National Exams May 2018

04-Env-A3, Geotechnical and 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 available on page 8.

5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1 (20 marks):

For the purposes of investigating a soil for suitability as a construction material, the following information was collected: (1) An undisturbed sample was obtained by taking a 100 mm diameter, 250 mm long core out of the ground; (2) The sampling tube used to collect the sample had an empty mass of 100 g; (3) When filled with the soil the mass of container and soil was 3490 g; (4) After removing the soil from the container it was oven-dried and found to have a mass of 3098 g; (5) When this soil was loosely poured into a container of water, the volume of water displaced was 1178 mL. For this soil calculate:

a) **(5 marks)** the bulk density of the soil,

b) **(5 marks)** the dry unit weight of the soil,

c) **(5 marks)** the degree of saturation of the soil, and

d) **(5 marks)** the saturated unit weight of the soil.

Question 2 (20 marks):

The grain-size distribution of an inorganic soil is shown in Figure 1. Its liquid and plastic limits are 40% and 20%, respectively.

a) **(10 marks)** Classify the soil according to the USCS classification system (i.e., determine the group symbol and group name), and

b) **(10 marks)** Explain why this soil may or may not be suitable as a cover material for a municipal solid waste landfill.

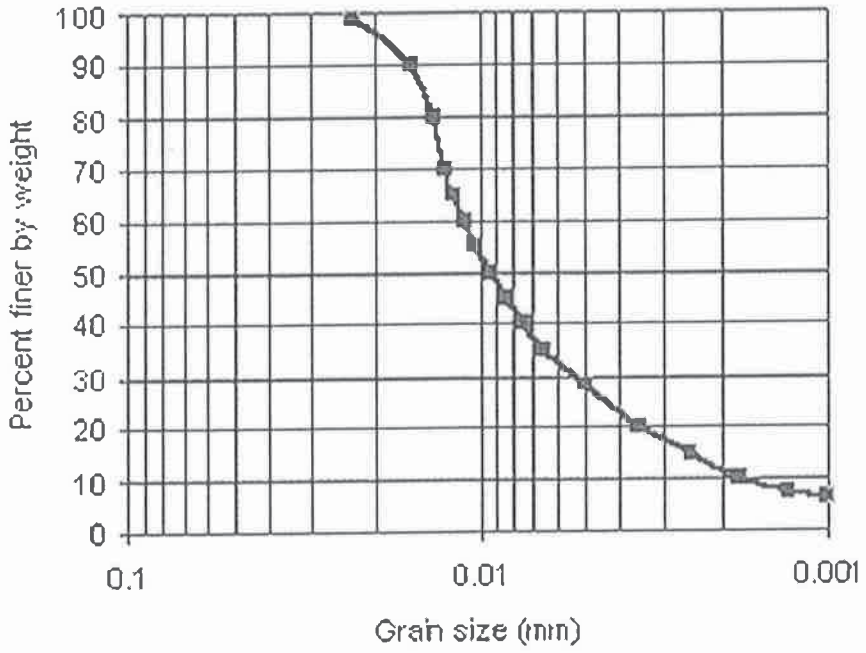

Figure 1: Grain-size distribution of the inorganic soil

Question 3 (20 marks):

Figure 2 shows the cross-section of an earth dam (compacted clay with saturated hydraulic conductivity of 0.0001 cm/s) and reservoir system resting on a 10 m thick layer of loam soil with saturated hydraulic conductivity of 0.01 cm/s underlain by impermeable shale rock. The crest of the dam is 50 m long (perpendicular to the picture).

a) **(10 marks)** Calculate the volume of water that will seep beneath the dam through the loam soil in a day (m^3/day), and

b) **(10 marks)** Calculate the time it would take for a tracer injected upstream of the dam (at point A) to show up at the downstream of the dam (at point B).

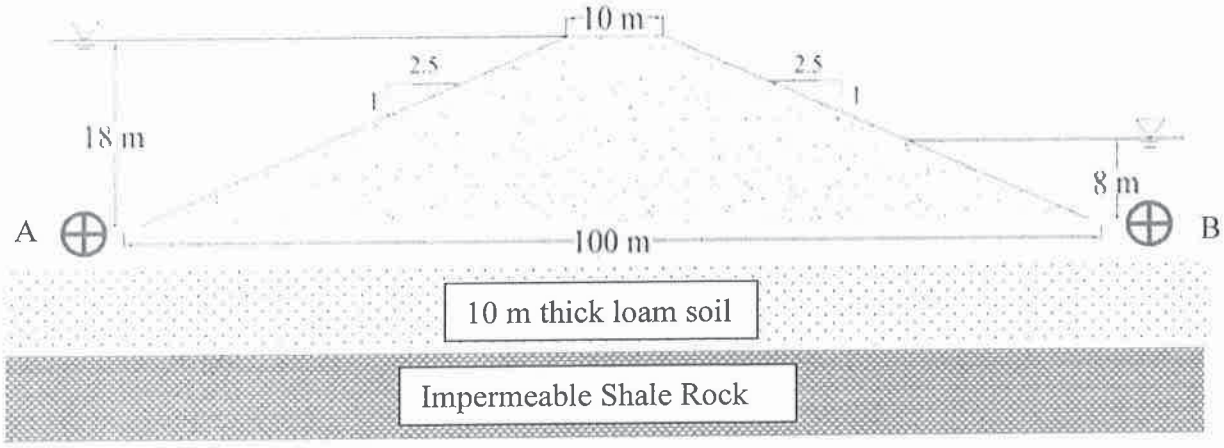

Figure 2: earth dam and reservoir system

Question 4 (20 marks):

A 2-m thick normally-consolidated clay soil is resting on impermeable shale rock; a 20-m thick layer of sandy soil is placed on top of the clay to expedite consolidation process. The unit weight of the sand is 15 kN/m^3 and the unit weight of the clay is 10 kN/m^3. For the clay layer, the initial void ratio is 2.0, the compression index of the clay is $C_c = 0.40$, the recompression index is $C_r = 0.10$, and the coefficient of consolidation is $C_v = 0.002\ cm^2\ s^{-1}$.

a) **(10 marks)** Compute the ultimate primary settlement of the clay layer.

b) **(10 marks)** Compute the time for 50% of primary consolidation to occur.

