Engineering Services Examination-2012

Serial No. [ ] **C–FTF–M–DJB**

CIVIL ENGINEERING

Paper—II

(Conventional)

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

INSTRUCTIONS

*Question No. 1 is compulsory. Out of the remaining **SEVEN** questions, attempt any **FOUR** 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 only 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.

Important note :—

All parts and sub-parts of a question being attempted are to be answered contiguously on the answer-book. That is, all the parts and sub-parts of one question are to be completed before attempting the next question.

Pages left blank in the answer-book, if any, are to be struck out. Answers that follow blank pages may not be given credit.

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1. (a) (i) The velocity in a boundary layer over a horizontal flat plate held in a free stream with a velocity U is given as

$$\frac{u}{U} = a + b\eta + c\eta^2$$

where u is velocity at y and U at δ and $\eta = y/\delta$; y and δ are measure of normal to the flat plate. Determine the value of co-efficients a, b and c using appropriate boundary conditions. If the shear stress on the plate is given $\tau_o = K\frac{\mu U}{\delta}$, find the value of 'K'. 4

(Contd.)

(ii) A Pelton wheel has a mean bucket speed of 10 m/sec with a jet of water flowing at the rate of 0·7 m^3/sec under a head of 30 m. The bucket deflect the jet through an angle of 160°. Calculate power given by water to the runner and the hydraulic efficiency of the turbine. Assume efficiency of the nozzle as 0·98. 4

(b) What are the different types of cross drainage works that are required when a canal crosses a natural drainage ? Draw a plan view of an aqueduct showing all details. 8

(c) What is a water bearing stratum ? On what basis ground water flows in it ? What is the difference between Specific Yield and Specific Retention ? 8

(d) (i) What do you understand by "index properties of soil" ? Explain and list the properties under different categories. 4

(ii) What is meant by "earth pressure at rest", active earth pressure and passive earth pressure ? Explain the difference in terms of wall movement. 4

(e) What are the factors to be considered in selection of a gauge ? Write advantages of uniformity of gauges. 8

(Contd.)

2. (a) (i) The x and y components in a three dimensional flow are given by

$$u = x^2 + z^2;\ v = y^2 + z^2.$$

Find the simplest z-component of velocity that satisfies the continuity equation. 4

(ii) A vertical gap 23·5 mm wide of infinite extent contains oil of specific gravity 0·9 and viscosity 2·5 N-s/m^2. A metal plate 1·5 m × 1·5 m × 1·5 mm weighing 50 N is to be lifted through the gap at a constant speed of 0·1 m/sec. Estimate the force required to lift the plate. 6

(b) A solid gravity dam has 10 numbers of waste weir sluices, the width of each sluice being 4·0 m. The waste weir is designed for a high flood discharge of 100 m^3/s and the weir constant is given as 1·76. It is proposed to increase the line storage of the reservoir behind the dam by replacing the waste weir by a saddle siphon spillway having the crest at all units being at the same level. The discharge coefficient of this siphon spillway is 0·64 and the operated head for all the units is 7 m. Find the number of siphon units necessary to replace the waste weir and also find the extra line storage obtained by remodelling of the spillway. The HFL (high flood level) is the same in case of both types of spillway and the priming depth for the saddle spillway is 15 cm. The area of water spread from HFL to about 1·5 m below HFL may be taken as constant and equal to 4·5 million m^2. 10

(c) (i) A soil sample has a porosity of 40%. The specific gravity of solids is 2·7. Calculate the (i) void ratio (ii) dry density (iii) unit weight if the soil is 50% saturated and (iv) unit weight if the soil is completely saturated. 5

(ii) A horizontal stratified deposit consists of four layers each uniform in itself. The permeabilities of the layers are $7{\cdot}5 \times 10^{-4}$ cm/sec, 49×10^{-4} cm/sec, 13×10^{-4} cm/sec and 17×10^{-4} cm/sec and their thicknesses are 5 m, 4 m, 17 m and 6 m respectively. Find the effective average permeabilities of the deposit in horizontal and vertical directions. 5

