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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.

Question 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.

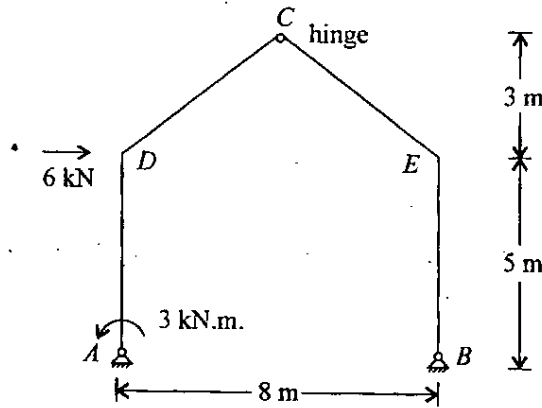
Unless otherwise mentioned, symbols and notations have their usual standard meanings.

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

Neat sketches may be drawn, wherever required.

SECTION 'A'

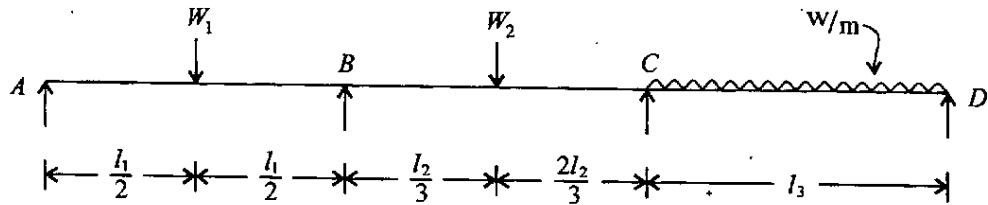
1.(a)(i)



Find the support reactions at A and B of the structure shown in figure. The structure has an internal hinge at C .

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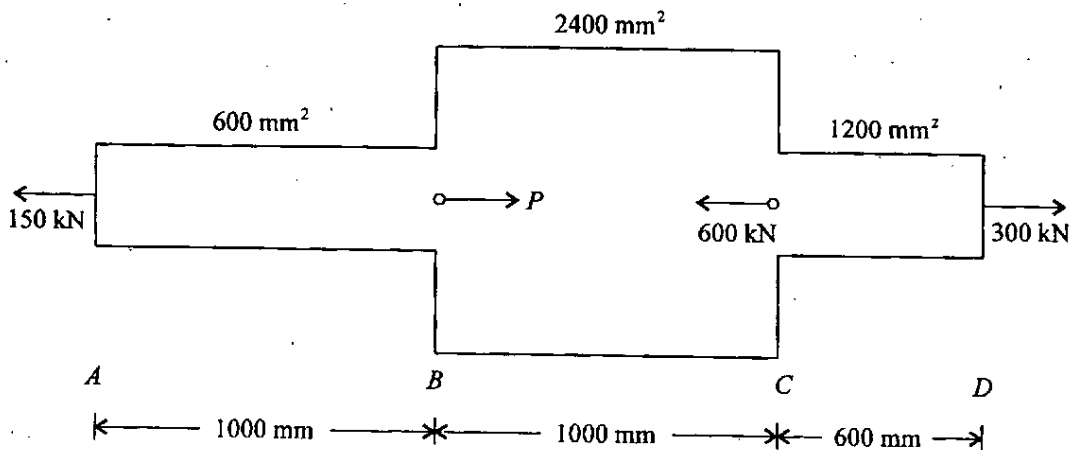
1.(a)(ii)



Draw the free body diagram for the spans AB , BC and CD and show the thrust acting on the supports A , B , C and D .

4

1.(b)



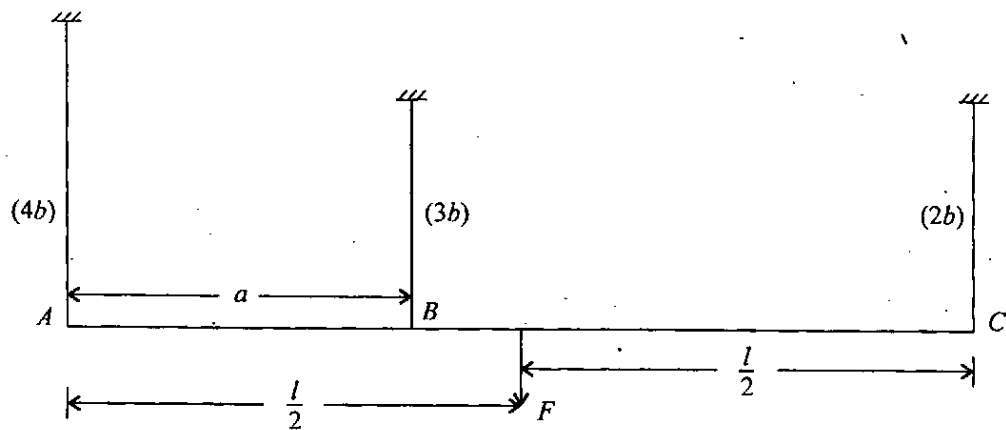
A member $ABCD$ is subjected to concentrated loads as shown. Calculate

- (i) the force P necessary for equilibrium and
- (ii) total elongation of the bar.

