2013 Soil Mechanics II and Exercises Midterm Exam

2013/06/12/ (Wed) 8:45～10:15 Room : Kytotsu-4

Attention:

- There are three questions and three answer sheets. Write down your name and ID number on every answer sheet. Use one answer sheet for one question and answer in sequence from 【Question 1】. If the front side of the answer sheet is not sufficient for answering that question, mention that and use the back side of that answer sheet.
- Carrying any personal belongings is prohibited. For any mischievous act, you will not be entitled to get the credit of this subject.
- Wherever necessary, show the units in your answers.

【1】Answer the followings:

(1) State the assumptions made to derive Terzaghi's one dimensional consolidation equation. Also, derive Terzaghi's one dimensional consolidation equation. Here, consider coefficient of consolidation as c_v and pore water pressure as u.

(2) A clay layer of 8.00 m thickness lies between two sand layers as shown in Fig. 1-1. Vertical stress acting at the center of this clay layer without any surcharge on the ground surface is 120 kN/m^2. Initial void ratio at this condition is 1.50. Consolidation test results of the specimen obtained from this clay layer show compression index, Cc = 8.00×10^{-1} and coefficient of consolidation, c_v = 250 cm^2/day. Due to the uniformly distributed soil embankment on the ground surface, there occur an incremental load of q=300 kN/m^2 in the clay layer. At this condition, answer the following questions:

Take time factor, T_v = 0.848 for 90% degree of consolidation.

(a) After the final settlement, find the change in void ratio, Δe with respect to the initial void ratio.

(b) Predict the final settlement, S_f for this ground.

(c) Predict the number of days required to reach the settlement equal to 90% of final settlement. Assume that the stress within the ground due to the embankment is uniformly distributed along the depth of the soil ground.

(d) If the bottom part of the clay layer is impermeable rock, then find the number of days it will take to reach settlement equal to 90% of final settlement.

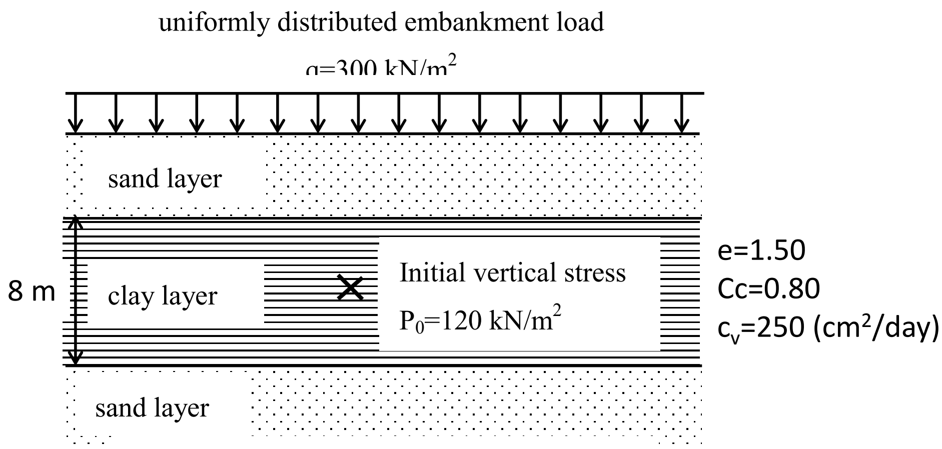

Fig. 1-1. Soil ground under considered.

(3) Real soil ground is not elastic. But in Bossenisque's solution for the prediction of stress within the soil ground, it is assumed to be semi-infinite elastic body. Give the reasons for this assumption.

【2】Answer the following questions:

(1) Unconfined compressive strength, q_u is obtained by conducting the unconfined compressive test for the specimen sampled from field which is saturated and normally consolidated. Show this test result by drawing Mohr's stress circle. Also, show how you can predict the theoretical value of undrained shear strength, c_u from this Mohr-circle. This specimen is remolded and unconfined compression test is done for this newly remolded specimen. Let the unconfined compressive strength obtained for this remolded specimen be q_{ur}. Derive the sensitivity of specimen sampled.

(2) Mention the characteristic features of Mohr-Coulomb Failure Envelope by comparing it with Coulombs failure criteria and Mohr's failure criteria.
Also, show the stresses at the Mohr-coulomb's failure envelope in terms of principal stresses by using Mohr's stress circle.

