

Serial No.

**A-FRF-M-BUA**

## **CIVIL ENGINEERING**

### **Paper—I**

**(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**.*

*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.*

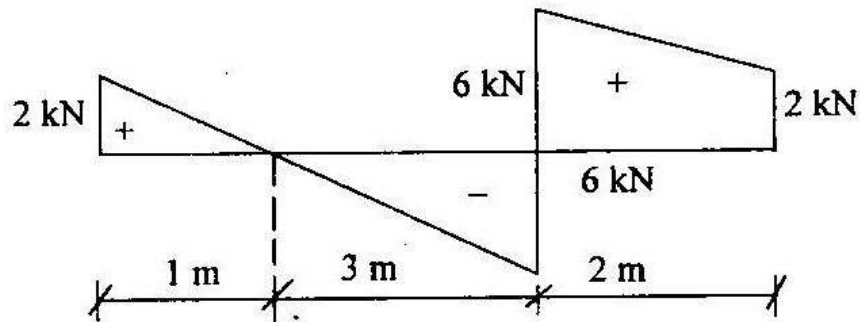
*Any pages left blank in the answer book must be clearly struck out.*



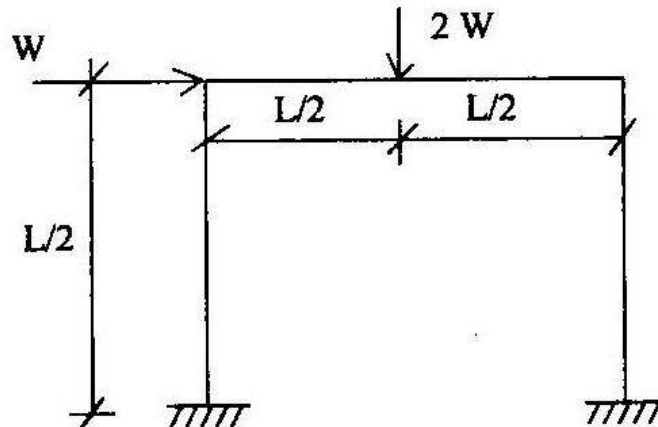
1. All parts carry equal marks :

10×4=40

- (a) Cement is made of solid complexes of oxides of calcium etc. Write the names of the four well known complexes along with the notation used to represent these. 4
- (b) Write the full form of the following in context of civil engineering construction : 4×1=4
- (i) RMC
  - (ii) GIS
  - (iii) BOLT
  - (iv) BOQ
- (c) Draw the bending moment diagram of a beam from the shear force diagram of the beam. 4



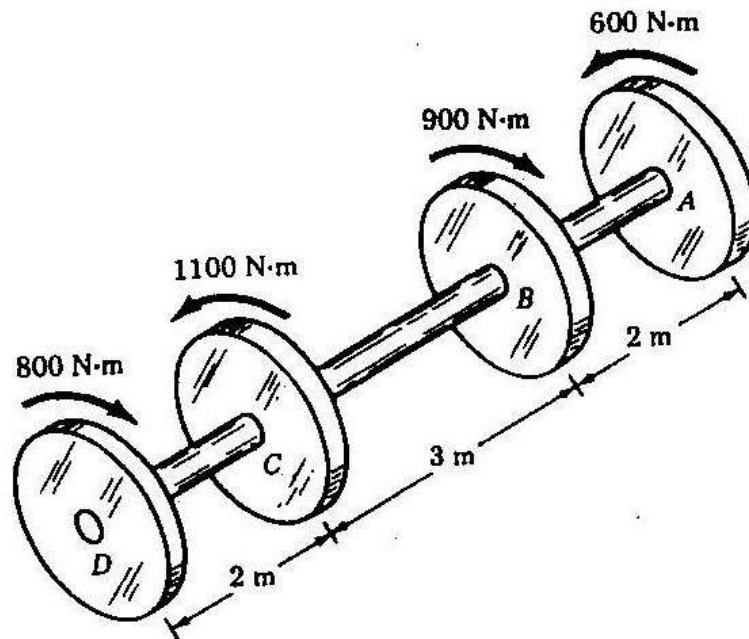
- (d) Draw the different mechanisms for the frame as shown in the fig. for plastic analysis. 4



- (e) (i) Name 10 commonly used hot rolled structural section for steel construction. 2
- (ii) Give 06 reasons for failure of rivetted joints. 2
- (f) A simply supported rectangular beam of length  $L$  carries a udl over its entire length. Determine the critical length at which the shearing stress ' $\tau$ ' and flexural stress ' $\sigma$ ' reach their allowable values simultaneously. The breadth of beam section is ' $b$ ' and depth is ' $d$ '. 4
- (g) A beam of square section of the side ' $a$ ' is placed such that (i) two sides are horizontal (ii) one diagonal is horizontal. Find the ratio of the moments of resistance of the section in two positions for same permissible bending stress. 4
- (h) Determine the moment of resistance of a Tee-section having the following properties :
- Flange Width = 2000 mm
- Flange Depth = 100 mm
- Web Width = 250 mm
- Effective Depth = 750 mm
- Area of Steel = 8 bars of 20 mm diameter
- Material used = M25 grade of conc and Fe415 HYSD bars. 4

