2020 Soil Mechanics I and Exercises Final Exam

2021/1/26 (Tue.) Test time 13:00-15:00, Submission time via PandA 15:15

Attention:

- The exam consists of four 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.
- Stop writing the answer at 15:00 and submit the answer sheet via PandA by 15:15.
- If possible, combine all answer sheets in sequence and submit in a single file. When submitting multiple files for multiple answer sheets, 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.
- Your submission will not be accepted after the deadline regardless of any reason. Give yourself ample time to get through Panda for submitting the answer sheet.
- During the examination, you may consult the lecture materials and reference sources, but carefully manage your exam time.
- Answer sharing and copying is academic dishonest. If the similarities in answers are observed among examinees, an extra oral examination may be conducted later for individual investigation.
- Wherever necessary, specify the units in your answers.
- Use of calculators and rulers are permitted.

[Question 1]

(1) Derive the following equation using Figure 1 where e is the void ratio, S_r is the degree of saturation, w is the water content and G_s is the specific gravity of soil particle. Draw Figure 1 on the answer sheet, then explain the derivation. Answer only the formula will not be graded.

$$eS_r = wG_s$$

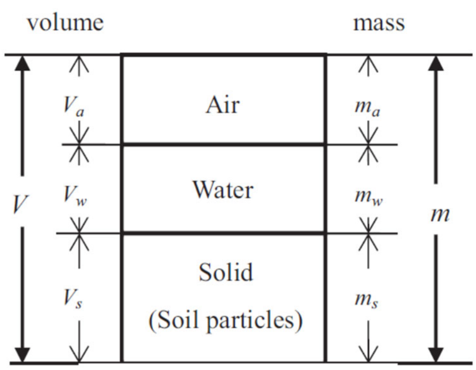


Figure 1

(2) Answer the following questions regarding the sandy ground in Figure 2. The depth z of ground water table is z_1. The bulk unit weight above the ground water table is γ_t. The saturated unit weight below the ground water table is γ_{sat}. The unit weight of water is γ_w.

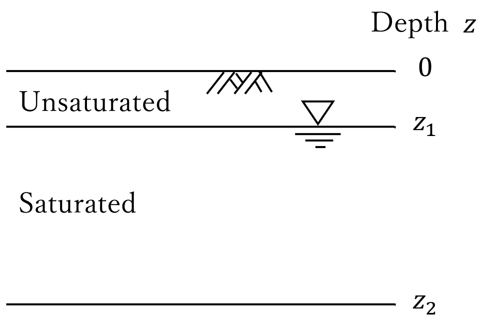


Figure 2

(a) Draw the distributions of vertical total stress, pore water pressure and vertical effective stress along the depth. Set 0～z_2 as the vertical axis. Show the algebraic expressions at the depth of 0, z_1, z_2, using the given symbols.

(b) The soil above the ground water table is unsaturated. Generally, suction (negative pore water pressure) exists under unsaturated conditions. Explain the reason.

(c) Generally, suction is not considered in (a). Explain the possible reasons.

(3) Regarding the well graded soil (with small coefficient of uniformity) and the poorly graded soil (with large coefficient of uniformity), draw the schematic particle size distribution curves and the schematic compaction curves, respectively. Show labels of both vertical and horizontal axes in the schematic drawings.

[Question 2]

2-1. Answer the following questions regarding the water flow in saturated soils. Assume that the water flow is governed by Darcy's law and the steady state condition is established for all cases below.

(1) Constant head permeability test was conducted on two soils filled in a column as shown in Figure 3. The hydraulic conductivity values of Soil 1 and Soil 2 are 4.0×10^{-4} m/s and 1.0×10^{-4} m/s, respectively. Determine the elevation heads, pressure heads and total heads at Point A and C. Assume that the bottom level of the system is the datum as indicated in the figure.

