Q1. Design a three-span continuous beam of a typical interior idealized plane frame of a building. The frames are spaced 5.5m apart and in the typical floor 140mm thick continuous slab is cast monolithically with beams. The thickness of floor finish is 40mm. The beam has three equal spans of length 6.1m. The floor is to support imposed load of 5 kN/m² at the service state. The unit weight of the finishing material is 20 kN/m³. The materials to be used are M-20 grade concrete mix and HYSD steel of grade Fe-415 for moderate exposure conditions. Use bending moment and shear force coefficients for the continuous beam given in IS-456.

Q1’(a). Determine the design moments at support and in the mid span region, before and after redistribution of moments of 30%, for a beam AB of span L, carrying a uniformly distributed load, when (i) it is fixed at both ends A and B; (ii) it is fixed at end A and simply supported at B. Draw the bending moment diagrams in each case, and show the points of contra flexures and points of maximum bending moments.

Q1’(b). A special reinforced concrete moment resisting frame building with infill panels is situated in Delhi. Height of the building is 12m. The building is resting on medium soil. The base dimensions of building at plinth level is 24m. Determine the design horizontal seismic coefficient and vertical seismic coefficient for a damping of 5%.

Q1’(c) What are the advantages of Redistribution of Moments?

Q2. Design an R.C.C circular water tank resting on the ground with a flexible base and a spherical dome for storing 500,000 liters of water. The depth of storage is to be 4.0 m. Freeboard = 200 mm. Adopt M-20 grade concrete and Fe-415 HYSD bars. Sketch the details of reinforcements in the dome and tank walls.

Q2’. A rectangular R.C.C water tank with an open top is required to store 80,000 liters of water. The inside dimensions of the tank may be taken as 6m x 4m. The tank rests on walls on all the four sides. Design the side walls of the tank using M-20 grade concrete and Fe-415 IIYSD bars.
Q3. Design a slab culvert for span of 4.5m and clear carriageway width of 10m between kerbs suitable for a single vehicle of IRC class AA tracked vehicle. Use M-20 grade concrete and Fe-415 HYSID bars.

Q4(a). Discuss the following:

(i) Merits and demerits of prestressed concrete.
(ii) Pre-tensioning and post-tensioning system with neat sketch.

Q4(b). A beam of 150mm x 300mm is prestressed by a force of 250 kN by steel cables located at an eccentricity of 60mm as shown in Fig.1. Determine the loss of prestress due to creep of concrete for the following data:

\[ \sigma_{ck} = 45 \text{ N/mm}^2; \] \[ \text{cables} = 6 \text{ Nos. - 7mm } \Phi; \text{ creep coefficient} = 2; E_s = 200 \text{ kN/mm}^2 \text{ and } E_c = 30190 \text{ N/mm}^2. \]

Q5. Design the staircase slab as shown in Fig.2. The stairs are simply supported on beams provided at the first riser and at the edge of the upper landing. Assume a finish load of 0.8 kN/m² and a live load of 5.0 kN/m². Use M-20 grade concrete and Fe-415 steel bars. Assume mild exposure conditions.

OR

Q5.' Design the toe slab of a cantilever retaining wall to retain an earth embankment 4m high above ground level. The density of earth is 18 kN/m³ and its angle of repose is 30°. The embankment is horizontal at top. The safe bearing capacity of the soil may be taken as 200 kN/m² and the coefficient of friction between soil and concrete is 0.5. Adopt M-20 grade concrete and Fe-415 HYSID bars.

(Fig. Enclosed)
**FIGURES**

**FIG. 1.**

**FIG. 2.**

*Note: All dimensions are in mm*
Answer all questions
Assume suitable data, if not given

Q: 1a What do you understand by the active and the passive earth pressure on retaining wall? Explain Resal and Bell theory of earth pressure and derive a relation for critical height of unsupported vertical cut.

Q: 1b Determine the magnitude and position of point of application of active thrust on the retaining wall as shown in Fig. 1.

(OR)

Q: 1’ a Briefly explain the design procedure for cantilever and anchored sheet pile walls and sketch the pressure distribution diagrams showing point of applications of active and passive thrust.

Q: 1’ b A 6.0m high retaining wall retains a soil with the following properties:

\[ c = 0.0 \text{ kPa}, \phi = 30^\circ, \gamma = 21 \text{ kN/m}^3 \] and \[ 
\delta = 20^\circ \]

The back side of wall is inclined at an angle of 15° with vertical and the backfill surface is sloping at an angle of 10° with horizontal.