(3) Drained triaxial tests with constant lateral (confining) stress are conducted for the dry sand of two different initial densities. Plot the graphs that show the relationship between the change in volumetric strain and axial strain for the loose and dense sand. Also, briefly explain dilatancy of sand.

【3】Answer the following questions:

(1) State the conditions at which the active earth pressures calculated based on Coulomb's earth pressure theory and Rankine's earth pressure theory become equal.

(2) As shown in Fig. 3-1, retaining wall of height H is set up in horizontal soil ground (unit weight = γ). Explain the active earth pressure that acts on the retaining wall which is calculated based on Coulomb's earth pressure theory, by using Force Polygon. Assume the frictional angle that acts between the wall and the soil is equal to δ.
Note: In regard with Force Polygon, show the respective force vectors and add the explanation for the components of those force vectors.

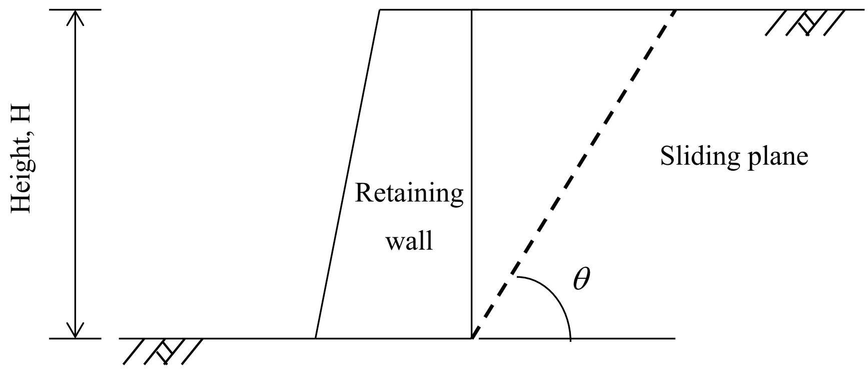

Fig. 3-1. Retaining wall on horizontal soil ground.

(3) Under the conditions shown in Fig. 3-2, the soil ground is excavated. Here, the uniform surcharge load, q is acting on the surface of the soil ground behind the excavation. Under this condition, installation of sheet pile wall is thought of based on the Rankine's earth pressure theory. If the excavation depth is H_1 and base of the sheet pile wall from the excavated depth is H_2, then answer the followings:

(a) Show the stress condition with Mohr stress circle for the point A which is at depth z from the ground surface behind the sheet pile.

(b) Based on the calculation done in (a), obtain the resultant active earth pressure, P that acts on the sheet pile. Also, find the position, h_1 at which this resultant force, P acts.

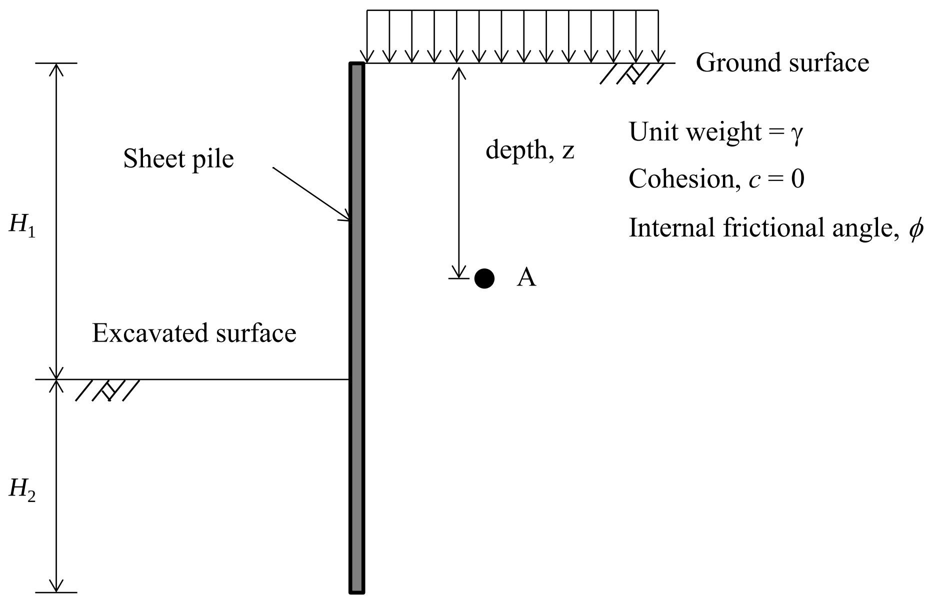

Fig. 3-2 Free supported Sheet pile.