The value of Young's modulus of Elasticity is given as $2 \times 10^5 \text{ N/mm}^2$.

8

1.(c)



Three steel bars A , B and C having the same axial rigidity EA support a horizontal rigid beam ABC as shown in figure. Determine the distance ' a ' between bars A and B in order that the rigid beam will remain horizontal when a load ' F ' is applied at its mid-point. The value of length is given within the parenthesis. 8

1.(d) A slab base for a steel column of ISHB 350 consists of steel plate $420 \times 420 \times 25$ mm, supported on concrete pedestal made of M 20 grade concrete. If the column is subjected to factored axial compressive load of 1600 kN, check the adequacy of the slab base provided. Take the bearing strength of concrete as 9.5 MPa.

For ISHB 350 : Flange width (b_f) = 250 mm
 Yield strength (f_y) = 250 MPa
 Yield strength of steel (f_y) = 250 MPa
 Partial safety factor (γ_{mo}) = 1.1

8

1.(e) A post tensioned cable of beam 10 m long is initially tensioned to a stress of 1100 MPa. The tendons used are of 600 mm² in cross-section and are curved so that the slope is 1 in 24 at each end. Calculate the loss of prestress due to friction and slip. Use the following data :

Coefficient of friction between duct and cable = 0.55
 Friction coefficient for wave effect = 0.0015 per m
 Slip at the Jacking end = 3 mm
 Modulus of Elasticity of cable wires (E_s) = 210 kN/mm².

8

2.(a) A three hinged parabolic arch has a span of 24 m and rise of 6 m. It carries a uniformly distributed load of 25 kN/m over its left half span and a concentrated load of 140 kN at 6 m from the right end. Calculate the bending moment, the normal thrust and radial shear at a section at a distance of 5 m from the left end.

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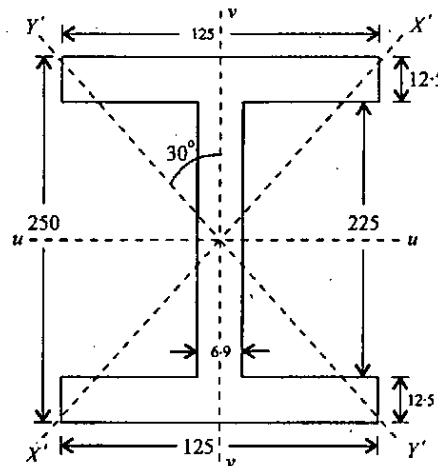
2.(b) A propped cantilever beam has a uniform cross-section and span ' L ' carries a single concentrated load ' W ' at a distance ' x ' from the built-in-end. Find the collapse load ' W_u ' when the section subjected to a plastic moment M_p . Also, find the increased ratio of the load at collapse when the both ends are built-in.

15

2.(c) The internal diameter of a steel shaft is 65% of external diameter. The shaft is to transmit 3600 KW at 210 r.p.m. If the maximum allowable stress in the shaft material is 50 N/mm^2 , calculate the diameter of the shaft. Find also the maximum twist of the shaft when it is stressed to the maximum permissible value. The length of the shaft is 3.8 m. Take $G = 80 \text{ MPa}$. 15

3.(a) Compare the bending strength of three beams one having a square cross-section, a rectangular section (with depth is twice the width) and a circular cross-section; all the three beams having the same weight and having a cross-sectional area of 95000 sq. mm. each. 10

3.(b)



Determine the moment of inertia of an ISMB 250 section as shown in figure about the axes $X'X'$ and $Y'Y'$ are inclined to an angle 30° the axis of symmetry. Calculate also the product of inertia $I_{X'Y'}$. The dimensions are in mm. 10

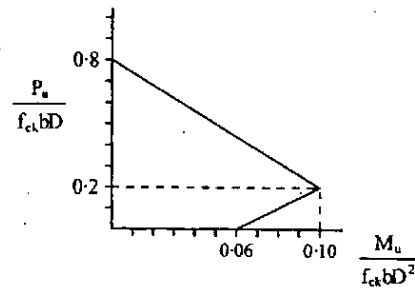
3.(c) A laterally supported steel beam of effective span 5 m consists of ISLB 325. The beam is subjected to maximum bending moment of 150 kNm and maximum shear force of 200 kN. Check the safety of the beam from the point of 'Bending Strength'.

