Civil Services (Main) Examination, 2010

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. (a) Determine the centroid of the Angle section shown in Fig. 1.

[Figure: Fig. 1 – Angle section (all dimensions in mm). Overall width 80 (top, dimensioned 40 + 40), overall height 80. Horizontal top flange 80 wide and 20 deep; vertical leg on the left 20 wide running down the full height of 80. The inner corner is chamfered: from the underside of the flange at 40 from the left edge (20 below the top) a sloping line runs down to the inner face of the leg (20 from the left edge) at 40 below the top. Right-hand dimensions from the top: 20, 20, 40 (total 80); bottom dimension of leg: 20]

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(b) A beam of length 5 m and of uniform rectangular section is supported at its ends and carries a uniformly distributed load over the entire length. Calculate the depth of the section if the maximum permissible bending stress is 10 N/mm^2 and central deflection is not to exceed 12 mm. Assume the value of $E=1.2\times10^4$ N/mm^2. **10**

(c) A beam *ABC*, as shown in Fig. 2, is fixed at *A* and is simply supported at *B*. Draw qualitative diagram for influence line of vertical reaction at *A*.

[Figure: Fig. 2 – Beam ABC: fixed support at A (left end), simple support at B at distance *L* from A, overhang BC of length *L*/2 with C free]

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(d) A Pitot tube was used to measure the quantity of water flowing in a pipe of 0.3 m diameter. The water was raised to a height of 0.25 m above the centre of pipe in a vertical tube. If the mean velocity is 0.78 times the velocity at the centre and the coefficient of Pitot tube is 0.98, find the quantity of water in litre per second. Static pressure head at the centre of the pipe is 0.2 m. **10**

(e) A water main of concrete pipe 3200 m long, 0.3 m diameter discharges into a reservoir at the rate of 10×10^6 litres per day. If this pipeline is gradually closed by operating a valve at the end of reservoir in 16 seconds, is there any possibility of pipe burst? The safe pressure of concrete pipe is 245.25 kN/m^2. **10**

(f) A water wheel has a number of hemispherical vanes equally spaced on the periphery. A jet of diameter of 300 mm having a velocity of 16 m/sec impinges on the vanes which have tangential velocity of 6 m/sec. Determine the work done on the wheel. **10**

2. (a) A beam-column frame *ABC*, as shown in Fig. 3, is rigidly jointed at *B*. End *A* is fixed, end *C* is laterally and rotationally restrained but free to move vertically. The column supports a horizontal load of 800 kg at midpoint. Both beam and column are of same cross-section throughout. Analyse the frame using moment distribution method and draw the bending moment diagram.

[Figure: Fig. 3 – Frame ABC: horizontal beam AB of length 6 m with A fixed (left end); vertical column BC rising 6 m from B (dimensioned 3 m + 3 m) to C at the top, where C is held by a support restraining lateral movement and rotation (hatched on the right side of C); horizontal load 800 kg acting towards the column at its mid-height (3 m below C and 3 m above B); rigid joint at B]

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(b) The expression for stream function is described by $\psi = x^3 - 3xy^2$. Indicate whether the flow is rotational or irrotational. Determine the value of velocity potential ϕ, if it exists. **15**

(c) A rapid stream has a depth of flow 1 m and velocity of flow 3.7 m/sec. Find the height of suppressed diversion weir which would be constructed across stream to raise the water level on the upstream to a depth of 3 m. Take coefficient of discharge for free weir = 0.58 and for submerged portion of weir as 0.8. **15**

3. (a) A rigid jointed tower frame, as shown in Fig. 4, has hinged support at *F* and fixed support at *G*. The pinnacle *A* carries a vertical load of 80 t. Calculate all components of reactions at *F* and *G*.

