IFoS-2010

№ 001112

B-JGT-K-DJA

CIVIL ENGINEERING

Paper I

Time Allowed : Three Hours

Maximum Marks : 200

INSTRUCTIONS

Candidates should attempt questions 1 and 5 which are compulsory, and any THREE of the remaining questions, selecting at least ONE question from each Section.

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

Standard notations are given in the questions and these notations have their usual meanings, unless otherwise indicated.

All questions have equal marks. Marks allotted to each part/subpart of a question are indicated against each.

Answers must be written in ENGLISH only.

SECTION A

1. Attempt any ***four*** of the following : *10×4=40*

(a) (i) Form Lame's equations for a thick cylinder having internal radius 'a' and external radius 'b' subjected to internal pressure p_0. What is the equation for shear stress at any radius r ? *5*

(ii) State and explain forced vortex as occurring in a centrifugal pump. *5*

(b) Parallel chord truss shown in Fig. 1 needs diagonal elements for stability. For the loading condition shown add diagonal element in an arrangement such that all diagonals are in a state of tension. What is the maximum force in the diagonal ? *10*

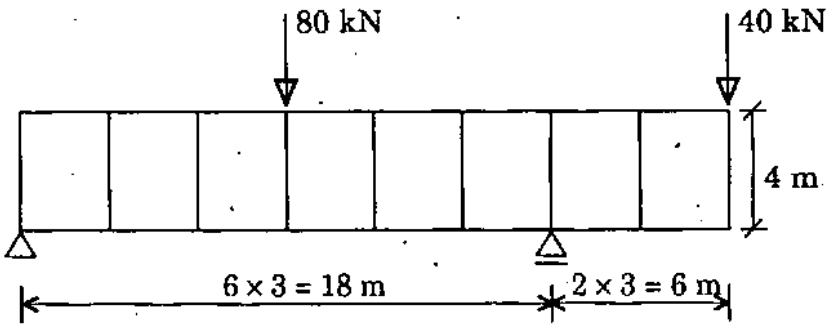

Fig. 1

(c) A box of mass 150 kg moves down on a rough inclined plane at a velocity of 4 m/sec when a force P is applied as shown in Fig. 2(a). The force P varies with time as shown in Fig. 2(b). Calculate the time elapsed when the velocity of box is zero.

Coefficient of friction $\mu = 0{\cdot}3$. $g = 9{\cdot}81$ m/sec^2. *10*

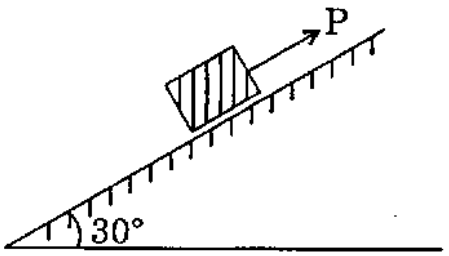

Fig. 2(a)

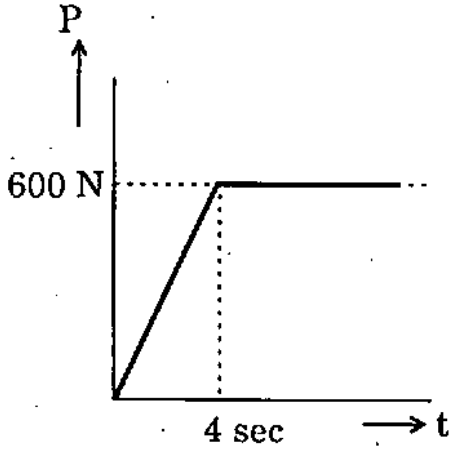

Fig. 2(b)

(d) Calculate the diameter of a parachute in the form of a hemispherical shell to be used for dropping a small object of mass 90 kg so that it touches the Earth at a maximum velocity of 6 m/sec. The drag coefficient for the hemispherical shell with its concave side upstream is 1·32 for $R_e > 10^3$. Air density = 1·22 kg/m^3. *10*

(e) For the given velocity profile, determine whether flow is attached, detached or on the verge of separation. The velocity profile is

$$\frac{u}{U} = 2\left(\frac{y}{\delta}\right)^2 + \left(\frac{y}{\delta}\right)^3 - 2\left(\frac{y}{\delta}\right)^4$$

where u : Velocity at distance y

δ : Boundary layer thickness

U : Free stream velocity. *10*

2. (a) A shaft is made up of partly solid section and partly hollow section as shown in the Fig. 3.

