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NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS, 2001

THIRD YEAR CIVIL AND ENVIRONMENTAL ENGINEERING

ELEMENTARY SOIL MECHANICS

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Time allowed: *two hours.*

Attempt a minimum of *three* questions.

Question 1

(a) Describe briefly the following terms: effective stress; total stress; excess pore water pressure; hydrostatic pore water pressure and artesian pressure. Use diagrams to illustrate your answer where appropriate.

(b) Describe, with the aid of diagrams, the change in total stress, pore water pressure, effective stress and volume of an embankment constructed and monitored over a long time period over a) gravels and b) slow draining silts and clays.

(c) A concrete bridge pier is 5 m tall, has a foundation area of 20 m^2 and carries an imposed load of 3 MN. The pier is founded on a tidal river overlying 15 m of sand with a unit weight of 18 kN/m^3. At low tide, the river water just covers the soil; at high tide the water rises to a height of 4 m above the sand. Calculate the effective stress of a soil element 2.5 m beneath the centre of the foundation at low and high tides. The unit weights of the concrete and water are 24 kN/m^3 and 10 kN/m^3 respectively.

Question 2

(a) Give a brief description of the following terms: Darcy's law, permeability and hydraulic gradient. Give typical values of permeability for 1) coarse gravels and 2) boulder clay with a high portion of clay particles.

(b) A borehole is driven through a homogenous soil to the bottom of the strata to impervious bedrock. The water level is drawn down by pumping water out at a steady discharge, q.

Two observation holes are driven on a radial line at a distance of r_1 and r_2 from the well to observe the head of water, h_1 and h_2 in the wells (Figure 1).

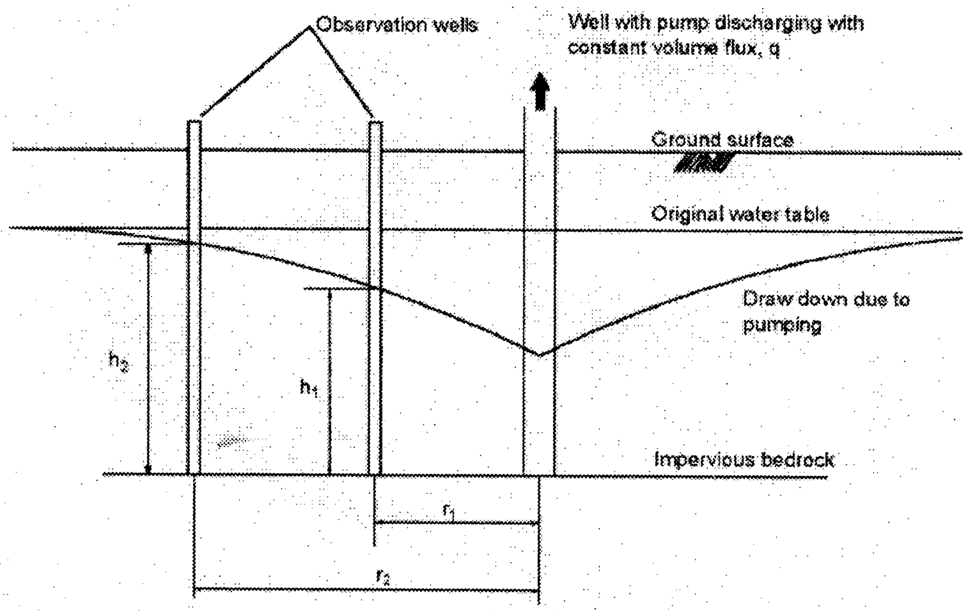

Figure 1.

Show that the permeability, k, of a soil can be determined using the following equation:

$$k = \frac{2.3q\log(r_2/r_1)}{\pi(h_2^2 - h_1^2)}$$

(c) A riverbed consists of a layer of sand 8 m thick overlying an impermeable rock; the depth of river water is 2 m. A long cofferdam 6 m wide is formed by driving two lines of sheet piling to a depth of 6.0 m below the level of the riverbed and excavation to a depth of 2.0 m below bed level is carried out. The water level is maintained by pumping (Figure 2). Draw a flow net for the excavation clearly showing the boundary conditions. Indicate the number of flow channels and equipotential drops What is the hydraulic gradient immediately below the excavated surface? Suggest why it is safe to work in the excavation.