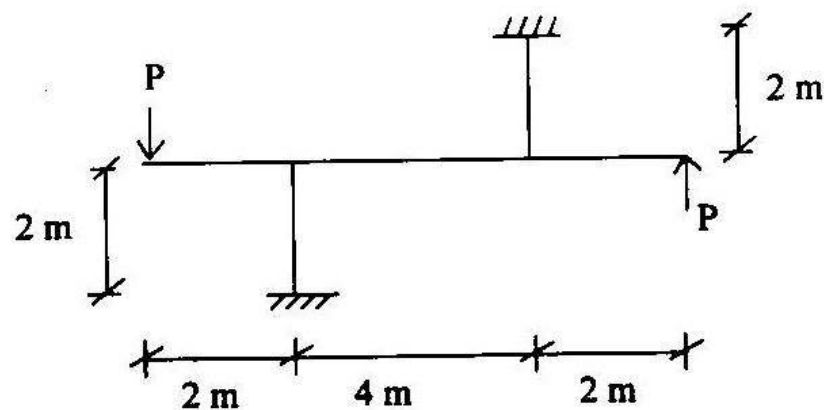
- (i) An aluminium shaft with a constant diameter of 50 mm is loaded by torques applied to gears attached to it as shown in Figure below. Using  $G = 28 \text{ GPa}$ , determine the relative angle of twist of gear D relative to gear A.

4



- (j) Sketch the elastic curve for the frame as shown.

4



(Contd.)

4

2. (a) A site is using a concrete where the unit content of water, cement, sand and coarse aggregate is  $180 \text{ kg/m}^3$ ,  $360 \text{ kg/m}^3$ ,  $700 \text{ kg/m}^3$  and  $1210 \text{ kg/m}^3$ , respectively. For a portion of the work, the Engineer permits volume batching and rectangular boxes measuring 35 cm by 45 cm have to be fabricated to measure coarse aggregate.

Assume the following :

- (i) The mixer available will mix concrete with one bag of cement (of 50 kg) at one time.
- (ii) 2 (two) boxes of coarse aggregate will be used in a batch (as defined above).
- (iii) When filled in a normal manner, the void content in the box is 40%.
- (iv) Specific gravity of the coarse aggregate is 2.75.

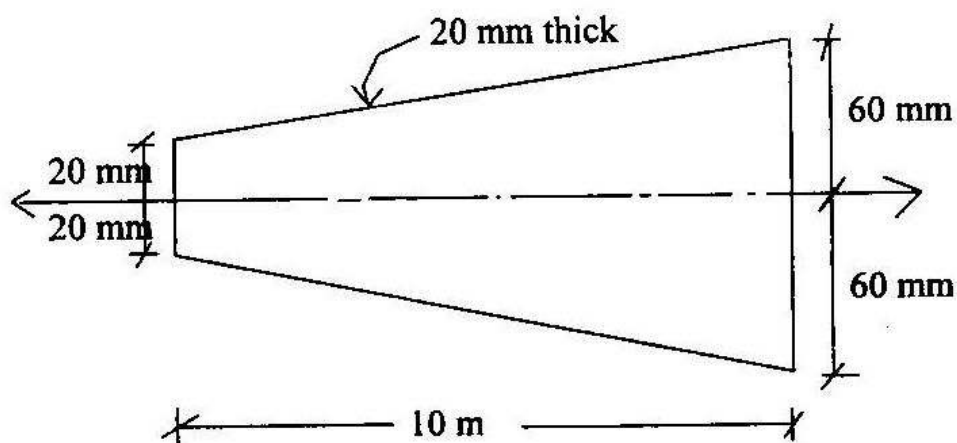
Find the height of the box. 10

- (b) Corrosion of reinforcement in reinforced concrete construction is matter of serious concern to civil engineers. List and briefly discuss some of the provisions made in codes (such as IS 456-2000) to address this problem during the design and construction of structures likely to be subjected to such deterioration. 10