(i) Determine the total active thrust by Culmann's graphical construction.

(ii) Find the position of critical slip plane.

Q: 2a Define slope failure and its various types. Explain friction circle method of stability analysis of slopes in detail.

Q: 2b Calculate the factor of safety against shear failure along the slip circle shown in Fig.2. Assume cohesion = 40 kN/m², angle of friction is zero, and bulk unit weight is 20 kN/m³.

Q: 3a Explain briefly standard penetration test for determining bearing capacity of foundation soil.

Q: 3b Calculate the ultimate bearing capacity of

i) Strip footing 1m wide at a depth of 1.0m.

ii) Square footing 2.5m × 2.5m at a depth of 3.0m.

iii) Circular footing of 3.0m diameter.

(Take unit weight of soil as 18 KN/m³, cohesion, c = 20 KN/m²,
For \( \phi = 20^\circ \), \( N_c = 17.5 \), \( N_q = 7.5 \) and \( N_y = 5 \))
Q: 4a  What are the various types of pile foundations? What type of foundation would you recommend for multi-storeyed building structures on black cotton soil? Explain briefly.

Q: 4b  A pile group of 16 piles is arranged in a square pattern @ 1.25 m c/c. The piles are circular in section, having 400 mm dia. each. If the unconfined compressive strength of soil is 160 kN/m², determine if the failure would occur by a single pile failure, or as a block. All the piles are 12m long. Take $\alpha = 0.65$ and F.O.S = 3.0. Also find out the safe load on the pile group.

(OR)

Q: 4'a  What do you understand by disturbed, undisturbed and non representative soil samples? Also discuss the uses to which soil samples can be put to, respectively.

Q: 4'b  Briefly explain the dynamic load empirical formulae for load carrying capacity of piles.
Using Engineering News Formula, determine the safe design load on a pile given that the weight of drop hammer is 25 kN and penetration of pile under the last blow of the hammer is 7.5 mm. Also find out the safe design load for same data for another pile if steam hammer is used. Height of drop hammer in both cases is 50 mm.

Q: 5a  Why is vibration isolation required? Discuss the design criteria for machine foundation and describe the degree of freedom for machine foundation block.

Q: 5b  The equation of motion in SI units for a machine foundation-soil system is as follows:

$$(6 \times 10^5) \frac{d^2z}{dt^2} + (2 \times 10^5) \frac{dz}{dt} + (1 \times 10^7) z = 0$$

(i) Undamped and damped natural frequency
(ii) Logarithmic decrement
(iii) Whether the system is under damped, over damped or critically damped
(iv) Number of cycles elapsed for 75% reduction in amplitude.
1. Analyze the frame shown in Fig. 1 using Kani's method. The variation in the geometrical moment of inertia is shown in figure; $E$ is same for all the members.

![Diagram of a frame with loads and dimensions]

Fig. 1

OR

1'. Analyze the sway frame shown in Fig. 2 using Portal method. $EI$ is same for all the members.

![Diagram of a sway frame with loads and dimensions]

Fig. 2
2. (a) Define stiffness and flexibility coefficient with the help of single and two coordinate systems. (04)
(b) Analyze the continuous beam shown in Fig. 3 using stiffness method. $E'$ is constant. Neglect freedom at D. (08)

![Fig. 3](image)

3. Analyze the frame shown in Fig. 4 using flexibility method. The variation in the geometrical moment of inertia is shown in figure; $E$ is same for all the members. (12)

![Fig. 4](image)

4. A beam ACB, 7 m long is fixed at A and simply supported at B. The beam is provided with an internal hinge at C, 4 m from A. Draw the Influence line diagram for
(i) Vertical reaction at A
(ii) Vertical reaction at B
(iii) Bending moment at A
(iv) Bending moment at D, the middle point of AC
(v) Bending moment at E, 2 m from B

OR

4'. (a) A live load of 20 kN/m, 6 m long moves on a simply supported girder of 20 m span from left to right. Find the maximum negative and positive shear that can occur at a section 8 m from the left end. (05)
(b) A girder 24 m long has supports 20 m apart with an overhang of 1 m over the left support and 3 m over the right support. Find the maximum positive and negative bending moment at a section 8 m from the left support due to a live load of 20 kN/m. (06)
5. Draw the influence line diagram (ILD) for the member forces in the members 1, 2, 3 and 4 of the truss shown in Fig. 5.

