इन्जीनियरिंग सेवा परीक्षा, 2010
Engineering Service Examination.

Sl. No. 5209 A-GUG-K-DFB

CIVIL ENGINEERING

Paper II

(Conventional)

Time Allowed : Three Hours	*Maximum Marks : 200*

INSTRUCTIONS

Question No. 1 is compulsory. Out of the remaining seven questions, attempt any FOUR questions.

Each question carries 40 marks.

The number of marks carried by each subdivision of a question is indicated at the end of the subdivision/question. Wherever a question is attempted, all its subdivisions must be attempted.

Answers must be written only in ENGLISH.

Assume suitable data, if found necessary, and indicate the same clearly.

Unless indicated otherwise, notations and symbols have their usual meanings.

Neat sketches to be drawn, wherever required.

(Contd.)

1. (a) (i) Following data are observed during testing of a Kaplan turbine :
Power developed = 2500 kW, Head = 60 m and speed = 350 r.p.m.
What will be the dimensionless specific speed of the turbine ? 2

(ii) Determine the total pressure on a plane rectangular surface of 1 m wide and 3 m deep when its upper edge is horizontal and coincides with water surface and plate is held perpendicular to water surface. 2

(iii) The velocity components in x and y directions are given as $u = x + y$ and $v = x - y$ respectively. Find whether these velocity components satisfy possible two dimensional incompressible flow or not ? 2

(iv) The diameters of the impeller of a centrifugal pump at inlet and outlet are 20 cm and 40 cm respectively. Determine the minimum starting speed of the pump against a head of 25 m. 2

(b) (i) Find the probable life of a reservoir with an initial capacity of 4×10^6 m^3 if the annual sediment inflow into reservoir 4×10^4 m^3. The average trap efficiency. 0·9 and life of a reservoir is terminated when 90 per cent of initial capacity is occupied by sediment. 2

(ii) Find the width of elementary gravity dam whose height is 100 m. Specific gravity of dam material 2·2 and seepage co-efficient at the base c = 0·8. 2

(iii) An aquifer of 25 m average thickness is overlain by an impervious layer of 30 m thickness. A test well 0·4 m in diameter and two observation wells at a distance of 12 m and 48 m are located in the aquifer. After pumping at a rate of 0·2 m^3/s for a long time, drawdowns in the wells were observed to be 3·5 m and 1·5 m respectively. Determine the coefficient of permeability in m/day. 2

(iv) A conical tube of length 2 m fixed vertically with its smaller end upwards. The velocity head, pressure head at upper ends are 1·27 m and 2·50 m respectively. The velocity head and pressure head at lower ends are 0·203 m and 5·407 m respectively. Find the direction of flow. 2

(c) (i) For a BOD test, raw sewage (3·0 ml) was diluted to 300 ml (capacity of a BOD bottle). The diluted sewage was observed for its dissolved oxygen at the beginning and end of 5 days incubation at 20°C. The respective values were 8·6 mg/L and 4·6 mg/L. Determine the BOD of the raw sewage. 2

(ii) A mixed liquor with 2,000 mg/L of suspended solids has the settled volume of 200 ml from a litre of this mixed liquor. Calculate its sludge volume index. Is it safe ? 2

(iii) If the alum dose to coagulate is 10 p.p.m., find out the amount of alum (in quintals) needed to treat 10 mld of water. 2

(iv) For a population of 2 lac having per capita daily demand of water of 150 litres, determine the water horse power to raise the water from a river of R.L. 120 m to treatment plant of R.L. 140 m through a rising main 1 m in diameter. Assume 2 m as the total head loss due to friction, etc. and pumping efficiency of 70%. 2

(d) (i) Estimate the value of coefficient of permeability for a uniform graded sand of size $D_{10} = 0{\cdot}15$ mm obtained from sieve analysis. $G = 2{\cdot}67$. 2

