2021 Soil Mechanics I and Exercises Midterm Exam

2021/11/30 (Tue.) Test time 13:15-14:15, Submission due by 14:30 on PandA

Attention:

- The exam consists of two questions. Separate answer sheet for each major question. Write your name and the question number **on ALL pages**. You may answer a major question over multiple answer sheets, but do not answer multiple major questions on the same answer sheet.
- If possible, combine all answer sheets in sequence and submit as a single file. When submitting multiple files for multiple answer sheets, please order them and set the file names in a way that the question number as well as the page number of answer sheet is understandable.
- Wherever necessary, specify the units in your answers.
- Stop writing the answer at 14:15 and submit the answer sheet via PandA by 14:30. Only when you cannot submit via PandA due to network troubles, etc., submission by email to takai.atsushi.2s@kyoto-u.ac.jp can be accepted.
- Your submission will not be accepted after the deadline for any reason. Give yourself ample time to get through PandA for submitting the answer sheets.
- During the examination, you may consult the lecture materials and reference sources, but consultation with others is strictly prohibited.
- Answer sharing and copying is academic dishonest. Close similarity in answers will result in failed credit of the course and serious penalties.

[Question 1]

1) Answer the following questions. Graphics may be used if necessary.

   (1) Explain the reason briefly why soils with higher clay content generally have larger plastic index in spite of having the same mineral compositions.

   (2) In general, while clay deposit has comparatively higher void ratio than sand deposit, clay deposit exhibits smaller coefficient of permeability. Explain the reason of this phenomena briefly.

   (3) Explain the definitions of void ratio and porosity briefly, and formulate the relationship between those two parameters.

2) Answer the following questions regarding the ground profile shown in Figure 1. Assume the density of water ρ_w = 1.00 Mg/m^3 (= 1.00 g/cm^3) and the gravitational acceleration g = 9.80 m/s^2.

   (1) Determine the degree of saturation above the groundwater level. Note that the void ratios above and below the groundwater level are the same.

   (2) The maximum and the minimum dry densities of the sand layer are 1.68 Mg/m^3 and 1.34 Mg/m^3, respectively. Determine the relative density of the sand layer. Maximum and minimum dry densities correspond to dry density with minimum and maximum void ratios, respectively.

(3) The embankment was constructed to achieve a water content of 15.0% and a dry density of 1.60 Mg/m^3, using soil having a water content of 10.0% at an excavation site. Calculate the mass of soil collected at the excavation site necessary for a a unit site area (1.00 m^2) of the embankment.

(4) Determine the total stress, the pore water pressure and the effective stress at the bottom of the sand layer.

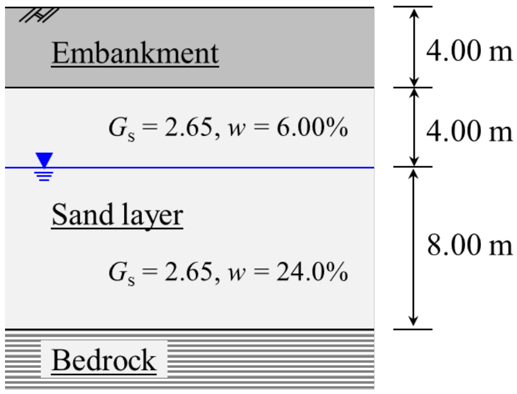

Figure 1

[Question 2]

Consider the steady-state flow through an isotropic and homogeneous permeable layer on a horizontal impermeable layer. Herein, h_1 and h_2 represent the total heads of two known points and k is the permeability coefficient of the permeable layer. Assume that the Darcy's law can be applied and the hydraulic gradient i in the horizontal direction is equal to the slope of the piezometric surface and is an invariant with depth z, complete the following questions.

1) When the two-dimensional seepage (uniform in the width direction) of Fig. 2 is considered as the plane of horizontal flow whose constant boundary conditions are $x = x_1$, $h = h_1$ and $x = x_2$, $h = h_2$, answer the questions below.

(1) Express the discharge velocity u in the x direction in terms of differential form of the piezometric head h.

(2) In regard to (1), express the flow rate q per unit width of the plane through any vertical section.

(3) As q is constant along any distance x between x_1 and x_2, express k from (2), after integration and substitution of the boundary conditions.

(4) Determine the piezometric head h at a distance x in terms of x, x_1, x_2, h_1, and h_2.

