National Exams May 2017

04-Agric-A2, Soil Physics & Mechanics

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.

5. Some questions require a written answer. Clarity and organization of the answer are important.

Question 1 (20 marks):

Provide definitions for the following terms (2 marks each):

1) Pore water pressure
2) Effective stress
3) Soil texture
4) Degree of saturation
5) Void ratio
6) Moisture content
7) Seepage
8) Proctor Density
9) Phreatic Surface
10) Soil shear strength

Question 2 (20 marks):

A falling-head hydraulic conductivity test, using the apparatus shown in Fig. 1, was conducted on a clay soil specimen that was 97 mm in diameter and 20 mm tall. The standpipe had an inside diameter of 6.0 mm. The water level in the bath surrounding the specimen was 120 mm above the laboratory counter top and the water level in the standpipe fell from a height of 510 mm to 261 mm above the counter top in 46 hours.

a) (10 marks) Compute the hydraulic conductivity. Does the result seem reasonable? Why or why not?

b) (10 marks) Compute how many more minutes would it would take for the water level in the standpipe to drop further to a height of 200 mm above the counter top?

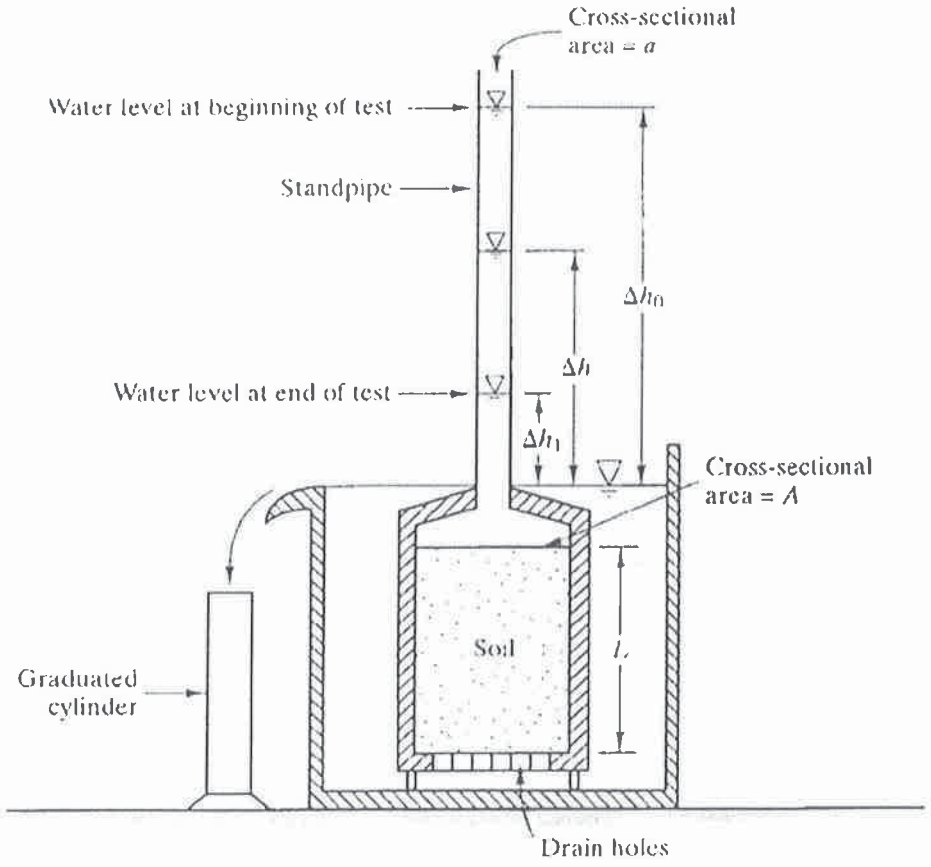

Figure 1: falling-head hydraulic conductivity test apparatus

Question 3 (20 marks):

The grain-size distribution of three inorganic soils (labeled A, B, and C) and one organic soil (labeled D) are shown in Figure 2, below.

a) (10 marks) Which one of the three inorganic soils has the highest uniformity coefficient C_u and which one has the lowest coefficient of gradation C_c?

b) (10 marks) Classify soil D according to the USCS classification system; assume its liquid and plastic limits are 52% and 22%, respectively and determine the group symbol and group name.

