Civil Services (Main) Examination, 2004

CIVIL ENGINEERING

(Paper I)

Time Allowed : Three Hours **Maximum Marks : 300**

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.

SECTION 'A'

1. Attempt any five parts of the following:

(a) Three 5 kg masses attached to a light rod ABCD are spun on a frictionless horizontal plane at 600 rpm (10 Hz) about a pinion. What is the maximum force induced in the rod due to spinning?

[Figure: Side view: a vertical pinion shaft on the left (rotation shown by a curved arrow about its vertical axis); the light horizontal rod ABCD is attached to the pinion at its end D and lies on a frictionless horizontal surface (hatched), with the labels C, B, A below the masses. Three equal masses (5 kg each, drawn as small circles on the rod) are at C, B and A. Dimensions measured along the rod from the pinion axis: pinion axis to C = 0.5 m, C to B = 0.5 m, B to A (end of rod) = 0.5 m, i.e. the masses are at radii 0.5 m, 1.0 m and 1.5 m] **12**

(b) Find forces in all members of the truss shown, due to a concentrated load 100 kN at C.

[Figure: Truss inscribed in a semicircle (shown dashed) of radius a with centre O. A and E are the ends of the horizontal diameter; A is a hinged (pinned) support and E is a roller support. Joints B, C, D lie on the semicircle, C at the crown vertically above O; radial members OB and OD make 45° with the horizontal, so the angles at O between OA–OB, OB–OC, OC–OD and OD–OE are each 45°. Members: AO and OE (bottom chord, length a each), OB, OC, OD (radial, length a each), and chords AB, BC, CD, DE. Vertical load 100 kN downward at C]

$OA=OB=OC=OD=OE=a$ $AB=BC=CD=DE$ **12**

(c) What are the strength theories for yielding and fracture of materials? State the theory more suited for (i) mild steel, (ii) concrete. **12**

(d) Find the discharge of water through a horizontal venturimeter having 400 mm diameter at the inlet main and 150 mm diameter at the throat, if the differential gauge between the inlet and its throat shows a pressure head of 25 cm of mercury. Assume coefficient of discharge for the meter as 0.98 and the specific gravity of mercury as 13.6 **12**

(e) The water is flowing with a velocity of 1.5 m/s in a pipe of length 2500 m and diameter 500 mm. At the end of the pipe a valve is provided. Find the rise in pressure (i) if the valve is closed in 5 seconds. (ii) if the valve is closed instantaneously. Take value of C=1460 m/s, pipe to be rigid and bulk modulus of water $=19.62\times10^4$ N/cm^2. **12**

(f) Explain (i) Boundary layer thickness, and (ii) Displacement thickness. The velocity distribution in a laminar boundary layer is given by

$$u/U=3(y/\delta)-2(y/\delta)^2$$

where u is the velocity at a distance y from the plate, δ is the boundary layer thickness and U is the free stream velocity. Find the ratio of displacement thickness to boundary layer thickness. **12**

2. (a) A solid steel rod of length 2 m diameter 20 mm vertically hangs from the ceiling and has a collar firmly attached to it. Above the collar an annular rubber washer of 40 mm thickness **20**

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having a stiffness k=5 N/mm is placed. Determine maximum stress in the rod caused by a mass of 5 kg falling through a height of 1.2 m.

(b) A beam of uniform cross-section resting on two supports 'b' m apart has an equal overhang of 'a' m on either end. Determine the ratio of b/a when the magnitude of mid span bending moment is equal to the magnitude of support bending moment due to its own weight. For this condition, draw the bending moment diagram, locate contraflexure points. **20**

(c) A Pelton wheel has a mean bucket diameter of 1 m and is running at 1000 rpm. The net head on the Pelton wheel is 700 m. If the side clearance angle is 15° and discharge through the nozzle is 0.1 m^3/s, find (i) power available at the nozzle, and (ii) hydraulic efficiency of the turbine. Take C_v=1. **20**

3. (a) A three hinged parabolic arch of span 60 m and rise 15 m has been loaded by a uniformly distributed load of 30 kN/m over the left half of the span. Calculate moment, shear force and axial thrust on a point situated at a section 15 m from the left support. **20**

