

CIVIL ENGINEERING
(Paper I)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. (a) A body of mass 1000 kg is acted upon by a force of 80 Newtons which increases uniformly until it becomes 100 Newtons in 4 minutes. If motion starts from rest in the direction of force, find the velocity of the body at the end of 3 minutes from the start and the distance traversed. 12
- (b) A steel rod of length 300 mm and diameter 30 mm, is subjected to a pull 'P' while the temperature is 100°C. If the total extension of the rod is 0.40 mm, calculate the magnitude of 'P'. Take 'α' for steel = 12×10^{-6} per °C and $E = 0.215 \times 10^{12}$ N/m². 12
- (c) If the velocity components of two-dimensional flow are
$$U_x = y^3/3 + 2x - x^2y$$
and
$$U_y = xy^2 - 2y - x^3/3$$
Obtain: (i) Stream function – ψ. (ii) Discharge passing between two points (2, 3) and (3, 4). 12
- (d) An open cylinder of 40 cm diameter and 90 cm height is with water level upto 40 cm. If the cylinder is rotated at 160 r.p.m. about its axis, calculate the pressure head (i) at the bottom of the cylinder at edge and (ii) at the centre of the cylinder at bottom. 12
- (e) A vertical rectangular gate is 3.0 m high and 2.0 m wide. It is hinged at the top. If the water is standing upto a depth of 1.5 m above the top edge of gate on one side, determine the force required at the lower edge of the gate so that gate remains closed.
[Figure: Vertical gate 3.0 m high with a hinge at its top edge; free water surface (∇) on the left side 1.5 m above the hinge; resultant water pressure force P acting horizontally on the gate from the water side (towards the right); force F (Force) applied horizontally at the lower edge of the gate acting towards the water side (to the left)] 12
2. (a) A railway truck is loaded so that the pressure on each wheel is 5500 kg weight and the centre of gravity of the loaded truck is 1.5 metres above the rails. The centre-to-centre distance of the wheels on an axle is 1.75 metres. Find the pressure on the inner and outer rails when the truck is going round a curve of 440 metres radius at 48 km/hour. $g = 9.8$ m/s². 30
- (b) A Kaplan turbine is working under a head of 75.0 m with a speed of 160 r.p.m. The rate of flow for the turbine is 200.0 m³/s. The diameter of the runner is 6.0 m and diameter of hub is 3.0 m. The turbine is developing 90000 kW power. Determine: (i) Flow ratio (ii) Speed ratio (iii) Specific speed (iv) Overall efficiency 15

- (c) A trapezoidal channel has a side slope of 1 : 1. It carries flow of $12.0 \text{ m}^3/\text{s}$ at a velocity of 2.0 m/s . It is to be designed as most economical cross-section. Calculate the area of concrete lining for 100.0 km long channel. 15
3. (a) Draw the Maximum Shear Force and Bending Moment diagrams for a girder of span 25.0 metres traversed by a load of 2.0 kN extended over a length of 6.0 metres. 15
- (b) A cast iron column of circular section of 20.0 cm external diameter and 2.0 cm thickness and of height 4.0 metres is required to carry 15.0 kN at an eccentricity of 2.5 cm . If both ends are fixed, find the extreme stresses in the column section. 15
- (c) A 2.0 m wide and 6.0 m long plate moves at a velocity of 1.75 m/s parallel to its length, through a stationary air of density 1.22 kg/m^3 and viscosity of $1.8 \times 10^{-5} \text{ Ns/m}^2$. Determine the drag force on one side of a plate assuming (i) Laminar flow boundary layer. (ii) Turbulent flow boundary layer. 15
- (d) Draw following water surface profiles of gradually varied flow, stating conditions justifying the types of profiles: (i) M_2 type profile (ii) S_1 type profile (iii) C_3 type profile (iv) A sluice gate in a channel with mild slope to supply water in a channel from reservoir 15
4. (a) A steel beam is of cross-section of right triangle of dimension 40 mm wide and 60 mm depth having yield point stress $Y=280 \text{ N/mm}^2$. Evaluate the Fully Plastic Moment for the condition that the neutral axis passes through point 'B' as shown in the figure below and divides the right triangle into two equal triangular parts. Assume that the plane of the load passes through the centroids of two triangles thus created.
- [Figure: Right-triangle cross-section ABC with the right angle at B: horizontal top edge AB = 40 mm , vertical right edge BC = 60 mm , hypotenuse AC. Centroidal axes x (horizontal) and y (vertical) intersect at the centroid O. The neutral axis n-n passes through B and O and meets the hypotenuse AC at D, dividing the section into two equal triangles: A_T (triangle ABD, upper left, tension, vertically hatched) and A_C (triangle BDC, lower right, compression, horizontally hatched). An inclined line through O, labelled "Plane of the Loads", runs from the top edge AB (between A and B) downwards to the right through O, passing to the right of C. Angles marked: α between the x-axis and the neutral axis n-n; ϕ between the x-axis and the plane of the loads; β between the y-axis and the plane of the loads] 30
- (b) If the velocity of the flow through orifice is dependent on diameter of orifice (D), head (H), and acceleration due to gravity (g), by using Buckingham's method, frame the equation of velocity through orifice. 15
- (c) Water is flowing through two pipes one of 10 mm diameter and second of 5 mm diameter and both are discharging in 12 mm diameter pipe. The rate of flow in 10 mm diameter is 1.0 c.c./s . If the Reynolds number for 12 mm diameter pipe flow is 4000 , determine the rate of flow in 5 mm diameter pipe. Consider kinematic viscosity equal to $6.5 \times 10^{-7} \text{ m}^2/\text{s}$. 15