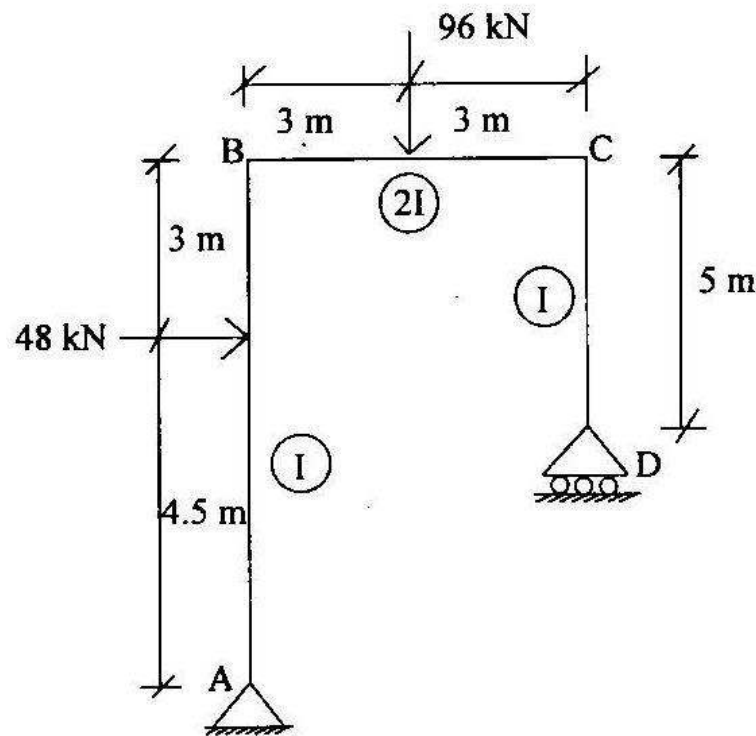
- (c) Write a short answer to the following : 20

- (i) When testing cements as per Indian Standards, it may not be possible to decide on their quality only on the basis of the compressive strength results. Why ?

- (ii) What are some of the steps that can be taken to prevent the formation of 'thermal cracks' in mass concrete ?
- (iii) Explain the concept of 'maturity' of concrete.
- (iv) IS 456-2000 suggests use of a certain stress-strain curve of concrete in the absence of actual experimental data. The code also allows use of an expression ( $5000 \sqrt{f_{ck}}$ ) to estimate the modulus of elasticity of concrete ( $E_c$ ). Draw a neat representation of that curve, briefly explain its salient features. The suggested value represents the value of  $E$  at which, if any, of the point(s) on the stress-strain curve.
3. (a) Compute the total elongation caused by an axial load of 100 kN applied to a flat bar 20 mm thick, tapering from a width of 120 mm to 40 mm in a length of 10 m as shown in figure. Assume  $E = 200$  GPa. 20



- (b) For the rigid frame shown in figure below, find by unit load method, the slopes and deflections at A and C. 20



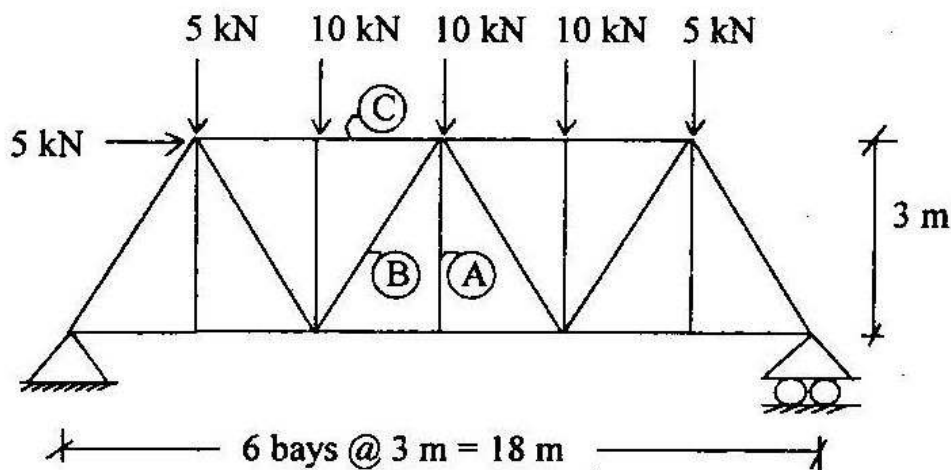
4. (a) Design a suitable section for steel plate beam girder carrying a uniformly distributed load of 60 kN/m (including self weight) over an effective span of 15 m. Check for shear and deflection also. Use limit state method of design. Use ISWB 600 @ 145.1 kg f/m with  $I_{xx} = 106198.5 \text{ cm}^4$  and  $I_{yy} = 4702.5 \text{ cm}^4$ . 20
- (b) A 5 m effective span simply supported beam is subjected to a load of 40 kN/m including its self weight. The size of the beam is 250 mm  $\times$  500 mm. The beam is reinforced with 4—20  $\Phi$  at bottom

(out of which two bars are curtailed) and 2—12  $\Phi$  at top. Design the beam against shear force and show the reinforcement details. Use M20 and Fe415. Use limit state method of design.

