CIVIL ENGINEERING
Paper – I

*Time Allowed : **Three** Hours*

*Maximum Marks : **200***

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.*

*Questions no. **1** and **5** are **compulsory**. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections A and B.*

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

*Answers must be written in **ENGLISH** only.*

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

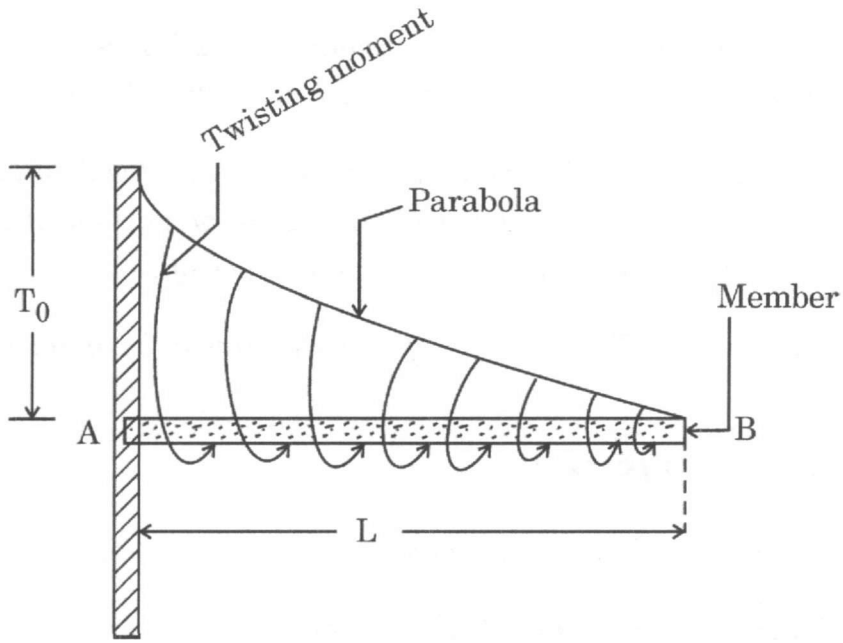
Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

SECTION A

Q1. (a) A uniform ladder rests against a rough vertical wall with its lower end on a rough horizontal floor, the ladder being inclined at 45° to the horizontal. The coefficient of friction between the ladder and the wall is $\frac{1}{3}$ and that between the ladder and the floor is $\frac{1}{2}$. A man whose weight equals one-half of that of the ladder ascends up the ladder till the ladder slips. Determine what length of the ladder the man will be able to ascend before the ladder commences to slip. *8*

(b) A member of circular cross-section is clamped at one end, free at the other and loaded by a twisting moment distributed parabolically along the length as shown in the figure below. The torsional rigidity of the member is (GJ) and the twisting moment intensity at the clamped end is T_0. Find the angle of twist of the free end of the member. *8*



(c) A quarter elliptical leaf spring has a length 600 mm and consists of plates each 50 mm wide and 6 mm thick.

(i) Determine the least number of plates which can be used if the deflection under a gradually applied load of 1·8 kN is not to exceed 80 mm.

(ii) If the load of 1·8 kN, falls from a height of 6 mm on the undeflected spring, find maximum deflection and stress produced. Take E = 200 GPa. *8*

(d) Design a butt joint to connect two plates 260 × 12 mm (f_y = 250 MPa) using ordinary M20 bolts. Arrange the bolts to give maximum efficiency. *8*

(e) A rectangular beam spanning 8·0 m is loaded as shown in the figure below. Design the beam for maximum shear force if the cross-section is 230 mm in width and 365 mm effective depth with four bars of 20 mm diameter as main reinforcement. Design the shear reinforcement considering the maximum shear force occurring in the beam. Consider M25 grade concrete and steel of grade Fe415. *8*

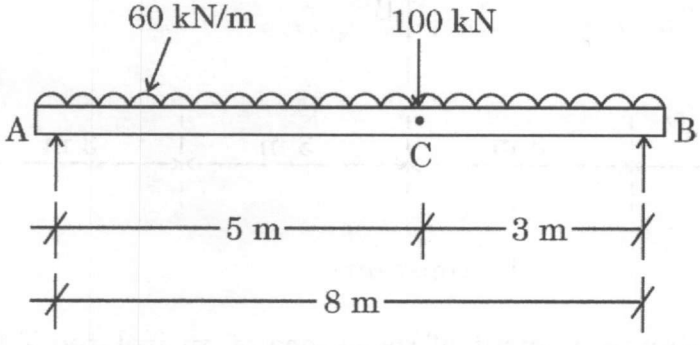
Table :

Permissible shear stress in concrete (τ_c) for M25 grade.

