2016 Soil Mechanics I and Exercises Final Exam

2017/1/31 (Tue.) 13:00-15:00 W2 Lecture room

Attention:

- The exam consists of four questions for which you are provided with four answer sheets. Write down your name and ID number on every answer sheet. Use one answer sheet per question and answer them in sequence, starting from [Question 1]. If the space provided in any answer sheet is insufficient, use the back of the page after clearly mentioning so (for example, "continues on the back").
- In addition to personal writing instruments, non-programmable calculators are permitted, but programmable calculators and all types 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] Answer the following questions

(1) In order to understand the physical properties of a soil extracted from a borrow pit used to build an embankment, a sample of 0.5 m^3 was taken and its weight was found to be 8.9 kN. From this soil, a sample of 4.0×10^{-3} kN was taken, oven-dried, and reweighted. The oven-dried weight was 3.48×10^{-3} kN. Based on a test conducted separately, it was found that the unit weight of soil particles was γ_s = 26.2 kN/m^3. Answer the following questions assuming unit weight of water γ_w = 9.8 kN/m^3.

1) Find the water content w (%), the total unit weight γ_t (kN/m^3), and the dry unit weight γ_d (kN/m^3) of this soil
2) Find the void ratio e of this soil
3) Find the degree of saturation S_r (%) of this soil
4) This soil is compacted to obtain a dry unit weight of γ_d = 16.7 kN/m^3 for the construction of the 30,000 m^3 embankment. Determine the weight and the volume of soil needed to be excavated from the borrow pit.

(2) Explain briefly the following terms

1) Relative density
2) Optimum water content

[Question 2] Answer the following questions

(1) Explain the following terms

1) Total water head
2) Darcy's law

(2) Derive the equation used to calculate the equivalent vertical hydraulic conductivity coefficient k_v for the stratified ground shown in Figure 2.1. Use the hydraulic conductivity coefficients of each layer (k_1 to k_3), as well as their thickness (H_1 to H_3) in your answer.

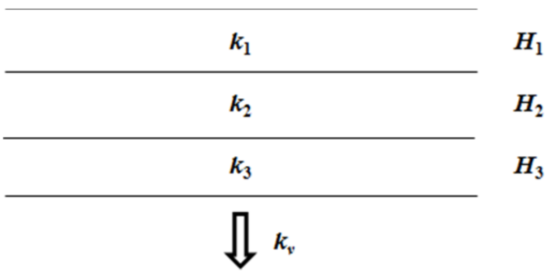


Figure 2.1

(3) Answer the following questions

1) Figure 2.2 shows a constant head hydraulic conductivity test with water flowing in the upward direction through the soil column. Plot the vertical distribution of total head, pressure head, and elevation head in the right side of the system, from elevation 0 to 3.6 m. The datum of the system is located at 0 m.
2) Calculate the vertical effective stress σ_v' at the bottom of the sand layer. Assume that the unit weight of water is 9.8 kN/m^3, and that the physical properties of the sand are those given in Figure 2.2, where k is the hydraulic conductivity of the sand layer, G_s is the specific gravity of the soil particles, and e is the void ratio of the soil.
3) Calculate the height of the water table on the left side of the system that would cause the sand column to reach quicksand state.