2014 Soil Mechanics II and Exercises Midterm Exam

2014/05/28 (Wed) 8:45~10:15 Room Kyotsu-4

Attention:

- There are three questions and five 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 front side of an answer sheet is not enough for answering one specific question, you can use the back side of the same answer sheet, after clearly mentioning so.
- All questions bear equal mark.
- Non-programmable calculators are permitted, but calculators that have programming functions and all types of mobile phones are prohibited.
- If you behave maliciously during the exam, you will not be entitled to get any credit on this subject.
- Wherever necessary, show the units in your answers.

【1】Answer the following questions about consolidation of clay soils:

(1) Assume that the ground is composed of a clay soil deposit located over an impermeable bedrock. For this soil, the water table coincides with the ground surface. Let's analyze, based on Terzaghi's one-dimensional consolidation theory, the consolidation process that occurs within this soil after the quick application of an external load. Given the excess pore water pressure u (= pore water pressure – hydrostatic pressure), the coefficient of consolidation C_v, time t, and depth z, the consolidation equation is defined as:

$$\frac{\partial u}{\partial t} = C_v \frac{\partial^2 u}{\partial z^2} \tag{1}$$

(a) If the upper surface of the clay soil (i.e., the ground surface) corresponds to $z = 0$, and its bottom surface (i.e., just above the impermeable bedrock) corresponds to $z = H$, define the upper boundary condition for the clay layer (i.e., for $z = 0$).

(b) Define the lower boundary condition for the clay layer (i.e., for $z = H$). [Hint: consider the conditions under which the flow rate becomes zero according to Darcy's Law.]

(2) To solve the consolidation equation, the solution to equation (1) can be written as:

$$u = f(t)\,g(z) \tag{2}$$

Substituting (2) in (1), and being $f'(t)$ the first degree derivative of $f(t)$, and $g''(z)$ the second degree derivative of $g(z)$, we obtain:

$$f'(t)\,g(z) = C_v f(t)\,g''(z) \tag{3}$$

Rearranging,

$$\frac{f'(t)}{f(t)} = C_v \frac{g''(z)}{g(z)} = -c \ (= \text{const}) \tag{4}$$

Therefore,

$$f'(t) = -cf(t) \tag{5}$$

$$g''(z) + \frac{c}{C_v} g(z) = 0 \tag{6}$$

Solving these,

$$f(t) = a_1 \exp(-ct) \tag{7}$$

$$g(z) = b_1 \sin\left(\sqrt{\frac{c}{C_v}} z\right) + b_2 \cos\left(\sqrt{\frac{c}{C_v}} z\right) \tag{8}$$

(a) From the upper boundary condition for the clay layer $(z = 0)$, find the coefficient b_2 of equation (8).

(b) From the lower boundary condition for the clay layer $(z = \mathrm{H})$, find the parameter c of equation (8). [Hint: describe your solution using H, C_v, and integers $m = 1, 2, \ldots$]

(3) Take the initial value for the excess pore water pressure in the consolidation process as $u = u_0$. For the same boundary conditions described in (1), find the solution to the consolidation equation.

(4) Explain time factor, T_v.

【2】Answer the following questions:

(1) In regard with Mohr-Coulomb failure criterion, derive Mohr-Coulomb failure criteria which consists of principal stresses using Mohr's stress circle.

(2) A specimen of saturated, normally consolidated clay, was subject to a process of isotropic consolidation up to 100 kPa. After this, keeping lateral stress, σ_3, constant, shearing was performed under undrained conditions. As a result, the clay specimen failed when the total vertical stress reached 160 kPa. Pore water pressure measured at failure was 70 kPa.

(a) Draw Mohr's stress circles at failure in terms of total stress and effective stress.

(b) Obtain deviator stress $q = \sigma_1 - \sigma_3$ and mean effective stress $\left[p' = \left(\sigma_1' + 2\sigma_3'\right)/3\right]$ at failure.

(c) Satisfying Mohr-Coulomb failure criterion and ignoring the value of effective cohesion $(c' = 0)$, find the value of effective internal frictional angle, ϕ'.

