Engineering Services Examination-201 2

Sl. No. [ ]

C-FTF-M-DJA

CIVIL ENGINEERING

Paper I

(Conventional)

Time Allowed : Three Hours	*Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt any FIVE questions.

The number of marks carried by each subdivision of a question is indicated at the end of the subdivision.

The total number of marks for each question will be 40.

Answers must be written only in ENGLISH.

Notations used are standard and will have their usual meanings, unless otherwise indicated.

Assume suitable data, if found necessary, and indicate them clearly. Newton may be converted to kgf using the relation 1 kilonewton (1 kN) = 100 kgf, if found necessary.

Important : ***Candidates are to note that all parts and sub-parts of a question are to be attempted contiguously in the answer-book. That is, all parts and sub-parts of a question being attempted must be completed before attempting the next question.***

Any pages left blank in the answer-book must be clearly struck out. Answers that follow pages left blank may not be given credit.

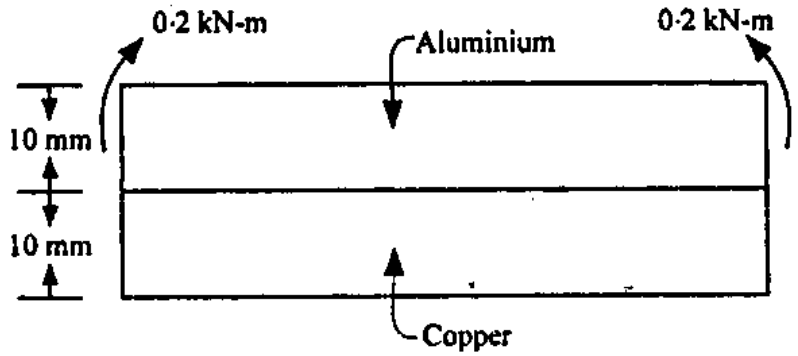
1. (a) List the principal constituents of fly ash. Explain its pozzolanic action when used in concrete. 10

(b) For a mix design of proportion 1 : 2 : 3·6 (by mass) with w/c ratio of 0·45 and air content 3% of the concrete volume, calculate the weights of water, cement, fine aggregate and coarse aggregate to make 1 m^3 of concrete. The specific gravities of cement, F.A. and C.A. are 3·15, 2·65 and 2·6 respectively. 10

(c) What are the varieties of industrial timber ? Indicate the procedure followed for making fibre boards. 10

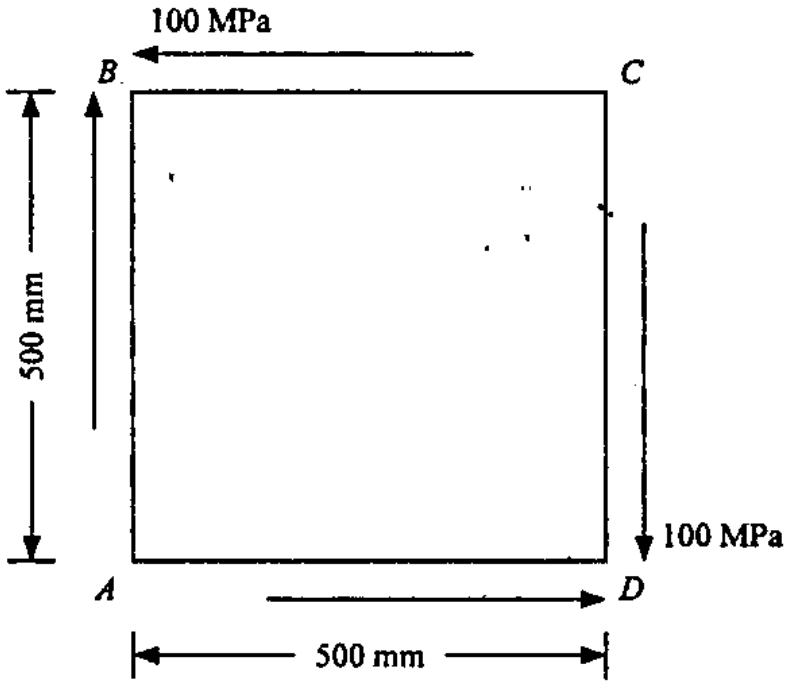
(d) Discuss the properties imparted to brick-earth by its constituents alumina and silica. 10