[Figure: Fig. 4 – Symmetrical A-shaped tower frame: two inclined legs A–B–D–F (left) and A–C–E–G (right) meeting at the apex A, which carries a vertical load of 80 t; horizontal member BC connects the legs 8 m below A; points D and E on the legs 4 m below BC, each marked with a solid dot (the same symbol as at the hinge F); supports F and G on the ground 4 m below D and E (total height 16 m = 8 m + 4 m + 4 m). F is a hinged support (labelled "Hinge") and G is a fixed support; F and G are each 4 m from the vertical centre line (base width 8 m)] **30**

(b) In a free cylindrical vortex of water, the tangential velocity at radius of 0.1 m from the axis of rotation is found to be 10 m/sec and the intensity of pressure is 196.2 kN/m^2. Find the pressure intensity at a radius of 0.2 m from the axis. **15**

(c) A pipe 0.6 m in diameter takes off from a reservoir 150 m high above the datum. The pipe is 5000 m long and is laid completely at the datum level. For the last 1200 m, water is drawn by service pipes at a uniform rate of 0.1 m^3/sec per 300 m. Find the head lost in the last 1200 m length of the pipe. Use $f=0.04$ and $h_f = fLV^2/2gD$. Velocity is zero at the dead end. **15**

4. (a) A timber beam of rectangular section of length 8 m is simply supported. The beam carries a uniformly distributed load of 12 kN/m run, over the entire length and a point load of 10 kN at 3 metre from the left support. If the depth is two times the width and stress in the timber is not to exceed 10 N/mm^2, find the suitable dimensions of the section. **30**

(b) A pipe carrying oil of specific gravity 0.877 changes in size from 0.15 m at section *A* to 0.45 m at section *B*. Section *A* is 3.6 m lower than section *B* and pressures are 90.252 kN/m^2 and 59.841 kN/m^2 respectively. If the discharge is 0.45 m^3/sec, determine the head loss and the direction of flow. Find the force acting on the conical portion of the pipe. Neglect the weight of water and the pipe. **15**

(c) A Kaplan turbine runner develops 9300 kW under a net head of 7.4 m. Mechanical efficiency of the wheel is 86%, speed ratio is 2.2 and flow ratio is 0.66. Diameter of the boss is 0.35 times the external diameter of the wheel. Determine (i) the diameter of the runner, (ii) synchronous speed and (iii) the specific speed of the runner. Assume mechanical efficiency equals to overall efficiency. **15**

SECTION 'B'

5. (a) A reinforced concrete T-beam is shown in Fig. 5. The area of the steel provided is 3140 mm^2 and its centroid is located 200 mm from the bottom of the beam. Determine the centroid of the transformed section taking the modular ratio as 21, without neglecting area in tension.

[Figure: Fig. 5 – Reinforced concrete T-beam (all dimensions in mm): flange 2000 wide and 200 deep; web 300 wide; distance from the underside of the flange down to the level of the steel = 2000; steel (3140 mm^2) placed 200 above the bottom of the web; the centroidal axis of the transformed section is shown as a horizontal line at an unknown height y_c=? above the bottom of the beam] **10**

(b) A masonry dam of rectangular section, 20 m high and 10 m wide, has water up to a height of 16 m on its one side. Determine (i) pressure force due to water on one metre length of the dam, (ii) position of the centre of pressure and (iii) the point at which the resultant cuts the base. Assume density of masonry = 19.62 kN/m^3 and density of water = 9.81 kN/m^3. **10**

(c) A steel flat 100 mm × 10 mm carries a tensile force of 16000 kg (160 kN). It is to be welded to a gusset plate with a lap of 10 cm. Determine the minimum size of the fillet weld. **10**

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Permissible stress in shear = 1000 kg/cm^2 (100 N/mm^2).

