National Exams December 2013

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.

Marking Scheme:

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

1.(20 Marks)

A long trench needs to be dewatered with a series of sand point wells spaced 10 m apart on either side of the trench. The trench is to be dug 5 m below the ground surface in a location where the water table is only 1.0 m below the surface. The water table needs to be lowered to a level 1.0 m below the trench bottom. The gravely sand aquifer is underlain by an essentially impermeable till layer 10 m below the ground surface.

a) What are reasonable estimates of the essential soil properties of the aquifer to solve this problem?
b) What discharge rate is necessary for each of the sand point wells?
c) What assumptions are necessary to allow you to solve this problem?

2. (20 Marks)

A massive cylinder of undisturbed soil is removed from its' natural state in a field for laboratory study. The cylinder without soil has a mass of 37.5 kg and with the soil sample taken has a mass of 445 kg. The inside dimensions of the cylinder is 50 cm while the length is 1.0 m. Separate measurements indicate the soil has a moisture content of 15% (wet basis) and a particle grain density of 2.65 gm/cm^3. For this information determine:

a) The dry and bulk densities of the soil,
b) The porosity and void ratio of the soil, and
c) The mass of the soil, water and cylinder if the soil is fully saturated.

3.(20 Marks) Provide short answers to the following

a) A relatively tall structure with a small footprint (e.g., a storage silo) is built in stable soils in which the water table is at least 15 m below the ground surface. With a rise in the water table to just below the foundation level the structure fails by tipping over while remaining structurally intact. Discuss possible reasons for the failure of this building?
b) The shear strength of soils can be determined in a number of different ways. What are the parameters used to describe the various parameters involved with the shear strength of soils and what are the common methods used to determine these parameters.
c) Construction of a planned large building is planned for a site. Two years before construction the top soil is removed and sand fill is placed over the entire footprint of the proposed building to a depth of 10 m. Shortly before constructing the building, the sand is removed and construction begins. Explain what the possible purpose of the sand fill is?

4.(20 Marks)

The soil cylinder in question 2 is to be used in a constant permeameter test. In this test the cylinder is placed in a bath of water some 10 cm deep and the sides of the cylinder are extended 76 cm above the top of the soil and filled with water. Water is added at a rate sufficient to keep the water level at a constant depth of 76 cm. Over the course of one 10 minute period 865 L of water are added to keep the level constant.

a) What is the seepage velocity in the system?
b) What is the saturated hydraulic conductivity of the soil?
c) What other methods, laboratory and field, methods are available to determine the insitu hydraulic conductivity of the soil?
d) What are the main soil characteristics that affect the hydraulic conductivity of a soil?

5.(20 Marks)

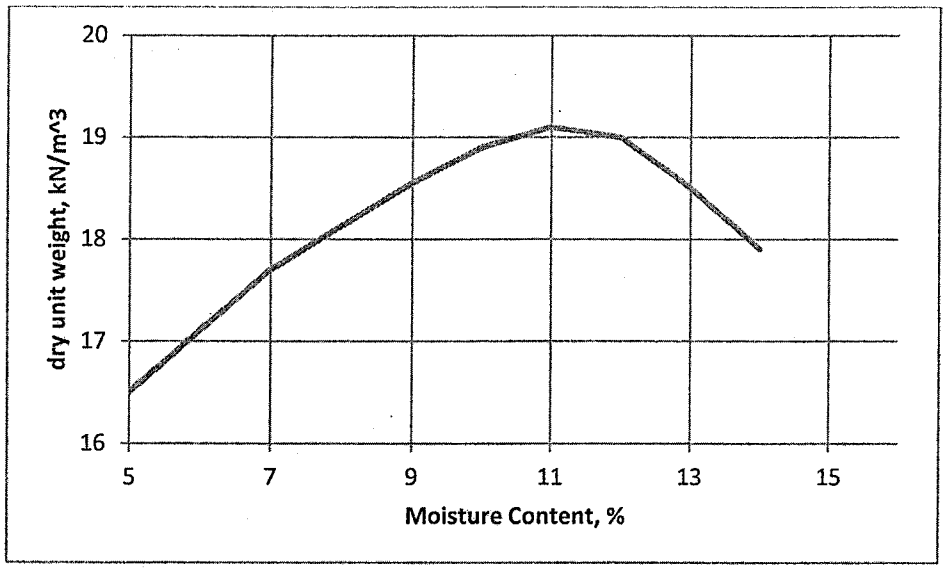
Soil infiltration has been measured with a double ring infiltrometer with the inner ring having a diameter of 30 cm and the outer ring a diameter of 60 cm. The water in each ring is kept relatively constant and the amount added to the inner ring recorded periodically. The results show that after about an hour, the volume added to the inner ring each 5 minutes becomes constant at 29.5 cm^3 per 5-minute interval. In the first minute of the test, 21.9 cm^3 of water was added. In the interval from 15 to 20 minutes after the test, 32 cm^3 are added. Infiltration is to be modelled by the Horton Infiltration approach.

a) What are the initial and final infiltration capacities?
b) What is the decay constant?
c) What volume of infiltration can be expected from time 0 to time 20 minutes
d) What is the purpose of the outer ring in this test?
e) What other methods are available to determine the infiltration parameters for soils?

6.(20 Marks)

The figure below shows the results of a standard proctor compaction test for soil to be used in construction. The soil is a gravelly, silty sand with particle grain specific gravity of 2.60

a) Sketch on the figure where the line of zero air voids would plot.
b) For the test completed at a water content of 10%, what is the % of the void volume filled with air?
c) What is the effect on the soil after it is compacted in terms of its hydraulic, structural and erosive behavior?



7.(20 Marks)

A large farm building is to be built using a slab-on-grade construction. Prior to construction the area has a water table at a 4 m depth. The soil beneath the proposed construction is 2 m of sand followed by 5.0 m of clay. The construction calls for removal of 1.0 m of sand before constructing the building. Soil specific weights are given below.

a) Prior to any work, what are the pore, effective and total pressures at the bottom of the clay layer?
b) After the excavation of the 1.0 m of sand, and prior to building construction, what are the pore, effective and total stresses at the bottom of the clay layer?
c) Immediately after construction of the building, whose total dead load is equivalent to 48 kN/m^2, what are the pore, effective and total pressures at the bottom of the clay layer.

Data:

Specific weight of dry sand:15.7 kN/m^3
Specific weight of saturated sand: 19.6 kN/m^3
Specific weight of dry clay: 16.7 kN/m^3
Specific weight of saturated clay: 17.9 kN/m^3