(ii) Calculate the active earth pressure at a depth of 3·6 m in a sandy soil with angle of internal friction as 30° and having a density of 1·9 gm/cc. 2

(iii) Using Terzaghi theory find the ultimate bearing capacity for a square footing of 2·0 m × 2·0 m placed at depth of 1·2 m below the ground on a pure cohesive soil having density 18 kN/m^3. Nc = 5·7. Use local shear failure conditions. C = 40 kN/m^2. 2

(iv) A Flow net is plotted for a homogeneous earthen dam of 30·0 m height with a free board of 5·0 m. If $K = 6 \times 10^{-4}$ cm/sec, No. of flow channels = 4, No. of potential drops = 10, calculate the discharge per metre run of dam. 2

(c) (i) The scale of an aerial photograph is 1 cm = 150 m and the size of the photograph is 20 cm × 20 cm. Determine the number of photographs in each strip to cover an area of 15 km × 15 km if the longitudinal overlap is 70% and side overlap 30%. 2

(ii) Using Prismoidal Rule calculate the volume of a 5 m deep pit whose top and bottom dimensions are respectively 10 m × 20 m and 20 m × 40 m. 2

(iii) In a locality where the rainfall is heavy, it is proposed to construct an ODR of WBM pavement (single lane), a two lane MDR of thin bituminous surface pavement. Taking IRC recommended camber and carriageway width, find out the height of the crown with respect to the edges. 2

(iv) A B.G. track has a sleeper density of $n + 6$. If the track is laid with welded rails of 26 m length, find out the number of sleepers required for constructing a railway track of 1690 m. 2

2. (a) (i) A power house has 5 impulse turbines. Each turbine has two runners. Each runner is installed with 4 nozzles. Total discharge is 40 m^3/s. Find the diameter of jet. Take coefficient of velocity as 0·985 and head as 250 m. 4

(ii) A pipe carrying water tapers from cross-section 0·3 m^2 at A to 0·14 m^2 at B. The average velocity at A is 1·8 m/sec and pressure is 441 kN/m^2 (gauge). If the frictional effects are negligible, determine the pressure at B which is 5·5 m above the level of A. 4

(b) (i) In 1 : 30 model spillway, the velocity and discharges are 2·0 m/sec and 2·0 m^3/sec respectively. Find the corresponding velocity and discharge in the prototype. 4

(ii) Draw surface profiles in the following cases :

(i) Upstream and downstream of sluice gate on a mild sloped channel when critical depth line is above the gate opening.

(ii) A steep sloped channel ending in an abrupt drop having reservoir level on the downstream side above the critical depth line.

(iii) Steep sloped channel followed by a mild sloped channel.

(iv) Mild sloped channel followed by a steep sloped channel. 4

(c) Explaining their qualitative differences in respect of total dissolved solids, turbidity and bacterial quality, suggest the units needed for the treatment of water drawn from (a) ground, (b) lake and (c) river. 8

(d) What will be the gross and net safe bearing capacity of sand having $\phi = 30°$ and density 2·1 t/m^3 below (a) 1·0 m wide strip footing (b) 1·0 m × 1·0 m square footing placed at a depth of 1·2 m below the ground. Take factor of safety as 2·5. Take Nc = 30·14, Nq = 18·4, Nr = 22·4. 8

(e) The observed altitude of β-ursac Minoris at lower and upper culminations are 29°58′15″ and 60°45′3″. Find the latitude of the place of observation assuming the correction for refraction to be equal to 57″ × tangent of apparent zenith distance. 8

3. (a) (i) Show that the hydrostatic pressure remains invariant in a horizontal plane parallel to free surface. 4

(ii) A sudden enlargement of a water pipeline from 200 mm to 400 mm. The hydraulic gradient rises by 10 mm. Estimate the discharge in the pipe. 4

