CSM – 18/20
Civil Engineering
Paper – I

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

(BIS, Railway & IRC codes are permitted)

SECTION – A

1. Answer any **three** of the following :

   (a) (i) State and explain the conditions of static equilibrium for both 2D and 3D structures. 3+3 = 6

(ii) If $\mu 1$ and $\mu 2$ are the coefficients of friction at the ends of a ladder resting on ground and against a vertical wall, respectively, as shown in Fig. 1, then find the maximum angle (θ) the ladder may make with horizontal. The weight of the ladder is W. 14

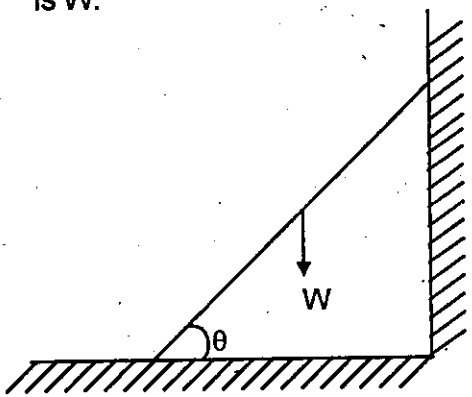

Fig. 1

(b) (i) Explain the terms balanced, under reinforced and over reinforced sections in RCC beams. State which section should be recommended for design of RCC beam and why ? (2×3)+2 = 8

(ii) A RCC cantilever beam of length 3 m having a cross section of 250 × 500 mm is reinforced with 4 bars of 20 mm dia. on the tension side with a nominal cover of 30 mm. Find the ultimate moment carrying capacity and the uniformly distributed load the beam can support excluding its self-weight if its span is 5 m. Use M20 concrete and Fe415 steel. 12

(c) Draw shear force and bending moment diagrams for the beam shown in Fig. 2. 20

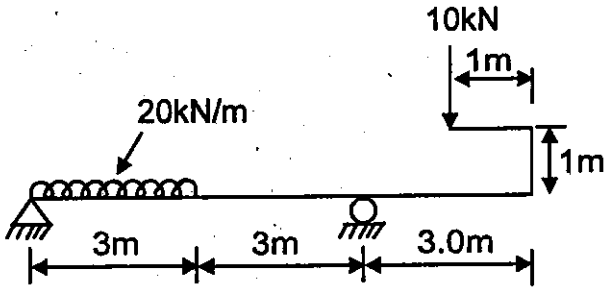

Fig. 2

(d) Design a double angle discontinuous strut to carry a factored load of 135 kN, resulting from the combination of wind load. The length of strut is 3 m between intersections. The two angles are placed back-to-back (with long legs connected) and are tack bolted. The angles are placed on opposite sides of 12 mm gusset plate. Use steel of grade E 250 (f_y = 250 N/mm^2). 20

2. (a) A compound bar consists of a circular rod of steel of 20 mm diameter rigidly fitted into a copper tube of internal diameter of 20 mm and outer diameter of 25 mm. If the bar is subjected to an axial load of 75 kN, find the stresses developed in steel and copper. Take $E_s = 2 \times 10^5$ N/mm^2 and $E_c = 1.2 \times 10^5$ N/mm^2. 20

(b) A parabolic three hinged arch having span of 20 m and rise 4 m. It carries a uniformly distributed load of 20 kN/m for a length of 8 m from the left end support. Draw the bending moment diagram and find the position and magnitude of maximum bending moment. 20

(c) A concrete beam of symmetrical I-section spanning 8 m has a flange width of 400 mm and a flange thickness of 100 mm. The overall depth of beam is 600 mm. Thickness of the web is 100 mm. The beam is pre-stressed by a parabolic cable with an eccentricity of 200 mm at the centre of the span and zero at supports. The live load on the beam is 3kN/m : 20

(i) Determine the effective force in the cable for balancing the dead and live loads on the beam.

(ii) Sketch the distribution of resultant stress at mid-span section of the beam.

