Civil Services (Main) Examination, 2014

CIVIL ENGINEERING

(Paper I)

Time Allowed : Three Hours **Maximum Marks : 250**

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.
Candidate has to attempt FIVE questions in all.
Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.
The number of marks carried by a question/part is indicated against it.
Wherever any assumptions are made for answering a question, they must be clearly indicated.
Word limit in questions, wherever specified, should be adhered to.
Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

SECTION 'A'

1. (a) Find the resultant of the force system acting on a lamina of equilateral triangle of sides 200 mm shown in Fig. 1(a). Also, find its direction and position with respect to *A*.

[Figure: Fig. 1(a) – Equilateral triangular lamina ABC of side 200 mm, A at bottom left, C at bottom right, B at the apex. Forces: 50 kN at B acting upwards along the line CB produced (up and to the left, away from C); 60 kN acting along the line from A through the mid-point of BC, arrow pointing away from A (upwards to the right); 30 kN at C acting horizontally to the right along AC produced; 80 kN acting vertically downwards along the vertical line from B through the mid-point of AC (arrowhead below AC). No other labels or dimensions.] **10**

(b) Determine the maximum load that a discontinuous strut having a single angle 80 mm×50 mm×6 mm of length 1.75 m in a roof truss can carry, if it is connected at the ends by a single bolt. Take f_y of steel as 250 MPa. For the given angle, the cross-section area and radius of gyration are 746 mm^2 and 10.7 mm, respectively. Take n=1.4. **10**

(c) The consistency limits of a clayey soil are as follows: Liquid limit = 55%; Plastic limit = 25%; Shrinkage limit = 15% If natural moisture content = 30%, determine liquidity index and plasticity index. **10**

(d) Draw plasticity chart and explain its use. **10**

(e) A pipe of 40 cm diameter is carrying 0.2 m^3/s water. The pipe is bent by 145 degrees from the horizontal counter-clockwise. The pressure of water flowing through the pipe is 400 kN/m^2. Find the magnitude and direction of the resultant force on the bend. **10**

2. (a) Determine horizontal deflection at point *D* in the frame shown in Fig. 2(a). *EI* is constant throughout.

[Figure: Fig. 2(a) – Portal-type frame ABCD: short vertical column AB of height a, fixed at its base A; horizontal beam BC of length 3a (B to load point a, load point to C 2a); vertical column CD of height 2a hanging down from C to a hinged (pin) support at D, so D is a below the level of A. A vertical downward point load P acts on BC at a distance a from B. EI constant.] **20**

(b) An embankment is being built of a soil whose effective stress shear strength parameters are as follows: c'=100 kN/m^2; ϕ'=20 degrees; Unit weight = 17 kN/m^3 The pore pressure parameters *A* and *B* determined by the triaxial shear tests are 0.6 and 0.8, respectively. The height of the embankment has just been raised from 5 m to 8 m. Determine the shear strength of the soil at the base of the embankment. Assume that the dissipation of pore pressure during this stage of construction is negligible and the lateral pressure at any point is one-half of the vertical pressure. **20**

English version compiled from published transcriptions and cross-checked across sources; not a facsimile of the official UPSC question paper.

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(c) An excavation is made with a vertical face in a clayey soil which has C_u=50 kN/m^2, γ_t=18 kN/m^3. Determine the maximum depth of excavation so that it is stable. The stability number, corresponding to ϕ_u=0 and β=90 degrees, may be taken as 0.261. Assume FS as 1.0. **10**

3. (a)(i) A vertical steel cylinder storage tank of 30 m diameter is filled up to a depth of 15 m with gasoline having relative density of 0.74. Determine the thickness required for the wall plate using a factor of safety of 2.5. Take f_y=250 MPa. Ignore the localized bending effects, if any. Use working stress method of design. **10**

(a)(ii) Calculate the quantities of ingredients required to produce one cubic meter of structural concrete. The mix proportions are 1 : 1.33 : 2.80 by dry volume of cement, with a water-cement ratio of 0.48 (by mass). The bulk densities of cement, sand and coarse aggregates are 1490 kg/m^3, 1700 kg/m^3 and 1610 kg/m^3, respectively, and the corresponding specific gravities are 3.15, 2.60 and 2.62, respectively. The percentage of entrained air is 2.0. **10**

(b) The width of a rectangular channel is 4.0 m and specific energy in the channel is 4.0 m. What would be the maximum possible discharge in the channel? **10**

(c)(i) What inputs are required for the estimation of settlement of a group of friction piles in clayey soil? Mention the assumptions made. **5**

(c)(ii) A group of nine piles, 12 m long and 250 mm in diameter, is to be arranged in a square form in clayey soil with an average unconfined compressive strength of 60 kN/m^2. Suggest centre-to-centre spacing of the piles for a group efficiency factor of 1.0. Neglect bearing at the top of the piles and assume an adhesion factor α=0.9. **15**

4. (a) A uniform ladder of length 7 m rests against a vertical wall with which it makes an angle of 45 degrees. The coefficient of friction between the ladder and the wall is 1/3, and between the ladder and the horizontal floor is 1/2. If a man weighing half as that of the ladder ascends it, how high will he be when the ladder just starts to slip? **10**

(b) A solid circular shaft of diameter d=100 mm is loaded with torque as shown in Fig. 4(b). Plot the diagrams showing the variation of T and θ.