(b) (i) A metallic sphere of specific gravity 8·0 falls in an oil of density 800 kg/m^3. The diameter of the sphere is 10 mm. The viscosity of oil is 7·848 $\frac{\text{N-Sec}}{\text{m}^2}$. Determine the terminal velocity of metallic sphere. 4

(ii) Show that for wide rectangular channel the bed slope 'S_0' is mild or steep according S_0 being less than or greater than $\frac{n^2 g^{\frac{10}{9}}}{q^{\frac{2}{9}}}$. 4

(c) Differentiate between a slow sand filter and a rapid sand filter in respect of

(i) Mechanisms of removal of impurities,

(ii) Cleaning process,

(iii) Effluent quality,

(iv) Bed size in qualitative term. 8

(d) (i) Discuss Pore pressure parameters. 3

(ii) In a laboratory vane shear test a vane 100 mm long and 60 mm diameter was pressed into the soft cohesive soil (G = 2·72). A torque of 40 kN-mm was required to achieve the failure. Same soil when remoulded required 15 kN-mm to achieve failure. Calculate the cohesion in both cases and value of sensitivity. Take the void ratio of soil as 30%. 5

(e) Find the difference in level between two points A and B in a reciprocal levelling with the following data :

$R \sin 1'' = 30{\cdot}876$ m, $\sin 1'' = \frac{1}{206265}$.

Horizontal distance between A and B = 6882·38 m

Angle of elevation from A to $B = 1°50'20''$

Angle of depression from B to $A = 1°51'10''$

Height of signal at A = 4·145 m

Height of signal at B = 3·597 m

Height of instrument at A = 1·463 m

Height of instrument at B = 1·554 m 8

4. (a) (i) A five cylinders reciprocating pump raises the water level by 150 m and the theoretical discharge is 0·20 m^3/s. The velocity in the delivery pipe is 2·0 m/s. Total head loss in pipes is 20 m. What is the input power, if the efficiency of the pump is 0·87 ? 4

(ii) Two pipes of lengths 2500 m each and diameters of 80 cm and 60 cm respectively, are connected in parallel. The friction factor for each pipe is $4f = 0·024$. Total flow is equal to 250 litres per second. Find the discharge in each pipe. 4

(b) (i) A 5·0 m wide rectangular channel carries 15 m^3/s of water with a velocity of 6 m/s. State whether hydraulic jump is a possibility. If yes compute height of the jump and power dissipated. 4

(ii) A trapezoidal channel with side slope 2 H : 1 V is carrying 25 m^3/s. The slope of the channel bed is 1 in 800. Take Chezy's C = 45 and design the channel. 4

(c) How much will be the settling velocity of a spherical particle *A* (having specific gravity of 2·65) of diameter 10×10^{-3} cm. Determine the size for a floating spherical particle having a specific gravity of 0·80 (rising with the same velocity as that of particle *A*).

Assume kinematic viscocity of water as $1·012 \times 10^{-2}$ cm^2/sec. 8

(d) In a consolidation test done in laboratory a sample of 20 mm thick consolidated 50% in 15 minutes with double drainage. How much time a 5·0 m thick layer of same soil will consolidate 50% and 30% ? If the soil layer has a rock below, how much time it will take to consolidate 50% and 30% ? 8

(e) The speeds of overtaking and overtaken vehicles are 80 kmph and 60 kmph respectively. If the acceleration of the overtaking vehicle is 2·5 kmph per second, calculate the safe passing sight distance for (i) single lane one way traffic (ii) three lane both way traffic. Assume perception time of driver = 2 sec. 8

5. (a) (i) A reaction turbine having inlet diameter as 1·0 m and rotational speed 400 r.p.m. has flow area 0·25 m^2 at the inlet and is working under a head of 65 m. Flow is radial at the outlet. Compute the hydraulic efficiency and power developed by the wheel taking velocity of flow at inlet as 8·0 m/s and velocity of whirl at inlet as 25·0 m/s. 4