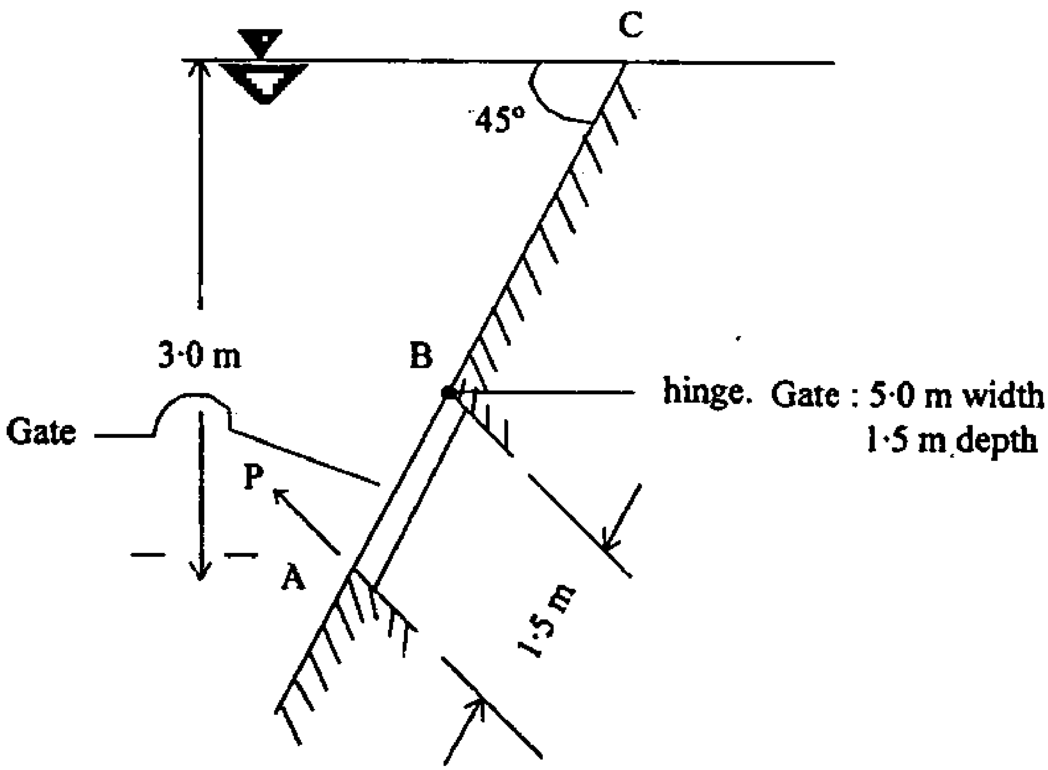
(d) Determine the gradient from a point A to B from the following observations made with a fixed hair tacheometer fitted with an anallatic lens, the constant of the instrument being 100.

	Bearing	Reading on Stadia	Hair	Reading on Axial Hair	Vertical angle
To A	345°	0·750	2·120	1·435	+ 15°
To B	75°	0·625	3·050	1·835	+ 10°

10

3. (a) (i) A 10 cm diameter orifice discharges water at 45 litres per second under a head of 2·75 m. A flat plate is held normal to the jet just downstream from the vena contracta requiring a force of 310 N to resist the impact of the jet. Find co-efficients of contraction C_c, velocity C_v and discharge C_d. 4

(ii) A rectangular gate of width 5 m and depth 1·5 m is installed to control the discharge as shown in Figure below. The end 'B' is hinged. Determine the force normal to the gate applied at 'A' to open it. 6



(b) In fine sand aquifer region, design a well to get 10 litres/sec. yield, under depression head of 2·5 meters. Value of $\frac{C'}{A}$ in cu m./hr. per sq. metre of the area may be taken as 0·60. 10

(c) (i) A specimen of fine dry sand, when subjected to triaxial compression test, failed at a deviator stress of 400 kN/m^2. It failed with a pronounced failure plane with an angle of 24° to the axis of the sample. Compute the lateral pressure to which the specimen would have been subjected. 5

(ii) An elevated structure with a total weight of 10,000 kN is supported on a tower with 4 legs. The legs rest on piers located at the corners of a square 6 m on a side. What is the vertical stress increment due to this loading at a point 7 m beneath the centre of the structure ?

(Assume that the load be approximated to a point load acting at the corners of a square of 6 m side). 5

(d) (i) Current Truck-traffic Volume (AADTT) for a Six-lane freeway are shown in the table below. A bituminous pavement with a 20 years design life is to be designed according to the Hveem method. Determine the design ESAL for lane-3 of this freeway, if it is assumed that traffic-volumes for each truckclassification will grow linearly by 25% over the next 20 years.

Vehicle-type	Current traffic Volume (AADTT)
2 axle Trucks	1000
3 axle Trucks	500
4 axle Trucks	250
5 axle Trucks or more	1200

Assume :

(i) Lane distribution factor for Lane-3 is 0·80.

