2017 Soil Mechanics I and Exercises Midterm Exam

2017/11/21 (Tue) 13:00-14:00 W2 Lecture room

Attention:

- The exam consists of two questions for which you are provided with two answer sheets. Write down your name and student ID number on every answer sheet. Use one answer sheet per question and answer them in sequence, starting from [Question 1]. If the front page of an answer sheet is insufficient to complete your answer, use the back page of the same answer sheet after clearly indicating your intent.
- Scores for each question are equally weighted.
- In addition to personal writing instruments, non-programmable scientific calculators are permitted. However, programmable calculators and calculator functions of mobile phones are prohibited. Any attempts at cheating on the exam will result in failed credit of the course and serious penalties.
- Wherever necessary, specify the units in your answers.

[Question 1]

An embankment is constructed from the soil excavated from a borrow pit. After compaction, the total volume of this embankment is 20,000 m^3. The soil taken from the borrow pit was investigated and the results obtained at natural soil conditions are as follows:

Bulk density: 1.80 t/m^3
Water content: 15.0%
Specific gravity of soil particles: 2.70
Maximum dry density: 1.90 t/m^3, Optimum water content: 17.0 %

From the above results of compaction test, water is sprayed during the construction of the embankment to meet the optimum water content condition in which the dry density reaches 90.0% of the maximum dry density (i.e., degree of compaction = 90.0%). Answer the following questions using the density of water 1.00 t/m^3.

1) Find the void ratio, degree of saturation and dry density of the soil in the borrow pit at natural conditions.

2) Find the volume and mass of the soil to be excavated from the borrow pit at natural conditions.

3) Find the mass of water per 1 m^3 of soil that is necessary to spray in the borrow pit at natural conditions.

4) Find the degree of saturation of the embankment after the completion of compaction.

[Question 2]

A sheet pile wall was installed in a fully saturated permeable soil as shown in the figure. Here, e is the void ratio of the permeable soil, G_s is the specific gravity of the soil particles, D is the depth of the sheet pile, and γ_w is the unit weight of water. Answer the following questions.

(1) While the water level to the right side of the sheet pile stays at the ground level, the water level to the left side raises and produces failure of the ground when it reaches a height of h. Assuming that the ground failure area is pqrs:

1) What is this phenomenon called?
2) If the total head at point p is h_p, express the pressure head and the pore water pressure at the same point p as functions of h_p and other given data. For this, assume that the datum for the elevation head is located at the ground surface.
3) Assume that u_1, the pore water pressure at point p obtained in 2), acts uniformly on pq, the bottom side of the ground failure area. Express the effective stress at pq as a function of h_p and other given data.
4) Considering an upward flow from the bottom side, pq, to the ground surface rs. The critical hydraulic gradient can be defined as h_p/D. Express h_p/D as a function of e and G_s.

(2) The figure shows the flownet in the permeable ground just before failure. The flownet is drawn so that each element surrounded by streamlines and equipotential lines approximates a square.

1) Assume that the hydraulic conductivity of the permeable ground is k. For the given flownet, obtain the discharge Q for the entire permeable soil, per unit width, per unit of time, just before failure, as a function of the given data.
2) Using the flownet, the total head at each equipotential line can be expressed as a function of h. Express h_p, the total head at point p, as a function of h.
3) Assume that the water pressure is linearly distributed between points p and q. If u_2 is the average pore water pressure acting on pq, express the difference between u_2 and u_1 as a function of h and γ_w.