Question 3

(a) Describe briefly four methods for retaining soil behind tall, vertical surfaces. Show how a retaining wall can fail in the active and passive case. Use diagrams to illustrate your answer.

(b) Show, with the aid of a Mohr circle diagram, that for a non- cohesive soil such as sand the ratio of major to minor principle effective stresses (σ_1' and σ_3' respectively) at active failure may be given by:

$$\sigma_3' = \sigma_1' K_a$$

where K_a is Rankine's coefficient of effective earth pressure.

(c) A 6 m deep excavation is to be maintained by sheet piling and a prop placed at an unknown height (Figure 2). An imposed stress of 10 kN/m^2 is applied t the top surface of the sand. The unit weight and effective shearing angle of the soil are 18 kN/m^3 and 35° respectively. Calculate the magnitude of the lateral thrust and the optimum position of the prop to resist the force if the props are spaced every 3 m. Ignore any passive resistance below the excavation.

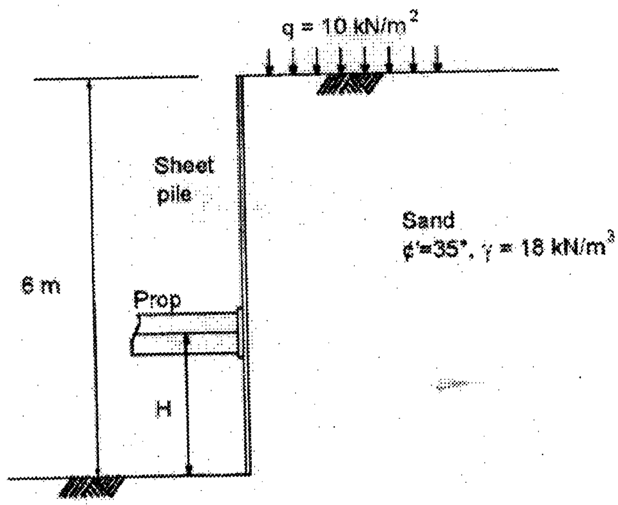

Figure 2.

Question 4

a) Describe briefly the following terms: *in situ* effective stress; normally consolidated soils; over consolidated soils and the preconsolidation stress of a soil. Use diagrams to illustrate your answers.

b) In an oedometer test on a saturated specimen of clay the applied pressure was increased from 100 to 200 kPa and the following compression readings were recorded (Table 1):

Table 1.

Time (min)	0	$\frac{1}{4}$	1	2.25	4	9	25	49	100

Gauge (mm)	8.83	8.42	8.21	7.99	7.78	7.49	7.29	7.21	7.15

The thickness of the specimen at start of the test was 17.10 mm. Determine the values of the coefficients of vertical compressibility, c_v, volume compressibility, m_v and vertical permeability, k_v.

c) Describe briefly using diagrams how lacustrine soils are formed in glacial regions. Show why the coefficients of permeability in the vertical and horizontal directions can differ significantly.

Question 5

a) Draw a simple sketch of a triaxial soil sample and indicate how the cell pressure and major principle stresses are applied.

b) Three undrained unconsolidated triaxial tests were carried out on specimens from the same depth (Table 2). Calculate the undrained shear strength, s_u, of the soil and the failure envelope. Show that the effective strength of the soil did not increase during the test.

Table 2.

Test	Cell pressure (kPa)	Deviator stress (kPa)	Pore water pressure (kPa)
1	50	70	20
2	75	70	45
3	100	70	70

c) The triaxial cell may be used to find the undrained shear strength of a soil. Describe briefly two other methods of determining the shear strength of a soil. Use diagrams to illustrate the apparatus and the application of forces to the soil.