(d) Obtain the failure angle that the failure plane makes with the major principal plane.

(e) Draw total stress path and expected effective stress path in $p - q$ and $p' - q$ space.

(f) Drained and undrained shearing tests are conducted to examine the strength of soil ground. Describe the purpose of these tests taking an example of embankment construction works.

(3) Choose a suitable word or phrase to fill up the blanks (1) to (6) in the context given below from the list of words (a) to (f) without any repetition.

When loose sand or normally consolidated clay are sheared under constant confining effective stress, its volume __(1)__ and if shearing is done under constant volume, its effective confining stress __(2)__ . This behavior is known as __(3)__. On the other hand, if dense sand or over-consolidated clay is sheared under constant effective confining stress, its volume __(4)__, and if shearing is done under constant volume, its effective confining pressure __(5)__. This behavior is known as __(6)__.

(a) increases, (b) decreases, (c) swells, (d) shrinks, (e) positive dilatancy, (f) negative dilatancy

(4) Drained triaxial tests were conducted for a given dry sand by considering two types of initial density; loose and dense. Show the relationship between volume change and axial strain for these loose sand and dense sand by drawing a figure.

【3】Answer the following questions:

(1) Explain the basic assumptions made in Rankine's earth pressure theory and Coulomb's earth pressure theory.

(2) Soil ground and frictionless retaining wall (AB) are shown in Fig. 1.

(a) Draw stress conditions at point P following Rankine's active and passive states using Mohr's stress circles and Mohr-Coulomb failure lines. Assume K_A and K_P as coefficients of earth pressure at active and passive states respectively.

(b) If $\phi = 30^{\circ}$, find the values of failure angles with respect to major principal plane for each state. Also, comment on the direction of failure planes in the soil ground.

(3) Consider a frictionless retaining wall. Assume its surface toward backfill side as vertical and soil ground as horizontal. If retaining wall moves towards backfill, answer the following based on Coulomb's earth pressure theory.

(a) Show forces acting on failure wedge.
(b) Draw force polygon for this condition.
(c) Write down the steps to find the resultant earth pressure per unit length of the wall.

(4) A frictionless retaining wall is shown in Fig. 2 where ground water table lies at 1.5 m depth from the ground surface. If retaining wall moves away from the soil ground, answer the following based on Rankine's earth pressure theory. Take the unit weight of water γ_w=9.8 kN/m^3.

(a) Show pressure diagrams of lateral earth pressure for this condition.

(b) Determine resultant earth pressure per unit length of the retaining wall.

(c) Also, determine the location of resultant earth pressure obtained in (b).

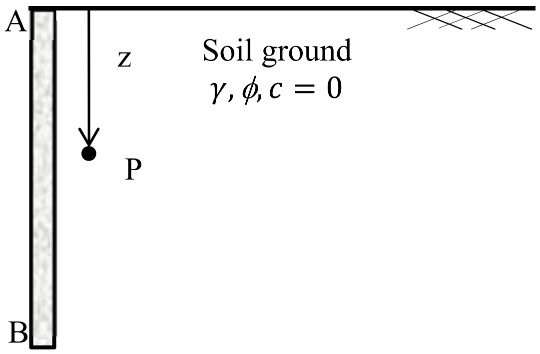

Fig. 1

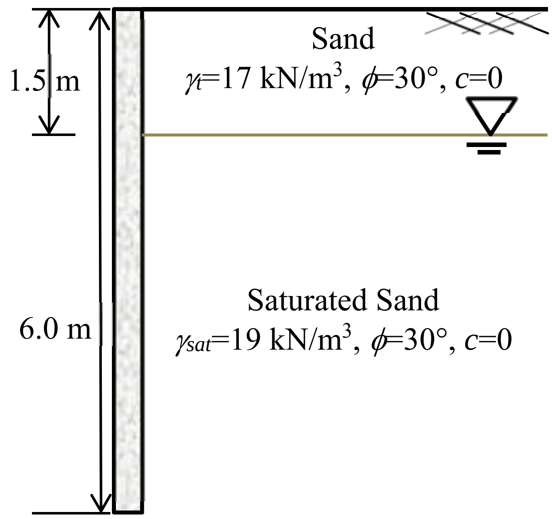

Fig. 2