(iii) Calculate the shift of the pressure line from the tendon-central line.

3. (a) Determine the deflection and slope at the free end of the beam shown in Fig. 3 using conjugate beam method. Take $E = 2.5 \times 10^4$ N/mm^2 and $I = 3.125 \times 10^9$ mm^4. 20

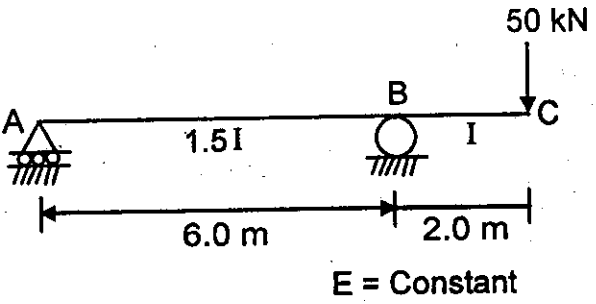

Fig. 3

(b) A steel beam of effective span 7.8 m carries a uniformly distributed load of 20 kN/m over the whole length including its own weight.

Design the beam for bending and shear assuming that the compression flange is laterally restrained throughout the length. Take allowable bending stress = 150 N/mm^2 and allowable shear stress = 100 N/mm^2. 20

(c) A trapezoidal masonry retaining wall is 6 m high and 1.2 m wide at the top. If retains earth, level with the top of the wall, calculate the minimum width at bottom of the wall so that no tension is induced at the base. The unit weight of masonry wall is 2.0 kN/m^3 and unit weight of soil is 1.6 kN/m^3. The angle of repose of soil is 30^o. The face of masonry retaining wall exposed to the soil is vertical. 20

4. (a) A continuous beam of uniform plastic moment capacity M_p has two equal spans and its ends are simply supported.

A concentrated load W is acting at the mid-point of each span. Determine the collapse load for the beam. 20

(b) Design an axially loaded tied column 400 × 400 mm pinned at both ends with an unsupported length of 3 m for carrying a factored load of 2300 kN. Use M20 concrete and Fe415 steel. 20

(c) A continuous beam, ABC, is shown in Fig. 4. Determine the support moments using the slope-defection method. 20

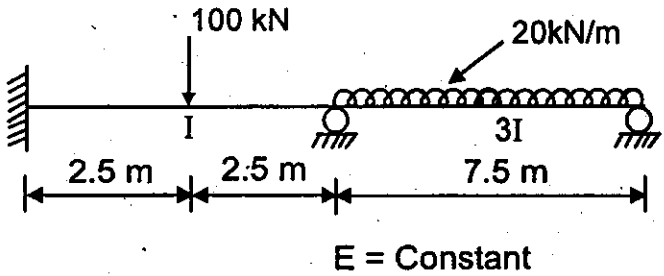

Fig. 4

SECTION – B

5. Answer any **three** of the following :

(a) (i) Define and distinguish between Velocity potential function and Stream function. 6

(ii) Calculate the velocity components u and v for the velocity potential function $\varphi = \tan^{-1}\left(\frac{y}{x}\right)$. Does the velocity potential function represent a flow field ? Determine the corresponding stream function for the velocity potential function. 14

(b) (i) Explain the term specific speed as applied to hydraulic turbines. 4

(ii) A turbine develops 7355 kW under a head of 24.7 m at 210 rpm. What is its specific speed ? Indicate the type of

turbine suitable for the purpose. If this turbine is tested in the laboratory where the head of water available is only 7.5 m, what power will it develop and at what speed ? 16

(c) (i) Define void ratio and porosity of a soil and derive the relation between them. 8

(ii) A soil has the following properties :

Void ratio = 0.72, moisture content = 12% and specific gravity = 2.72.

