FS – 13 / 15-16

Civil Engineering

Paper – I

Time : 3 hours

Full Marks : 200

The figures in the right-hand margin indicate marks.

*Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and any **three** of the remaining questions, selecting at least **one** from each Section.*

SECTION – A

1. Answer any **two** of the following : 20×2 = 40

(a) A composite spring has two close coiled helical springs connected in series, each spring has 16 coils of mean diameter 25 mm. Find the diameter of wire if the diameter of wire in other spring is 2.50 mm and the stiffness of the composite spring is 0.80 N/mm. Find the greatest load that

can be carried by the composite spring and the corresponding extension for a maximum shearing stress of 195 N/mm^2. Take $C = 8 \times 10^4$ N/mm^2.

(b) Determine the concentrated load which when placed at the free end of a cantilever would produce a shear stress of 1.5 N/mm^2 at the level of the neutral axis of the section carrying the maximum shear. Assume that the beam has a uniform rectangular cross-section 250 mm × 500 mm.

(c) A hollow cast iron cylinder is 4 m long, both ends being fixed. Design the column to carry an axial load of 275 kN. Use Rankine's formula and adopt a factor of safety of 5. The internal diameter may be taken as 0.8 times the external diameter. Take $F_c = 550$ N/mm^2 and $\alpha = \frac{1}{1600}$.

2. (a) A parabolic arch with 30 m span and 5 m rise and hinged at ends is subjected to a concentrated load of 12 kN acting at 10 m from left hinge. The second moment of area varies with the secant slope of rib axis. Calculate horizontal thrust and reactions at support. 15

(b) The three hinged stiffening girder of a suspension bridge of 100 m span subjected to two points load of 10 kN each, placed at 20 m and 40 m respectively from right hand hinge, determine the bending moment and the shear force in the girder at section 25 m from each end. Also determine the maximum tension in the cable which has a central dip of 9 m. 15

(c) Calculate factor moment for a T beam of the following data : 10

(i) Width of flange = 1500 mm

(ii) Depth of beam = 750 mm

(iii) Width of web = 300 mm

(iv) Flange thickness = 100 mm

(v) Beam is reinforced with 6 nos. of 30 mm φ at an effective cover of 50 mm.

Take M-15 and f_y = 250 MPa

What U. D. L. the above beam can carry if it is supported on 6 m span.

3. (a) A rectangular water tank 5 m long, 2.5 m wide and 2.5m high has its wall rigidly jointed at the vertical edges and pin jointed their horizontal edges. Design the tank if it is supported on all sides under the wall. Use M-20 concrete and mild steel reinforcement. 14

(b) Design a circular column to carry an axial load of 1200 kN by using helical reinforcement. Use M-25 concrete and Fe-415 steel. Sketch the reinforcement details. 13

(c) A member of steel roof truss consists of two angles ISA 75 × 75 × 6 mm placed back to back on either side of 8 mm thick gusset plate. The member carries an ultimate tensile load of 150 kN. Determine the number of 16 mm diameter 4.6 grade

ordinary bolts required for the joint. Assume f_u of plate as 410 MPa. 13

4. (a) A compound column comprising of 2 ISMC placed back to back at a distance of 160 mm has actual length 4.2 m with both ends effectively held in position and restrained against rotation. Find load carrying capacity of the column. Take f_y = 250 MPa. Assume the column is laced. 14

(b) R.C. beam of overall dimensions 300 mm × 500 mm rests on a brick wall 300 mm thick, clear span is 5 m. The beams are spaced at 3.5 m intervals. Thickness of slab supported by the beam is 120 mm. Live load on the slab is 2 kN/m^2. Floor finishes weighs 0.6 kN/m^2. Concrete adopted is M-20 and mild steel is used for reinforcements, effective cover to the centre of the reinforcement is 50 mm. Design the reinforcement required for flexure and shear. Draw a net longitudinal

section of the beam and indicate the placement of reinforcements. 13

(c) Design a channel purlin of a roof truss for an industrial building having span of 20 m and a pitch of 1/5. The height of truss at eave level is 10 m. The trusses are spaced at 4.5 m. Spacing between purlins is 1.53m. Weight of roof sheet including fixtures is 165 N/m^2. Weight of purlin per meter length is 100 N/m. Wind pressure acting away and perpendicular to roof is 1300 N/m^2. Consider live load as per IS 875 (II). 13

SECTION – B

5. Attempt any **two** of the following :

(a) Show that a cylindrical buoy 1.25 m diameter and 3.25 m high weighing 11.127 kN will not float vertically in the sea water weighing 10:055 N/m^3. Find the tension necessary in the vertical chain attached to the centre of the base of the buoy that will just keep the cylinder vertical. 20

(b) The velocity component of the two dimensional plane motion of a fluid are :

$u = y^3 + 6x - 3x^2y$ and $v = 3yx^2 - 6y - x^3$

(i) Is the flow continuous ?