Question 5 (20 marks):

Figure 3 shows a square column foundation that is 2.5 m x 2.5 m in plan view, installed 1 m below ground surface in a dry sandy soil with: $\phi' = 30°$, $C' = 10$ kPa, $\gamma = 16.0$ kN/m^3. Assume the unit weight of the concrete is 24 kN m^{-3}.

a) **(10 marks)** Calculate the maximum allowable load P (in kN), applied at the center of the footing (i.e., eccentricity e = 0), assuming a minimum factor of safety of 3.0, and

b) **(10 marks)** Assume the load P is applied with an eccentricity of e = 0.3 m. Calculate the ultimate load P that can be placed on this footing with a minimum factor of safety of FS = 2.

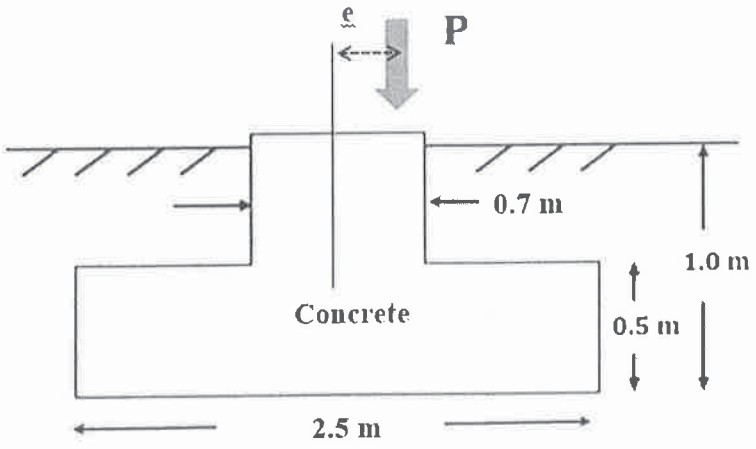

Figure 3: a square column foundation

Question 6 (20 marks):

Figure 4 shows a single, 20 cm diameter well, that draws from a nearly horizontal, unconfined sandy-gravely aquifer from a depth of 10 m below the ground surface. Two observation well are located at radius $r_1 = 20$ m and $r_2 = 50$ m from the pumping well. The aquifer materials have a porosity of 0.35 and saturated hydraulic conductivity of 5 m/d. Without the well, the water table is approximately horizontal and 2 m below the ground surface. The material below the aquifer is impermeable bedrock.

a) **(10 marks)** 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 2 m?

b) **(10 marks)** How long would it take for a conservative tracer to travel the distance between the observation wells?

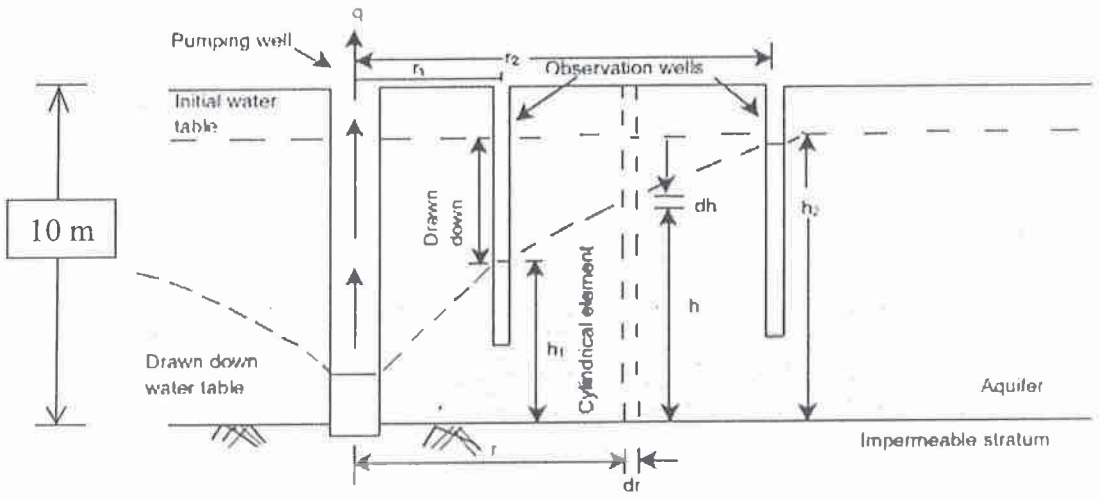

Figure 4: a pumping well in unconfined aquifer

Marking Scheme

1. 20 marks total (4 items times 5 marks each)
2. 20 marks total part (a) 10 marks and part (b) 10 marks
3. 20 marks total part (a) 10 marks and part (b) 10 marks
4. 20 marks total part (a) 10 marks and part (b) 10 marks
5. 20 marks total part (a) 10 marks and part (b) 10 marks
6. 20 marks total part (a) 10 marks and part (b) 10 marks