(ii) ESAL constant as

Vehicle-type	ESAL Constant
2 axle Trucks	1380
3 axle Trucks	3680
4 axle Trucks	5880
5 axle Trucks or more	13780

5

(ii) What are advantages of Traffic-Rotary ? 5

4. (a) (i) In 1 : 20 model of a spillway, the velocity and discharge are 1·5 m/sec and 2·0 m^3/sec respectively. Find the corresponding velocity and discharge in the prototype. 4

(ii) An overflow spillway is 50 m high. At the design the energy head is 2·5 m over the spillway. Find the sequent depth and energy loss in a hydraulic jump formed on a horizontal apron at the toe of the spillway. Neglect energy loss due to flow over the spillway face. Assume co-efficient of discharge C_d = 0·735 and velocity at the toe, before the jump can be approximated as $V = \{2\ g\ (\text{total head})\}^{1/2}$. Where g is acceleration due to gravity. 6

(b) In a watershed four non-recording raingauges have been installed to record rainfall data. The annual rainfall record for one of the years is furnished below :

Location site of raingauge station	A	B	C	D
Recorded annual rainfall in 'cm'	100	120	140	80

Assuming an error of 10 per cent in the estimation of mean rainfall find out the optimum number of non-recording and recording raingauges for this watershed. 10

(c) A square footing located at a depth of 1·3 m below the ground surface has to carry a safe load of 800 kN. Find the size of the footing if the desired factor of safety is 3. The soil has the following properties :

Void ratio, $e = 0{\cdot}55$

Degree of saturation, $S_r = 50\%$

Specific gravity = 2·67

$C = 8\ \text{kN/m}^2$

For $\phi = 30^\circ$ — $N_c = 37{\cdot}2$, $N_q = 22{\cdot}5$, $N_\gamma = 19{\cdot}7$ (Bearing capacity factors) 10

(d) (i) What are the various methods of tunnelling in hard rocks ? Write the advantages of Mole-tunnelling method. 5

(ii) Determine the turning radius of the taxiway of a supersonic transport aircraft with a wheel-base of 30 m and tread of main loading gear as 6·0 m. for a design turning speed of 50 kmph. Assume co-efficient of friction between tyre and pavement surface as 0·13 and width of taxiway pavement as 22·5 m. 5

5. (a) (i) A metallic ball of diameter 5 mm drops in a fluid of density 800 kg/m^3 and viscosity 3 N-S/m^2. The specific gravity of metallic ball is 9·0. Find the terminal fall velocity of the ball, and the drag experienced by the ball. 4

(ii) A triangular channel of apex angle 90° and a rectangular channel of the same material have the same bed slope. If the rectangular channel has the depth of flow equal to the width of the channel and flow areas in both channels are the same, find the ratio of discharges in the rectangular and triangular channels respectively. Use Manning's roughness equation for estimation of velocity. 6

(b) (i) A homogeneous earthdam 42 m high is built to store water for irrigation water requirement with a freeboard of 2 m. A horizontal filter of 30 m length is provided at its downstream end. The coefficient of permeability of the material of the dam is given as 2×10^{-3} cm/sec. A flow net was constructed through the body of the dam and the following results were obtained :

No. of potential drops = 25

No. of flow channels = 4

Calculate the seepage flow per meter length of the dam in ℓps . 6

(ii) The main canal from the headwork of a dam has been designed to carry a discharge of 40 m^3/s. At a certain location along the course of the canal a drop of 4·0 m head is available.

(Contd.)

It is proposed to utilize the drop for generation of hydropower. Estimate how much kW (kilowatt) of energy can be generated assuming efficiency of the machinery used as 75 per cent. 4

(c) Calculate the size of a rectangular tank to treat 2·0 million litres of water per day. The detention period may be assumed as 3 hours and overflow rate less than 40,000 lit. per sq. m. of the surface area per day. 10

(d) (i) What is Wet-dock ? Write the uses of Wet-dock and explain operation of wet-dock using Lock and gate. 5

(ii) Why is efficient ventilation system required in tunnelling operation ? What are the requirements of ventilation system ? Explain combination of blowing and exhausting system of ventilation. 5

6. (a) (i) A tube well of 15 cm diameter penetrates fully an artesian aquifer 27 m thick. Determine permeability of the aquifer if a steady discharge of 30 ℓps is obtained from the well under a drawdown of 3·0 m at the well face. Take radius of influence equal to 200 m. 6

(Contd.)