2. (a)



A strip of copper 40 mm wide and 10 mm thick is bonded with another strip of aluminium of same size to form a bimetallic strip of 40 mm × 20 mm. The strip is subjected to a pure bending moment of 0·2 kN-m as shown in the above figure. Calculate the radius of curvature of the strip and the maximum tensile and compressive stresses. $E_c = 1 \times 10^5$ MPa, $E_{al} = 0{\cdot}6 \times 10^5$ MPa. 20

(b)

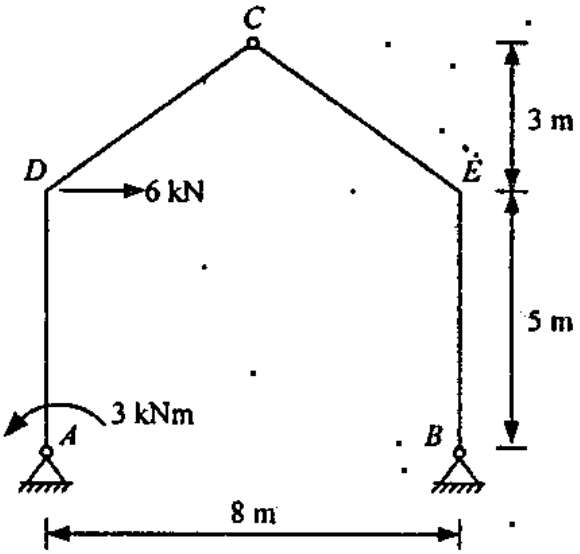


A square plate of side 500 mm is subjected to pure shear of intensity 100 MPa as shown in the above figure. Young's modulus of the material is 2×10^5 MPa and Poisson's ratio is 0·2. Find the principal stresses, their directions and the change in lengths of the diagonals of the plate. 10

(c) A thin walled tube of circular cross-section with outer diameter 100 mm, thickness 2 mm and length 1000 mm is fixed at one end. It is subjected to a twisting moment of 1 kN-m at the free end. Find the shear stress in the wall of the tube and the angle of twist at the free end. $E = 2 \times 10^5$ MPa and Poisson's ratio = 0·25.

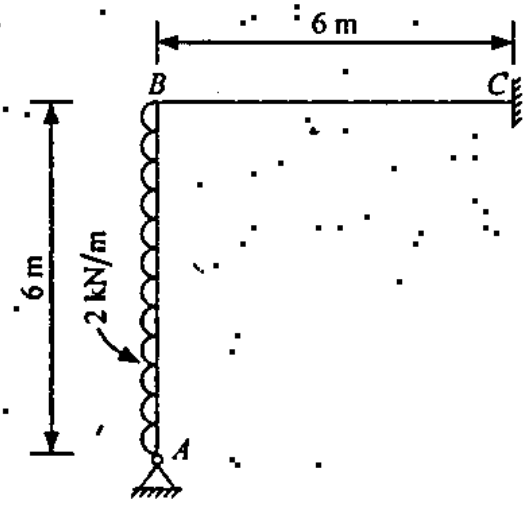
What will be the shear stress in the wall of the tube if the cross-section of the tube is square with outside dimensions 100 mm × 100 mm and wall thickness 2 mm ? 10

3. (a)