(d) A sample of coarse sand taken from the field was found to have void ratios of 0.87 and 0.52 in its loosest and densest states respectively. The in situ density and water content of the sand were 1.95 g/cc and 23%. Determine the degree of saturation and relative density of the sand in the field, if G=2.66. **10**

(e) A raft foundation is to be constructed on a 7.5 m thick clay layer sandwiched between two sand layers. In order to predict the time rate of settlement of the building, a consolidation test was conducted in the laboratory on a 2.5 cm thick undisturbed sample of the soil by keeping porous stones both at the top and bottom. The sample was found to have undergone 50% consolidation in 12.5 minutes. Determine the time required for realising 50% settlement of the building. **10**

(f) A 2 m wide strip footing is founded at a depth of 1.5 m below the ground level in a homogeneous bed of sand having unit weight = 18.5 kN/m^3 and angle of internal friction ϕ=36 . Using Terzaghi's theory, determine the safe bearing capacity of the footing. The water table is at 1 m below the ground surface and for ϕ=36 , N_c=60, N_q=42 and N_γ=47. **10**

6. (a) A steel beam *ABC* carrying working loads, as shown in Fig. 6, is simply supported at *A*, *B* and *C*. Calculate the minimum value of section modulus using plastic analysis. Adopt load factor of 1.85 and yield stress = 2500 kg/cm^2. Given the following table, which section would you suggest?

[Figure: Fig. 6 – Continuous beam ABC on three simple supports A, B and C; span AB = 4 m carrying a uniformly distributed load of 30 t/m over its whole length; span BC = 5 m carrying a point load of 50 t at 3 m from B (2 m from C)]

Section	Z_{xx} (in cm^3)
ISMB 500	1809
ISMB 550	2360
ISMB 600	3060
ISWB 450	1558
ISWB 500	2092
ISWB 550	2724
ISWB 600	3540
ISWB 600H	3854

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(b) The moisture content, void ratio and specific gravity of soil solids of a given soil mass are 10.5%, 0.67 and 2.68 respectively. It is required to prepare three triaxial test specimens (diameter 3.75 cm and height 7.5 cm) from this soil mass. Each specimen should have a moisture content of 15% and a dry density of 1.6 g/cc. Determine (i) the quantity of the given soil to be used for this purpose and (ii) the quantity of water to be mixed with it. **30**

7. (a) A reinforced concrete slab 3.0 m × 3.0 m is simply supported on two parallel walls 30 cm wide with a clear distance of 2.4 m between them. It carries a uniformly distributed load of 3000 kg/m^2 including finishes and impact load. Design the slab using M-20 concrete and Fe-415 grade HYSD bars by working stress design method. Sketch the reinforcement. Note that available reinforcement bars are of 16 mm dia. **30**

(b) A retaining wall with a smooth vertical backface has to retain a backfill of C−ϕ soil up to 5 m above GL. The surface of the backfill is horizontal and it has the following properties: γ=18 kN/m^3, C=15 kN/m^2, ϕ=12 (i) Plot the distribution of active earth pressure on the wall. (ii) Determine the depth of the zone of tension cracks. (iii) Determine the magnitude and point of application of active thrust. (iv) Determine the intensity of a fictitious uniform surcharge which, if placed over the backfill, can prevent the formation of tension cracks. (v) Compute the resultant active thrust after placing the surcharge. **30**

8. (a) A trapezoidal masonry dam, having 4 m top width, 8 m bottom width and 12 m height, is retaining water up to a height of 10 m. The density of the masonry is 20 kN/m^3 and coefficient of friction between the dam and soil is 0.55. The allowable compressive strength **30**

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stress is 343.350 kN/m^2. Check the stability of the dam.

(b) The results of a soil investigation at a particular site are given below. The water table is at 1 m below the surface:

[Figure: Soil profile (depths from the surface): 0.00 to 4.0 – Very soft clay, N_{av}=1, C_u=6 kN/m^2, γ=15 kN/m^3; 4.0 to 13.0 – Loose sand, N_{av}=8, γ=17 kN/m^3; 13.0 to 32.0 – Med. stiff silty clay, N_{av}=7, C_u=13.5 kN/m^2, γ=16 kN/m^3; 32.0 to 40.0 – Dense sand, N_{av}=45, γ=19 kN/m^3; water table symbol shown at the top]

Compute the safe capacity of a 500 mm diameter, 35 m long bored cast in situ pile. [For N=8, ϕ=28 ; N=45, ϕ=40 , N_γ=109 and N_q=130] Any other data, if required, can be assumed suitably. **30**

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