National Exams May 2009

04-Env-A3, Geotechnical & Hydrogeological Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FOUR (4) questions constitute a complete exam paper.
   The first four questions as they appear in the answer book will be marked.

4. Each question is of equal value.

1. (25 Marks)

A constant head permeameter test is to be carried out for a soil sample to determine the in-situ hydraulic conductivity of the soil. For this a large sample is collected from a test pit as some of the sample is to be used for a grain sized analysis while some of it is to be used for the permeameter test. Part of the sample is lightly packed into the permeameter which has a sample length of 20.0 cm and a circular cross section with a diameter of 5.0 cm. Water is introduced to slowly saturate the soil and a constant head difference across the sample established of 175 cm. The data below shows the cumulated water volumes collected as a function of time for the 3-hour test.

a. What is your estimate of the hydraulic conductivity of the soil?
b. Comment on the representativeness of the test and the determined hydraulic conductivity of the in-situ soil?
c. How might the procedure be improved?
d. Suggest what types of soil this might be a typical hydraulic conductivity for?

Table 1: Results of Permeameter Test

Time (min)	Total Volume Collected (mL)
0	0.0
30	22.2
60	50.5
90	84.9
120	120.4
150	155.0
180	190.1

2. (25 Marks)

A soil sample is taken from test pit by pushing a thin walled tube with an inside diameter of 5.0 cm and a length of 10.0 cm and extracting a sample in the tube. The ends are capped and the sample returned to the lab for analysis. In the lab the tube and sample are weighed and the then the soil removed and empty tube weighed again. Following this the soil is placed in an oven at 100°C for 24 hours and reweighed again. At this point the soil is poured into a graduated cylinder with 250 mL of water in it and the additional volume determined. Using the information in the table below, determine the following properties:

a. Soil Porosity
b. Void Ratio
c. Degree of Saturation
d. Soil In-situ Bulk Density
e. Soil In-situ Dry Density
f. Soil Particle Density

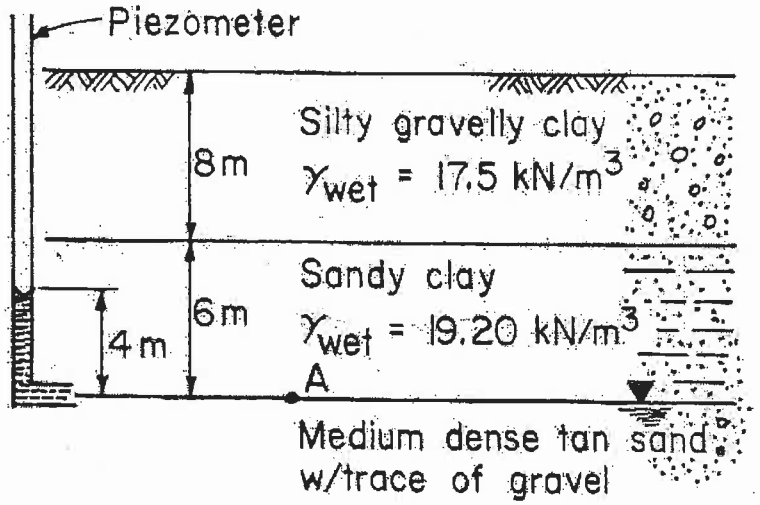
Table 2: Data Collected

Data	Value
Diameter of Sample Tube (cm)	5.0
Length of Sample Tube (cm)	10.0
Mass of Soil and Tube (g)	478.83
Mass of Empty Tube (g)	120.00
Mass of soil after drying (g)	338.21
Volume of water in graduated without soil (mL)	250.0

3. (25 Marks)

