इन्जीनियरिंग सेवा परीक्षा, 2009
Engineering Service Examination.

No 018725

A-FTF-J-DFB

CIVIL ENGINEERING

Paper II

(Conventional)

Time Allowed : Three Hours | *Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt any FIVE questions. Each question carries 40 marks.

The number of marks carried by each subdivision of a question is indicated at the end of the subdivision/question. Wherever a question is attempted, all its subdivisions must be attempted.

Answers must be written in ENGLISH.

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

Unless indicated otherwise, notations and symbols have their usual meanings.

Neat sketches to be drawn, wherever required.

1. (a) A metallic cube 30 cm side and weighing 450 N is lowered into a tank containing a two fluid layer of water and mercury. Top edge of the cube is at water surface. Determine the position of block at water-mercury interface when it has reached equilibrium. *10*

(b) Water is pumped from a well tapping an unconfined aquifer at a rate of 2400 m^3/day. A no-drawdown boundary exists at a distance of 5 km from the well centre. Assuming the well to be fully penetrating, compute the steady state drawdown at the well face. Given : Initial saturated thickness = 50 m, hydraulic conductivity = 20 m/day, effective well radius = 1 m. *10*

(c) A large stream has a reoxygenation constant of 0·4 per day. At a velocity of 0·85 m/s; and at the point at which an organic pollutant is discharged, it is saturated with oxygen at 10 mg/L (D_0 = 0). Below the outfall, the ultimate demand for oxygen is found to be 20 mg/L and the deoxygenation constant is 0·2 per day. What is the dissolved oxygen 48·3 km downstream ? *10*

(d) (i) Explain the term "optimum moisture content". How is it affected by compacting effort ? *5*

(ii) State the factors affecting field compaction of soil. *5*

2. (a) If the velocity distribution in a pipe is given by

$$u = u_{max}\left(1 - \frac{r}{r_o}\right)^n$$

where u is the velocity at any radius r, r_o is the radius of pipe and u_{max} is the maximum velocity, find (i) average velocity and (ii) kinetic energy correction factor. *10*

(b) The recorded annual rainfall from five raingauge stations in a catchment and the corresponding Thiessen polygon areas are as follows :

Thiessen polygon areas (cm^2)	Rainfall (cm)
25	125
30	175
30	225
10	275
5	325

The scale of the map is 1 : 50,000. Estimate the volume and the mean depth of the rainfall. Estimate the average annual discharge at the outlet, if the runoff coefficient of the catchment is 0·3. *10*

(c) Water table in a canal command receives a recharge at the rate 2·5 mm/day. Sub-surface ditch drains at a spacing of 2 km are provided for the sub-surface drainage. Estimate the maximum rise of the water table at steady state. Given : hydraulic conductivity of the soil = 10 m/day, depth of the impervious layer below initial water table position = 20 m. Assume the ditches to be fully penetrating. *10*

(d) (i) A deposit of fine sand has a porosity of 45%. Estimate the critical hydraulic gradient to develop quicksand condition if the specific gravity of grain is 2·7. *5*

(ii) Design slow sand filters for a population of 40,000 with an average rate of water supply of 150 litres per capita per day. *5*

3. (a) A 10·0 m wide rectangular channel with bottom slope of 0·00016 carries a discharge of 22·92 m^3/s at a normal depth of 2·0 m and critical depth of 0·8 m. The depth immediately upstream of dam is 10·0 m. Compute the length of the surface profile between 10·0 m and 6·0 m using Chow's or step method. Take step of 2·0 m and assume M = 3·0 and N = 3·33 and Manning's n = 0·015. The length of surface profile by Chow's method between two depths is given by

$$x_2 - x_1 = \frac{y_n}{S_o}\left[(u_2 - u_1) - \{F(u_2, N) - F(u_1, N)\} + \left(\frac{y_c}{y_n}\right)^M \cdot \frac{J}{N}\{F(v_2, J) - F(v_1, J)\}\right]$$ *10*

u	F(u, N)	v	F(v, J)
5	0·01	9	0·027
4	0·017	8	0·031
3	0·034	7	0·038
		6	0·048
		5	0·062
		4	0·087

(b) Following observations were made for conducting a water budget of a reservoir over a period of one month :

Average surface area = 10 km^2, Mean surface inflow rate = 10 cumec, Mean surface outflow rate = 15 cumec, Rainfall = 10 cm, Fall in the reservoir level = 1·5 m, Pan evaporation = 20 cm.

Assuming the pan-factor as 0·7, estimate the average seepage discharge from the reservoir during the month. *10*

(c) Design a rectangular grit chamber for a flow of 40 MLD. Specific gravity = 2·65 and size to be removed is 0·2 mm.

Find the

(a) settling velocity of 0·2 mm particles,

(b) critical horizontal velocity of flow, and

(c) size of the grit chamber. *10*

Assume kinematic viscosity of the liquid = $1{\cdot}0 \times 10^{-2}$ cm^2/s.