(b) A river stretch 10 km long and 920 m wide is to be modelled for flood studies in a hydraulic laboratory where the available flume size is 2 m width, 20 m length and 70 cm height. It is decided to use a depth scale of 10. If the peak flood in the river is 3000 cumec at a depth of 6 m, find the suitable horizontal scale to be adopted for construction of the model. Maximum available flow is 150 litres/s in the laboratory. The horizontal scale should be a multiple of 10 and such that the model is as big as possible. Determine the model dimensions, depth and discharge. Assume the hydraulic depth is same as the depth of flow in both the model and the prototype. **20**

(c) A centrifugal pump has an impeller of 0.5 m outer diameter and when running at 600 rpm discharges at the rate of 8000 litres/minute against a head of 8.5 m. The water enters the impeller without whirl and shock. The inner diameter is 0.25 m and the vanes are set back at the outlet at an angle of 45° and the area of flow which is constant from inlet to outlet of the impeller is 0.06 m^2. Determine (i) manometric efficiency of the pump, (ii) the vane angle at inlet, and (iii) the least speed at which the pump commences to work. **20**

4. (a) Analyse the frame shown in the figure by Moment distribution method and draw bending moment diagram. EI for all members are equal.

[Figure: Z-shaped rigid frame of three members. Top horizontal member, 5 m long, fixed at its left end; its right end is a rigid joint from which a vertical member 5 m long goes downward; at the bottom of the vertical member a rigid joint from which a horizontal member 5 m long goes to the right and is fixed at its right end. A vertical load of 70 kN acts downward at the top right joint (junction of the top horizontal member and the vertical member). EI same for all members] **20**

(b) A Warren girder of 25 m span has six panels of 5 m each with all triangles being equilateral. Draw influence line for the bottom chord member in the second panel from the left due to uniform dead load of 10 kN/m and live load of 20 kN/m, longer than the span. **20**

(c) An unlined canal has its bed and side slopes composed material having mean diameter of particles 6 mm. Angle of repose of the material is 40°, the bed width of the canal is 5 m and the side slopes 1.5 (H) : 1 (V). Determine the minimum discharge that can be admitted into the canal without any sediment movement. Take bed slope 1 in 5000 and Manning's n=0.025. **20**

SECTION 'B'

5. Attempt any five parts from the following:

(a) A tension member is of pair of equal angles ISA 65 × 65 × 6 placed back to back on either side of gusset plate 10 mm thick. Calculate maximum pull resisted by the member. Design the welded connection with the Gusset plate. f_y=250 MPa. **12**

(b) A reinforced concrete beam of rectangular cross-section 230 mm × 450 mm has a clear cover to reinforcement of 30 mm. At the support the tension reinforcement is of 3 numbers **12**

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of 20 mm diameter Fe 415 steel rods. The support transfers a factor of shear force of 110 kN to the beam. Design the spacing of two legged 8 mm stirrups. For concrete grade M 20 T_c values are tabulated

$100A_s/bd$	0.75	1.00	1.25
T_c (MPa)	0.56	0.62	0.67

(c) Explain the reasons for the following: (i) Ordinary mild steel cannot be used for prestressed wires. (ii) Loss due to elastic shortening in post-tensioned beam is less than that in pre-tensioned beam. (iii) Deflection of prestressed beams with tendons provided as a parabolic profile compensates part of dead load deflections. **12**

(d) During a compaction test a soil attains the maximum dry density of 18.6 kN/m^3 at a water content of 15 percent. The specific gravity of soil is 2.7. Determine the degree of saturation, air content and percentage of air voids at the maximum dry density. What would be the maximum theoretical dry density corresponding to zero air voids at optimum water content. **12**

(e) A canal 6 m deep runs through a soil having C_u=18 kN/m^2, ϕ_u=10°, e=0.8 and G=2.72. The angle of slope of a bank is 45°. Determine the factor of safety with respect to cohesion when the canal is full upto the top of the banks. If the sudden drawdown takes place upto the bed level of the canal, what will be the factor of safety? For β = angle of slope of bank = 45°; ϕ_u=10° Stability number = 0.108 ϕ_u=4.88° Stability number = 0.137 **12**

(f) A settlement analysis carried out for a proposed structure indicates that 5 cm of settlement will occur in 5 years and that the final settlement will be 25 cm. The computation was made on the basis of double drainage condition. However, subsequent borings established only single drainage condition. Calculate the final settlement and the settlement in 5 years for the changed condition. **12**