(ii) Find the critical depth for a discharge of 4 m^3/sec for flow in right angle triangular channel. 4

(b) (i) Two reservoirs are connected by a pipe 100 m long and 100 mm in diameter followed by another pipe 60 m long and 50 mm in diameter. The total head loss between the reservoirs is 10·3 m. Given f = 0·03. Compute discharge neglecting minor losses. 4

(ii) The velocity distribution within the boundary layer is given by $\frac{u}{U}=\left(\frac{y}{\delta}\right)^{\frac{1}{n}}$. Obtain the ratio of displacement thickness to momentum thickness. 4

(c) Using $n = 0{\cdot}015$ in Manning's formula, design a sewer running half-full at a flow rate of 650 *l*/sec and laid at an invert slope of 0·0001. 8

(d) A 1·5 m layer of soil is subjected to an upward seepage head of 1·95 m. What depth of course sand will be required above this soil to provide a factor of safety of 1·5 against piping. Coarse sand and soil have specific gravity 2·67 and porosity as 30%. 8

(e) Calculate the design traffic in million standard axles (MSA) and commercial vehicles per day (CVD) required for design of flexible pavement as per current Indian procedure (revised IRC method) for the following data :

Annual daily commercial vehicles at last count (May 2008) = 200
Rate of traffic growth = 6%
Design life = 10 years
Vehicle damage factor = 2
The road is proposed to be completed in May 2011. 8

6. (a) (i) Find the magnitude of Froude number after the hydraulic jump given the Froude number before the jump is $\sqrt{6}$. 4

(ii) An oil having viscosity 0·08 Ns/m^2, specific weight 8829 N/m^3, density 900 kg/m^3 flows at the rate of $5{\cdot}4 \times 10^{-3}$ m^3/s through a horizontal circular pipe of 0·12 m diameter and length 150 m. Find

(i) pressure difference in 150 m length in kN/m^2

(ii) wall shear stress in N/m^2 and

(iii) average and maximum velocity. 4

(b) (i) A three dimensional flow is given by

$$\vec{V} = \left(y^2 + z^2\right) i + \left(x^2 + z^2\right) j + \left(x^2 + y^2\right) k$$

Determine the components of acceleration at a point (2, 3, 4). 4

(ii) Show that the normal depth of flow in a triangular channel having side slope ZH : 1V is given by

$$y_n = 1{\cdot}189 \left[\frac{Q \cdot n}{\sqrt{S_0}}\right]^{\frac{3}{8}} \left(\frac{z^2 + 1}{z^5}\right)^{\frac{1}{8}}$$ 4

(c) The BOD rate constant (k) for a river's BOD assimilation was determined to be 2·0 day^{-1} (base e). The BOD of this river after leaving a heavily populated town was determined to be 50 mg/L. Determine the distance after which the river's BOD would become 4 mg/L when the average velocity of the river was 1 m/sec. What would have been the K value if this distance would have been 300 km and state what K manifests. 8

(d) A 6·0 m high retaining wall is to support a soil with unit weight $r = 17{\cdot}4$ kN/m^3, $\phi = 26°$ and $c' = 14{\cdot}36$ kN/m^2. Determine the Rankine active force per unit length of wall before the tensile crack occurs. Find the critical depth. 8

(e) A locomotive on B.G. track with four pairs of driving wheels each carrying axle load of 20 tonnes is required to haul a train at a speed of 80 kmph. The train is made to run on a level track with curvature of 2°. Calculate the maximum permissible load that can be pulled by the engine. Take hauling capacity $\frac{1}{6}$ time the load on driving wheels. 8

7. (a) (i) Show that the most efficient trapezoidal channel section is half regular hexagon given the side slope $m = \frac{1}{\sqrt{3}}$. 4