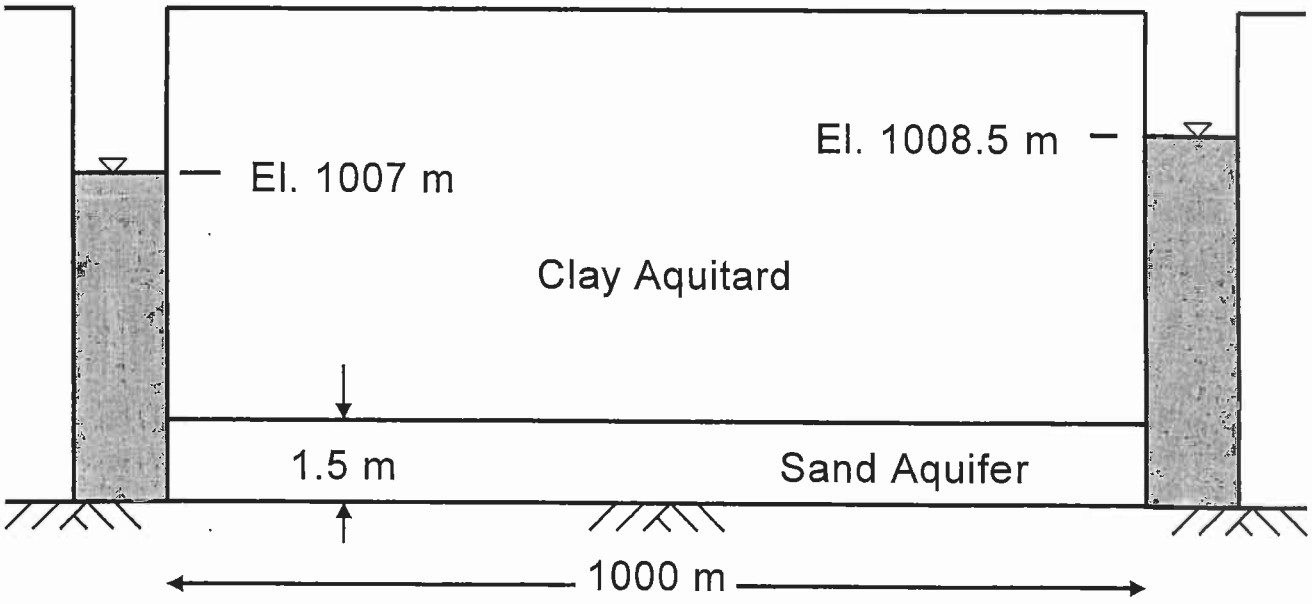
The figure below shows a soil profile for a three-layer system.

a. Determine the total stress, effective stress and pore pressure at point "A" in the figure for the conditions shown.
b. If the piezometric head drops 1.0 m due to a change in water table, what is the effective stress at "A"?
c. What piezometric head due to a change in water table location is required to make the effective stress at "A" = 0 kN/m^2?



4. (25 Marks)
The figure below shows a thin aquifer connecting two irrigation canals 1000 m apart and running parallel to each other. The canal to the left has a water surface elevation of 1007 m while that to the right has a water surface elevation of 1008.5 m. The sand aquifer connecting the two has a constant thickness of 1.5 m, bottom elevation of 1000 m, porosity of 0.035 and a saturated hydraulic conductivity of 250 m/d. The sand layer is confined from above by a clay layer.

a. Sketch the steady state piezometric height in the aquifer for the situation above.
b. What will be the discharge (in m^2/day) in the aquifer from one canal to the other?
c. If a contaminant was accidently introduced into the upper canal, how long would it take to reach the lower canal?
d. If instead of a clay aquitard above the sand continued to the surface, what would the discharge be?
e. If, in addition to the sand continuing to the ground surface as in part d, there was a recharge of 1.5 mm/day to the whole system:
    a. What would the piezometric surface look like (sketch this), and
    b. What would the discharge into the lower canal be?