% tension steel	0.15	0.25	0.5	0.75	1.0
$\tau_c$ (MPa)	0.28	0.36	0.48	0.56	0.62
% tension steel	1.25	1.5	2.0	2.5	3 & above
$\tau_c$ (MPa)	0.67	0.72	0.79	0.82	0.82

20

5. (a) Find the member forces in the member marked A, B and C for the truss as shown. 10

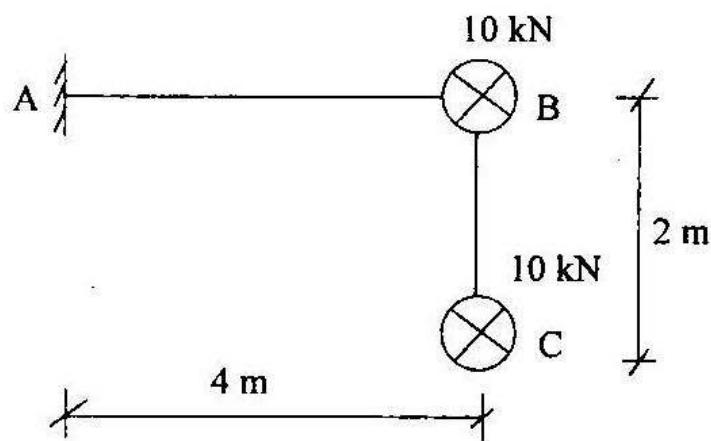


- (b) A rigid bent ABC is of uniform cross-section and is in a horizontal plane. It is fixed at A and free at C as shown in Fig. It carries two vertical loads



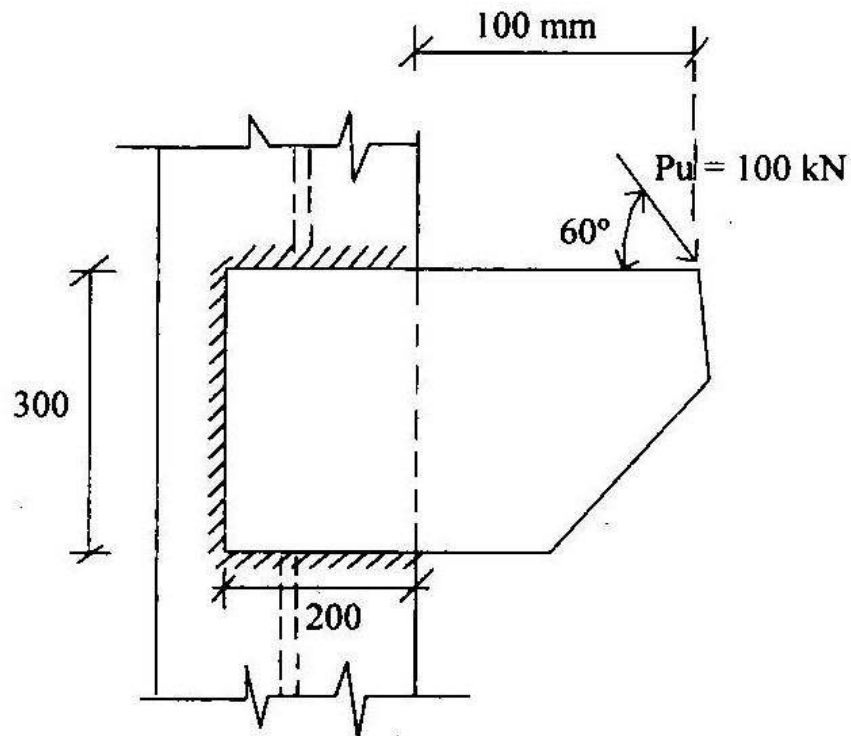
10 kN each at B and C. Draw Bending moment, shear force and torsional moment in the bent.

10

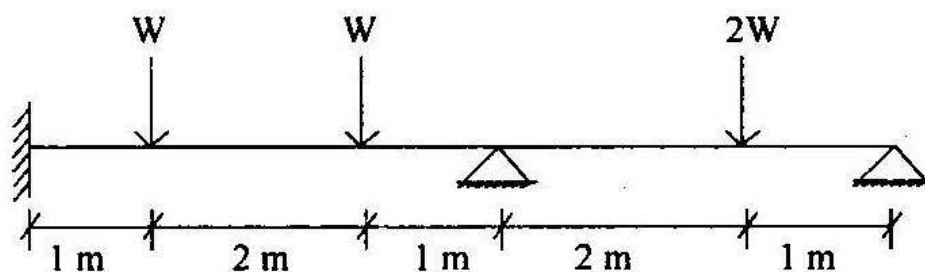


- (c) A plate is connected to the flange of an ISMB as shown. The factored load is 100 kN. Find the size of the weld. Assume shop weld and ultimate strength of weld as 410 MPa.