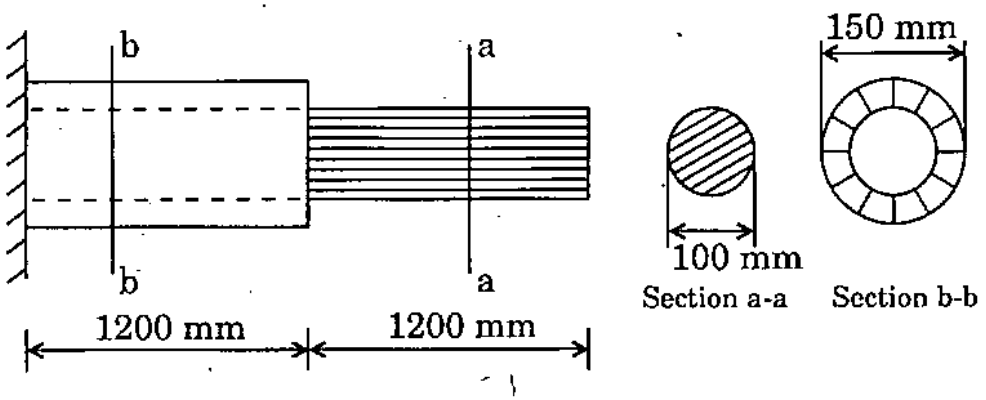

Fig. 3

What is the maximum torque that can be transmitted when maximum shear stress is 80 mPa, with modulus of rigidity = 80 GPa ? What is the maximum free end rotation ? *12*

(b) A 50 mm cube is subjected to uniform pressure of 200 mPa. When the change in dimension between two parallel faces of the cube is 0·025 mm, determine the change in volume of the cube. Poisson's ratio $\mu = 0{\cdot}25$. *8*

(c) A fixed beam of 2·4 m has been loaded as shown in Fig. 4(a). The cross-section is uniform tee as shown Fig. 4(b). The load on the span is increased to w, when plastic hinges are formed at A and B. What is the magnitude of w, and what is the maximum deflection corresponding to this load ? E = 200 GPa, Yield strength f_y = 250 mPa. *20*

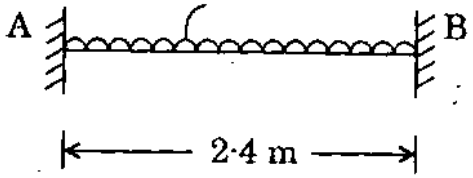

Fig. 4(a)

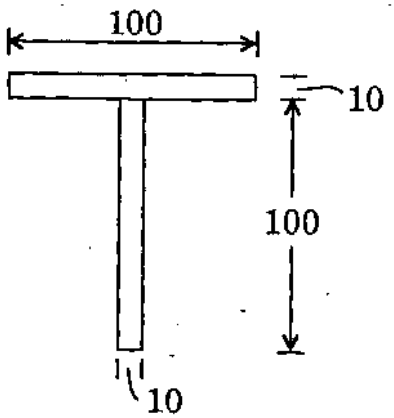

Fig. 4(b)

3. (a) By direct stiffness method, analyse the pin jointed frame shown in Fig. 5. Take AE = 1. Determine forces in all members. Find joint displacements at O. *20*