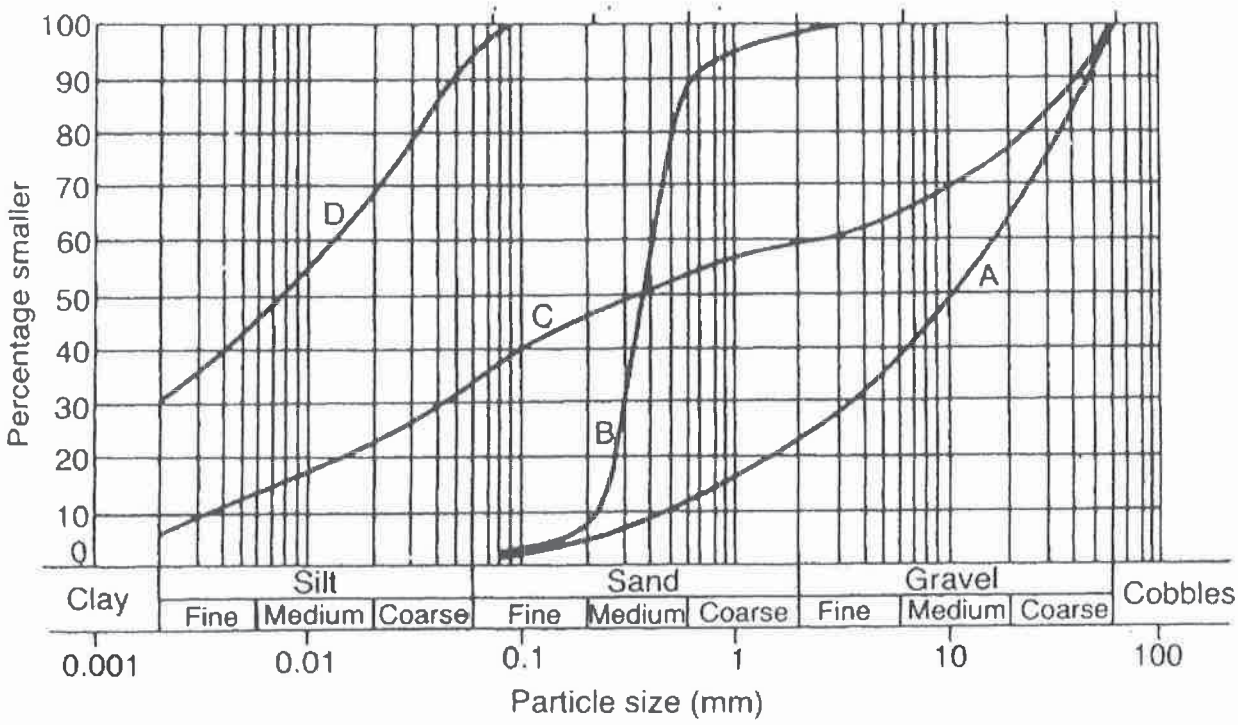

Figure 2: particle size distributions of soils A, B, C, and D.

Question 4 (20 marks):

A proctor compaction test completed in the laboratory on a borrow pit soil gave a maximum unit weight of 19 kN/m^3 and an optimum water content of 11.5%. The bulk unit weight and water content of the soil in the borrow pit are 17.2 kN/m^3 and 8.2%, respectively. A 100,000 m^3 fill is to be constructed using this soil. The specifications require the fill to be compacted to 95% Proctor compaction.

a) (10 marks) What is the additional weight of water required to bring the moisture content of the borrow pit soil to the optimum value to achieve 95% Proctor compaction?

b) (10 marks) How many truckloads of the borrow pit soil will be required for a 100,000 m^3 fill, assuming each truck has a capacity of 10 m^3?

Question 5 (20 marks):

Municipal drains have been used in rural Ontario since the 1800's to improve the drainage of agricultural land by serving as the discharge point for private agricultural tile drainage systems. A 3 m deep municipal drainage ditch is cut in a saturated clay with side slopes of 2 horizontal to 1 vertical, as shown in Figure 3 below. The saturated unit weight of the soil is 18.5 kN m^{-3} and its undrained cohesion is C_u = 40 kN m^{-2}. If undrained friction angle, $\phi_u \approx 0$, determine:

a) (10 marks) the factor of safety against shear failure of the slide slopes; and
b) (10 marks) the required side slopes that would satisfy minimum factor of safety of 3 against shear failure.