P_t	Permissible Stress
1·46	0·736
1·48	0·739
1·50	0·743
1·52	0·746
1·54	0·749

Maximum Shear Stress ($\tau_{c\ max}$)

Concrete Grade	M25
$\tau_{c\ max}$ (MPa)	3·10



Beam loading

Q2. (a) A particle is projected so as to just clear two walls. The first one is of height h_1 and at a distance of h_2 from the point of projection. The second one is of height h_2 and at a distance of h_1 from the point of projection. If h_1 is greater than h_2, find the angle of projection and horizontal range. *15*

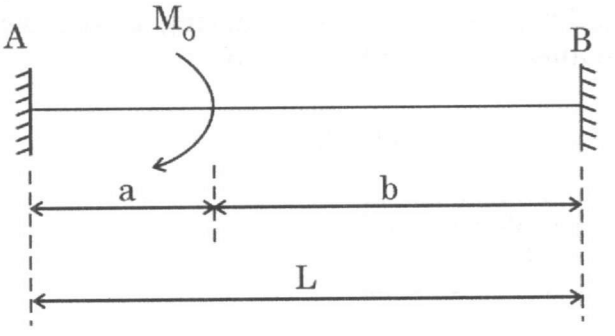
(b) Design a two-way slab for a room 5·0 m × 4·0 m clear in size if the superimposed load is 4 kN/m^2. Use M20 mix and Fe415 grade steel. The side edges are simply supported and corners not held down.

Table :

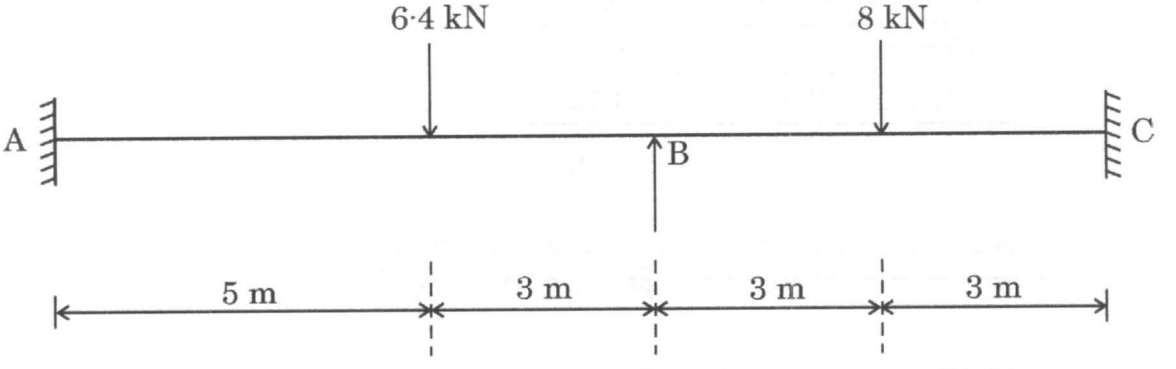
Bending moment coefficients for two-way slab (simply supported on four sides) *15*

l_y/l_x	1·2	1·3	1·4	1·5
α_x	0·084	0·093	0·099	0·104
α_y	0·059	0·055	0·051	0·046

(c) Determine the fixed end moments for the beam shown in the figure by column analogy method. *10*

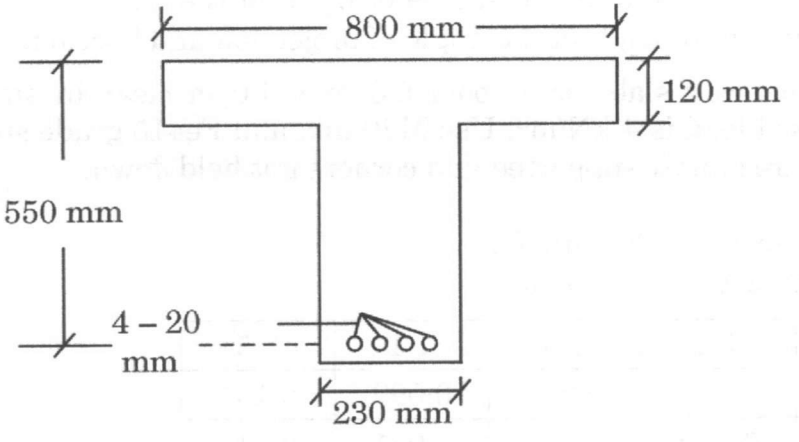


Q3. (a) Analyse the continuous beam shown in the figure by stiffness matrix method. Also draw the bending moment diagram. *15*



