Time : 3 hours

Full Marks : 300

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 three of the remaining questions, selecting at least one from each Section.

SECTION – A

1. Answer any **three** of the following : **[20×3 = 60]**

    (a) A cantilever beam with a circular cross-section of 150mm is subjected to a UDL over the entire span. It is given that the deflected shape of the beam has a maximum curvature of $1.018592 \times 10^{-6} mm^{-1}$ and a maximum shear force of 2kN. Find the intensity of the load on the beam and its span.

(b) A UDL of 2,000 kg/m, 6m long crosses over a girder simply supported at ends over a span of 10 m from left to right. Calculate maximum bending moment in the girder at a point 4.5 m from left hand end using influence lines.

(c) A symmetrical three hinged circular arch has a span of 16m and a rise to the central hinge of 4m. It carries a vertical load of 26 kN at 6m from left hand end . Find the maximum positive and negative bending moment.

(d) A suspension cable is supported at two points 20m apart. Left support is 2m above the right support the cable is loaded with UDL of 10 kN/m over whole span. The maximum dip in cable from left support is 4m. Find the maximum tension in cable.

2. (a) An R. C. C. beam 300mm wide and 700mm deep overall is reinforced with 3-20mm ϕ bars. The centers of the bars are 50mm from the other sides of the beam. The effective span of the beam is 6 m. Use M20 concrete and Fe 415 steel :

   (i) Find the safe UDL (Super-imposed) the beam can carry. [10]

   (ii) Find the central concentrated load that the beam can carry in addition to its self-weight. [10]

   (b) A stepped beam ABC simply supported at A and fixed at C, as shown in the figure below, carries a UDL of intensity 'w' per unit length over BC. Determine the vertical reaction at A using moment area method : [20]
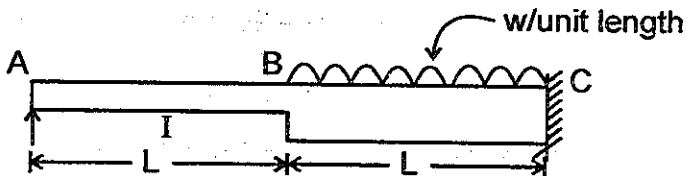

Figure – 1

(c) A reinforced beam 300mm × 400mm effective is supported over a clear span of 6.5m. Width of support is 500mm. It carries a factored UDL of 48 kN/m (including self-weight). The section is reinforced with 5-16mm ϕ bars. Using M20 concrete and Fe 450 steel, calculate shear reinforcement if :

(i) Only vertical stirrups are used. **[10]**

(ii) Two bars are bent-up at 45° at the same cross section. **[10]**

3. (a) A mild steel T section has the following cross-section dimensions :

Total depth = 200mm

Width of flange = 120 mm

Thickness of flange = 20mm

Thickness of web = 20mm

If the yield stress, σ_y = 250 MPa, determine the plastic moment capacity of the section.

[20]

(b) A reinforced concrete beam of rectangular cross-section is shown in the figure below. Assume M 20 grade concrete and Fe 415 grade steel. Permissible compressive stress of concrete in bending σ_{cbc} = 7.0 MPa for M 20 grade concrete. Compute the maximum stresses in concrete and steel when a moment of 50kNm is applied to the cross-section : [20]
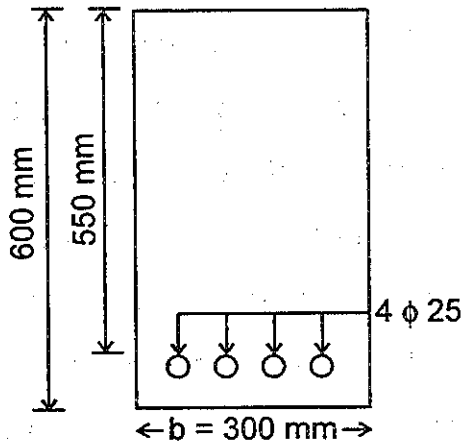

Figure – 2

(c) A closed coil helical spring whose free length when not compressed is 150mm, is required to absorb strain energy equal to 50 N-m when fully compressed with the coils in contract. The maximum torsional shear stress is limited to 140 N/mm^2. Assuming a mean coil diameter of 100mm, find the diameter of steel wire required and the number of coils. Take N = 0.8×10^5 N/mm^2.