6. (a) A stratum of saturated clay (G=2.7) has an initial water content of 44 percent throughout its depth. After a long dry spell, the water content at the ground surface is 20 percent and at a depth of 3 m, the water content is 44 percent. The water content may be taken to vary linearly with depth. The shrinkage limit of the clay is 28 percent. If the change in height per unit height of the clay ($\Delta H/H$) is 80 percent of its change in volume per unit volume ($\Delta V/V_0$), what is the amount of settlement of the ground surface due to change in water content which occurred? **20**

(b) (i) A loading of 50 kN/m^2 is acting on an annular foundation of width 5 m and inside diameter of 10 m. Find the vertical stress intensity at a depth of 10 m below the centre of the foundation. (ii) In a direct shear test on clean dry sand, failure occurred at a shear stress of 30 kN/m^2 when the normal stress was 50 kN/m^2. Draw the Mohr's stress circle and find the angle of internal friction. Determine the magnitudes of principal stresses and the orientation of principal planes with respect to plane of shearing. **20**

(c) A built-up laced column of overall square cross-section, 300 mm side has been formed by placing four angles of ISA 50 × 50 × 6 at the corners of the square. If the effective height of column is 10 m, calculate the load carrying capacity of the column. Also design lacings.

l/r	40	50	60	70	80	90	100	145
σ_{ac} (MPa)	164	153	139	125	111	98	86	50

For ISA 50 × 50 × 6, Area = 568 mm^2, I_x=I_y=11×10^4, C_y=14.5 mm. **20**

7. (a) (i) What is SPT? How is the SPT value obtained and corrected? (ii) What will be the safe load carrying capacity for a strip footing 2 m wide with a factor of safety of 3? The footing is located in a cohesive soil with c=60 kN/m^2 and ϕ=5° at a depth of 1.5 m below G.L. The soil has specific gravity of 2.7 and void ratio of 0.7. Take water table at ground surface and the bearing capacity factors for ϕ=5° as N_c=7, N_q=2 and N_γ=1. **20**

(b) (i) Differentiate between 'state of elastic equilibrium' and 'state of plastic equilibrium' of soil mass. Show them by drawing Mohr's circle and envelope. Show the state of equilibrium for active, passive and at rest conditions. What will be the active and passive pressures in a **20**

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fluid with density 20 kN/m^3 at a depth of 2 m? (ii) A cut 10 m deep is excavated in sand (ϕ=30° and γ=17 kN/m^3) and is to be braced by sheeting and bracing system. The top strut will be at 0.5 m below G.L. followed by subsequent struts at every 1.5 m centre to centre in vertical direction. The spacing of struts along the cut is 3 m centre to centre. Compute the top, middle and bottom strut loads.

(c) Design a reinforced concrete floor slab for a residential building for the following particulars, adopting limit state method of design. Clear dimensions of room: 3 m × 8 m Wall thickness: 230 mm Live load on floor: 2 kN/sq. m Finishes: 1 kN/sq. m Concrete: M 20 Steel: Fe 415 Minimum total depth of slab: 125 mm **20**

8. (a) A combined rectangular footing for supporting two reinforced columns A and B has to be designed. Particulars of the columns are as follows:

Column	Size (mm)	Position	Working Load (kN)
A	350 × 350	Outer face at boundary	1000 kN
B	450 × 450	3 m from centre of column A	2400 kN

Safe bearing capacity of soil: 300 kN/sq. m Obtain plan dimensions of footing. Draw shear force and bending moment diagrams of the footing. **20**

(b) A trapezoidal masonry retaining wall 6 m high and 1.2 m wide at top retains earth of unit weight 16 kN/m^3, ϕ=35° to the top of the wall on the vertical face. Calculate the minimum bottom width necessary so that no tension occurs at the base. Density of masonry: 20 kN/m^3. **20**

(c) (i) List the criteria laid down by IS 2911 for assessing the allowable load on a single pile from the results of a routine pile load test. (ii) A column carrying a load of 1000 kN is to be supported on a group of piles having 30 cm diameter and 10 m length. The soil is clay having unconfined compressive strength of 100 kN/m^2. Compute the number of piles required for bearing capacity considerations. Also check for the group capacity if the spacing is two times the diameter of the pile. Take: m=0.7 and factor of safety of 3. **20**

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