(EI = constant)

(b) Determine the ultimate moment of resistance of an isolated T beam of span 5·0 m and cross-sectional dimensions as shown in the figure. Assume f_{ck} = 20 MPa and f_y = 415 MPa. *15*



(c) Check the adequacy of ISLB 200 @ 194·2 N/m (Z_{xx} = 169·7 × 10^3 mm^3) when used as a simply supported steel joist with an effective span of 4·20 m. It carries a uniformly distributed load of 35 kN/m over its span inclusive of self-weight. The beam is supported laterally throughout. (f_y = 250 MPa). *10*

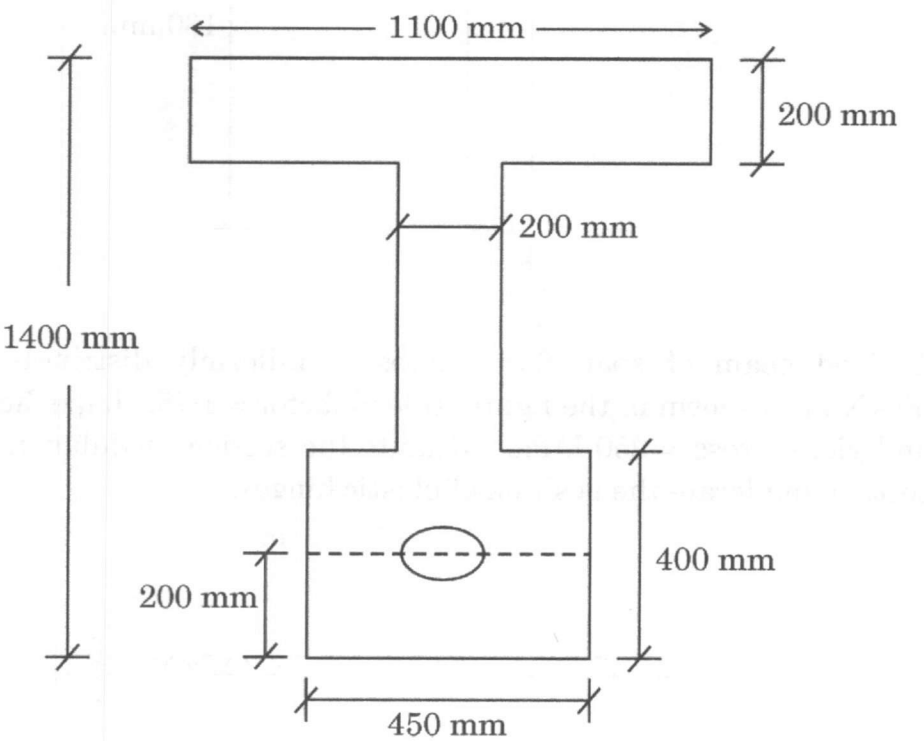
ISLB 200 properties :