SECTION 'B'

5. (a) A pretensioned beam 250 mm wide and 300 mm deep is prestressed by 12 wires each of 7 mm diameter initially stressed to 1200 N/mm^2 with their centroids located at 100 mm from soffit. Estimate final percentage loss of stress due to elastic deformation, creep, shrinkage and relaxation using IS 1343 – 1980 Code and the following data: Relaxation of steel stress = 90 N/mm^2 ; $E_s = 210 \text{ kN/mm}^2$, $E_c = 35 \text{ kN/mm}^2$; Creep coefficient $\phi = 1.6$; Residual shrinkage strain = 3×10^{-4} 12
- (b) Design the battens for top chord member of a steel bridge truss. It is 6 m long and subjected to an axial load of 600 kN . Slenderness ratio is limited to $70 - 90$. Allowable compressive stress = 100 N/mm^2 . The member consists of 2 ISMC 175 with a steel plate of $240 \times 8 \text{ mm}$ at top.
- [Figure: Built-up section: two ISMC 175 channels placed back to back with their webs vertical and flanges pointing outwards, 90 mm apart (dimension between the webs), with a 240×8 plate across the top flanges; axes x-x (horizontal) and y-y (vertical, midway between the channels); a batten (dashed) across the bottom flanges] 12

Properties of ISMC: $A=24.38 \text{ cm}^2$, $I_{xx}=1223.3 \text{ cm}^4$, $w=19.1 \text{ kg/m}$, $I_{yy}=121.0 \text{ cm}^4$, $t_f=10.2 \text{ mm}$, $r_{xx}=7.08 \text{ cm}$, $t_w=5.7 \text{ mm}$, $r_{yy}=2.23 \text{ cm}$, $c=2.20 \text{ cm}$

l/r	Allowable Stress in Axial Compression (N/mm^2)
70	107.5
80	100.7
90	92.8
100	84.0
110	75.3
120	67.1
130	59.7
140	53.1