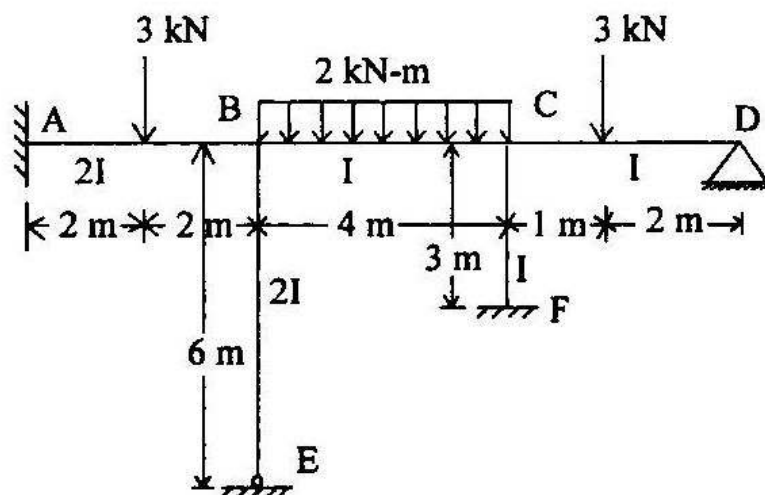
20



6. (a) A concrete beam simply supported at both ends with a rectangular section  $300 \text{ mm} \times 600 \text{ mm}$  is prestressed by 2 post tensioned cables of area  $500 \text{ mm}^2$  each. The cables are located at a constant eccentricity of  $100 \text{ mm}$  throughout the beam of span  $8 \text{ m}$ . The cables are stressed to  $1600 \text{ MPa}$  initially. Calculate the deflection of the beam (maximum) when it carries an imposed load of  $20 \text{ kN/m}$  allowing  $20\%$  loss in prestress. Assume the modulus of elasticity of concrete and steel are  $30000 \text{ MPa}$  and  $2 \times 10^5 \text{ MPa}$  respectively. Neglect the effect of shrinkage and creep. 10
- (b) Determine the collapse load of the beam as shown below.  $EI = \text{constant}$ . 10



- (c) Find the end moments of the frame shown below. Use Moment Distribution method. Also draw BMD. 20



7. (a) In a small project, three activities, A, B and C, are on the critical path. Their optimistic, most likely and pessimistic time durations (weeks) is given below :

Activity	Optimistic duration	Most likely duration	Pessimistic duration
A	6	8	11
B	4	6	8
C	11	15	18

Assuming that the non-critical activities are completed within that time :

- (i) What is the probability that the project can be completed in 29 weeks ?
- (ii) What is the probability that the project can be completed in 27 weeks ?

For a probability of 10%, 20% and 30% the Z values may be taken to be 1.26, 0.84 and 0.53, respectively. 10

- (b) Safety precautions to be taken at a construction site are related to the nature of the construction activity. Discuss this statement with appropriate examples. 10
- (c) As part of routine quality control, a sample of three cubes is taken from a site using M30 concrete. The cubes are appropriately cured and tested for

their compressive strength. The values obtained for the three cubes are : 31 MPa, 28 MPa and 28 MPa.

Based on the provision of IS 456-2000, answer the following :

- (i) Does the above constitute a valid set of results from the point of view of acceptance ? Justify your answer.
- (ii) Is the concrete represented by the results acceptable ? Clearly indicate if any additional information may be needed before a final decision on acceptance is made. 10
- (d) Explain with appropriate sketches how a 'tremie' is used to place concrete underwater. 5
- (e) Explain briefly the highlighted terms in the following sentence. (not more than 20 words)  
The contractor and the client agreed to send the matter for **arbitration**.

**OR**

The contractor was informed that the plea of **force majeure** for the delay in the completion was not acceptable. 5

Sl. No.

A-FRF-M-BUB

**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.*

*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.*

*Any pages left blank in the answer book must be clearly struck out.*

*A detachable semi-log graph sheet is attached to this question paper for use. Fasten it securely to your answer-book(s).*

1. (a) The velocity distribution for flow over a plate is given by

$$u = 2y - y^2$$

in which  $u$  is the velocity in  $\text{ms}^{-1}$  at a distance  $y$  metres from the plate. Determine the shear stress in  $\text{Nm}^{-2}$  at the boundary and at 0.2 m from it. Dynamic viscosity of fluid is  $0.9 \text{ Ns/m}^2$ .

4

- (b) Define

(i) shape number

(ii) NPSH in pumps

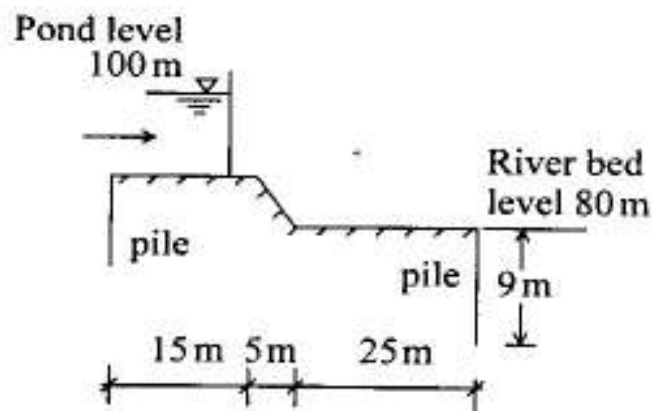
Describe the occurrence of cavitation in propeller turbine or Kaplan turbine.

