191006

COMBINED COMPETITIVE EXAMINATION (MAIN)

CIVIL ENGINEERING

Paper-I

Time : 3 Hours *Full Marks* : 200

Note : *(1) The figures in the right-hand margin indicate full marks for the question.*
*(2) Attempt **five** questions in all.*
(3) Question No. 1 is compulsory.

1. Answer any ***ten*** questions from the following : 4×10=40

(a) Describe briefly the general solution procedure underlying the method of consistent deformations.

(b) Explain briefly the basis of the slope deflection method of analysis.

(c) Define influence line. What are the uses of influence lines in structural analysis?

(d) State the two Castigliano's theorems. What are their uses?

(e) Under what conditions the meniscus between two liquids in a glass tube will concave upwards?

(f) The velocity distribution for a three-dimensional flow is given by $u = -x$, $v = 2y$ and $w = 3 - z$. Find the equation of the streamline passing through (1, 1, 2).

(g) A pipeline carries oil (sp. gr. 0.83), at a velocity of 2 m/s through a 20 cm pipe. At another section the diameter is 15 cm. Find the velocity at this section and the mass rate of flow.

(h) What are various approaches used to estimate the load bearing capacity of a pile?

(i) Differentiate between positive pore water pressure and negative pore water pressure.

(j) A sand sample has a natural void ratio of 0.6 and its density index is 0.6. If its void ratio in the loosest state is 0.9, what will be the void ratio in its densest state?

(k) Explain the difference between coefficient of compressibility and the compression index.

(l) How is the static cone penetration test different from standard penetration test?

2. Answer any ***eight*** questions from the following : 5×8=40

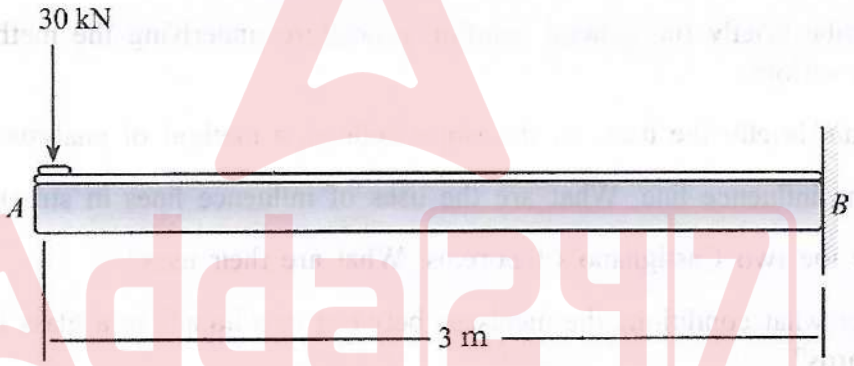
(a) What are the differences between compaction and consolidation? Explain the improvement in the engineering properties of a soil mass that can be brought about through compaction.

(b) Grain distribution analysis of a soil was done and based on it, the D_{10}, D_{30} and D_{60} values of a given soil were found to be 0.23 mm, 0.3 mm, and 0.41 mm respectively. What will be the classification of the soil as per the specifications in IS code?

(c) Justify the IS 456:2000 code specification for the limiting neutral axis depth in limit state method.

(d) What are the reasons for which the riveted joint has lost their importance?

(e) Using Castigliano's theorem, determine the displacement at A. The point A is free, and the point B is fixed supported. EI is constant.



(f) Explain clearly the difference in the behaviour of one-way slabs and two-way slabs.

(g) What is meant by slenderness ratio of a compression member and what are its implications?

(h) What is meant by limit state? Discuss different limit states to be considered in reinforced concrete design.

(i) Calculate the capillary effect in millimetres in a glass tube of 4 mm diameter, when immersed in (i) water, and (ii) mercury. The temperature of the liquid is 20°C and the values of surface tension of water and mercury at 20°C in contact with air are 0.0736 N/m and 0.51 N/m respectively. The angle of contact for water is zero and that for mercury is 130°. Take γ_{water} at 20°C as 9790 N/m^3 and $\gamma_{mercury}$ at 20°C as 133 N/m^3.

(j) A rectangular barge is 20 m long, 7 m wide and 3 m deep. It has a draft of 2 m when fully loaded. The c.g. of the barge is on the axis of symmetry at the water surface. Determine the stability condition of the barge and the metacentric height.

3. Answer any ***five*** questions from the following : 8×5=40

(a) A geometrically similar model of an air duct is built to 1/25 scale and tested with water which is 50 times more viscous and 800 times denser than air. When tested under dynamically similar conditions, the pressure drop is 200 kN/m^2 in the model. Find the corresponding pressure drop in the full-scale prototype and express in cm of water.