Figure 3: the 3-m deep municipal drain.

Question 6 (20 marks):

A single, 30 cm diameter well draws from a nearly horizontal, unconfined sandy-gravely aquifer located 20 m below the ground surface. Two observation wells are located at radius r_1 = 10 m and r_2 = 100 m from the pumping well, as shown in Fig. 4. The aquifer materials have a porosity of 0.35 and saturated hydraulic conductivity of 20 m/d. Without the well, the water table is approximately horizontal and 2 m below the ground. Below the aquifer material is impermeable bedrock. Assume the radius of influence of the well is about 500 m.

a) (10 marks) What is the maximum discharge that can be drawn from the well if the maximum drawdown in the well, relative to the static level, is 2 m?

b) (10 marks) How many days would it take for a conservative tracer that is injected in the observation well located at radius r_1 = 10 m to reach the pumping well during a steady pumping rate of 500 m^3/d?

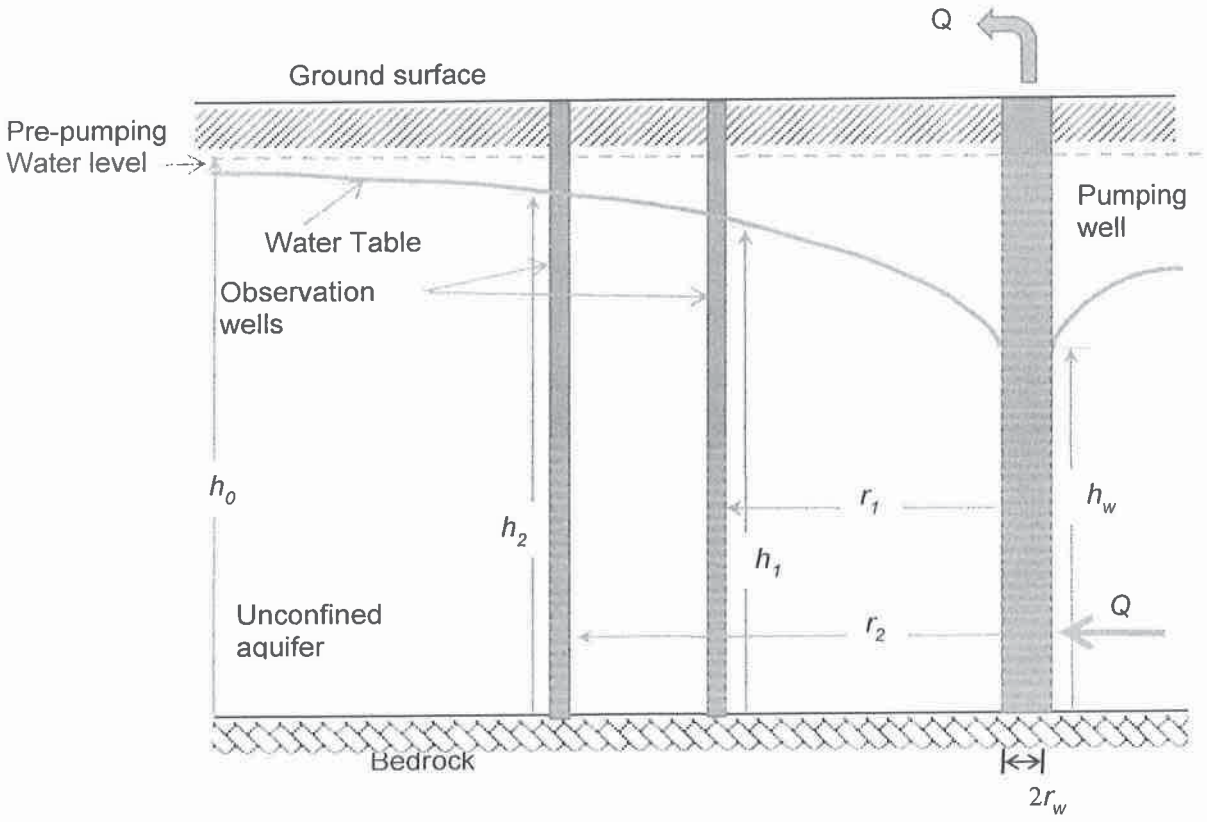

Figure 4: the pumping well in an unconfined sandy-gravely aquifer.