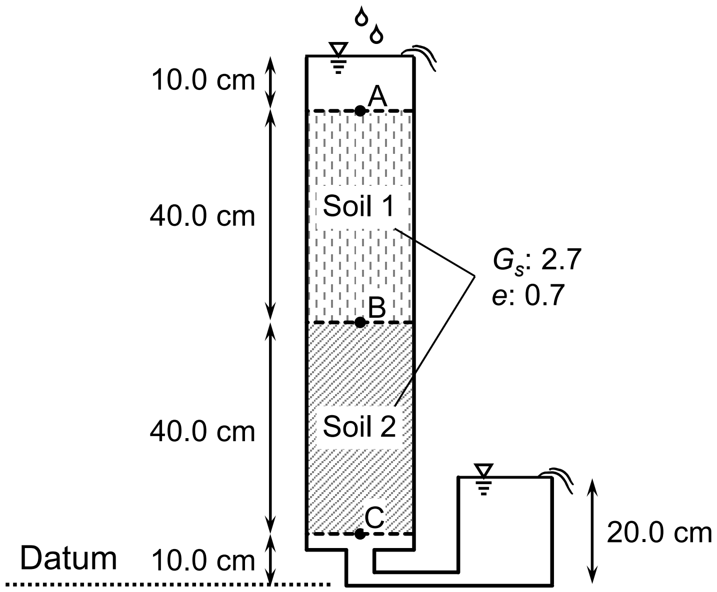


Figure 3

(2) Let i_1 and i_2 be the hydraulic gradients "between A and B" and "between B and C", respectively. Describe the relationship between i_1 and i_2.

(3) Determine the flow velocity in the soils.

(4) Draw the variations of elevation head, pressure head and total head from the datum to the elevation of 100 cm (the top of the column). Then, determine the effective stress at Point B, assuming that the unit weight of water γ_w is 9.8 kN/m^3.

2-2. Compare the magnitudes between the equivalent hydraulic conductivity in the vertical direction, k_V, and that in the horizontal direction, k_H, of the stratified ground and judge which one is larger. Write about 3 lines on the reasons why such relationship is observed.

[Question 3]

Embankment construction on the ground as shown in Figure 4 will be carried out in a very short period of time; therefore, the instant embankment load of 100 kN/m^2 is considered. Assuming that the embankment width is wide enough and consolidation of the ground below be one-dimensional, answer the following questions. Note that the excess pore water pressure is not generated in each sandy gravel layer and pore water drains immediately. The ground water level lies on the ground surface, and the unit weight of water is 9.8 kN/m^3. The material constants for soils are listed in Figure 4.

(1) Draw the distribution (schematic figure) of the pore water pressure (total pressure of static pressure and the excess pore water pressure) over the depth in the ground ($1 \leq z \leq 14$ m) for each of ① immediately after embankment loading, ② during consolidation, and ③ after sufficient time has passed.

(2) Find the total stress, effective stress, and pore water pressure at point A (z =12 m) shown in Figure 4 for each of ① immediately after embankment loading, and ③ after sufficient time has passed.

(3) Find the minimum time it takes for all clay layers to reach an average degree of consolidation of 90 % or higher. The time factor corresponding to an average degree of consolidation of 90 % is T_v= 0.848.

(4) Find the final settlement of the whole ground. It is assumed that the amount of compression of the sandy gravel layers is negligible.

(5) Show Terzaghi's one-dimensional consolidation equation (no need for derivation). Also, explain how this consolidation equation was associated (how it was used) with (1) and (3) above.