(b) Why is it necessary to relax one of the boundary conditions in case of solution to Navier-Stokes equations applied for an ideal fluid? Identify the boundary condition.

(c) A model of spillway is made to test the flow. The discharge and the velocity of flow over the model were measured as 2.5 m^3/s and 1.5 m/s respectively. Find the discharge and the velocity over the prototype which is 50 times larger than its model.

(d) A propped cantilever of length L carryies a point load W at the centre of the beam length. Find the moment at the fixed end. Assume EI is constant.

(e) If a retaining wall 5 m high is restrained from yielding, what will be the at-rest earth pressure per metre length of the wall? Given : the backfill is cohesion-less soil having $\varphi = 30°$ and $\gamma = 18$ kN/m^3. Also determine the resultant force for the at-rest condition.

(f) Describe different modes of bearing capacity failures.

(g) Explain how the frequency and amplitude of vibration generated by an earthquake is associated with the behaviour of sand mass during an earthquake.

4. Answer any ***four*** from the following : 10×4=40

(a) What is the shearing strength of soil along a horizontal plane at a depth of 4 m in a deposit of sand having the following properties : Angle of internal friction, $\varphi = 35°$, Dry unit weight, $\gamma_d = 17$ kN/m^3, Specific gravity, $G_s = 2.7$.
Assume the groundwater table is at a depth of 2.5 m from the ground surface. Also find the change in shear strength when the water table rises to the ground surface.

(b) A reinforced concrete short column is 400 mm × 400 mm and has 4 bars of 20 mm diameter. Determine the ultimate load carrying capacity of column if M20 concrete and Fe415 steel is used. Assume minimum eccentricity $e_{min} < 0.05D$. Consider $P_u = 0.4 f_{ck} A_c + 0.67 f_y . A_{sc}$ *where,* P_u = Ultimate load carrying capacity of the column, f_{ck} = characteristic strength of concrete, A_c = Area of concrete, A_{sc} = Area of steel D = Dimension of column.

(c) A smooth flat plate with a sharp leading edge is placed at zero incidence in a free stream of water flowing at 3.5 m/s. Determine the distance from the leading edge where the transition from laminar t turbulent flow may commence. The viscosity of water is 1 centipoise. Calculate the boundry layer thickness at the transition point.

(d) A rough plastic pipe 50 cm in diameter and 300 m in length is carrying water with a velocity of 3 m/s and has an absolute roughness of 0.25 mm and a kinematic viscosity

of 0.9 centistokes. Is the flow turbulent or laminar? What is the head lost in friction?

For laminar flow $f = \frac{64}{R}$

For turbulent flow $\frac{1}{\sqrt{f}} = 2\log_{10}\frac{r_0}{k_s} + 1.74$

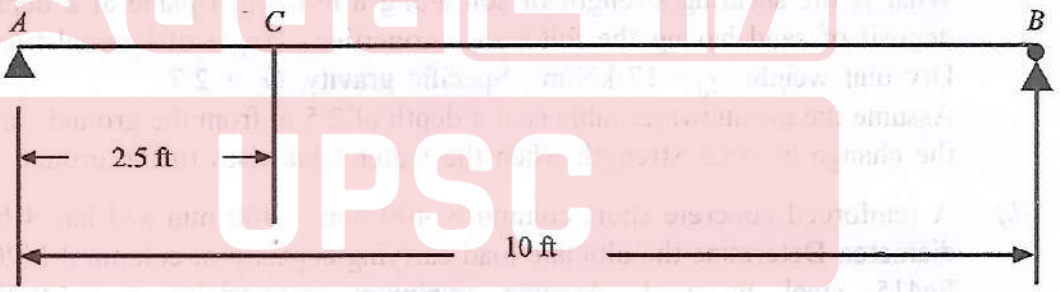
(e) A rough timber flume (Manning's $n = 0.012$) in the form of equilateral triangle (apex down) of 1.2 metres sides is laid on slope of 0.01. Calculate the uniform flow rate which occurs at a depth of 90 cm.

5. Answer any ***two*** questions from the following : 20×2=40

(a) Determine the ultimate moment of resistance of a beam of dimension 250 mm × 350 mm. The area of steel consists of 3 bars of 12 mm diameter placed at a distance of 40 mm from bottom of beam. Use M20 and Fe415 steel. Use limit state method.

(b) Determine various stresses set up at mid span in a pre-tensioned beam 250 mm × 500 mm, subjected to an initial pre-stress of 1500 kN and a uniformly distributed superimposed load of 5 kN/m over a span of 15 m. Assume total loss of pre-stress as 12% and eccentricity of pre-stress at midspan is 100 mm.

