion factor of 0.6, determine (i) load capacity of the group based on the individual pile failure, (ii) load capacity of the group based on the block failure and (iii) design load capacity of the group. Assume a factor of safety of 2.0 for individual pile failure and 3 for block failure. 20

(c) The following internal angles and length of sides are observed for a closed traverse ABCDA (in anti-clockwise direction) :

Angle	Observed value	Side	Measured length (m)
DAB	92°38'	AB	27.15
ABC	104°33'	BC	52.16
BCD	70°46'	CD	41.96
CDA	92°07'	DA	46.73

Adjust the internal angles for closing error. Also adjust the traverse by Bowditch method and calculate the consecutive coordinates of points A, B, C and D. Assume line AD in north direction. 20

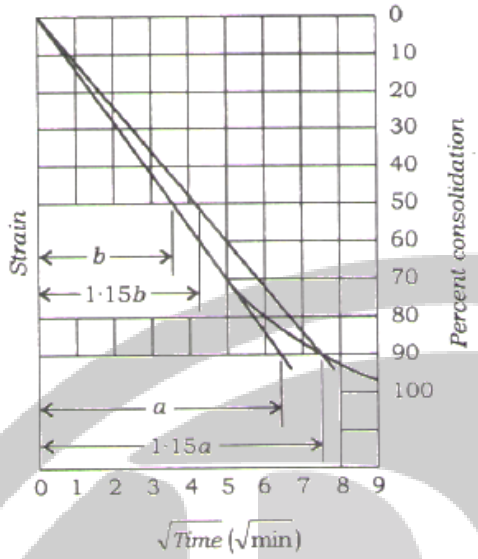
8. (a) (i) What is spectral reflectance curve (spectral signature) in remote sensing? Explain any four applications of remote sensing in civil engineering.

(ii) A simple circular curve of radius 30 chain length has been set out to connect two tangents with external deflection angle of 30°. The chainage of point of tangency is 300 chains. On further inspection, it is proposed to alter the radius of curve to 45 chain length. Calculate the chainage of point of curve and point of tangency for revised curve. Also calculate the length of long chord for revised curve. (Chain length = 20 m) 10

(b) The figure given below represents time-consolidation relationship for a 30 mm thick clay sample subjected to a given pressure range under double drainage condition. Determine the coefficient of consolidation, C_v, for the clay sample. How long will it take (in days) to reach 50% consolidation for the same soil if it was 2.5 m thick and drained in one direction only? Given

$T = \frac{\pi}{4}\left(\frac{U\%}{100}\right)$, $U \leq 60\%$

$T = 1.781 - 0.933\log(100 - U\%)$, $U > 60\%$



(c) A two-lane, two-way highway is designed for design speed of 80 km/hr. A vertical curve is to be provided at intersection of downward gradient of 1 in 50 with another downward gradient of 1 in 20. Calculate the length of the vertical curve fulfilling the requirement of stopping sight distance and overtaking sight distance. The coefficient of longitudinal friction and the acceleration may be taken as 0.35 and 3.6 km/hr/sec respectively. 25

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