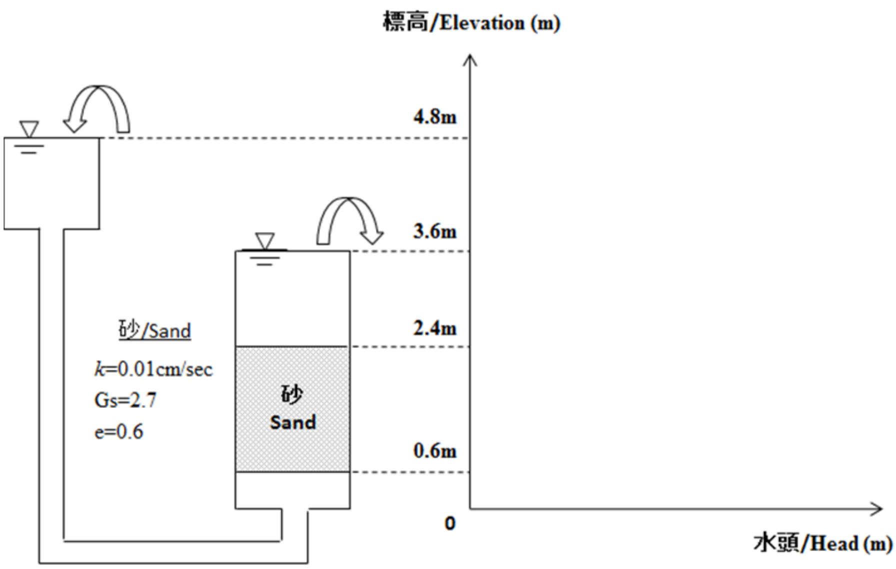


Figure 2.2

[Question 3] The construction of an embankment represents a surcharge load of q = 90 kN/m^2 over a wide area, as shown in Figure 3.1. The compression index of the clay layer is C_c = 0.80, its initial void ratio is e_0 = 2.2, and its consolidation index is c_v = 10 m^2/year. Assume, for this problem, that the clay layer is normally consolidated and that its consolidation settlement can be calculated by using the compressive stress at mid-depth (i.e., z = 7 m) as representative for the whole layer. Similarly, assume that the water pressure distribution in the sand layer does not change due to the surcharge loading and remains at hydrostatic pressure. If necessary, use Table 3.1, which shows the relationship between the average degree of consolidation U and the time factor T_v, and Figure 3.2, which represents how dimensionless excess pore water pressure distribution changes for different values of time factor T_v, at different dimensionless depths $Z = z/h$. For this problem, the unit weight of water is γ_w = 9.8 kN/m^3.

(1) Calculate the total consolidation settlement expected for the clay layer.

(2) Calculate the consolidation settlement expected for the clay layer after six months.

(3) Calculate, at mid-depth of the clay later (z = 7 m), the values of pore water pressure (sum of the hydrostatic pressure and the excess pore water pressure) immediately after the application of the surcharge load, six months later, and at the end of the consolidation process.

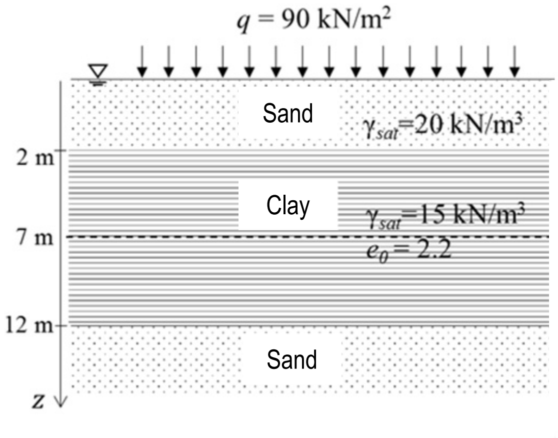


Figure 3.1 Representation of the ground layers including their values of saturated unit weight

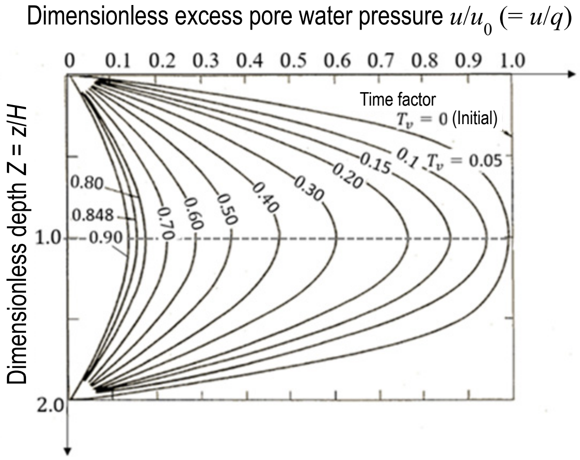


Figure 3.2 Distribution of dimensionless excess pore water pressure

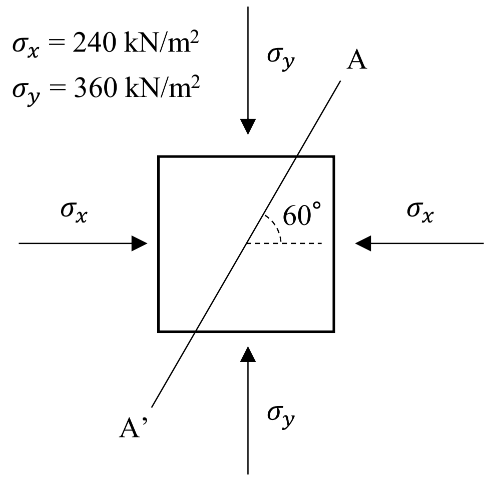
Table 3.1 Relationship between the average degree of consolidation U and the time factor T_v

T_v	0.05	0.10	0.15	0.20	0.30	0.40	0.50
U	0.252	0.357	0.437	0.504	0.613	0.698	0.764

T_v	0.60	0.70	0.80	0.848	0.90	1.00
U	0.816	0.856	0.887	0.900	0.912	0.931

[Question 4] Answer the following questions

(1) Consider the principal state of stress of a given point in the ground shown in the figure below. By using Mohr's stress circle, obtain the normal stress and shear stress acting on the A-A' plane that makes an angle 60° anticlockwise from the horizontal plane.



(2) Let the cohesion c be zero and the friction angle be 30° for this ground. During the excavation work being carried out near this point, σ_y remains constant while σ_x decreases until failure occurs. Predict the value of σ_x at failure using Mohr's stress circle and the Mohr-Coulomb failure criterion.

(3) In regard to (2), find the normal stress and shear stress on the failure plane. Also, determine the orientation of the failure plane.

(4) During the consolidated undrained triaxial compression test of a normally consolidated clay, the value of the positive excess pore water pressure generally rises. Explain the reason from the concept of dilatancy. Herein, the pressure is taken as positive for compression.