4

- (c) A 12-hour rainfall with uniform intensity of  $4 \text{ cm/hr}$  produces a storm hydrograph of peak discharge  $1000 \text{ m}^3/\text{s}$ . The abstractions of rainfall is at the rate of  $1 \text{ cm/hr}$  and base flow is  $30 \text{ m}^3/\text{s}$ . Compute the peak discharge of 12-hr unit hydrograph.

4

- (d)



Check the safety of a barrage shown above against the piping action. The safe exit gradient is  $\frac{1}{5}$ .

4

(e) What are the sources and impact of hardness in water supplies? Also mention standard of hardness in water supply. 4

(f) Discuss thermal stratification and its importance in temperature of lakes. 4

(g) The mass of saturated soil sample is 150 gm and its mass when oven dried is 90 gm, find the water content. Suppose that the sample, used for triaxial test, has a diameter of 38 mm and the height of 76 mm, find the void ratio. 4

(h) A circular concrete pier of 3 m diameter carries a gross load of 3500 kN. The supporting soil is a clayey sand having the following properties :

$C = 5 \text{ kN/m}^2$ ,  $\phi = 30^\circ$  and  $\gamma = 18.5 \text{ kN/m}^3$ . Find the depth at which the pier is to be located such that a factor of safety of 3.0 is assured. The bearing capacity factor for  $\phi = 30^\circ$  are  $N_c = 30.1$ ,  $N_q = 18.4$  and  $N_r = 22.4$ . 4

(i) Calculate the Sun's Azimuth and Hour Angle at sunset at a place in Latitude  $40^\circ \text{ N}$ , when its declination is  $20^\circ \text{ N}$ . 4

(j) Sketch a typical cross-section of a runway and taxiway. Explain the importance of drainage of Airport. 4

2. (a) A new 5 km long pipeline connects two reservoirs. The water surface elevation of the upper reservoir is 1100 m and that of the lower reservoir is 835 m. The pipeline is 400 mm nominal diameter of welded steel (Hazen Williams Coefficient  $C = 130$ ) with a square mouth inlet (14.32 m long) and including the following fittings :

1. Gate valves	10 numbers	Each gate valve of equivalent length	0.98 m
2. Standard radius 90° elbow	19 numbers	Each elbow of equivalent length	6.4 m
3. Standard radius 45° elbow	37 numbers	Each elbow of equivalent length	4.57 m
4. Straight Tees	8 numbers	Each Tee length	2.19 m

What is the water flow rate between the reservoirs ? Use the concept of equivalent pipe.

$$\text{Given } h_f = \frac{10.7 Q^{1.85} L}{C^{1.85} D^{4.87}} \quad 8$$



- (b) Rainfall over a basin in three consecutive hours are 4 cm, 5 cm and 3 cm respectively. Estimate the surface runoff from the basin assuming negligible surface retention and evaporation losses. The infiltration loss can be estimated using the following Horton's equation

$$f = 1.2 + 4.2e^{-2.5t}$$

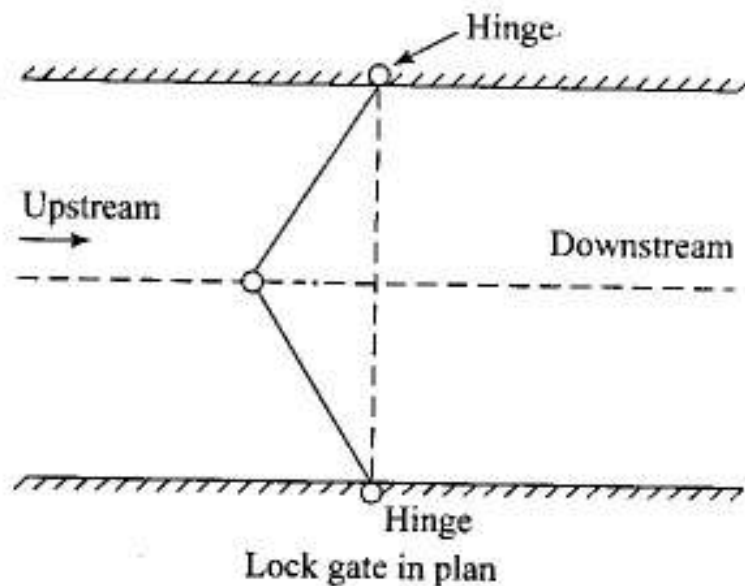
Here  $f$  = infiltration in cm/hr and  $t$  = time in hour from start of rainfall. 8