The Properties of ISLB 325

Depth of section (h)	= 325 mm
Width of flange (b_f)	= 165 mm
Thickness of flange (t_f)	= 9.8 mm
Thickness of web (t_w)	= 7.0 mm
Radius at the root (r_1)	= 16 mm
Elastic section modulus (z_{ez})	= $607.70 \times 10^3 \text{ mm}^3$
Plastic section modulus (z_{pz})	= $687.76 \times 10^3 \text{ mm}^3$
Section classification	= Plastic
Yield strength (f_y)	= 250 MPa
Partial safety factor (γ_{mo})	= 1.1

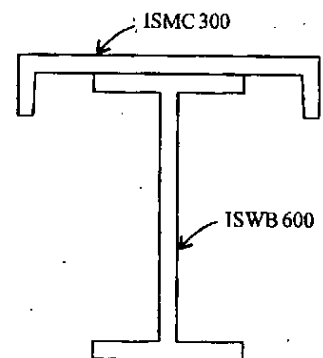
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3.(d) An RC column consists of cross-section 300×500 mm, is subjected to a load of 1200 kN at an eccentricity 'e' with respect to the major axis of bending. If the RC column has the load-moment interaction curve as shown in figure, determine the maximum eccentricity 'e' with respect to the major axis of bending at which the load of 1200 kN can be applied safely. The grade of concrete is M 25. 10



4.(a) A gantry girder used for a span of 8 m, has the cross-section shown in figure. Check the cross-section safety under the bending due to both vertical and lateral loads. Steel used is of Fe 410 grade. The crane supported by the gantry is hand operated. The lateral loads due to crane operation may be taken as 5% of the maximum static wheel load (MSW). Assume the cross-section of gantry is 'plastic' from the point of section classification. Use the following data. Assume 10% impact due to vertical moving loads.

- Crane capacity = 200 kN
- Self wt. of crane girder (Excluding trolley) = 200 kN
- Self wt. of trolley = 40 kN
- Minimum approach of crane hook = 1.2 m
- Wheel base = 3.5 m
- Span of crane = 16 m
- Self wt. of rail section = 300 N/m
- Diameter of crane wheel = 150 mm
- Self wt. of gantry girder = 2 kN/m



Properties of sections used

Property	Unit	ISWB 600	ISMC 300
• C/S Area (A)	mm ²	17038	4564
• Flange thickness (t _F)	mm	21.3	13.6
• Web thickness (t _w)	mm	11.2	7.6
• Flange width (b _F)	mm	250	90
• Moment of Inertia (I _z)	mm ⁴	106198.5 × 10 ⁴	6362.6 × 10 ⁴
• radius @ root (r)	mm	17	—
• C _{YY}	mm	—	23.6
Moment of Inertia (I _y)	mm ⁴	4702.5 × 10 ⁴	310.8 × 10 ⁴

- 4.(b) Design a rectangular isolated footing of uniform thickness for an RC column subjected to axial load of 700 kN. The cross-section of column is 300×500 mm. The safe bearing capacity of soil is 150 kN/m^2 . Use M20 grade concrete and Fe415 grade steel. The allowable stress in steel is 230 MPa. Permissible bend stress in concrete is 0.8 MPa. Use the following data. Sketch the detailing of reinforcement.

Per cent of tension steel (ρ_t) vs Permissible shear stress (τ_c)

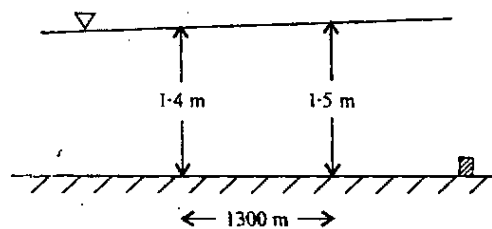
ρ_t	0.5	0.75	1.0	1.25	1.5
τ_c (N/mm ²)	0.30	0.35	0.39	0.42	0.45

Permissible bending strength of concrete (c) = 7 MPa.

20

SECTION 'B'

- 5.(a) What is meant by local and convective acceleration? For a one-dimensional flow, described by $u(x, t)$, derive the expression for the convective acceleration in terms of the velocity and its gradient. 8
- 5.(b) A sluice-gate in a rectangular channel holds water at a depth of 1 m when the gate opening is 5 cm. The coefficient of contraction, C_c , is 0.6. Find the force acting on the gate per unit width. 8
- 5.(c)



A very wide rectangular channel has a bed slope of 1 in 10,000 and Manning's Roughness, $n = 0.01$. Due to an obstruction in the channel, the flow depth increases, and the flow depths at two sections, 1300 m apart, were measured as 1.4 m and 1.5 m, respectively, as shown. Using the step method, estimate the discharge per unit width of the channel. 8

- 5.(d) A soil profile consists of three layers with properties shown in the table below. Initially there was 0.5 m of water above the surface of the soil. What will be the time required for the water level to drop to the ground surface by draining vertical direction through the layers only ?