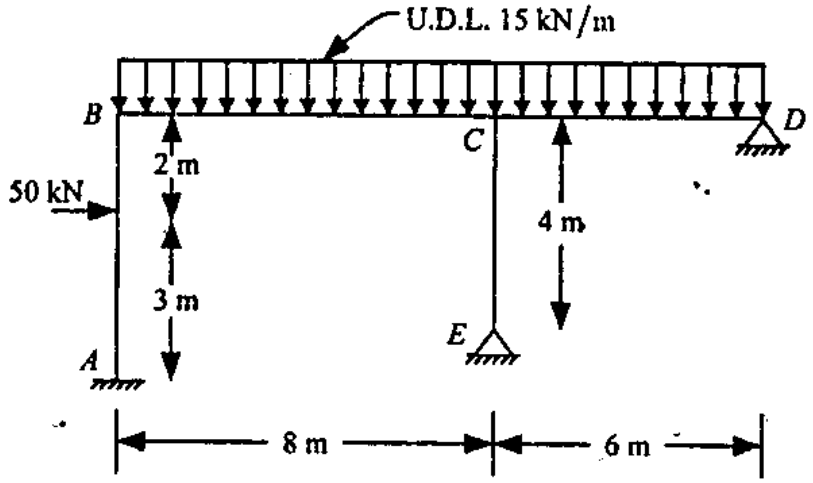
Find all the support reactions and draw BM diagram for the frame shown above. Frame has hinged supports at *A* & *B* and internal hinge at *C*. 15

(b)



Analyse the frame shown above by compatibility method. EI is constant. Draw BM and SF diagrams. 25

4. (a)



Analyse the rigid frame shown in the above figure by moment distribution method, taking flexural rigidity EI to be uniform for all members. 20

(b) ISMB 450 is used as a propped cantilever beam of span 12 m. Assuming $\sigma_y = 250$ MPa determine the factored uniformly distributed load q_u the beam can carry including self weight, if the load is to be applied over the entire span.

The properties of ISMB 450 are as follows :

weight/metre	:	72·4 kg
area of cross-section	:	9227 mm^2
width of flange	:	150 mm
thickness of flange	:	17·4 mm
I_{xx}		$= 3{\cdot}039 \times 10^8$ mm^4
I_{yy}		$= 8{\cdot}34 \times 10^6$ mm^4

20

5. (a) Rolled steel section ISWB 300 is used as a column of height 6 m, fixed at base and pinned at top. Find the permissible compressive load on the column using the table of permissible compressive stresses as given in the table below :

Cross-section properties of ISWB 300 section are as follows :

Area of cross-section = 6133 mm^2

Flange width = 200 mm

Flange thickness = 10 mm

Web thickness = 7·4 mm

I_{xx} = $98{\cdot}216 \times 10^6$ mm^4

I_{yy} = $9{\cdot}9 \times 10^6$ mm^4

λ	50	60	70	80	90	100	110	120
σ_{ac}	132	122	112	101	90	80	72	64

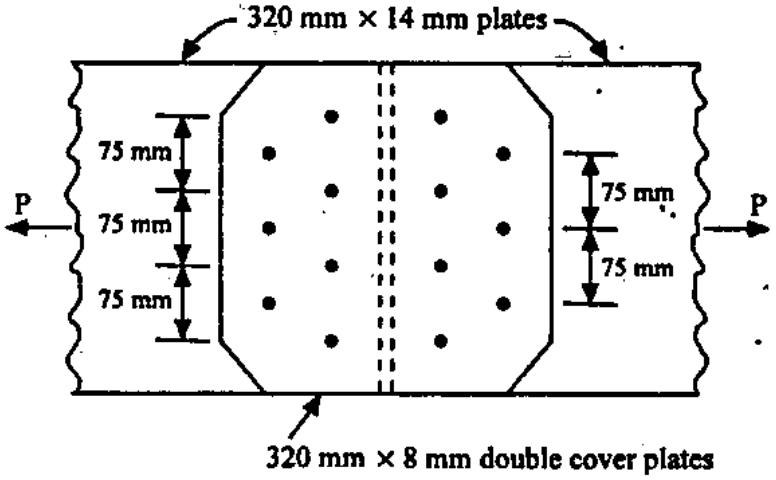
λ	130	140	150	160	170	180	190	200
σ_{ac}	57	51	45	41	37	33	30	28

λ = slenderness ratio

σ_{ac} = allowable compressive stress in MPa

Use linear interpolation for intermediate values of λ. 15

(b)



A double cover butt joint is provided with the following details :

Size of plates to be spliced 320 mm × 14 mm

Size of cover plates 320 mm × 8 mm

No. of 20 mm dia rivets provided = 7
(as shown in the above figure)

Allowable stress in tension 125 MPa

Allowable stress in shear 80 MPa

Allowable stress in bearing 250 MPa

(i) Determine the strength of the connection.