- (c) Why a circular section is most widely adopted for sewer pipes? Discuss the hydraulic characteristics of circular sewer sections running partially full. 8
- (d) (i) An earth dam is built on an impervious foundation with a horizontal filter at the base near the toe. The permeability of the soil in the horizontal and vertical directions are  $3 \times 10^{-2}$  mm/sec and  $1 \times 10^{-2}$  mm/sec respectively. The full reservoir level is 30 m above the filter. A flow net constructed for the transformed section of the dam, consists of 4 flow channels and 16 head drops. Estimate the seepage loss per metre length of the dam. 4
- (ii) For a flexible foundation with sides 2 m and 3 m and an axial load of 750 kN, determine the elastic settlement under one of the corners. The soil has properties  $\nu = 0.37$  and  $E = 9.8$  MPa. 4

- (e) (i) Calculate the safe stopping distance for a vehicle travelling at 90 kmph, on an upward gradient of 3 per cent, given total reaction time is 2.5 seconds and the coefficient of friction for the road surface as 0.35. 4

- (ii) Discuss the cause and effects of "Creep of Rails". 4

3. (a)



The gates of lock are 5 m wide by 6 m and when closed, at an angle of  $120^\circ$ . Each gate is held on by two hinges placed at the top and bottom of the gate.

If the water levels are 6 m and 4.5 m on the upstream and downstream sides respectively, determine the magnitude of the forces on the hinges due to the water pressure. 20

- (b) A trapezoidal channel (slope = 0.006,  $n = 0.014$ ) has a bed width of 4 m and is with a side slope of 1 : 2 (V : H). The flow rate is  $100 \text{ m}^3\text{s}^{-1}$ . At a particular point canal confluences with a stream of 3.5 m depth. The invert elevations of the stream and the canal are same.

Determine whether the flow in the channel is subcritical or supercritical flow.

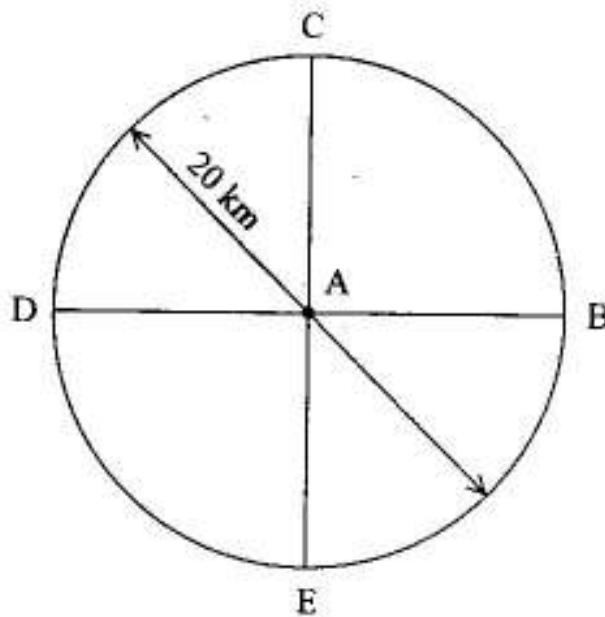
What is the type of control the stream represents the channel ? 20

4. (a) (i) The velocity distribution in a stream is generally governed by one by seventh

law, i.e.  $\frac{V}{V_0} = \left( \frac{Y}{Y_0} \right)^{\frac{1}{7}}$ , where  $V$  and  $V_0$  are

point velocities at heights  $Y$  and  $Y_0$  from the stream bed. Show that point velocity at 0.6 depth from free surface is equal to average velocity. 5

(ii)



Five rain-gauge stations namely A, B, C, D and E are located on a circular shape basin of diameter 20 km as shown in the above figure. Compute the mean areal rainfall over the basin using Thiessen Polygon method, if the rainfall at stations A, B, C, D and E are 100 cm, 90 cm, 110 cm, 120 cm and 80 cm, respectively.

5

- (b) An overflow ogee spillway has six bays each of 8 m clear length and five rounded nose piers ( $K_p = 0.01$ ) each of 2.5 m thick. Both the abutments are sharp edged ( $K_a = 0.2$ ). The upstream face of the spillway is vertical. Compute the discharge that will pass over the spillway at the design head,  $H_d = 3$  m. The discharge coefficient for design head  $C_o = 2.1$ .

Also compute the passing discharge over spillway for head over the crest  $H = 3.45$  m. Neglect the approach velocity to the spillway. Discharge coefficients for head other than design head are given below :

$H/H_d$	$C/C_o$
0.6	0.94
0.85	0.98
1.15	1.02
1.50	1.06

$C$  is discharge coefficient for head  $H$ . 10

- (c) (i) Derive the following Lacey's regime equations

$$V = \left[ \frac{Qf^2}{140} \right]^{\frac{1}{6}}$$

$$\text{and } P = 4.75\sqrt{Q}$$

with the use of following basic equations of Lacey

$$V = \sqrt{\frac{2}{5}fR}$$

$$Af^2 = 140 V^5$$

Here  $V$  = velocity;

$Q$  = discharge;

$f$  = silt factor;