Layer No.	Thickness (m)	k_z (parallel, m/s)	k_z (normal, m/s)
1	3.0	2.0×10^{-6}	1×10^{-6}
2	4.0	5.0×10^{-8}	2.5×10^{-8}
3	3.0	3.0×10^{-5}	1.5×10^{-5}

8

- 5.(e) A 4.0 m high smooth vertical wall retains dry cohesionless soil with unit weight, $\gamma = 17.5 \text{ kN/m}^3$ and angle of internal friction, $\phi = 35^\circ$. What is the approximate thrust on the wall if the wall is prevented from yielding ? Assume backfill surface is horizontal.

8

- 6.(a) Oil ($\rho = 900 \text{ kg/m}^3$, $\mu = 0.01 \text{ NS/m}^2$) is being pumped through a 5 cm diameter steel pipe (Roughness height = 0.01 mm) at a rate of $7 \times 10^{-4} \text{ m}^3/\text{s}$. It is required to reduce the head loss to half by replacing this pipe with a larger diameter steel pipe. Find the diameter of the new pipe.

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- 6.(b) For a 2 m wide rectangular channel carrying a certain discharge, the alternate depths, i.e., depths with same specific energy, are 0.5 m and 2.0 m. What would be the conjugate depths, i.e., depths with same specific force, corresponding to these two depths ?

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- 6.(c) What are distorted models ? Give an example where distorted models are necessary and explain why.

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- 7.(a) In a field density test the following results were obtained : $\gamma_b = 19.1 \text{ kN/m}^3$, $\omega = 16\%$. The specific gravity of soil's solid = 2.7. Determine dry density, void ratio, air content, degree of saturation, moisture content at saturation and saturated unit weight.

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- 7.(b) The following data were obtained from a set of triaxial tests on three identical samples :

Test No.	Confining pressure, σ_3 (kN/m ²)	Deviator stress, $\Delta\sigma_f$ (kN/m ²)
1	30	57
2	60	79
3	90	92

Determine

- (i) the values of strength parameter C and ϕ .
(ii) the orientation of the failure plane and the shear and normal stresses on the failure plane for test 3.

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7.(c) A layer of saturated clay 4 m thick having drainage from both top and bottom is subjected to a loading that increases the average effective stress from 185 kPa to 310 kPa. Determine

- (i) the total primary consolidation settlement,
- (ii) the settlement at the end of one year,
- (iii) the time in days for 75% of consolidation settlement to occur, and
- (iv) the time in days for 25 mm of settlement to occur.

Given : $M_v = 0.00025 \text{ m}^2/\text{kN}$, $C_v = 0.75 \text{ m}^2/\text{yr}$. The following data may be used :

$U\%$	0	15	25	35	40	45	50	60	70	75
T_v	0	0.018	0.049	0.096	0.126	0.160	0.196	0.286	0.403	0.477

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7.(d) A column footing of $1.8 \text{ m} \times 1.8 \text{ m}$ is to be placed 1.5 m below the ground level in a dense cohesionless soil. The unit weight of soil is 21 kN/m^3 and angle of internal friction, $\phi = 36^\circ$. The footing is to carry a total load of 1350 kN including column load, weight of footing and weight of soil surcharge. Determine the factor of safety against bearing capacity failure assuming

- (i) ground water level well below the base of the footing, and
- (ii) ground water level at the ground level.

Given for $\phi = 36^\circ$, $N_c = 63.53$, $N_q = 47.16$ and $N_\gamma = 51.7$.

(Assume $\gamma_{\text{bulk}} = \gamma_{\text{saturated}} = 21 \text{ kN/m}^3$)

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8.(a) Write the formula for rotation of a fluid element about the z-axis in terms of the velocity gradients in the Cartesian co-ordinate system. For a free vortex, although the streamlines are circular, the flow is irrotational. Explain why. 10

8.(b) How are hydroelectric power plants classified based on the availability of head? Which type of turbines are suitable for each of these plants? Explain the working of a pumped-storage plant and list its advantages. 10

8.(c) A concrete pile is to be driven into a medium dense to dense sand with $\gamma = 20.5 \text{ kN/m}^3$, $\phi = 38^\circ$ and $K = 0.95$. Diameter of the pile is 300 mm and its embedded length is 15 m. The ground water table is located 3 m below the ground surface. Determine the capacity of the pile with a FS = 2.0. Assume $N'_q = 100$ for the given soil and $\tan \delta = 0.55$. (Assume $\gamma_{\text{bulk}} = \gamma_{\text{sat}} = 20.5 \text{ kN/m}^3$) 10

8.(d)

- (i) Briefly explain the use of plasticity chart in classifying fine grained soil.
- (ii) What are the differences between compaction and consolidation? What are the objectives of compaction? 10