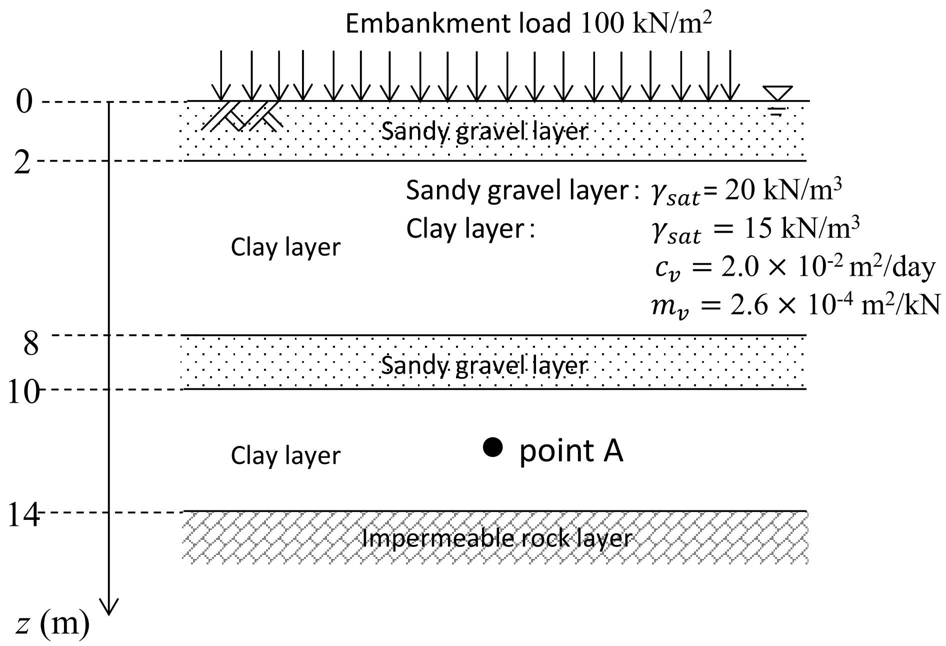
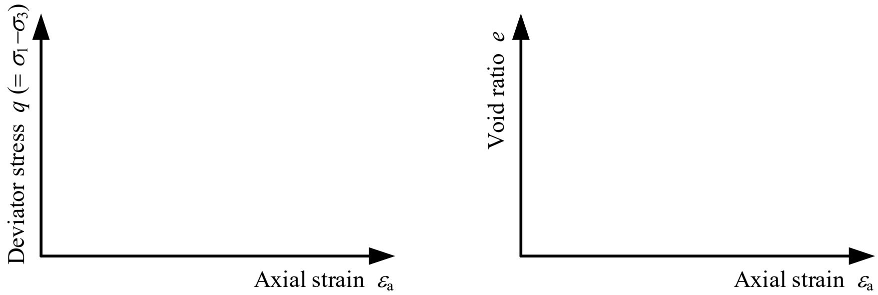


Figure 4

[Question 4]

(1) Answer the following questions regarding shear tests on sand and clay.

1) Explain the shearing behaviors of dense sand and loose sand during triaxial compression test by drawing the expected experimental results in the graphs shown in Figure 5 to reflect the term "dilatancy". Here, draw the experimental results of the dense sand and the loose sand on the same graphs.



Axial strain - Deviator stress relationship   Axial strain - Void ratio relationship

Figure 5

2) Unconfined compression tests are performed for specimen on natural clay. Explain with a figure the typical experimental results for the non-disturbed clay and the disturbed clay. In addition, explain the sensitivity ratio obtained through the tests.

(2) Answer the following questions regarding the slope stability.

As shown in Figure 6, consider a soil element in a slope. The slope consists of a dry sand, and the ground water table is far below.

1) Let $\sigma_x = 90$ kN/m^2, $\sigma_y = 150$ kN/m^2, $\tau_{xy} = \tau_{yx} = 30$ kN/m^2. Using Mohr's stress circle, show the principal stresses and the angle of the major principal stress plane α measured from the horizontal direction.

2) A consolidated undrained triaxial compression test was conducted on the soil specimen sampled from the site. Under the lateral pressure of $\sigma_3 = 280$ kN/m^2, the axial stress of $\sigma_1 = 680$ kN/m^2 and the pore water pressure of $u = 80$ kN/m^2 were measured at failure. Assuming $c' = 0$, obtain the value of ϕ'.

3) Due to the rainfall, the ground water table rose and the soil element was fully saturated. Answer how much the pore water pressure u will cause the failure of the soil element at that point. Here, the total stress remains unchanged due to the rise of ground water.

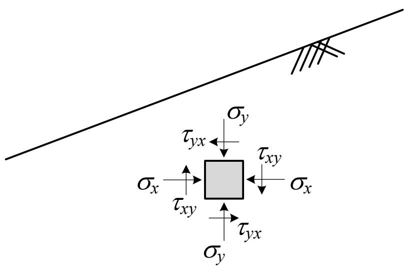


Figure 6