2307/304
SOIL MECHANICS AND HYDRAULICS
Oct./Nov. 2011
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN CIVIL ENGINEERING

SOIL MECHANICS AND HYDRAULICS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:

Answer booklet;
Drawing instruments;
Scientific calculator.

*This paper consists of **EIGHT** questions in **TWO** sections: **A** and **B**.*
*Answer any **FIVE** questions choosing at least **TWO** questions from each section.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.

This paper consists of 8 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

Turn over

SECTION A: SOIL MECHANICS

*Answer at least **TWO** question from this section*

1 (a) Describe the formation of the following types of soils:

(i) transported soils;
(ii) residual soils.

(5 marks)

(b) (i) Derive an expression for the bulk density of a partially saturated soil in terms of the specific gravity of the particles Gs, the void ratio e, the degree of saturation $S\gamma$, and the density of water ρ_w.

(ii) Describe the sand replacement method of determining the in-situ density of a soil. (9 marks)

(c) In a sample of clay, the void ratio is 0.72 and the specific gravity of the particles is 2.70. If the voids are 90 per cent saturated, determine:

(i) the bulk density;
(ii) the dry density;
(iii) the percentage moisture content.

(6 marks)

2 (a) (i) Differentiate effective pressure from pore water pressure.

(ii) Figure 1 shows a soil profile obtained during a site investigation. Determine the effective stress at the bottom of the clay layer:

- under normal conditions;

- if the ground water level is lowered by 2.4m and assuming that sand remains saturated with capillary water up to the original level. (10 marks)

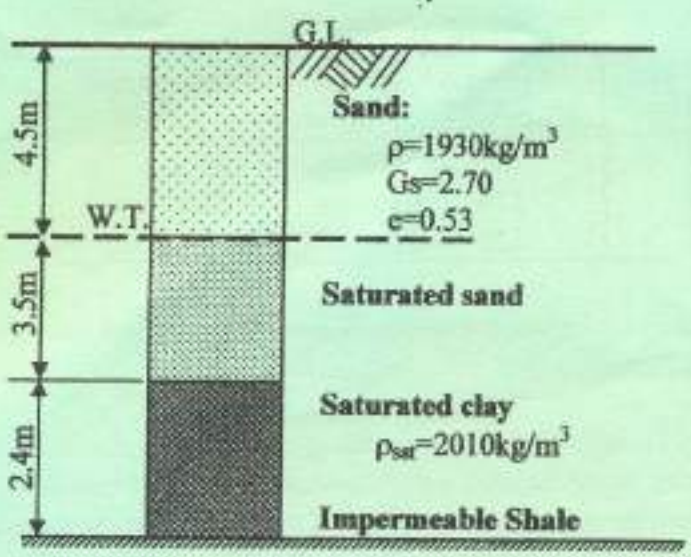

Fig 1

(b) (i) Derive from basic principles the equation for the coefficient of permeability in variable - head permeameter.

(ii) In a falling head permeameter, head falls from 350mm to 240mm in a stand pipe of diameter 3.5mm. The sample through which water flows has a depth of 100mm and diameter of the sample is 75mm. If $k = 2 \times 10^{-4}$ mm/s, determine the time required in minutes for water to fall from 350mm to 240mm in the stand pipe. (10 marks)

3 (a) Outline the types of laboratory trial tests specified to be carried out in connection with each of the following field problems, and state the reason for the choice of test:

(i) initial stability of a footing on saturated clay;

(ii) long term stability of a slope in stiff fissured clay;

(iii) stability of clay foundation of an embankment, the rate of construction being such that some consolidation of clay occurs. (4½ marks)

(b) The data in table 1 shows the results obtained from three triaxial tests carried out on representative undisturbed samples of a soil.
The load dial calibration factor is 1.41 N per division. Each sample is 75mm long and 37.5mm in diameter. Determine graphically the value of apparent cohesion and the angle of internal friction of the soil. (7 marks)

Table 1

Test	Cell pressure (kN/m^2)	Axial load dial reading (divisions) at failure
1	50	65
2	150	105
3	250	145

(c) (i) Distinguish between ultimate bearing capacity and safe bearing capacity in soils.

(ii) State Terzaghi's equation for the gross ultimate capacity q_f of a strip footing of breadth B and depth Z on soil of cohesion C and unit weight W, and hence explain the significance of each of the three terms in the equation.

