HJI-F-CVLE

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.*

*Questions No. **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.

Diagrams / Figures, wherever required, shall be drawn in the space provided for answering the question itself.

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

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.

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

SECTION A

Q1. **(a)** **(i)** How are aggregates classified based on particle size ? What is bulking of sand ? **6**

(ii) How is workability of concrete defined as per Indian Standard Specification IS 1199 – 1959 ? Briefly explain the method of measurement of workability through compacting factor test. **6**

(b) A semi-composite steel bar as shown in Figure 1 is loaded at free end with an axial load of 50 kN. Determine the axial stiffness of the system and extension of the free end. Diameter of steel bar is 40 mm, outer diameter of the concrete portion is 200 mm. Modulus of elasticity of steel = 200 GPa, Modulus of elasticity of concrete = 20 GPa. Central portion of the bar is embedded with concrete. **12**
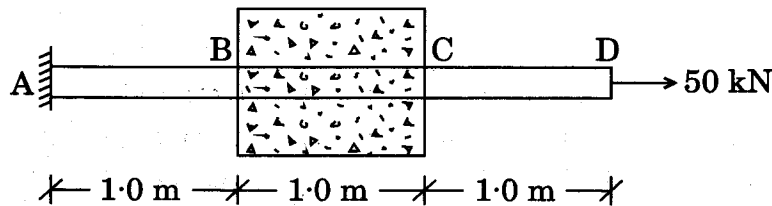

Figure 1

(c) A machine is mounted at the centre of a simple supported beam that can exert a harmonic load $F(t) = 20 \sin (0.12 t)$ kN in vertical direction. The length of beam is 4 m and its cross-section is uniform throughout. Cross-section of beam : width 20 mm and depth 40 mm. A weight W = 200 N is suspended from the centre of the beam by a spring of spring constant K_s = 40 N/m. Determine the natural frequency of the weight W. Neglect mass of the beam and weight of machine. $E = 2 \times 10^5$ MPa. **12**

(d) A cable of uniform cross-section hangs between two points A and B, which are 150 m apart. The end 'A' of the cable is 3 m above the other end of the cable. The sag of the cable measured from 'B' is 2 m. If the cable carries a UDL of 12 kN/m, determine the maximum tension in the cable. Also find the horizontal pull. **12**

(e)   A 200 mm × 150 mm × 10 mm aluminium plate is subjected to uniform bi-axial stresses σ_x and σ_y. Two strain gauges A and B are attached to the surface of the plate as shown in the Figure 2. If readings in strain gauges are $\varepsilon_A = 200 \times 10^{-6}$ and $\varepsilon_B = 285 \times 10^{-6}$, what are the values of σ_x and σ_y ? What is the reduction in thickness of the plate as a result of stresses ?   12

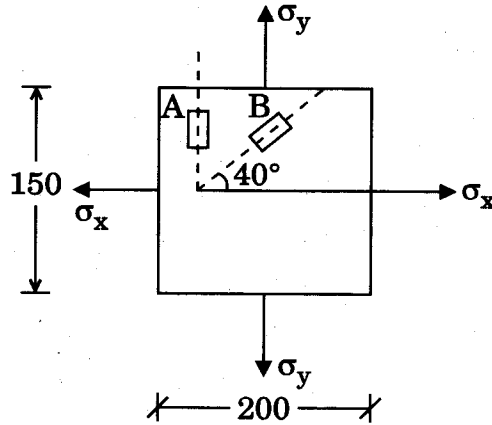Take Young's modulus E = 75 GPa and Poisson's ratio ν = 0·33.

Figure 2

Q2.   (a)   A steel tube is to be used as a post for a road sign board as shown in Figure 3. The maximum wind pressure on the sign board is 1960 N/m². The angle of rotation of the tube at the bottom of the sign board marked as A must not exceed 4° and the maximum shear stress (due to torsion only) must not be greater than 38 MPa. Determine the mean diameter of the tube if the wall thickness is 4·2 mm. Take G = 70 GPa. Assume wind is transmitting only over the sign board portion.   20
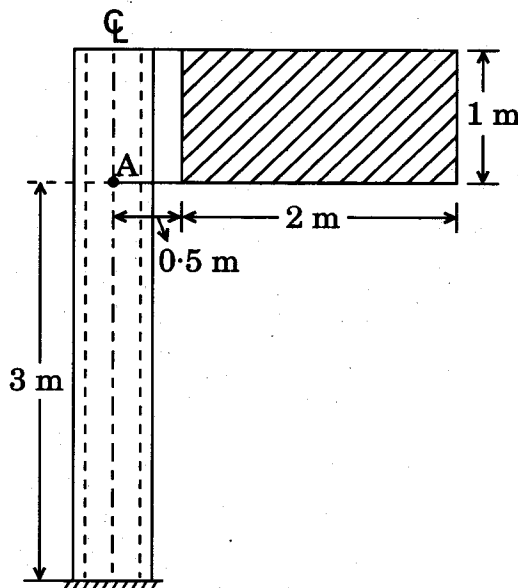