- (c) Design a short concrete column to carry an axial factored load of 1600 kN. Use M 20 concrete and Fe 415 steel. Unsupported length of column is 3 m. 12
- (d) A partially saturated sample from a borrow pit has a natural moisture content of 15 percent and bulk unit weight of 1.9 g/cc. The specific gravity of solids is 2.70. Determine the degree of saturation and void ratio. What will be the unit weight of the sample on saturation? 12
- (e) A masonry dam has pervious sand as foundation. Determine the maximum upward gradient, if a factor of safety of 4 is required against boiling. For the sand the porosity, $\eta=45\%$ and specific gravity of solids, $G_s=2.65$. 12
6. (a) For the retaining wall shown in figure, the retained soil is well drained sand having unit weight of 16 kN/m^3 and angle of repose 30° . The safe bearing capacity of the soil below is 170 kN/m^2 . The coefficient of friction between concrete and soil below is 0.73. Find the factor of safety against sliding and overturning. Find eccentricity associated with vertical load. Check that thickness of stem is sufficient and find vertical steel required in stem at its base and at 2 metres from top. Ignore passive pressure while checking stability. Draw neat sketch showing the steel of stem.
 [Figure: Cantilever retaining wall section: base slab 0.45 m thick with toe 1 m (left), stem 0.4 m thick at its base, and heel 1.6 m (right); the stem tapers slightly towards its top (top thickness not dimensioned); backfill on the right level with the top of the stem, 4 m above the top of the heel slab; ground level in front of the wall (left) 0.55 m above the top of the toe slab] 30
- (b)(i) A strata of normally consolidated clay of thickness 3 m is drained on one side only. It has a hydraulic conductivity of $k=5 \times 10^{-8} \text{ cm/s}$ and coefficient of volume compressibility $m_v=125 \times 10^{-2} \text{ cm}^2/\text{s}$. Determine the ultimate value of the compression of the stratum assuming a uniformly distributed load of 250 kN/m^2 and also determine the time required for 20 percent consolidation. 20
- (b)(ii) How is consolidation different from compaction? What do you understand by the terms – immediate settlement, primary consolidation and secondary consolidation? 10
7. (a) Figure shows the cross-section of a plate girder. The shear force at this section equals 800 kN. Using 20 mm diameter bolts design (i) Flange to web connection, (ii) Flange angle to cover plate connection.
 [Figure: Plate girder cross-section: web plate 6 mm thick; at each flange two ISA $130 \times 130 \times 12$ angles, one on each side of the web; top and bottom cover plates 360×20 (20 mm thick); distance between the inner faces of the cover plates 1800; distance between the top and bottom edges of the web 1790 (each marked "Edge of the web", slightly inside the backs of the angles); bolts connecting angles to the cover plate at 80 and 80 from the web centre line (gauge 80 mm on each side); bolts through the vertical legs of the angles connecting them to the web] 30
- (b)(i) Explain clearly the difference between the active earth pressure and passive earth pressure. Give two examples of each state. 10
- (b)(ii) A retaining wall 6 m high, with a smooth vertical back is pushed against a soil mass having $c'=40 \text{ kN/m}^2$, $\phi'=15^\circ$ and $\gamma=19 \text{ kN/m}^3$. What is the total Rankine pressure if the horizontal soil surface carries a uniformly distributed load of 50 kN/m^2 ? What is the point 20

of application of resultant thrust?

8. (a) Design a two way slab of size $3.5 \text{ m} \times 4.5 \text{ m}$ to support an imposed load of 2 kN/m^2 and floor finish of 1.0 kN/m^2 . Two adjacent edges of slab are discontinuous. Assume moderate exposure condition. Use M 20 grade of concrete and Fe 415 HYSD bars. Assume depth as per L/d ratio. Adopt 10 mm dia bars. Safe shear stress is given as 0.40 N/mm^2 . Draw one typical cross-section along longitudinal direction of slab and show details of steel. Use following data for calculating moment:

L_y/L_x	Short span coefficient α_x – Negative moment at continuous edge	Short span coefficient α_x – Positive moment at mid-span	Long span coefficient α_y
1.2	0.060	0.045	0.047
1.3	0.065	0.049	0.047

30

- (b)(i) A group of nine piles, 12 m long and 250 mm diameter, is to be arranged in a square pattern in clay soil with an average unconfined compressive strength of 60 kN/m^2 . Work out the centre-to-centre spacing of the piles for a group efficiency factor of 1. Neglect the bearing at the tip of the piles. (For $c_u = 30 \text{ kN/m}^2$ assume adhesion factor $\alpha = 0.9$)

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- (b)(ii) What is a “standard penetration test”? How is the data obtained from the standard penetration test utilized in foundation design?

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