[Figure: Fig. 4(b) – Solid circular shaft fixed to a wall at its left end and free at the right end, total length 6 m, divided by vertical lines into three lengths from the wall: x m, (4–x) m and 2 m. Torques shown as curved arrows: 4 kN-m drawn on the first length (x m), 8 kN-m drawn on the second length ((4–x) m), both curved arrows with the arrowhead at the top; 4 kN-m applied at the free right end, drawn as a couple with the upper arrow pointing up and to the right and the lower arrow pointing down and to the left.] **20**

(c) A rectangular footing 4 m × 2 m in plan, transmits a pressure of 150 kN/m^2 on a cohesive soil having E=6×10^4 kN/m^2 and μ=0.50. Determine the immediate settlement of the footing at the centre, assuming it to be (i) a flexible footing and (ii) a rigid footing. Take influence factor I_f=1.52 for flexible footing and 1.20 for rigid footing, respectively. **20**

SECTION 'B'

5. (a) Determine the forces and their nature in the members meeting at joint A of the truss shown in Fig. 5(a).

[Figure: Fig. 5(a) – Truss ABCD of span 20 m: A (left) on a hinged support and C (right) on a roller support at the same level, AC = 10 m + 10 m. Apex B at mid-span, 6 m above A (dimensioned 3 m + 3 m); internal joint D vertically below B, 3 m above A. Members AB, BC, AD, DC and BD (no bottom chord AC). Loads at B: 32 kN acting vertically upwards and 24 kN acting horizontally to the right.] **10**

(b) A saturated soil sample has water content of 40% and specific gravity of soil grains is 2.7. Determine its void ratio, porosity, saturated and dry unit weight. **10**

(c) A sand deposit has dry unit weight = 15 kN/m^3 and porosity = 45%. Determine critical hydraulic gradient. **10**

(d) Define Eülerian method of fluid motion. State the various types of fluid flow. Explain (i) uniform and non-uniform flow, and (ii) laminar and turbulent flow. **10**

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(e) Differentiate between the following: (i) Compaction and Consolidation (ii) Pore water pressure and Seepage pressure (iii) Liquidity index and Relative consistency (iv) Shallow foundation and Deep foundation **10**

6. (a) Two cantilever beams of same cross-sections and separated by a roller, jointly support a uniformly distributed load as shown in Fig. 6(a). Determine the collapse load.

[Figure: Fig. 6(a) – Cantilever AB of length L/2, fixed at A (left wall), plastic moment M_P. A second cantilever of length L, fixed at C (right wall), plastic moment M_P, lies at a slightly higher level; its free left end rests on a roller placed on the free end B of the first cantilever. A uniformly distributed load w/unit length acts over the whole length L of the upper cantilever.] **20**

(b) A cylindrical gate shown in Fig. 6(b) is 5 m in diameter and 20 m long. Find the total pressure on the gate in magnitude and direction.

[Figure: Fig. 6(b) – Cylindrical gate of diameter 5 m (marked along an inclined diameter) resting on two short inclined hatched seats on either side of its lowest point A. Water on the left side of the gate between a horizontal bed line at the level of A and a free surface level with the top B of the gate (water depth 5 m, dimensioned from the bed at A to the level of B). B is the top and A the bottom of the vertical diameter (dashed); C is the left end of the horizontal diameter.] **15**

(c)(i) Write the Navier-Stokes equation in Cartesian coordinates for incompressible fluid. **5**

(c)(ii) For steady laminar flow between two infinitely wide stationary plates, B=2.0 mm, $\mu=5\times10^{-2}$ kg/m s and pressure gradient $\partial p/\partial x=-15$ kN/m^3, determine discharge per unit width q, maximum shear and maximum velocity. **10**

7. (a) Compute I_u, I_v and I_{uv} with respect to u- and v-axis for a rectangular section 150 mm wide and 300 mm deep. The u- and v-axis are inclined 30 degrees counter-clockwise to x- and y-axis. **15**

(b) Design the stem of a cantilever retaining wall of height 6 m above the base slab. The thickness of the stem at the top is 200 mm. The unit weight of well-drained backfill is 17.5 kN/m^2 with angle of repose of 30 degrees. Use concrete of grade M20 and HYSD steel of Fe415 grade. Draw reinforcement details. **15**

(c) A Kaplan turbine produces 10000 kN working under a head of 15 m at an overall efficiency of 0.86. If hydraulic efficiency = 0.9, speed ratio = 2.1, flow ratio = 0.65, diameter of boss/diameter of runner = 0.3 and Q=79.0 m^3/s, compute the following: (i) Velocity of flow, peripheral velocity, both at inlet (ii) Speed and specific speed (iii) Guide vane angle and vane tip angle at inlet Assume that the discharge is radial. **20**

8. (a) The reinforced concrete rectangular section of a 6 m span beam has overall size 300 mm × 650 mm, and has tension reinforcement consisting of 3 bars of 20 mm diameter at a nominal cover of 40 mm. The simply supported beam is subjected to uniformly distributed load and concentrated load at its centre. If the ratio of total uniformly distributed load to concentrated load is 4, find the safe uniformly distributed and concentrated loads that can be supported. The concrete is of grade M20 and HYSD steel of Fe415 grade is used. **15**

(b) A prestressed concrete simply supported rectangular beam of size 220 mm × 400 mm carries imposed load of 5.0 kN/m over an effective span of 10 m. The prestressing cable is with parabolic profile placed 100 mm from the bottom at the mid-span and concentric at supports. If the prestressing force is 480 kN, determine the stresses in the beam at transfer and service load conditions using load balancing concept. The losses in prestress may be considered to be 15%. **15**

(c) Discharge through an orifice depends on head H, acceleration due to gravity g, mass density ρ, diameter of orifice d and viscosity μ. Make out a dimensional analysis using Buckingham's pi theorem and show that

$$Q/(H^{5/2}g^{1/2})=f(\rho H\sqrt{(gH)}/\mu,d/H)$$

Use ρ, H and g as the repeating variables. **20**

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