[20]

4. (a) Design a circular column of diameter 400mm with helical reinforcement subjected to a working load of 1,200 kN. Use M25 concrete and Fe415 steel. The column has unsupported length of 3m and is effectively held in position at both ends but not restrained against rotation. Steel can be taken between 0.8 to 4%.

[20]

(b) Design a simply supported beam of span 6m, laterally unrestrained. The beam carries a working DL of 15 kN/m and LL of 10 kN/m. Use F2 410 steel. The beam is laterally restrained by a cross beam framing at mid span. [20]

(c) Using conjugate beam method find the mid-span deflection of the beam shown in figure below: [20]

Given $\Rightarrow E = 2 \times 10^8 \text{ kN/m}^2$

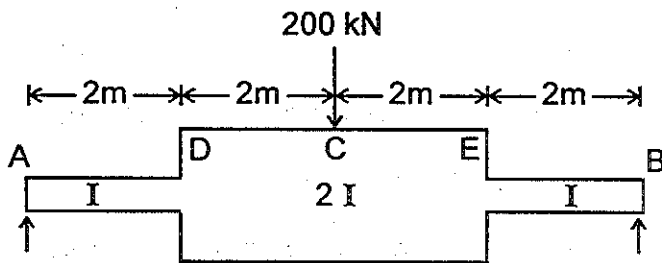$$I = 2 \times 10^{-2} \text{ m}^4$$

Figure – 3

SECTION – B

5. Answer any three of the following : [20×3 = 60]

(a) Water is pumped from a well tapping an unconfined aquifer at a rate of 2,400m^3 per day. A no-drawdown boundary exists at a distance of 5 km from the well center. Assuming the well to be fully penetrating, compute the steady state of drawdown at the well face. Given : Initial saturated thickness = 50m, hydraulic conductivity = 20m/day, effective well radius = 1m. [20]

(b) A cylindrical vessel 12cm in diameter and 30cm deep is filled with water up-to the top. The vessel is open at the top. Find the quantity of liquid left in the vessel, when it is rotated about its vertical axis with a speed of (a) 3,000 r. p. m. and (b) 600 r. p. m. [20]

(c) (i) If the velocity distribution in a pipe is given by :

$$u = u_{max}(1 - r/r_0)^n,$$

where u is the velocity at any radius r, r_0 is the radius of pipe and u_{max} is the maximum velocity then find (i) average velocity and (ii) kinetic energy correction factor. **[10]**

(ii) State the factors affecting the field compaction of the soil. Also, explain the term optimum moisture content. **[10]**

(d) A trapezoidal channel has side slopes 1 to 1. It is required to discharge $13.75 m^3/s$ of water with a bed gradient of 1 in 1,000. If unlined, the value of Chezy's C is 44. If lined with concrete its value is 60. The cost per meter excavation is 4 times the cost per m^2 of lining. The channel 1 to be most efficient one. Find whether the lined or unlined canal will be cheaper. What will be the dimensions of that economical canal ? **[20]**

6. (a) A retaining wall 10m high is proposed to hold dry sand of void ratio of 0.6. The value of angle of internal friction $\phi = 30^\circ$ and specific gravity of soil grain is 2.7. The back face of wall is vertical and smooth. Top surface of the backfill is horizontal. Calculate the magnititude of total effective earth thrust against the wall assuming the wall is free to move. Also, show the distribution of earth pressure and point of application of the resultant. Assume the unit weight of water as 10 kN/m^3. **[20]**

   (b) A smooth pipe of diameter 80mm and 800m long carries water at the rate of 0.480m^3/min. Calculate the loss of head, wall shearing stress, center line velocity, velocity and shear stress at 30mm from pipe wall. Also, calculate the thickness of leminar's sub-layer. Take kinematic viscosity of water as 0.015 stokes.