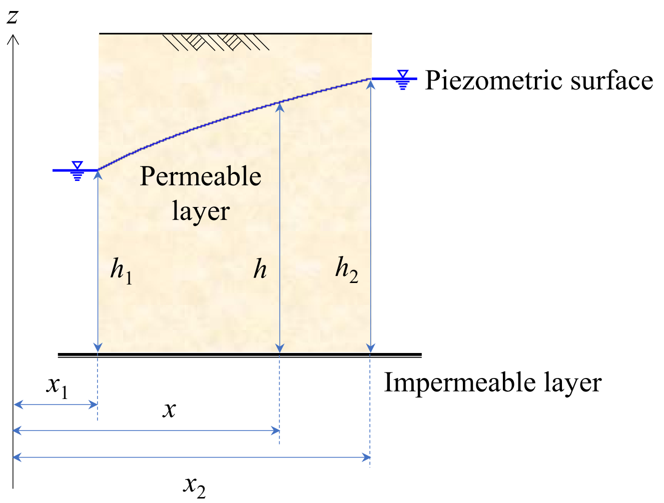

Figure 2

2) When the radial seepage at any radius r from the center of a pumping well is considered as the plane of axisymmetric flow whose constant boundary conditions are $r = r_1$, $h = h_1$ and $r = r_2$, $h = h_2$, answer the questions below. Note that r_w is a radius of the pumping well and h_w is a water level in the pumping well.

(1) Express the volume flow rate q in an unconfined permeable layer through any vertical section of Fig. 3, in terms of difference form of the piezometric head h, using parameters given in the figure.

(2) As q is constant along any radius r ($\geq r_w$), express k from (1), after integration and substitution of the boundary conditions.

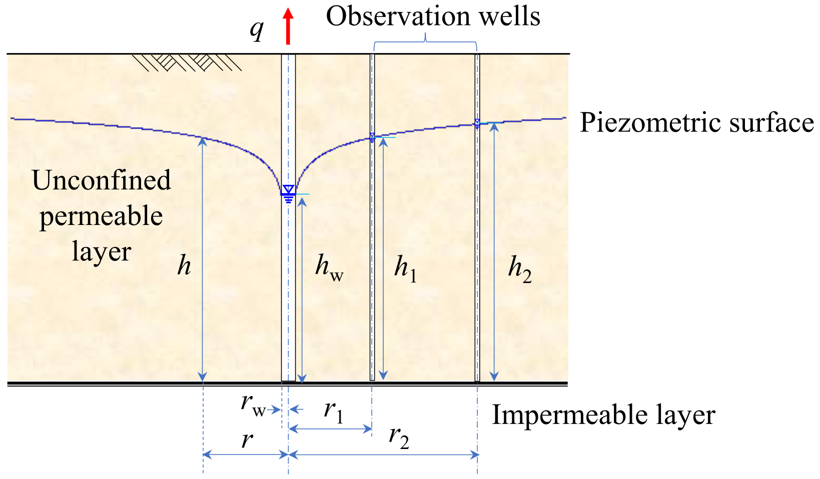

Figure 3

(3) If the permeable layer with a thickness of H is confined by upper and lower impermeable layers, express the volume flow rate q in a confined permeable layer through any vertical section of Fig. 4.

(4) As q is constant along any radius r ($\geq r_w$), express k from (3), after integration and substitution of the boundary conditions.

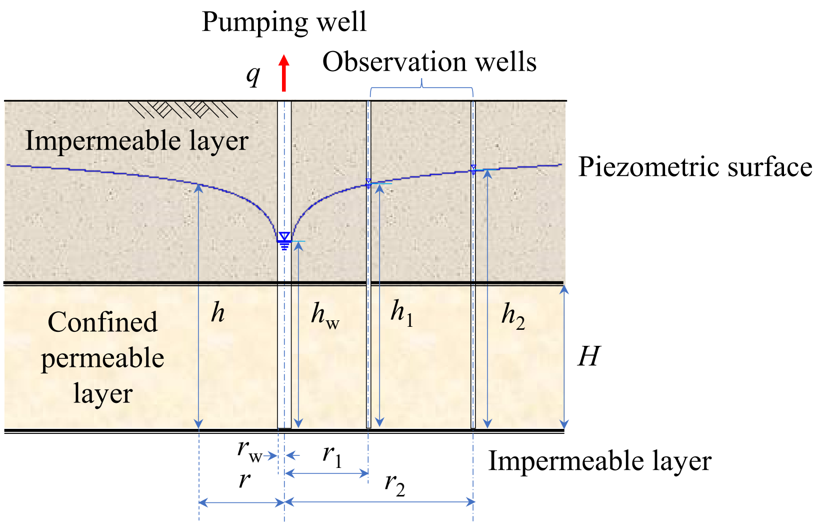

Figure 4

(5) A pumping well with a radius r_w of 0.100 m was installed in an unconfined permeable layer as shown in Fig. 3. The water levels measured from two observation wells were h_1 = 105 m at r_1 = 10.0 m and h_2 = 125 m at r_2 = 100 m. Once the pumping well reached a steady state, calculate the water level h_w in the pumping well.

(6) When the pumping test was conducted under the same conditions as (5) in a permeable layer with a thickness H = 40.0 m, confined between two impermeable layers as shown in Fig. 4, the same water level as (5) was obtained for each observation well. Calculate the water level h_w in the pumping well.