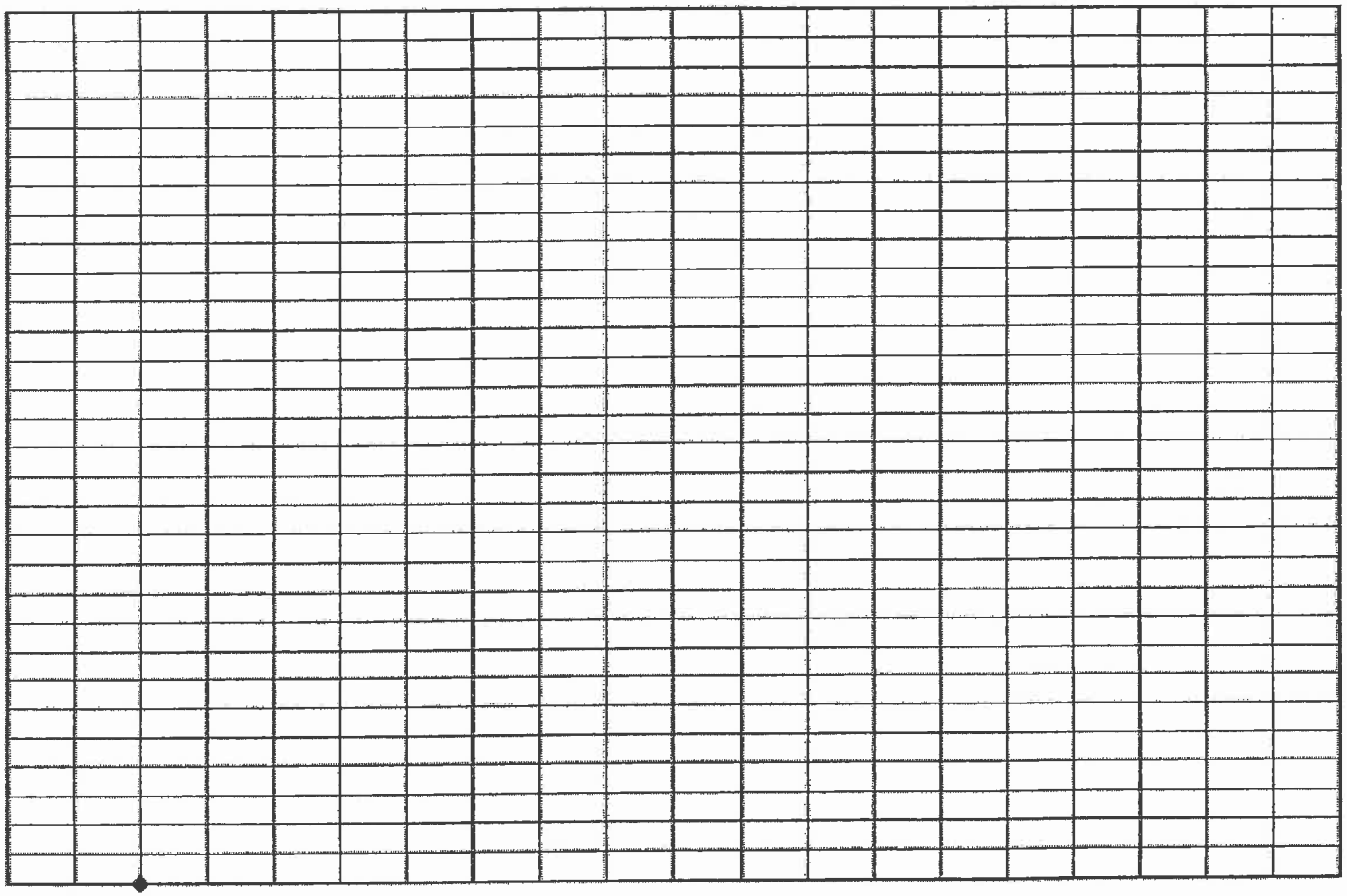


5. (25 Marks)
The data in the table below were collected from a triaxial test conducted on a soil specimen. The specimen has a diameter of 10.1 cm and an overall length of 25.0 cm. Note that a sheet of graph paper is provided for you to use on the next page and you may want to submit this with your answer booklet.

Table 3: Triaxial Data

Test Run	Confining Stress (kN/m^2)	Applied Axial Load (N)
1	100	320.5
2	200	480.7
3	300	640.9
4	400	801.2

a. What are the values of c and φ for this soil?
b. What is the orientation of the failure plane and the shear and normal stresses on the failure plane for test 2?
c. Based on the information above, would you estimate this to be a cohesion less or cohesive type soil?



6.(25 Marks)
The ability of a soil to infiltrate rainwater is to be determined using a 1.13 m diameter metal ring pushed into the ground. The ring is filled with water to a depth of 5 cm and the amount of water required to be added over time to keep it at this depth is recorded to determine the parameters which describe infiltration. In the first 10 minutes of the test 50 L was needed to maintain the water level. Volumes needed at 2-hour intervals are given in the table below as the cumulative volumes added.

Table 4: Infiltration Results

Time (hr)	Total Cumulative Volume Added (L)
0	0
2	635
4	810
6	920
8	1020
10	1120
12	1220
14	1320
16	1420
18	1520
20	1620
22	1720
24	1820

a. Determine the parameters for any one of the potential infiltration equations you feel is appropriate (Green-Ampt, Horton, Holtan, or Phillips). Note that if information is required for any of these formulations that is not available in the above data, you may assume any reasonable value.
b. Over this 24-hr period of time, estimate the total amount of water volume infiltrated into the soil through this device.
c. Discuss the validity of this device for developing infiltration characteristics of a soil under rainfall conditions.