National Exams December 2008

04-Env-A3, Geotechnical & Hydrogeological Engineering

3 hours duration

NOTES:

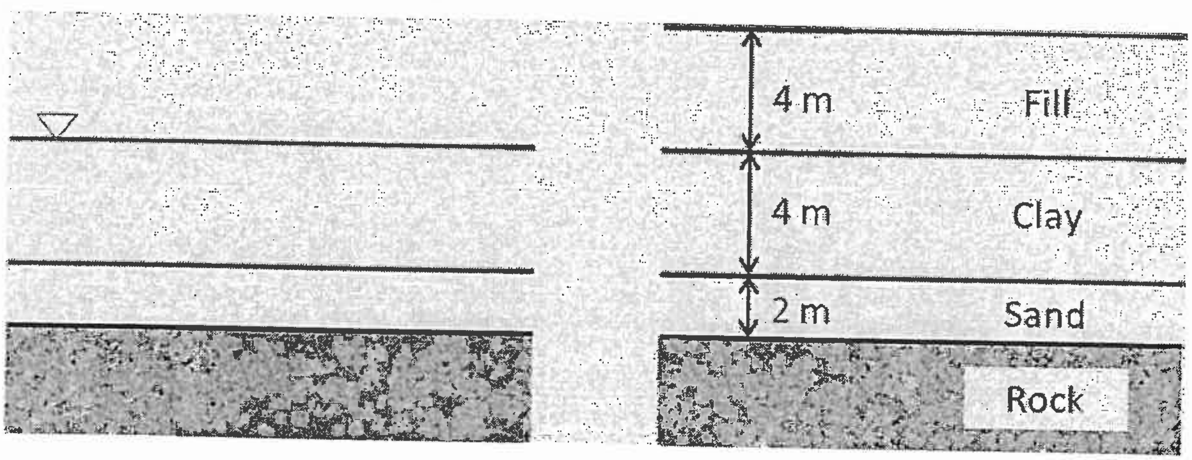
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM. Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value.

Marking Scheme:

1: 5, 5, 5,5
2: 10, 5, 5
3: 15, 5
4: 7, 7, 6
5: 14, 6
6: 7, 7, 6
7: 15, 5

1. (20 Marks)
   A sample of saturated soil is 38 mm in diameter and 76 mm long. Before drying its mass is 142 g and after drying is 86 g. For this soil sample determine:
   a) The unit weight of the saturated sample,
   b) The water content of the wet sample,
   c) The porosity and void ratios of the soil, and
   d) The particle density of the soil grains.

2. (20 Marks)
   The soil profile in the figure consists of 4 m of clay over 2 m of sand over rock. The unit weights of all natural materials are 20 kN/m^3 and the steady state water level is at the ground level. A wide embankment 4 m high is constructed from fill with a unit weight of 15 kN/m^3. Determine the total and effective vertical stresses at the centre of the clay and the centre of the sand:
   a) Before the construction of the embankment,
   b) Immediately after the embankment is completed, and
   c) After a very long time.



3 (20 Marks)
The data in the table below are the data collected from a falling head permeameter test conducted on a sample taken from the field. The sample has a diameter of 100 mm and a length of 150 mm. The standpipe used to measure the falling head is 10 mm in diameter. Determine:

a) The saturated hydraulic conductivity for the soil, and
b) Suggest what types of soil this might correspond to.

Time from start of test (s)	Height of water in standpipe above overflow (m)
0	1.60
60	1.51
120	1.42
240	1.26
480	0.99

4.(20 Marks)
A single, 30 cm diameter, well draws from a nearly horizontal, unconfined sandy-gravely aquifer with a depth of 20 m below the ground surface. The aquifer materials have a porosity of 0.35 and saturated hydraulic conductivity of 100 m/d. Without the well the water table is approximately horizontal and 6 m below the ground. Below the aquifer material is a clay till with a saturated hydraulic conductivity of 0.1 m/d. Precipitation in the region is approximately 810 mm, of which a third is lost to run-off and a third to ET.

a) What is the maximum discharge (in m^3/day) that can be drawn from the well if the maximum allowable drawdown in the well, relative to the static level, is 5 m?
b) For the discharge determined in part a, what is the area of recharge for the well?
c) If source water protection requirements are to be put in place that limit the type of development allowed within a 1 year time of travel to the well, what area would this apply to?

5.(20 Marks)
The figure on the last page of the examination shows a sheet pile wall used to keep an excavation dry. The material below the water above the impervious layer is homogeneous and isotropic with a saturated hydraulic conductivity of 6×10^{-4} m/s.

a) Using a flow net analysis, determine the seepage under the sheet pile wall per linear meter of the wall. Submit this page with your answer sheet.
b) What is the pore pressure on the sheet pile wall 1 m above the lowest point on either side of the wall?