D = 200 mm Z_{xx} = 169·7 × 10^3 mm^3

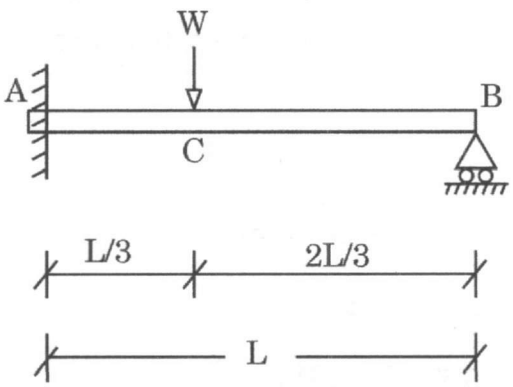
T = 7·3 mm h_2 = 17·15 mm

t = 5·4 mm I_{xx} = 1696·6 × 10^4 mm^4

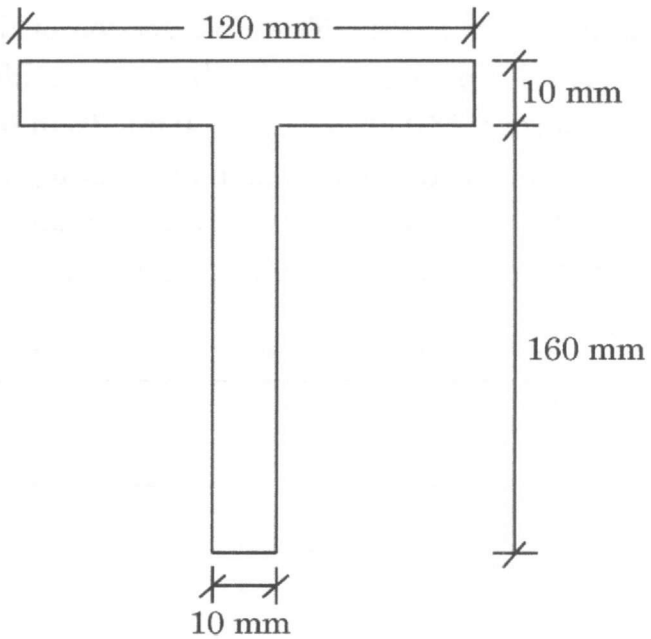
Q4. (a) A prestressed concrete bridge deck comprises unsymmetrical I section beam spanning over 18·0 m. The cross-section of the beam is shown in the figure. The beam is prestressed by seven cables, each carrying an effective prestress of 550 kN located 200 mm from the soffit at the centre of the span section. If the total maximum bending moment at the centre of the span of the girder is 3400 kNm, estimate the resultant stress developed at the section using internal resisting couple method. *15*



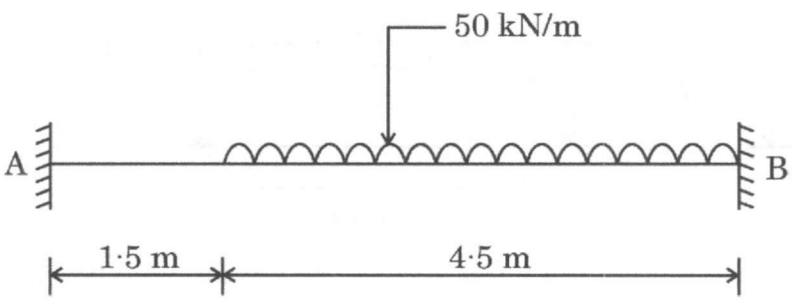
(b) (i) A uniform beam of plastic moment capacity M_P fixed at one end and simply supported at the other, carries a load W at middle third point as shown in the figure. Determine the ultimate load. *5*



(ii) Find the shape factor of a Tee section with a flange 120 × 10 mm and web 160 × 10 mm. *10*



(c) A fixed beam of span 6 m carries a uniformly distributed load of 50 kN/m as shown in the figure. If load factor = 1·75, shape factor = 1·15 and yield stress = 250 MPa, calculate the section modulus of the beam section and locate the position of plastic hinges. *10*



SECTION B

Q5. (a) A model turbine employs 2 m^3/s water flow when simulating a full scale prototype designed to be served by a 15 m^3/s flow. If the scale is $\frac{1}{5}$, calculate the speed ratio and the shaft-delivered power ratio. *8*

(b) A 4·0 m long, 4·0 m wide and 1·5 m high, above ground swimming pool is filled with water to the rim. If the density of water is 1000 kg/m^3 throughout, answer the following :

(i) What is the hydrostatic force on each wall and the distance of the line of action of this force from the bottom of the swimming pool ?

(ii) If the height of the walls of the pool is doubled and the pool is filled completely with water, will the hydrostatic force on each wall double or quadruple ? Why ? Show the calculations. *8*

(c) Air at 20°C and with a free stream velocity of 40 m/s flows past a smooth thin plate which is 3·0 m wide and 10·0 m long in the flow direction. Assuming a turbulent boundary layer from the leading edge, determine the shear stress and the boundary layer thickness 6·0 m from the leading edge. Take density of air as 1·2 kg/m^3 and kinematic viscosity as $1{\cdot}49 \times 10^{-5}$ m^2/s. The following shear stress formula may be used, if required :

$$\tau_o = 0{\cdot}029 \frac{\rho V^2}{(R_{ex})^{1/5}},$$

where R_{ex} is the Reynolds number at a distance x from the leading edge and V is the free stream velocity. *8*

(d) In order to determine the unit weight of a clay soil, an undisturbed sample was taken in a sampling tube of volume 0·001664 m^3.

The following data were obtained :

Mass of tube (empty) = 1·880 kg

Mass of tube and clay sample = 5·020 kg

Mass of tube and clay sample after drying = 4·320 kg

Calculate the moisture content, the bulk and dry unit weights. If the particle specific gravity is 2·69, determine the void ratio and degree of saturation of the clay. Assume unit weight of water, $\gamma_w = 9{\cdot}81$ kN/m^3. *8*

(e) A foundation trench is to be excavated in a stratum of stiff clay, 9 m thick, underlain by a bed of coarse sand. In a trial borehole, the groundwater was observed to rise to an elevation 3·0 m below the ground surface. Determine the depth up to which an excavation can safely be carried out without the danger of the bottom becoming unstable under the artesian pressure in the sand stratum. The specific gravity of clay particles is 2·72 and void ratio is 0·8.