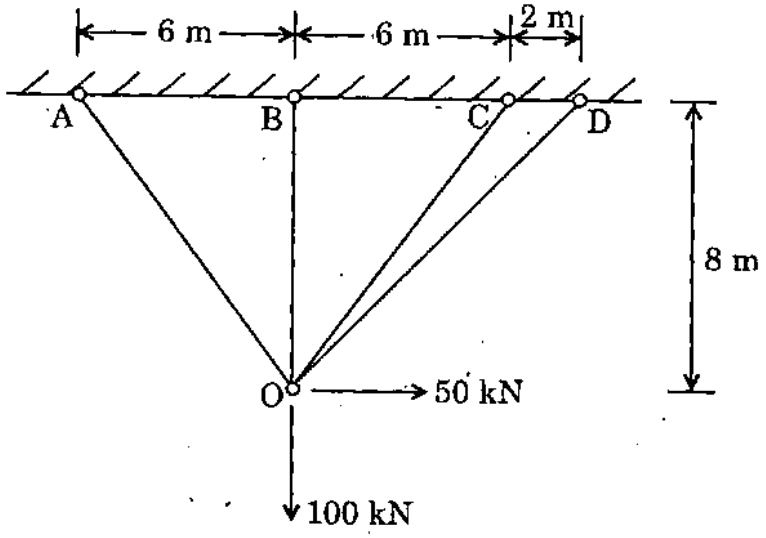

Fig. 5

(b) State at least five conditions for channel flow to be critical. 5

(c) For a critical flow in a rectangular channel prove that :

$$x^2y^3 = \frac{Q^2}{8g}$$

where x is top width

y is the distance of the water surface below energy line

Q : Discharge in the channel. 10

(d) A lock sluice at a dam has a surface width of 1·0 m and cross-sectional area of 1·25 m^2 at the critical depth. What velocity of flow would correspond to critical depth ? 5

4. (a) A pump is needed to operate at 3000 rpm with a lift of 7 m and a discharge of 0·15 m^3/sec. Calculate the specific speed; determine which among the following is most suited :
1. Reciprocating pump 2. Centrifugal pump
3. Mixed flow pump and 4. Axial flow pump. 8

(b) At its normal operating point a centrifugal pump with one stage delivers 0·3 m^3/sec against a head of 30 m at a speed of 1500 rpm. At another site it is required that 0·4 m^3/s be raised over a height 105 m, by using a similar pump operating at the same speed but with multi stages in series (one after the other). How many stages are required ? 12

(c) A hydro electric scheme has a 10 m diameter tunnel 1700 m long within which water flows with a mean velocity 'v' of 5 m/s, connected to the tunnel is a surge shaft. Estimate the rise in water level in the shaft following a sudden closure of the valves leading to the turbines. Neglect the energy losses. *12*

(d) The boundary layer thickness at a distance of 1·0 m from the leading edge of a flat plate kept over zero angle of incidence to the flow direction is 1·0 mm. The velocity outside the boundary layer is 25 m/sec. Calculate the boundary layer thickness at 4 m from the leading edge. Assume that the boundary layer is entirely laminar. *8*

SECTION B

5. Attempt any ***four*** of the following : *10×4 =40*

(a) Determine the ultimate moment of resistance for an r.c. beam given the following data :

Width of beam = 300 mm; Total depth = 600 mm

Effective cover = 50 mm; Tension steel consists of 4 bars 25 mm diameter. M 20 concrete and Fe 415 steel are used. *10*

Strain	Design stress for Fe 415 steel (N/sq.mm)
0·00144	288·7
0·00163	306·7
0·00192	324·8
0·00241	342·8
0·00276	351·8
≥ 0·0038	360·9

(b) Design a stanchion 2·4 m long to carry an axial load of 180 kN. The ends of the column are restrained in position and direction.
f_y = 250 N/sq.mm. *10*

Properties of available sections and permissible compressive stress (σ_{ac}) for various slenderness ratios (λ) are given in the tables below :

ISMB	Weight kg/m	Area (sq.mm)	I_x (10^4 mm^4)	I_y (10^4 mm^4)
100	11·5	1140	183	12·9
125	13·3	1700	445	38·5
150	15	1910	718	46·8
175	19·6	2500	1260	76·7
200	25·4	3080	2120	137

λ	σ_{ac} (N/sq.mm)
50	132
60	122
70	112
80	101
90	90
100	80
110	72

(c) (i) State the purpose of mix design for concrete and list out four important factors influencing the strength of concrete. 5

(ii) Compute the porosity of sand in the loosest possible state, considering it to be made up of equal diameter spherical particles. 5

(d) During a compaction test, a soil attains a maximum dry density of 18·6 kN/m^3 at a moisture content of 15%. Taking specific gravity of soil as 2·7, find the degree of saturation and percentage air voids at maximum dry density. What will be the dry density corresponding to zero air voids at o.m.c. ? 10

(e) A smooth vertical wall 6 m high retains a cohesionless backfill with horizontal surface. The properties of the fill are $e = 0{\cdot}49$, $\phi = 30°$ and $G = 2{\cdot}65$. Compute the magnitude of total lateral pressure for dry backfill when

(i) the wall is restrained against yielding.