6.(20 Marks)
For the purposes of determining groundwater vulnerability, you need to assess the infiltration characteristics of the soils in a given area.

a) Describe what field tests you might do to accomplish this, detailing the tests you would conduct, how you would conduct them, and some of the strengths and weaknesses of the tests proposed.
b) Describe how the infiltration rate into a soil will change over time:
    a. During a long steady rainfall after a significant period of time of no rain, and
    b. During a steady rainfall that occurs shortly after a previous rainfall event.
c) What mathematical models would you use to model infiltration into the soil under the conditions in parts a) and b) above? What parameters are required for these models?

7. (20 Marks)
Four runs were completed using a direct shear apparatus on a sandy soil. In all cases the samples have areas of 5.5x5.5 cm. The results are summarized in the table below.

a) Determine the values for c and φ for this soil.
b) Describe alternate methods (in-situ and laboratory) for determining the shear properties of soils and when they would be more appropriate than the direct shear apparatus used here.

Run Number	Normal Force (N)	Shear Force (N)
1	40	58.0
2	80	69.4
3	120	81.0
4	160	96.0

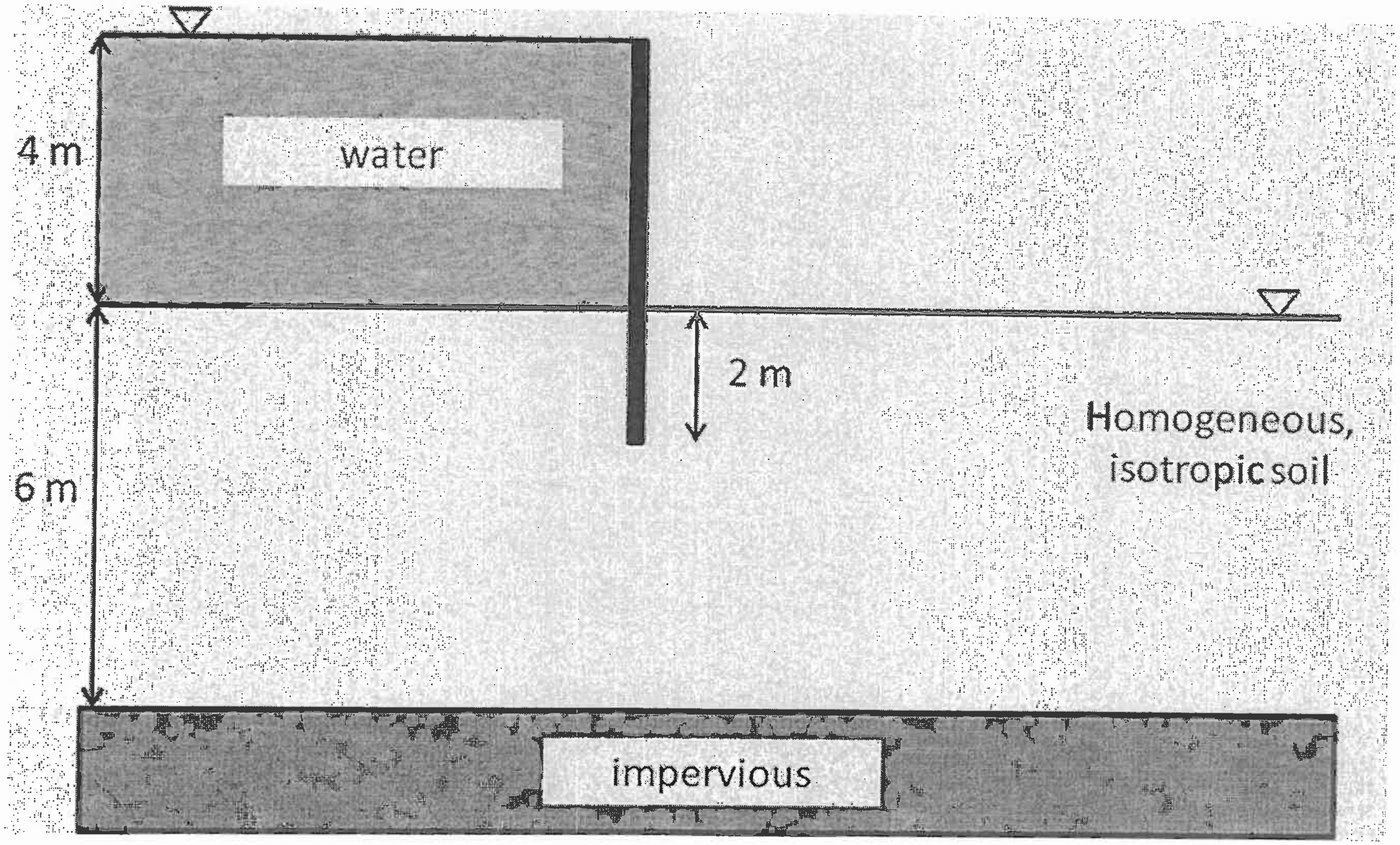


Figure for question 5 – submit this with your answer book.