(ii) Find the force on the extreme rivet when the connection is subjected to a pull of 280 kN with an eccentricity of 20 mm.

(iii) Find the limiting value of eccentricity if force on any rivet is not to exceed its strength. 25

6. (a) Distinguish clearly between pretensioned and post-tensioned prestressed concrete bringing out all the operations involved. 8

(b) A simply supported T-beam of span 9 m in reinforced concrete has the following dimensions :

Flange width = 2000 mm

Flange thickness = 150 mm

Overall depth = 750 mm

Rib width = 300 mm

The beam is provided with 6 No. 32 mm diameter HSD bars of grade Fe 500.

Concrete used is of grade M 25:

Find the moment of resistance of the beam using limit state method.

Also find the magnitude of two point loads at 3 m distance from the ends. 12

(c) A rectangular simply supported prestressed concrete beam of cross-section 200 mm wide and 300 mm deep is prestressed by 15 No. 5 mm diameter wires located at 65 mm from soffit and 3 No. 5 mm diameter wires at 25 mm from the top. Assuming effective stress in steel wires as 840 N/mm^2,

(i) calculate the stresses in concrete at the extreme fibres at midspan section due to prestress and its own self weight over a span of 6 m.

(ii) if a uniformly distributed working load of 6 kN/m is imposed on the beam, obtain the maximum compressive stress in concrete.

(iii) if the modulus of rupture of concrete is 6·5 N/mm^2, estimate the load factor against cracking.

Assume density of concrete = 24 kN/m^3. 20

7. (a) (i) Calculate the time required to grade and finish 30 km of road formation of 9·0 m width for two-lane road with motor-grader having width of 3·0 m, using six passes with speed for each of the successive two passes as 5 kmph, 7 kmph and 9 kmph respectively. Assume machine efficiency based on operator skill, machine characteristics and working conditions as 80%. 6

(ii) Enlist major concreting equipments required to carry out following operations :

Mixing, transportation delivery and compacting equipment. 4

(b) (i) Calculate number of transit mixers (TM) required for transporting concrete from central batching plant to site. The cycle time data of a 6 m^3 typical transit mixer is given below :

Loading time of TM = 6·0 minutes.

Travel time of loaded TM to site = 30·0 minutes

Average waiting time at site = 5·0 minutes

Discharge time of concrete at site through concrete pump = 15 minutes

Travel time for return trip = 24 minutes

If the central batching plant having average output of 60 m^3/hr is to run continuously, work out the requirement of no. of concrete pumps and TM. 6

(ii) Name various types of Earth Excavating Equipments and give their corresponding digging depth. 4

(c) The data for planning a certain Civil Engineering project by CPM-Network analysis is given below. Draw the network and establish the critical path.

Also determine the following :

(i) Prepare a CPM schedule and calculate total float, free float and independent float.

(ii) Compute the project duration :

Activity	*Duration in weeks*	*Activity immediately*	
		Preceding	*Following*
A	03	–	E
B	04	–	D, F, G
C	14	–	H
D	03	B	H
E	05	A	–
F	06	B	–
G	04	B	I
H	01	C, D	I
I	01	G, H	–

10

(d) (i) PERT calculations indicate that duration of a given project is 72 weeks. With the variance of 15, work out number of weeks within which the project is expected to be completed with probability of 50%, 80% and 98%. Take Z-values of 0·89 and 2·1 for probability of 80% and 98% respectively. 5

(ii) For an activity of casting a raft foundation of a High rise building, three engineers A, B and C have given the time estimates as follows. State who is more certain about the time of completion of job. Also calculate expected time of completion of each engineer.