Figure 3

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(b) In a strained body the normal stresses on three planes inclined as shown in Figure 4 are 60 MPa (Tensile), 80 MPa (Tensile) and 100 MPa. Determine the shear stresses acting on these planes. Also find the principal stresses. *20*
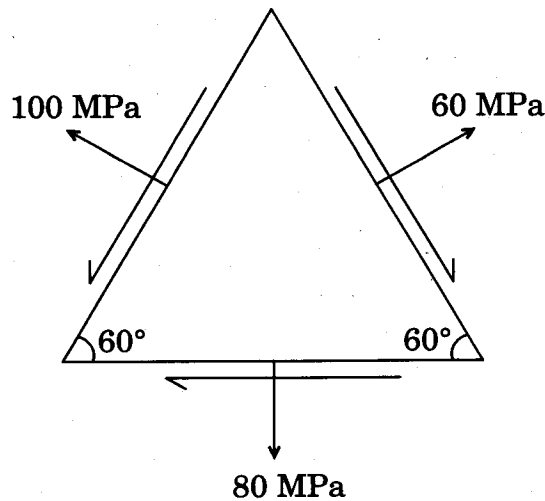

Figure 4

(c) (i) Describe how the compounds of clinker affect the properties of cement. *12*

(ii) What do you mean by normal consistency of cement ? What is its significance ? How is it tested ? *8*

Q3. (a) Develop the flexibility matrix for the beam shown in Figure 5, with respect to the generalized coordinates mentioned. EI is constant for all members. *20*
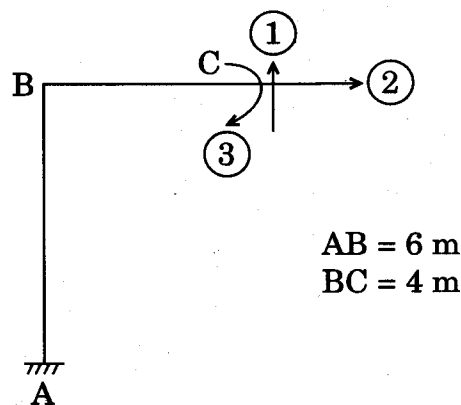

AB = 6 m
BC = 4 m

Figure 5

(b) A bar of length 1·2 m, diameter 40 mm is subjected to an axial tensile load of 130 kN and a twisting moment of 600 N.m. If the same material yielded at an axial stress of 200 N/mm^2, determine the safety factor associated with the bar, considering *20*

   (i)   Principal stress failure theory

   (ii)   Maximum shear stress theory

   (iii)   Distortional strain energy theory

Take E = 200 GPa and $\mu = 0.25$.

(c) Determine the forces in the members of the truss shown in Figure 6. All members have same axial rigidity. *20*
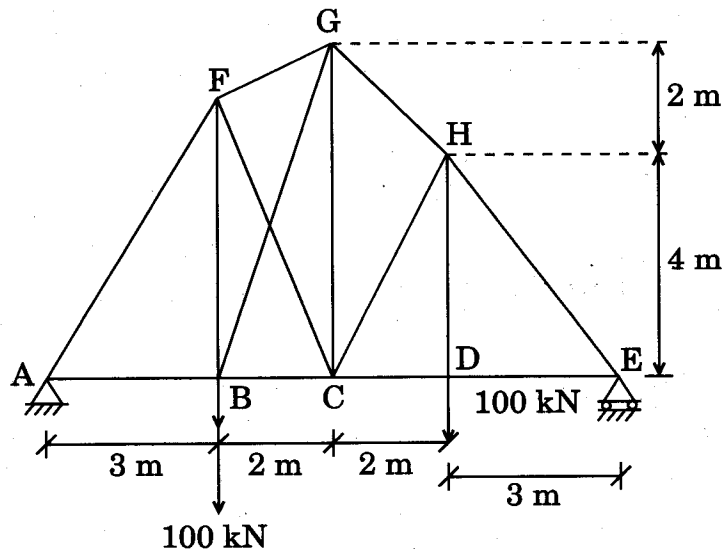

Figure 6

Q4. (a) (i) Differentiate in brief between Thermoplastic and Thermosetting plastic. *8*

     (ii)   Discuss in brief the methods of preserving timbers by water soluble preservatives. *12*

(b) Sketch influence line diagram for the bending moment at a point 'C' located 6 m from one of the supports of a three hinged symmetrical parabolic arch having span of 18 m and central rise 2·5 m. Locate the point from where the moving load changes the sign of bending moment at C. *20*