(iii) A strip footing 2.5m wide is to be constructed at a depth of 2m below ground level. The cohesion of the soil is $65kN/m^2$, its density is $1800kg/m^3$, and angle of shearing resistance $\emptyset = 25°$. Determine the safe bearing capacity of the soil. Use Terzaghi's bearing capacity factors in Figure 2, and apply a factor of safety of 3. (8½ marks)

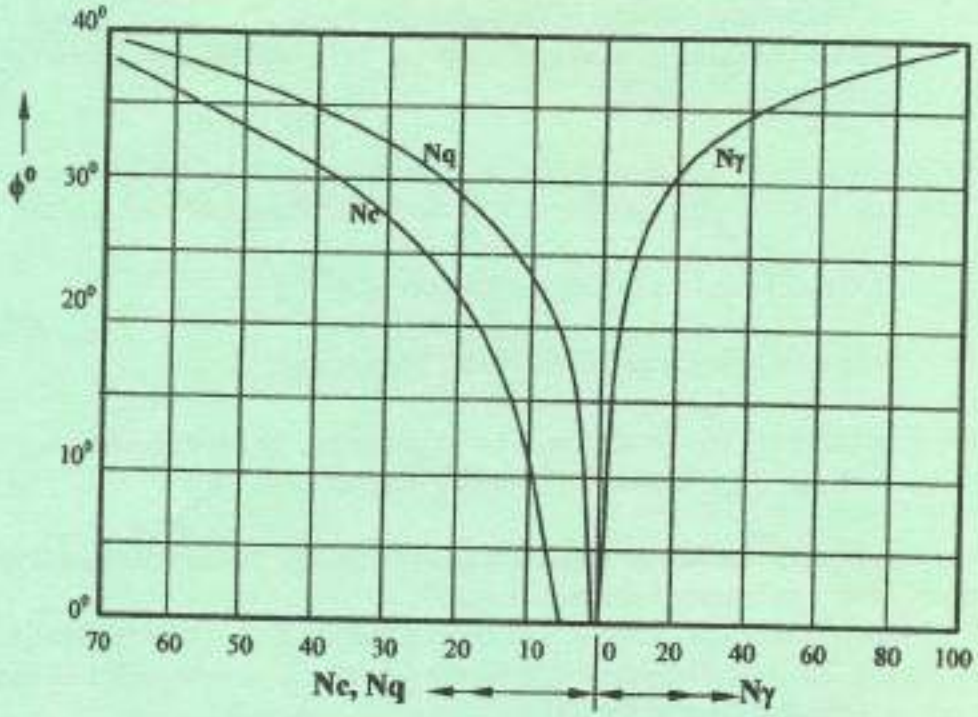

Fig 2: Bearing Capacity Factors

4 (a) A retaining wall 6m high has a vertical earth face and supports cohesionless soil of dry density 1600kg/m³, angle of shearing resistance 30° and void ratio 0.68. The surface of the soil is horizontal and level with the top of the wall. Neglecting wall friction, determine the total earth thrust and its point of action above the base per metre run of the wall if:

(i) the soil is dry;

(ii) owing to inadequate drainage, it is waterlogged to a level 2.5m below the surface. (14 marks)

(b) Figure 3 shows a section of a clay bank, in which a trial slip surface BFED is chosen in the form of a circular arc of radius 12m. The area if the figure BCDEF is 93m² and its centroid is at G. The average density of the soil is 1800kg/m³. Above the level ABE the cohesion of the soil is 20kN/m², and below this level, the cohesion is 32kN/m². Estimate the factor of safety on this assumed surface, taking Ø = 0. (6 marks)