Engineer	*Times in week*		
	Optimistic	*Most likely*	*Pessimistic*
A	05	07	09
B	04	06	07
C	03	05	08

5

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

(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

(Contd.)

(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 $7{\cdot}5\times10^{-4}$ 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.

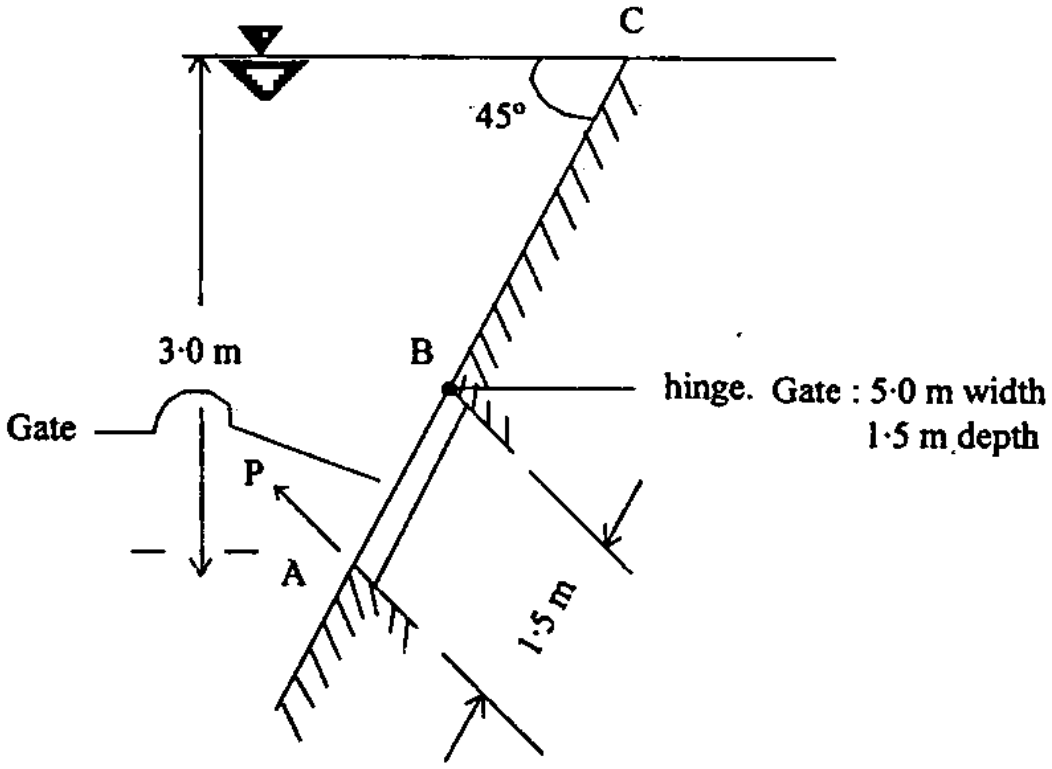
	Bearing	Reading on Stadia	Hair	Reading on Axial Hair	Vertical angle
To A	345°	0·750	2·120	1·435	+ 15°
To B	75°	0·625	3·050	1·835	+ 10°

10

(Contd.)

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



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(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 truck-

classification 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

(Contd.)

(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

(Contd.)

following properties :

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

Degree of saturation, $S_r = 50\%$

Specific gravity = 2·67

$C = 8\ kN/m^2$

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 $N\text{-}S/m^2$. 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

(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 :

$W_L = 30\%$, $W_n = 40\%$, $G_s = 2{\cdot}70$

$\phi_u = 0°$, $C_u = 0{\cdot}5$ 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 ($E = 2{\cdot}07\times10^{11}$ N/m^2) with a wall thickness of 1·25 cm. The pipe carries a liquid of specific gravity 0·88 and bulk modulus $K = 1{\cdot}03\times10^{9}$ 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 = $\frac{fLU^2}{2gd}$ where f = 0·026. 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 = 0·04 and head above the outlet is 30 m. 6

(Contd.)

(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