Take the value of co-efficient of friction 'f' from the relation given as : **[20]**

$$f = 0.0791 / (R_e)^{0.25}$$

Where R_e = Reynold's number.

(c) A pelton wheel develops 9,000kW under a net head of 150m at a speed of 240 r. p. m.. Assuming the coefficient of velocity for the nozzle 0.98, hydraulic efficiency 85%, speed ratio 0.44 and jet diameter to wheel diameter ratio 1/9. Determine :

(i) The discharge required.

(ii) The diameter of wheel.

(iii) The diameter and number of jets required.

(iv) The specific speed.

Mechanical efficiency is 78%. **[20]**

7. (a) How many days would be required by a clay stratum 5m thick, draining at both ends with

coefficient of consolidation $= 50 \times 40^{-4}$ $cm^2/$ sec to attain 50% of its ultimate settlement ?

Give : $T_{50} = 0.197$. [20]

(b) Sketch the variation in total stress, effective stress and pore water pressure upto a depth of 6m below ground level, given the following data. The water table is 2m below ground level. The dry density of soil is 17.66 kN/m^3, water content is 12% ; specific gravity is 2.65. Water would be the change in these stresses, if water table drops by 1.0m. [20]

(c) A rectangular gate 5m × 2m is hinged at its base and inclined at 60° to the horizontal as shown in figure below. To keep the gate in stable position a counter weight of 5,000 kgf is attached at the upper end of the gate. Find the depth of water at which the gate begins

to fall. Neglect the weight of the gate and
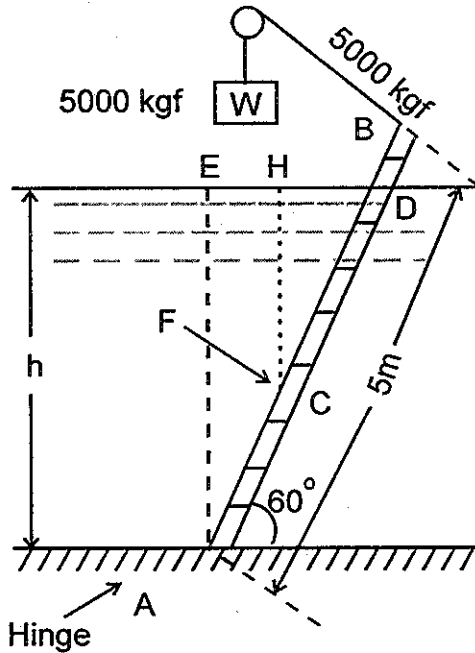friction at the hinge and pully : **[20]**

Figure – 4

8. (a) (i) Explain Geometric, Kinematic and
Dynamic similarity. **[10]**

(ii) A 72m high and 15m long spillway
discharges $94m^3/s$ under a head of 2m.

If a 1 : 9 scale model of this spillway is to be constructed, determine model dimensions, head over spillway model and the model discharge. If model is experiencing a force of 750 kgf, determine the force on prototype. **[10]**

(b) (i) The soil profile at a building site consists of dense sand up to 2m depth, normally loaded soft clay from 2 to 6m depth, and stiff impervious rock below 6m depth. The ground water table is at 0.40m depth below ground level. The sand has a density of 18.5 kN/m^3 above water table and 19 kN/m^3 below it. For the clay, natural water content is 50%, liquid limit is 65% and grain specific gravity is 2.65. Calculate the ultimate probable settlement resulting from a uniformly a distributed surface load of 40 kN/m^2 applied over an extensive area of the site. **[10]**

(ii) In a laboratory consolidation test with porous discs on either side of the soil sample, the 25mm thick sample took 81 minutes for 90% primary compression. Calculate the value of coefficient of consolidation for the sample. **[10]**

(c) 1 in 20 model of a naval ship having a submerged surface area of $5m^2$ and length 8m has a total drag of 20 N when towed through water at a velocity of 1.5 m/s. Calculate the total drag on the prototype when moving at the corresponding speed. Use the relation given as $F_t = 0.5 f_0 AV^2$ for calculating the skin (frictional) resistance. The value of C_f is given by $C_f = 0.0735/(Re)^{1.5}$. **[20]**

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