(c) Frame ABCD shown in Figure 7, is acted upon by a UDL of intensity 20 kN/m on the horizontal span. What should be value of horizontal force 'P' applied at C, that will prevent sway of the frame ? Draw BMD.   *20*
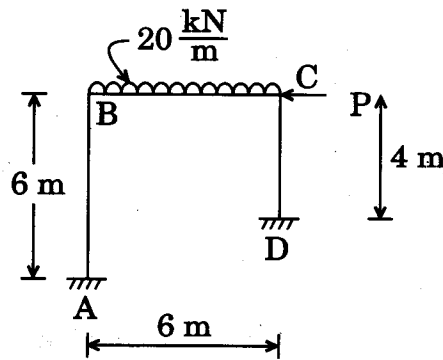
Figure 7

EI is same for all members.

SECTION B

Q5. **(a)** A tie member of a truss consisting of an angle section ISA $65 \times 65 \times 6$ is welded to a gusset plate. Design a fillet weld to transmit a load equal to full tensile strength of the plate. Assume shop weld. Take grade of steel E 250 (Fe 410). Also sketch the weld length. **12**

Properties of ISA $65 \times 65 \times 6$

$$A = 744 \text{ mm}^2$$
$$C_z = 18 \cdot 1 \text{ mm}$$

Thickness of gusset plate is 10 mm.

(b) Find the web buckling and web crippling strength of a beam (ISLB 350) simply supported at both ends. Assume the stiff bearing length 100 mm and grade of steel E 250. **12**

Section properties of ISLB 350 : $t_w = 7 \cdot 4$ mm

$$t_f = 11 \cdot 4 \text{ mm}$$
$$R = 16 \text{ mm}$$

R = Radius of root.

Given : Design compressive stress f_{cd}, N/mm^2

KL/r	f_{cd}
90	121
100	107
110	94·6

(c) A symmetrical reinforced concrete frame building 25 m × 25 m in plan is located in seismic zone IV on hard soil. The height of the building is 30 m. Determine the base shear due to earthquake. **12**

Given :

Z = 0·24, I = 1·5

Total dead load = 1,50,000 kN

Total live load (effective) = 50,000 kN

$$T = 0 \cdot 09 \, \frac{h}{\sqrt{D}}$$

$$\frac{Sa}{g} = \begin{cases} 1 + 15\,T & 0 \le T \le 0 \cdot 10 \\ 2 \cdot 5 & 0 \cdot 10 \le T \le 0 \cdot 40 \\ 1/T & 0 \cdot 40 \le T \le 4 \cdot 0 \end{cases}$$

(d) A floor of an old building consists of 150 mm thick RC slab monolithic with the beam of width 300 mm and total depth 400 mm. The beams are spaced 3·5 m c/c and their effective span (simply supported) is 7 m. The beams are reinforced with 5 Nos. 28 φ bars as tension reinforcement. Determine the moment carrying capacity of the beams. Use M 25 and Fe 500. Adopt limit state method of design. Nominal cover = 30 mm. Diameter of the stirrups = 8 mm. *12*

(e) What is Work Breakdown Structure (WBS) with respect to construction planning and management ? How is WBS classified into different levels ? *12*

Q6. (a) A simply supported reinforced concrete beam of size 300 mm × 500 mm is reinforced with 5 Nos. 16 φ bars as tension reinforcement. Two bars are curtailed at quarter span from both ends. Find out the load carrying capacity (UDL) of the beam having effective span of 6 m. Also design the beam against shear force. Use M 25 and Fe 415. Nominal cover = 30 mm. Use limit state method of design. Show the reinforcement detail (cross-section) also. Use 2 Nos. 12 φ bars as hanger bars. *20*

$\dfrac{M_u}{bd^2}$	2	2·5	2·75	3	3·25	3·5
P_t	0·51	0·61	0·74	0·83	0·91	–

P_t	0·25	0·5	0·75	1·0	1·25
τ_c, MPa	0·36	0·49	0·57	0·64	0·7

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(b) A bracket plate is connected to a flange of ISMB 500 as shown in Figure 8. Find the safe load P carried by the joint. M 16 bolts of grade 4·6 are provided at a pitch of 50 mm and end distance 30 mm. *20*

Given :

Thickness of bracket plate = 10 mm

Width of flange b_f = 180 mm

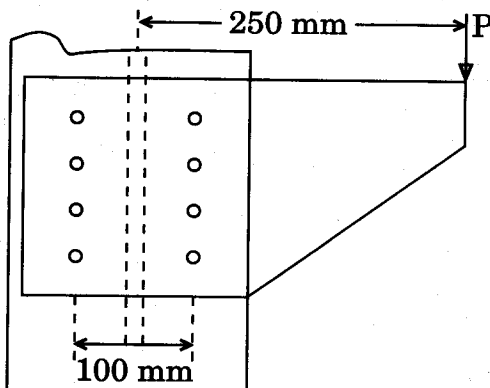Thickness of flange t_f = 17·2 mm

Steel grade of bracket plate Fe 410

Figure 8

(c) What is a crane ? How is it used in the construction industry ? Briefly explain three different types of cranes that are being used in construction works. *20*