(ii) Determine the amount of evapotranspiration from an area if the total rainfall precipitated during a storm is 10·0 mm. Given the antecedent moisture at the root in the soil was 5·00 mm, the loss of water due to seepage 2·5 mm, losses due to percolation 2·00 mm, surface run-off 3·00 mm and the moisture retained in the soil is 1·00 mm. 4

(b) Explain the process of Anaerobic sludge digestion. Name the experiments to be performed in the laboratory to determine the digestibility of sludge. 10

(c) A footing, 2 m square, rests on a soft clay with its base at a depth of 1·5 m from ground surface. The clay stratum is 3·5 m thick and is underlain by a firm sand stratum. The clay soil has following properties :

$$W_L = 30\%, \quad W_n = 40\%, \quad G_s = 2{\cdot}70$$
$$\phi_u = 0^\circ, \; C_u = 0{\cdot}5 \text{ kg/cm}^2$$

It is known that the clay stratum is normally consolidated. Using Skempton's equation determine the net safe bearing capacity of footing. Natural water table is close to the ground surface. 10

(d) A National-highway passing through rolling-terrain in heavy rainfall area has a horizontal curve of radius 550 metre. Design the length of transition curve, assuming design-speed of 80 kmph, normal pavement width = 7 metre, allowable rate of change of centrifugal acceleration between 0·5 to 0·8 and allowable rate of introduction of Super-elevation is 1 in 150. 10

7. (a) (i) Determine the maximum time for rapid closure of pipe 60 cm diameter, 450 m long made of steel ($E = 2{\cdot}07 \times 10^{11}$ N/m^2) with a wall thickness of 1·25 cm. The pipe carries a liquid of specific gravity 0·88 and bulk modulus $K = 1{\cdot}03 \times 10^9$ N/m^2 flowing at 1 m^3/sec. E = Young's modulus of steel. 4

(ii) A centrifugal pump having an impeller of 35 cm outside diameter rotates at 1050 rpm. The vanes are radial at exit and are 7·0 cm wide. The velocity of radial flow through the impeller is 3 m/sec. The velocity in the suction and delivery pipes are 2·5 m/sec and 1·5 m/sec respectively. Neglecting frictional losses, determine the height through which pump lifts and the horse-power of the pump. 8

(b) Describe photochemical oxidants. What are the sources of photochemical oxidants and how the detection and analysis for the same is done ? 12

(c) A retaining wall 4 m high, has a smooth vertical back. The backfill has a horizontal surface in level with the top of the wall. There is a uniformly distributed surcharge load of 36 kN/m^2 intensity over the backfill. The unit weight of backfill soil is 18 kN/m^3 with angle of shearing resistance, ϕ of 30° and cohesion is zero. Determine the magnitude and point of application of active pressure per metre length of wall. 16

8. (a) (i) A pipeline of length 26·5 km is used for transmission of water. If the 100 kW power is to be transmitted through the pipe in which water is having 490·5 N/cm^2 pressure at inlet of the pipe, find the diameter of the pipe corresponding to maximum efficiency of transmission. Use head loss due to friction $= \dfrac{fLU^2}{2gd}$ where $f = 0{\cdot}026$. 4

(ii) A pipeline of 0·6 m diameter is 1·5 km long. To augment the discharge another pipe-line of the same diameter is introduced parallel to the first in the second half of the length. Neglecting minor losses find the increase in discharge if $f = 0{\cdot}04$ and head above the outlet is 30 m. 6

(b) (i) The working life of dam built to store irrigation requirement is expected to be 100 yrs. The spillway capacity is designed to accommodate the peak flood having a return period of 500 yrs. Calculate the risk of failure of the dam. 4

(ii) Show with the help of a neat sketch the storage capacities allotted for various purposes in a multipurpose reservoir.

Briefly explain what is meant by useful life of a reservoir and how it is estimated. 6

(c) Design a friction pile group to carry a load of 3000 kN including the weight of the pile cap at a site where the soil is uniform clay to a depth of 20 m underlain by rock. Average unconfined compressive strength of clay is 70 kN/m^2. The clay may be assumed to be of normal sensitivity and normally loaded with liquid limit of 60%. A factor of safety of 3 is required against shear failure. (Assume length of pile as 10 m). 10

(d) Two straights meet at an angle of 137°. Due to the position of a building, a curve is to be so chosen that it may pass near a point F, 50 metre on the bisector of the angle of intersection from the point of intersection. Find the degree of the curve and calculate how near it passes to point F. 10