(ii) Is the flow irrotational ?

(iii) In case the flow is irrotational, find the velocity potential function and the stream function. 6+7+7 = 20

(c) A portion of a pipe for conveying water is vertical. The diameter of the upper part of the pipe is 50 mm and the section is gradually reduced to 25 mm diameter at the lower part. A pressure gauge is inserted where the diameter is 50 mm and a second gauge 2 m below the first where pipe is 25 mm diameter. When the quantity of water flowing up through the pipe is 0.210 m^3 per minute, the gauges show a pressure difference of 30 kN/m^2. Assuming that the head loss varies as the square of the velocity

determine the quantity of the water passing through the pipe when the two gauges show no pressure difference and the water is flowing downwards. 20

6. (a) A smooth brass pipe line 80 mm in diameter and 1000 m long carries water at the rate of 9 litres per second. If the kinematic viscosity of water is 0.0198 stokes, calculate loss of head, wall shearing stress, centre line velocity, shear stress and velocity at 30 mm from centre line and the thickness of the laminar sublayer. 13

(b) (i) Derive the expression for energy correction factor and momentum correction factor for open channel flow.

(ii) Find the velocity and rate of flow of water thoroughly channel of 8 m wide and 4.5 m deep when it is running full. The channel is having a bed slope of 1 in 1500. Assume Chezy's constant C = 60. 14

(c) A propeller turbine runner has outer diameter of 4.5 m and the diameter of the hub 2 m. It is required to develop 20600 kW when running at 150 rpm, under a head of 21 m. Assuming hydraulic efficiency of 94% and overall efficiency of 88%, determine the runner vane angles at inlet and exit at the mean diameter of the vanes. Also determine the runner vane angles at inlet and exit at two sections — near the hub and the outer periphery. 13

7. (a) (i) The mass specific gravity of a fully saturated specimen of clay having a water content of 30% is 1.98. On oven drying, the mass specific gravity drops to 1.65. Calculate the specific gravity of the clay.

(ii) A uniform soil deposit has a void ratio of 0.6 and specific gravity of 2.67. The natural ground water is at 2.5 m below

natural ground level. Due to capillary moisture, the average degree of saturation above ground water table is 50%, determine the neutral pressure, total pressure and effective pressure at a depth of 6 m. Draw a neat sketch. 14

(b) The void ratio of clay A decreased from 0.572 to 0.505 under a change in pressure from 1.2 to 1.8 kN/m^2. The void ratio of clay B decreased from 0.612 to 0.597 under the same change of pressure. The thickness of sample A was 1.5 times that of B. Nevertheless the time required for 50% consolidation was three times longer for sample B than for sample A. What is the ratio of coefficient of permeability of A to that of B ? 13

(c) Explain Bishop's method of stability analysis. 13

8. (a) A rectangular foundation, 2m × 4m, transmits a uniform pressure of 450 kN/m^2 to the underlying soil. Determine the vertical stress at a depth of 1.2 m below the foundation at a point within the loaded area, 2 m away from short edge and 0.5 m away from a long edge. Use Boussinesq's theory. 13

(b) A footing, 3 m square, is located in a dense sand at a depth of 2.5 m. Determine the ultimate bearing capacity at ground surface, at footing level and 1.8 m below footing level. The moist unit above the water table is 20 kN/m^3 and the saturated weight is 20 kN/m^3 ; $\Phi = 35^\circ$; $c = 0$; $N_q = 33$ and $N_r = 34.0$ 13

(c) (i) A vertical wall with a smooth face is 7.5 m high and retains soil with a uniform surcharge angle of 10°. If the angle of internal friction of soil is 28°, compute

the active earth pressure and the passive earth resistance assuming $\gamma = 22\ kN/m^3$. 7

(ii) A 9-pile group has to be arranged in the form of a square in soft clay with uniform spacing. Neglecting end bearing, determine the optimum value of the spacing of the piles in terms of the pile diameter, assuming a shear mobilisation factor of 0.6. 7