Q7. (a) Design a square column of height 3 m subjected to an axial load of 1500 kN under dead and live load condition. Use limit state method of design. Assume effective length factor = 1·2. Size of the column is fixed at 400 mm × 400 mm. Show the reinforcement detail (cross-section). Use M 25 and Fe 500. *20*

(b) In an industrial shed, it is proposed to provide a hot rolled section ISMB 500 to carry a two-wheeled system crab on it. The crab can move over the flange of the beam from one end to another end and each wheel of the crab is capable to carry a maximum vertical load of 60 kN (including self weight of wheel).

The centre to centre distance between two supporting ends of the beam is 6 m and the end of the beams are restrained against torsion.

The space between two wheels = 2·4 m. Take impact factor for vertical load as 25%.

Verify the capability of the beam to carry the bending moment developed due to vertical load only. Assume the section is plastic. Grade of steel E 250. *20*

Given data :

Properties of ISMB 500 :

$$b_f = 180 \text{ mm}, \quad t_f = 17 \cdot 2 \text{ mm}, \quad t_w = 10 \cdot 2 \text{ mm}$$

$$r_z = 202 \cdot 1 \text{ mm}, \quad r_y = 35 \cdot 2 \text{ mm}$$

$$Z_{ez} = 1808 \cdot 7 \text{ cm}^3, \quad Z_{pz} = 2074 \cdot 67 \text{ cm}^3$$

Critical stress, $f_{cr, b}$ (MPa)

$\dfrac{KL}{r}$	h/t_f	
	25	30
170	136·7	121·3
180	127·1	112·2

Design bending compressive stress to lateral buckling f_{bd}, for $f_y = 250$ MPa.

$f_{cr, b}$	f_{bd} (MPa)
150	106·8
100	77·3

(c) The following table gives the activities in a construction project and other relevant information.

Activity	Duration (Days)
1 – 2	20
1 – 3	25
2 – 3	10
2 – 4	12
3 – 4	6
4 – 5	10

(i) Draw the network for the project.

(ii) Find the critical path.

(iii) Find free, total and independent floats for each activity. *20*

Q8. **(a)** A combined footing is to be provided for two columns (size 300×300) spaced at 3 m c/c. Axial load on each of the columns is 350 kN. The width of the footing is fixed at 1·4 m. A foundation beam of 400 mm × 800 mm is provided along the length. Design the foundation slab using M 25 and Fe 500. Assume the thickness of the slab varies from 250 mm to 150 mm. Also show the reinforcement detail (in cross-section) of the footing slab. Use limit state method of design. Bearing capacity of the soil is 100 kN/m². **20**

Given :

$\dfrac{M_u}{bd^2}$	0·3	0·35	0·4	0·45	0·5
p_t	0·070	0·082	0·094	0·106	0·118

p_t	< 0·15	0·25	0·5	0·75	1·0
τ_c, MPa	0·29	0·36	0·49	0·57	0·64

(b) A rafter member of a roof truss carries 40 kN compressive load (DL + LL) and 67 kN tensile load (DL + WL). The effective nodal length of the member is 2·1 m. A circular tube section of nominal bore diameter of 50 mm is used. Check the adequacy of the section. Grade of steel = E 250, Young's Modulus E = 200 GPa. **20**

Given :

Sectional properties of the section A = 523 mm², r = 20·3 mm. Outside diameter = 60·3 mm.

Stress reduction factor $\chi = \dfrac{1}{\phi + \sqrt{\phi^2 - \lambda^2}}$

$\phi = 0\cdot5[1 + \alpha\,(\lambda - 2) + \lambda^2]$

$\lambda = \sqrt{\dfrac{f_y}{f_{cc}}} \qquad f_{cc} = \dfrac{\pi^2\,E}{\left(\dfrac{KL}{r}\right)^2}$

Buckling class	a	b	c	d
α	0·21	0·34	0·49	0·76

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(c) A simply supported prestressed concrete beam of width 100 mm, depth 200 and span 10 m, carries a UDL of intensity 'w'. If the member is prestressed with a parabolic cable having zero eccentricity at the ends and 60 mm eccentricity at mid, determine the value 'w' for the following conditions, for effective prestressing force of 125 kN.

    (i)   Load Balancing Case

    (ii)   For no tensile stress condition at mid span

    (iii)   For cracking condition taking the tensile strength of concrete as 1.5 N/mm^2

For all cases neglect the weight of concrete.   *20*