(c) Using influence line methods, determine the maximum positive shear at C due to the concentrated moving load of 4000 lb from left to right. Point A is hinged support and point B is roller support. The length of the beam is 10 feet and point C is at a distance 2.5 feet from A as shown in the figure below :



6. Answer any ***four*** questions from the following : 10×4=40

(a) Define a shallow foundation. What are the factors that are to be considered for design of foundations? Briefly describe Terzaghi's bearing capacity theory.

(b) A soil sample in its natural state has, when fully saturated, a water content of 32.5%. Determine the void ratio, dry and total unit weights. Calculate the total weight of water required to saturate a soil mass of volume 10 m^3. Assume $G_s = 2.69$.

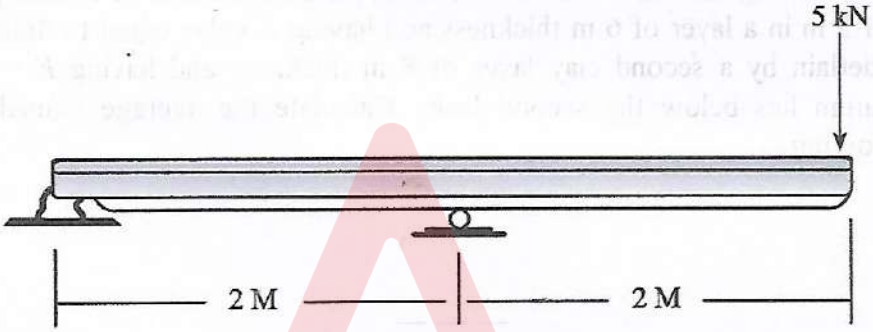
(c) A beam of length 4 m and width 0.75 m rests in dry medium dense sand. A plate load test carried out at the same site and at the same level gave a coefficient of subgrade reaction k_1 equal to 47 MN/m^3. Determine the coefficient of subgrade reaction for the beam.

(d) Describe the process of consolidation. What is the difference between normally consolidated and over consolidated clay?

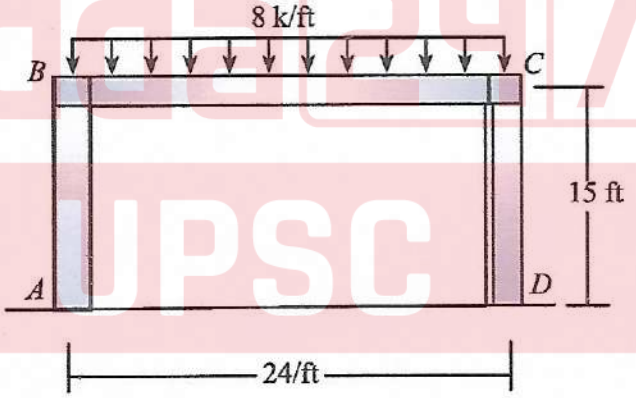
(e) Show that at the critical state of flow, the specific energy in a rectangular channel is equal to 1.5 times the depth of flow. Will the depth of flow be greater or less than 2/3 times specific energy for the trapezoidal channel and why?

7. Answer any *two* questions from the following : 20×2=40

(a) Using stiffness matrix method determine the reactions at the supports below :



(b) Using moment distribution method, determine the unknown moments of the frame. Assume the supports A and D are fixed and B and C are fixed connected. The length of the frame is 24 feet and the height is 15 feet and uniformly distributed load of 8000 lb per feet (i.e., 8 k/ft) is acting between B and C as shown in the figure below :



(c) An open channel of most economical section, having the form of half hexagon with horizontal bottom, is required to give a maximum discharge of 20.2 m^3/s of water. The slope of the channel bottom is 1 in 2500. Taking $C = 66\ m^{0.5}/s$ in Chezy's equation, determine the dimensions of the cross-section. Taking the value of the velocity of the flow in the channel as obtained by Chezy's equation, determine the value of n in the Manning's formula.

8. Explain different types of programming language. Design an algorithm as well as flowchart for finding out the large number out of three given numbers. 40

9. *(a)* What is irrotational flow? Explain how a two-dimensional flow of an incompressible fluid along a curved boundary can be irrotational.

(b) The wind velocity in a cyclone may be assumed to vary according to free vortex law. If the velocity is 16 km per hour 50 km from the centre of cyclone, what pressure gradient should obtain at this point? What reduction in barometric pressure should occur over a radial distance of 10 km from the point towards the centre of the storm? Take mass density of air as 1.208 kg per cubic metre. 40

10. A rectangular footing of 5 m × 2.5 m size, carries a uniform load of intensity 160 kN/m^2 at a depth of 1.5 m in a layer of 6 m thickness and having E value equal to 40000 kN/m^2. This layer is underlain by a second clay layer of 8 m thickness and having E = 70000 kN/m^2. A hard stratum lies below the second layer. Calculate the average immediate settlement under the footing. 40

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