(d) Differentiate between the following terms : *10*

(i) Time mean speed and Space mean speed

(ii) Wet dock and Dry dock

(iii) Stopway and Clearway of runway length

(iv) Hydrophilic aggregates and Hydrophobic aggregates

(v) Base tunnel and Saddle tunnel

4. (a) A pipe network in the form of a triangle ABC has inflows of 5 m^3/s and 4 m^3/s at A and B respectively. The outflow at C is 9 m^3/s. Given K_{AB} = 10, K_{BC} = 50 and K_{AC} = 20, compute discharges in each pipeline [$h_f = KQ^2$]. *10*

(b) A 1200 m long storm sewer collects wastewater from a catchment area of 50 hectare, where 35% area is covered by roof (I = 0·9), 20% area is covered by pavements (I = 0·8) and 45% area is covered by open land (I = 0·13). Determine the average I, and diameter of storm sewerline assuming

(i) the time of entry = 3 min

(ii) velocity of full flow = 1·50 m/s

(iii) n = 0·013 and slope = 0·001
I = runoff ratio. *10*

(c) A retaining wall 10 m high is proposed to hold dry sand of void-ratio of 0·6. The value of angle of internal friction $\phi = 30°$ and specific-gravity of soil grain is 2·7. The back face of wall is vertical and smooth. Top surface of backfill is horizontal. Calculate the magnitude of the total active earth thrust against the wall assuming the wall is free to move. Also show the distribution of earth pressure and point of application of the resultant. Assume unit weight of water = 10 kN/m^3. *10*

(d) (i) What are the assumed conditions of runway length for standard environment which decide the basic runway length ?

(ii) Determine the actual runway length after applying necessary corrections for elevation and temperature as per ICAO and gradient correction as per FAA specification for the data given below. *5+5*

- Basic runway length = 1800 metres
- Elevation of Airport site = 600 metres
- Monthly mean of average daily temperature for the hottest month of the year = 15° C
- Monthly mean of maximum daily temperature for the same month = 21·6° C
- Effective gradient = 0·6%

5. (a) Draw indicator diagram for the following cases of a reciprocating pump : *10*

(i) When no air vessel is installed.

(ii) When air vessel is installed on suction side close to the pump.

(iii) When air vessel is installed on delivery side close to the pump.

(iv) When air vessels are installed on both sides of the pump.

(b) How many days would be required by a clay stratum 5 m thick, draining at both ends with coefficient of consolidation = 50×10^{-4} cm^2/sec to attain 50% of its ultimate settlement ?
Given : $T_{50} = 0{\cdot}197$. *10*

(c) Determine the length of transition curve and offsets at every 15 metres for B.G. curved track having 4° curvature and cant of 12 cm. The maximum permissible speed on curve is 85 kmph. *10*

(d) Water emerges from a spillway with a velocity of 15 m/sec and a depth of 0·5 m. Calculate the necessary subcritical depth at the toe of the spillway for the occurrence of a hydraulic jump. Calculate the associated energy loss. *10*

6. (a) Why is vertical shaft necessary in case of long tunnel ?

A circular tunnel of 3 metres diameter and 3 kilometres long is to be driven by full face excavation. The proposed tunnel alignment is passing through rock. The rate of excavation per blast is 5 metres. Calculate the number of hauling trucks required for mucking operation from the data given below. *10*

- Capacity of hauling truck = 10 tonnes
- Average hauling and return speed of hauling truck = 25 kmph
- Average hauling distance = 3 km

–	Density of muck	= 1600 kg/m^3
–	% swell	= 15
–	% over-breaking	= 5
–	Operating efficiency of hauling truck	= 75%
–	Loading time, dumping time, acceleration and deceleration time etc.	= 4·6 minutes

(b) A Pelton wheel is producing 300 kW working under a head of 180·0 m with discharge of 0·2 m^3/s. Compute hydraulic efficiency and velocity of whirl at inlet and outlet and the mean bucket speed. Take coefficient of velocity = 0·985, angle of deflection of jet = 165° and relative velocity at exit = relative velocity at inlet. *10*

(c) The ordinates of 6 hour unit hydrograph of a catchment are as follows.

Time (hours)	Discharge (m^3/sec)
0	0
6	10
12	40
18	55
24	45
30	30
36	7
42	0

The unit depth of the unit hydrograph is 1 cm. Arrive at the direct runoff hydrograph resulting from the following excess-rainfall hyetograph occurring over the catchment. *10*

Duration (hours)	Rainfall intensity (cm/hr)
0 – 6	1
6 – 12	0·5

(d) A 2 m wide strip footing is located at a depth of 2 m in a stiff clay of saturated unit weight of 20 kN/m^2 and having $\phi_u = 0$ and $c_u = 120$ kN/m^2. Using Terzaghi's bearing capacity equation, compute the safe load carried by footing per metre length with factor of safety = 3 with respect to shear failure. Given : $N_c = 5{\cdot}7$. *10*

7. (a) (i) How are following bitumen binders classified ?

Penetration grade bitumen
Blown bitumen
Cut-backs
Emulsions

(ii) Explain briefly construction procedure and quality control measures for dense bituminous macadam (DBM). *5+5*

(b) Draw and discuss the single stack system of plumbing. *10*

(c) (i) What is "negative skin friction" and its significance in the design of pile foundation ? *5*

(ii) Describe 'differential free swell' test of soil. *5*

(d) The following are the observed values of an angle and their weightage :

Angle	Weightage
30° 24′ 20″	2
30° 24′ 18″	2
30° 24′ 19″	3

Find :

(i) Probable error of single observation of unit weight.

(ii) Probable error of weighted arithmetic mean.

(iii) Probable error of single observation of weight 3. *10*