Fig. 5

OR

5'. Calculate maximum radial shear and bending moment in an arch at a section 10 m from the left hand support having a span of 30 m and a rise of 6 m, when it is subjected to a rolling load of 120 kN, crossing the arch from one end to the other.
Maximum Marks : 60

Answer all the questions.

Each question carries equal marks.

Symbols used bear usual meanings

Assume suitable data if not supplied.

1(a) What are various sources of energy in nature. Compare wind energy with solar energy. Give two examples of power plants based on theses sources.

1(b) Differentiate among:

(i) Flow duration curve and power duration curve

(ii) Mass curve and flood hydrograph

(iii) Capacity factor and load factor

OR

1'(a) Draw the neat sketch of a very high head hydel scheme of India showing all its necessary components

1'(b) Following data have been observed for a river where a hydel scheme is to be proposed.

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan.</th>
<th>Feb.</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q(m³/s)</td>
<td>47</td>
<td>35</td>
<td>32</td>
<td>28</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>Q(m³/s)</td>
<td>200</td>
<td>180</td>
<td>145</td>
<td>98</td>
<td>89</td>
<td>44</td>
</tr>
</tbody>
</table>
Taking efficiency as 85%, effective head 70 m and unit weight of water 9810 N/m³, find:

(i) Firm power

(ii) Minimum flow in river

(iii) \( P_{50} \) and \( P_{75} \)  \( \text{(10)} \)

2(a) List out various types of intakes. Briefly explain tower intake \( \text{(6)} \)

2(b) What are the functions of draft tubes? How the efficiency of a draft tube is defined? \( \text{(4)} \)

2(c) Classify the tunnels based on their shapes.

OR

2'(a) How penstocks are classified? Using various empirical formulae, calculate the diameter of the penstock. Effective head = 45 m, discharge = 10 m³/s. Assume other data \( \text{(8)} \)

2'(b) Explain the phenomena of cavitation in pumps and turbines. \( \text{(7)} \)

3. What is a surge tank? Draw the neat sketch of any type of surge tank. Taking usual notations, develop the expressions for up and down surges and time of oscillation. \( \text{(15)} \)

OR

3' Explain the phenomena of water hammer in penstocks. Discuss the rigid water column theory and list out all its assumptions. \( \text{(15)} \)

4. Write short notes on three of the following: \( \text{(15)} \)

(i) Dimensioning of power houses

(ii) Losses in intakes

(iii) Elastic column theory

(iv) Specific speed of turbines

(v) Setting of turbines
Answer all questions
Assume suitable data, if not given

Q: 1a  Briefly explain the CBR method of pavement design and discuss its advantages and limitations. (07)

Q: 1b  Design the pavement section by triaxial test method for the following data:

(i)  Wheel load = 5100 kg
(ii) Radius of contact area = 15 cm
(iii) Traffic coefficient, \(X = 1.65\)
(iv) Rainfall coefficient, \(Y = 0.85\)
(v)  Design deflection, \(\Delta = 0.30\) cm
(vi) E-Value of subgrade soil, \(F_s = 175\) kg/cm²
(vii) E-value of base course material, \(E_b = 700\) kg/cm²
E-value of 8.5 cm thick bituminous concrete surface course = 1000 kg/cm²  (08)

Q: 1'  Explain any three of the following:

(i) Flexible and Rigid Pavement  (ii) McLeod Method of Pavement Design
(iii) Design Wheel Load  (iv) Westergaard's concept of temperature stresses
(v) Critical combination of stresses in CC Pavement  (OR) (5×3)

Q: 2a  What are the special points to be considered in the alignment of hill road? Specify the details of geometric design and standards of hill roads including hair pin bends. (7.5)

Q: 2b  Write short notes on any three of the following:
(i) Rock cutting  (ii) Precipice work  (iii) Resisting length  (iv) Revetment wall

Q: 3a  Discuss the importance and requirements of a good drainage system.  (08)

Q: 3b  Discuss the design approach for surface drainage system of highway.  (07)

Q: 4a  Briefly explain the maintenance works of bituminous surfacing.  (05)

Q: 4b  What are the various types of failures in flexible and rigid pavements? Discuss and show the general pattern of failures of the following.
(i) Alligator cracking  (ii) Frost cracking  (iii) Mud pumping

(OR)

Q: 4'a  Explain the principle and uses of Benkelman Beam test  (05)

Q: 4'b  Explain the necessity of design approach and method of strengthening of existing pavements for the Flexible overlay over rigid pavement  (10)