$P$  = wetted perimeter; and

$R$  = hydraulic mean radius. 10

- (ii) Annual maximum flood data in a river at a station have been processed to estimate the maximum flood for different return periods using the Gumbel's method. If the estimated maximum flood for return periods 100 and 50 years are  $450 \text{ m}^3/\text{s}$  and  $400 \text{ m}^3/\text{s}$ , respectively, estimate the flood discharge for return period of 500 years. 10

5. (a) (i) Discuss various methods of landfilling and its operation. Also discuss control of gas movement and leachate movement in landfill sites. 10

- (ii) What are various secondary air pollutants? Discuss sources, origin and hazardous effect of sulphur dioxide and carbon monoxide on human body. 10

- (b) What is type I settling? How analysis of type I settling is done? Find the settling velocity of a discrete particle in water having diameter  $4 \times 10^{-3} \text{ cm}$  and specific gravity 2.65. Take kinematic viscosity of water =  $1.02 \times 10^{-2} \text{ cm}^2/\text{sec}$ . 10

- (c) What are different zones of pollution in river stream ? Explain the importance of reoxygenation, deoxygenation and oxygen deficit in problems of stream sanitation. 10

6. (a) A liquid limit test conducted on a soil sample in the cup device gave the following results :

Number of blows	10	19	23	27	40
Water content (%)	60.00	45.20	39.80	36.50	25.20

Two determinations for the plastic limit gave water content of 20.30% and 20.80%.

Determine

- the liquid limit and plastic limit
- the plasticity index
- the liquidity index if the natural water content is 27.40% and
- the void ratio at the liquid limit, if the sp. gravity,  $G_s = 2.7$ . If the soil were to be loaded to failure, would you expect a brittle failure ? 10

- (b) At a vertical stress of 200 kPa, the void ratio of a saturated soil sample tested in an oedometer is 1.52 and lies on the normal consolidation line. An increment of vertical stress of 150 kPa in the second stage compress the sample to a void ratio of 1.43.
- (i) Determine the compression index  $C_c$  of the soil.
  - (ii) The sample was unloaded to a vertical stress of 200 kPa and the void ratio increased to 1.45. Determine the slope of the recompression index  $C_r$ .
  - (iii) What is the over consolidation ratio of the soil at second stage ?
  - (iv) If the soil were reloaded to a vertical stress of 500 kPa, what void ratio would be attended ? 10
- (c) (i) High displacement concrete piles, 15 m long are to be installed in loose sand. The choice is between 450 mm square precast driven piles and 500 mm diameter driven cast in situ piles. Which type of pile should be used for (a) building that imposes a very small lateral load on the piles and (b) building that imposes high lateral load on the piles ? The two buildings apply the same axial load on the piles. Give the answer with suitable explanation. 10



- (ii) A cut is to be made in a soil that has  $\gamma = 16 \text{ kN/m}^3$ ,  $C' = 28 \text{ kN/m}^2$  and  $\phi' = 20^\circ$ . The side of the cut slope will make an angle of  $45^\circ$  with the horizontal. What should be the depth of the cut that will have a factor of safety  $F_s$  of 3.5 ? 10

7. (a) In a city property survey, following observations were made. Calculate the latitude, departures and closing error, prior to computation of the area enclosed in the traverse. Adjust the coordinates using Bowditch's Rule.

<i>Line</i>	<i>Length in m</i>	<i>Whole Circle Bearing</i>
AB	89.31	$45^\circ 10'$
BC	219.76	$72^\circ 05'$
CD	151.18	$161^\circ 52'$
DE	159.10	$228^\circ 43'$
EA	232.26	$300^\circ 42'$

10

- (b) (i) Determine the minimum non-passing sight distance that should be provided for a vehicle coming down a 6 per cent gradient, using the following data :

1. Design speed,  $V = 56$  kmph
2. Reaction time of the driver = 2 seconds
3. Coefficient of friction between Tyre and Road surface = 0.5.                      5

- (ii) A descending gradient of 1 in 30 meets an ascending gradient of 1 in 40 to form a valley curve. Find the length of the curve if the stopping sight distance is 120 m.                      5

- (c) Calculate the Maximum Permissible load that a B.G. steam locomotive with three pairs of driving wheels with axle load of 22 tons each, on a straight level track at a speed of 80 kmph.

Also calculate the reduction in speed, if the train has to run on a rising gradient of 1 in 200.

What would be the further reduction in speed, if the train has to negotiate a  $4^\circ$  curve on the rising gradient ?

Assume, coefficient of friction as 0.20.                      10

- (d) (i) What is a breakwater ? Classify different types of breakwaters. Under what condition a rubble mound breakwater is preferred ? 2
- (ii) Describe Beanfort Scale. 2
- (iii) What is dredging ? Classify different types of dredging work. 2
- (iv) What are navigational aids ? Why are they necessary ? 2
- (v) What is a dock ? Classify the docks and explain the purpose of each type. 2
-