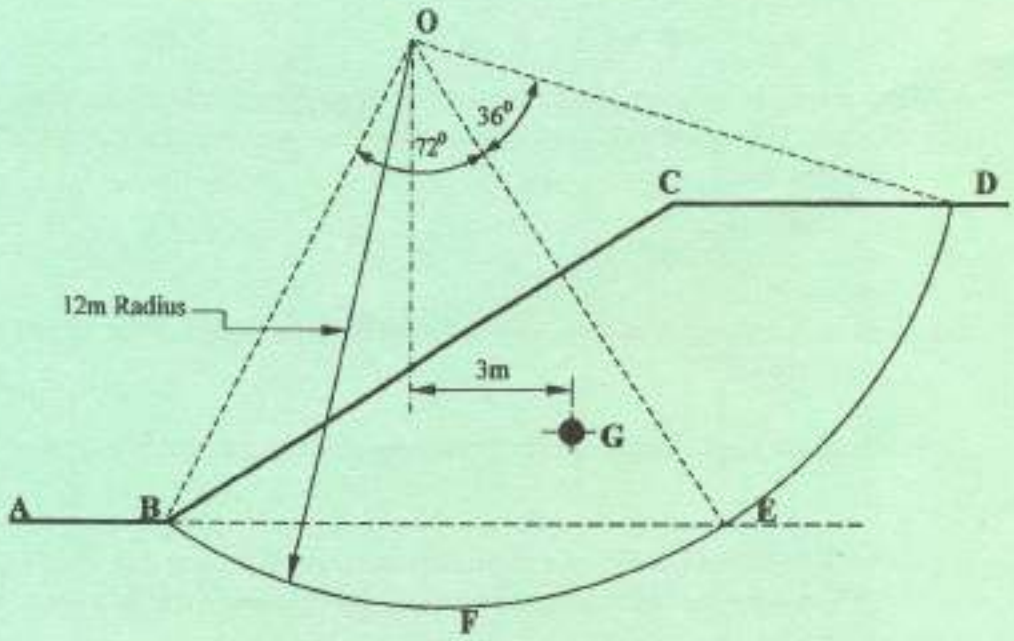

Fig 3

SECTION B: HYDRAULICS

*Answer at least **TWO** question from this section.*

5 (a) (i) With the aid of a diagram, explain the working principle of a single acting reciprocating pump.

(ii) A single acting reciprocating pump operating at 150rpm, has a piston diameter 200mm and a stroke of 300mm. The suction and delivery heads are 3m and 30m respectively. If the efficiency of both suction and delivery strokes is 75 percent, determine:

- the theoretical discharge;
- the power required by the pump.

(10 marks)

(b) (i) Sate **four** advantages of a Francis turbine over a Pelton wheel turbine.

(ii) Sketch and label the components of a Pelton wheel turbine.

(6 marks)

(c) A 75mm diameter horizontal jet having a velocity of 30m/s strikes a flat plate, the normal which is inclined at 30° to the axis of the jet. Determine the normal pressure on the plate when the:

(i) plate is stationary;

(ii) plate is moving with a velocity of 15m/s in the direction of the jet and away from the jet.

(4 marks)

6 (a) Derive from the basic principles the equation for discharge over a broad crested weir.

(7 marks)

(b) A trapezoidal channel has side slopes of 3 horizontal to 4 vertical and a bed slope of 1 in 2000. Determine the optimum dimensions of the channel, if it is to convey $0.5m^3/s$ of water. Take Chezy's constant as 50.

(7 marks)

(c) Water flows over a rectangular sharp-crested weir 1m long, the head over the sill of the weir being 0.6m. The approach channel is 1.4m wide and depth of flow in the channel is 1.2m. From first principles, determine the discharge over the weir considering the velocity of approach and the effect of end contractions. Take Cd = 0.6.

(6 marks)

7 (a) An inclined rectangular sluice gate AB, 1.2m x 5m is installed as shown in Figure 4. If the end A is hinged, determine the force F normal to the gate applied at B to open it.

(6½ marks)