(ii) Design a transition using Mitra's hyperbolic transition given by

$$B_x = \frac{B_c\, B_f\, L_f}{L_f\, B_c - \left(B_c - B_f\right) x}$$

and compare the results using Chaturvedi's semi-cubical parabolic transition given by

$$x = \frac{L_f\, B_c^{3/2}}{B_c^{3/2} - B_f^{3/2}} \cdot \left(1 - \left(\frac{B_f}{B_x}\right)^{3/2}\right)$$

Given nominal bed width = 25 m, width of flumed section = 10·0 m and total length of transition = 15·0 m. 4

(b) (i) The shear stress τ in open channel depends on depth of flow y, velocity v, density ρ, surface tension σ and acceleration due to gravity g. Using Buckingham's Pi Theorem, make out the dimensional analysis of the problem. 4

(ii) The depth of moisture in root zone at field capacity and permanent wilting point per m depth of soil are 0·5 m/m and 0·2 m/m respectively. Compute the field capacity and permanent wilting point. Take dry weight of soil as 13·73 kN/m^3. 4

(c) On the basis of a detention period of 24 hrs, determine the size (assuming length to width ratio of around· 2 and depth of waste water about 1 m) of a Septic Tank required for a large house dwelling 100 persons. The flow into the tank may be assumed at the rate of 70 lpcd. What will be the surface loading and equivalent weir loading of the tank ? 8

(d) A 450 × 450 mm concrete pile 20·0 m long is driven into sand deposits with $\gamma = 17$ kN/m^3 and $\phi' = 30°$. Find the ultimate load ie point load QP by Meyerhoff's method and Janbu method.

Meyerhoff's $Nq' = 55$, Atmospheric pressure = 100 kN/m^2, Janbu's $Nq' = 18·4$. 8

(e) (i) From the following tidal data determine the wave height and wave velocity for a non-translatory wave

Depth of water = 3 m

Fetch = 800 km 4

(ii) What are the considerations for determining the thickness of concrete lining in a tunnel. Find out the concrete lining thickness for a tunnel with a bore diameter of 7·6 m. 4

8. (a) (i) Flood frequency computation yields the following results :

Return Period Years	*Peak flood* m^3/s
50·0	20,500
100·0	25,400

Using Gumbel's method, estimate the flood for a return period of 150 years. 4

(ii) Show that if a plate 10 m × 5 m is towed through a fluid so that the boundary layer is entirely laminar, the ratio of towing speeds so that the drag force remains constant regardless of whether 10 m or 5 m side is in the flow direction is given by

$$\frac{U_{10\,m}}{U_{5\,m}} = 1{\cdot}2598$$

If the boundary layer is entirely turbulent and Reynolds number is less than 10^7,

$$\frac{U_{10\,m}}{U_{5\,m}} = 1{\cdot}08.$$ 4

(b) (i) A rectangular channel 15 m wide has a normal depth of 0·8. The discharge carried is 10 m^3/s, what is the alternate depth ? 4

(ii) An inward flow reaction turbine is supplied water at the rate of 0·36 m^3/s. Outlet pipe of the turbine is 380 mm in diameter. Turbine operates under a head of 55 m. Radial velocity of wheel is the same as the velocity of flow in the outlet pipe. The tangential velocity of wheel at inlet is 20 m/s. Compute guide vane angle and vane tip angle at inlet. 4

(c) Discuss the impact of air pollution on
(i) Monuments
(ii) Animals
(iii) Plants and
(iv) Climate 8

(d) A rectangular foundation 6·0 m × 3·0 m in size exerts a pressure of 20 kN/m^2 to the soil underneath. Compute the increase of vertical stress at a point 0·5 m below the centre of foundation. Use Boussinesq equation. 8

(e) Determine the radius of a taxiway for a supersonic aircraft to negotiate the curve at a turning speed of 50 kmph. The wheel base is 35 m and the tread of main landing gear is 7·5 m. The airport is of type *A* as per ICAO. Assume co-efficient of friction between tyre and pavement surface as 0·13. 8