Determine its dry unit weight, moist unit weight and the amount of water to be added per cubic metre of soil to make it saturated. 12

(d) (i) Define coefficient of uniformity and coefficient of curvature of a soil and state their importance in soil classification system. 8

(ii) The following test results were obtained for a fine-grained soil : WL = 48%; WP = 26%; clay content = 55%; silt content = 35%; sand content = 10% and in-situ moisture content = 39%. Classify the soil, and determine its activity and liquidity index. 12

6. (a) Define the efficiencies of a hydraulic ram. In a hydraulic ram, supply pipe is 75 mm diameter, waste valve is 100 mm diameter, 5 mm lift and 20 N weight. Calculate the maximum velocity that can occur in supply pipe. 4+16 = 20

(b) If two pipes of diameter D and d and equal length L are arranged in parallel the loss of head for a flow of Q is h. If the same pipes are arranged in series the loss of head for the same flow Q is H. If d = 0.5 D, find the

percentage of total flow through each pipe when placed in parallel and the ratio (H/h). Neglect minor losses and assume friction factor, f to be constant. 20

(c) A venturimeter is used for measuring the flow of petrol in a horizontal pipeline. The specific gravity of the petrol is 0.90 and throat area ratio is 5. If the difference in mercury levels in the gage is 50 mm, calculate the flow in litres per hour if the pipe diameter is 0.3 m. Take discharge coefficient of the venturimeter as 0.96. take specific gravity of mercury = 13.6. 20

7. (a) Determine the following from a three-layered soil shown in Fig. 5. : 7+7+6 = 20

(i) Equivalent coefficient of vertical permeability of three layers.

(ii) The rate of flow per m^2 of plan area.

(iii) The total head loss in three layers.

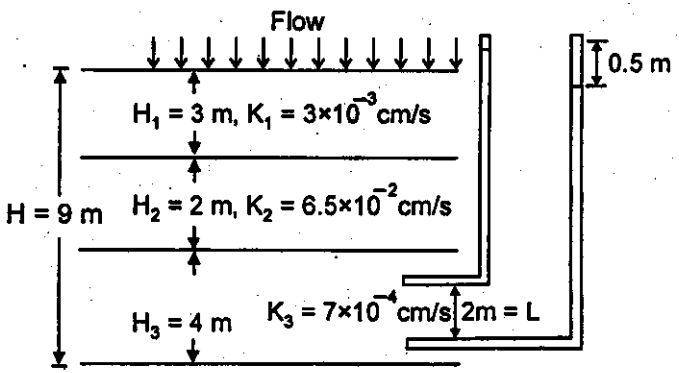

Fig. 5

(b) For a field pumping test, a well was sunk through a horizontal stratum of sand 14.5 m thick and underlain by a clay stratum. Two observation wells were sunk at horizontal distances of 16 m and 34 m, respectively from the pumping well. The initial position of the water table was 2.2 m below ground level. At a steady-state pumping rate of 1850 litres/min, the drawdowns in the observation wells

were found to be 2.45 m and 1.20 m, respectively. Calculate the coefficient of permeability of the sand. 20

(c) A 3 m thick clay layer in the field under a given surcharge will undergo 7 cm of total primary consolidation. If the first 4 cm of settlement takes 90 days, calculate the time requried for the first 2 cm of settlement. 20

8. (a) Define the kinetic energy and momentum correction factors. Derive the expressions for both the terms. State the values for the kinetic energy and momentum correction factors for laminar flow in pipes. 2×(2+7+1) = 20

(b) The unit discharge in a rectangular channel is 18 m^3/s and the head loss across a hydraulic jump that forms in this channel is 1.1 m. Estimate the pre-jump and post-jump depths. 20

(c) A square footing is to be constructed at a depth of 2 m below the ground level on a sandy clay for which the cohesion C is 0.575 kg/cm^2 and density is 1.73 g/cm^3. The total load applied on the soil is 200 tonnes uniformly distributed over the area of contact.

Find the size of footing using Terzaghi's theory with the values of the relevant factors as $N_c = 10$, $N_q = 4$ and $N_r = 2$. Assume a factor of safety of 3 for calculating safe bearing capacity of soil. 20