(ii) the wall is free to yield.

(iii) the wall is pushed towards the backfill. 10

6. (a) Design the roof slab for a room of size 4 m × 9 m. The slab is supported by one brick wall all around. Live load is 3 kN/sq.m and load due to floor finish is 1 kN/sq.m. *20*

M 20 concrete and Fe 415 steel are used.

Modification factor k_t for percentage of tension steel (P_t) are given in the table below :

P_t	k_t
0·2	1·6
0·3	1·4
0·4	1·27
0·5	1·17
0·6	1·11
0·8	1·02

(b) Design the vertical wall of a circular r.c. tank with flexible base resting on ground for a capacity of 500 kilo litres. The height of the tank with 0·2 m free board is 4 m. Calculate the vertical and horizontal reinforcements for 1 m height from the base. Concrete grade M 20 and Fe 415 steel are used. *12*

(c) A tie member in a truss consists of two angles 150 × 115 × 10 mm with long legs connected to a gusset plate by 20 mm diameter rivets such that each angle section is reduced in section by one rivet hole.

Area of section of one angle = 2552 sq.mm. *8*

7. (a) (i) State the need for provision of stiffners in plate girders and list out three types of stiffners. *4*

(ii) An ISMB 300 beam is supported over a span of 5 m. It carries a concentrated load of 300 kN at midspan section. Length of bearing plate below the load is 200 mm. Length of bearing plate at support is 120 mm. f_y = 250 N/sq.mm. Permissible stress in bearing = 185 N/sq.mm. Depth of root filling h_2 = 29·25 mm. Thickness of web t_w = 7·7 mm.
Is the design above, with respect to the bearing, safe ? *6*

(b) (i) State the reasons for using high tension steel in prestressed concrete and list out the forms of availability of this steel. *4*

(ii) Modular bricks (190 × 90 × 90 mm) are used to construct a brick wall of 200 mm thickness. The wall carries an axial load of 50 kN/m from the wall above it and a load of 36 kN/m from the roof slab acting at a distance of 47·5 mm from the centre of the wall. Determine the maximum and minimum stresses in the wall. *6*

(c) Upto what depth can an excavation be made vertically without support in a cohesive soil with c = 30 kN/m^2, ϕ = 10° and γ = 19 kN/m^3. What will be the depth upto which tension crack may develop ? If the tension crack develops, will the above computed depth of excavation be safe ? Why ? *8*

(d) A stratum of saturated clay (G = 2·7) has an initial water content of 44 percent throughout its depth. After a long dry spell, the water content at the ground surface is 20% and at 3 m, the water content is 44%. The water content may be taken to vary linearly with depth. The shrinkage limit of the clay is 28%. If the change in height per unit height of the clay $\left(\frac{\Delta H}{H}\right)$ is 80% of its change in volume per unit volume $\left(\frac{\Delta V}{V_0}\right)$, what is the amount of settlement of the ground surface due to change in water content which occurred ? *12*

8. (a) The footing of a wall is 1·2 m wide at the base and is located in a homogeneous cohesive soil at a depth of 1 m below G.L. The soil has γ = 17·6 kN/m^3, c′ = 36 kN/m^2 and ϕ' = 20°. Assuming the soil as soft which is likely to fail under local shear, determine the safe load which can be taken by the footing per metre length of the footing.

(For ϕ' = 20° N_c = 17, N_q = 7, N_γ = 4·5

ϕ' = 13·6° N_c = 11, N_q = 4, N_γ = 1·6) *12*

(b) Explain 'Quick Sand' condition with a neat sketch. Obtain the critical gradient expression for this condition. The submerged unit weight of fine sand is 9·9 kN/m^3. Compute the critical gradient for the fine sand. *8+5*

(c) A group of sixteen piles arranged in a square pattern is to be proportioned in a deposit of soft saturated clay. Assuming piles to be square (with side 300 mm) and 12 m long, work out the spacing of piles for 100 percent efficiency of the pile group. Take mobilisation factor of 0·8 and consider both point bearing and skin friction. *15*