If the excavation is to be carried out safely to a depth of 7·0 m, how much should the water table be lowered in the vicinity of the trench ? Assume unit weight of water, $\gamma_w = 9{\cdot}81$ kN/m^3. *8*

Q6. (a) A 500 mm diameter concrete pile, 15 m long is driven in a deep deposit of a uniform clay. Laboratory unconfined compression tests on undisturbed soil samples indicate an average unconfined compressive strength, q_u value of 80·0 kN/m^2. Determine the allowable load capacity of the pile with a factor of safety of 2·0. If 9 such piles are used in a square group with a spacing of 3 times the diameter of the pile, what will be the allowable capacity of the group based on individual pile failure criterion ? Assume adhesion factor $\alpha = 0{\cdot}8$. *15*

(b) Water flows over a 2 m high sharp-crested rectangular weir. The flow depth upstream of the weir is 3·0 m and water is discharged from the weir into an unfinished concrete very wide rectangular channel of equal width where uniform flow conditions are established. If no hydraulic jump is to occur in the downstream flow and Manning's rugosity coefficient for unfinished concrete (n) is 0·014, determine the maximum slope of the downstream channel. Take discharge coefficient of the weir as 0·643. *15*

(c) A square footing, 3 m × 3 m, rests on a dry sand and gravel stratum with the following physical properties : γ_t = 20 kN/m^3; ϕ = 35°; c = 0. If the base of the footing is at 2·5 m below the surface, determine the total load the footing could support with a safety factor of 4 via the Terzaghi's general bearing capacity equation. Given for ϕ = 35°, N_c = 57·8, N_q = 41·4 and N_γ = 42·4. Assume water location is at a great depth and its effect can be neglected. *10*

Q7. (a) An inward flow reaction turbine works under a total head of 25 m. The velocity of wheel periphery at inlet is 15 m/s. The outlet pipe of the turbine is 30 cm in diameter and the turbine is supplied with 275 litres per second of water. The radial velocity of flow through the wheel is same as velocity in the outlet pipe. Neglecting friction, determine (i) vane angle at inlet, (ii) guide vane angle, and (iii) power of turbine. *15*

(b) (i) How does surface roughness affect the pressure drop in a pipe if the flow is turbulent ? What would the response be if the flow were laminar ? *5*

(ii) Air and water are flowing through separate pipes of identical diameter, at the same temperature and mean velocity. Which of the two fluids is more likely to exhibit turbulent flow, and why ? *5*

(c) A compaction test was carried out on a soil sample as per Indian Standards (light compaction) and the following data were obtained :

Water content (%)	8·5	12·2	13·7	15·5	18·2	20·2
Mass of wet sample (kg)	1·80	1·94	2·0	2·05	2·03	1·98

If the specific gravity of soil grains was 2·7,

(i) Plot the compaction curve and obtain the maximum dry unit weight and the optimum moisture content.

(ii) Plot the 80% and 100% saturation line.

(iii) If it is proposed to secure a relative compaction of 95% in the field, what is the range of water content that can be allowed ? *15*

Q8. (a) An 8 m thick clay layer with single drainage settles by 120 mm in 2 years. The coefficient of consolidation for this clay was 6×10^{-3} cm^2/s. Calculate the likely ultimate consolidation settlement. Also determine how long it will take to undergo 90% of the ultimate settlement. The following given equations may be used : *15*

$$T = \frac{\pi}{4}\left(\frac{U\%}{100}\right)^2 \qquad U \leq 60\%$$

$$T = 1{\cdot}781 - 0{\cdot}933 \log_{10}(100 - U\%) \quad U > 60$$

(b) A 7·5 cm diameter jet having a velocity of 40 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Answer the following by taking density of water = 1000 kg/m^3 :

(i) What would be the normal force exerted on the plate when the plate is stationary ?

(ii) Calculate the normal force exerted on the plate when the plate is moving with a velocity of 15 m/s in the direction of jet, away from the jet.

(iii) Determine the power and efficiency of the system when the plate is moving with a velocity of 15 m/s in the direction of jet, away from the jet. *15*

(c) On a failure plane in a purely frictional mass of dry sand, the stresses at failure were : Shear 3·5 kN/m^2, Normal = 10·0 kN/m^2.

Determine the angle of shearing resistance of the soil and the angle of inclination of the failure plane to the major principal plane. Also determine the major and minor principal stresses. *10*