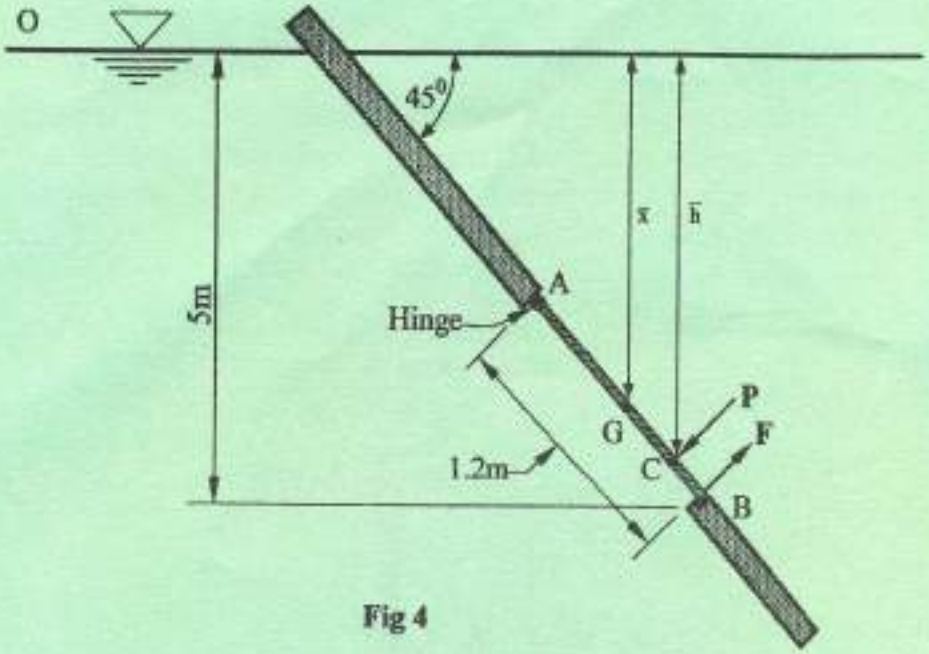

Fig 4

(b) A horizontal pipeline 50m long is connected to a reservoir at one end and discharges freely into the atmosphere at the other end as shown in Figure 5. For the first 30m of its length from the tank, the pipe is 150mm in diameter and its diameter is suddenly enlarged to 300mm. The height of water level in the tank is 12m above the centre of the pipe. Considering all losses of head which occur:

(i) determine the discharge;
(ii) draw the hydraulic and energy gradient lines.
Take f = 0.01 for both pipes.

(13½ marks)

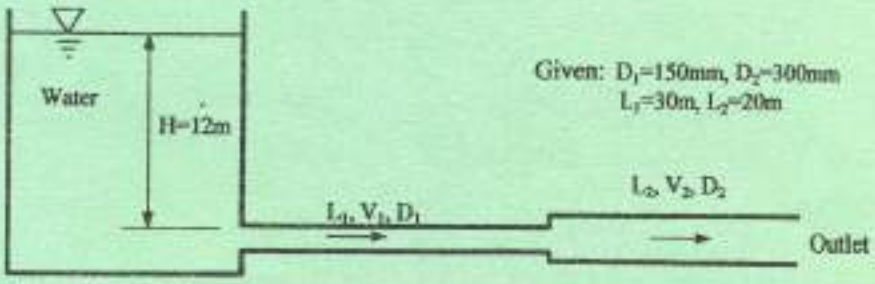

Fig 5

8 (a) With the aid of a sketch, explain the use of a tipping bucket rain-gauge. (5 marks)

(b) Explain the mid-section method of measuring stream discharge. (5 marks)

(c) A 150 x 75mm venturimeter is connected in a vertical pipe conveying a liquid of relative density 0.8 as shown in Figure 6. The pressure connection at the throat is 200mm above that at the inlet. If the actual discharge is 50 litres per second, and Cd = 0.96, determine the pressure difference between the inlet and the throat in N/m². (5 marks)

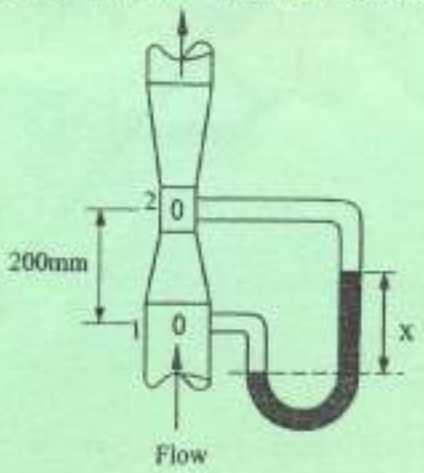

Fig 6

(d) Figure 7 shows an inverted U-tube manometer used to measure the pressure difference between two points A and B in an inclined pipeline through which water flows. The difference of level h = 0.35m, a = 0.3m and b = 0.2m. Determine the pressure difference between points A and B, if the top of the manometer is filled with:

(i) air;
(ii) oil of relative density 0.8.

(5 marks)

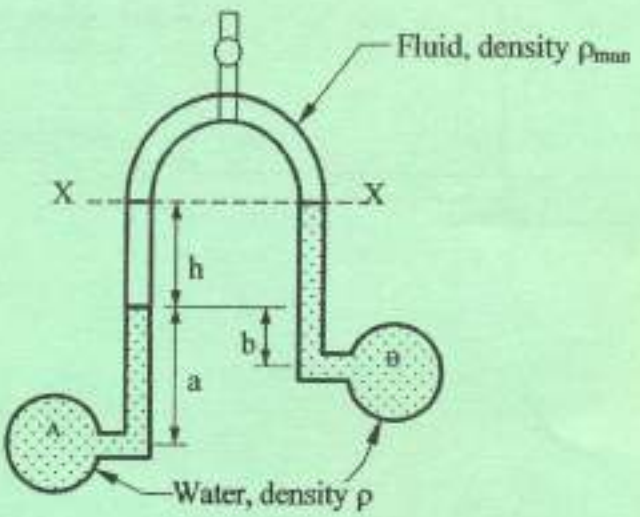

Fig 7