2020　Soil Mechanics I and Exercises　Mid Exam

2020/12/1 (Tue.)　Test time 13:00-14:00, Submission time via PandA 14:15

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.
- Stop writing the answer at 14:00 and submit the answer sheet via PandA by 14:15.
- 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.
- If possible, combine all answer sheets in sequence and submit in 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.
- 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.

[Question 1]

1) Fill in the blanks in the following sentences with appropriate words for [①] to [⑧].

Soil compaction is a process by which the soil density is increased by mixing and compacting of soil and water for the purposes of [①], [②], [③]. Even if the same soil sample is compacted with the same energy, the dry density after compaction varies with the water content. The relationship between the water content and the dry density is referred to as “compaction curve”. The water content and the dry density obtained at the peak position of the curve are called [④] and [⑤], respectively. In general, the compacted soil exhibits maximum [⑥] at water content less than [④] and minimum [⑦] at a water content greater than [④]. [⑧] is an indicator for density control in embankment construction, which is defined as the ratio of dry density of compacted soil to [⑤].

2) (2-1) Specify the range of particle size classified as “fine fraction”.

(2-2) Void ratio of the clay is generally larger than that of the sand. Concisely describe the particle shape and the particulate structure of the clay, which are considered as possible causes of the large void ratio of clay.

(2-3) List two indices regarding the consistency limits and give a definition for each of which. Symbols used in the definition formula should be explained (e.g., water content: $w = m_w/m_s$, m_w: mass of water, m_s: mass of soil particles).

3) An embankment with a volume of 20,000 m^3 is planned to be constructed. A soil sample of a volume of 1,000 cm^3 was taken at the excavation site, and its total mass was 1.60 kg. The soil was compacted to construct the embankment with a dry density ρ_d = 1.71 g/cm^3. After the construction, the total density of the embankment was ρ_t = 2.00 g/cm^3. Given the specific gravity of soil G_s = 2.70, the density of water ρ_w = 1.00 g/cm^3, and the gravitational acceleration g = 9.81 m/s^2, answer the following questions with three significant digits.

(3-1) Find the total weight and the water content of the embankment.

(3-2) Find the total density and the dry density of the soil at the excavation site.

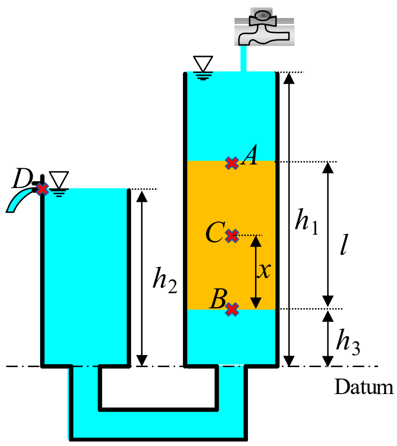
(3-3) Find the volume and the weight of the soil to be taken from the excavation site.

(3-4) Find the void ratio and the degree of saturation of the soil at the excavation site.

(3-5) Find the void ratio and the degree of saturation of the soil at the embankment.

[Question 2]

(1) The equipment for hydraulic conductivity test under constant head condition consists of two tanks and the connection pipe as shown in the figure. The water flows vertically down through the cylindrical specimen whose length and diameter are l and d, respectively. Answer the following questions assuming that a steady state condition is established in this relatively slow one-dimensional flow for which Darcy's law can be applied. Moreover, energy loss due to friction and deformation in the tanks and the connection pipe can be ignored. When necessary, report numeric answers with three significant digits.



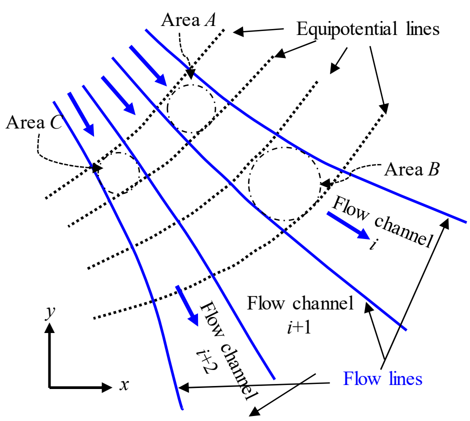
(1-1) Describe the potential head, z_A, and the pressure head, p_A at point A.

(1-2) Describe the potential head, z_B, and the pressure head, p_B at point B.

(1-3) Describe the potential head, z_C, and the pressure head, p_C at point C.

(1-4) Discharge at point D per one hundred seconds is 5.10×10^1 cm^3 when the diameter and the length of the sample are 5 cm and 10 cm, respectively, and the amounts of h_1, h_2 and h_3 are 23, 18, 3 cm for each length. Find the hydraulic conductivity, k.

(1-5) Given the gravitational acceleration g = 9.81 m/s^2, find the velocity head in regard to (1-4) and show that the pressure head can be taken to the total head.



(2) The flow net as shown in the figure is described for an isotropic ground with the hydraulic conductivity of k under the difference of head, H, in two-dimensional steady state condition. Answer the following questions.

(2-1) The number of flow channels is N_f and the number of equipotential drops, which is separated by the potential curves, is N_d. Describe the total discharge per unit second, Q.

(2-2) In the flow net drawn for an isotropic ground, each element surrounded by the flow lines and the potential lines should be a square. Explain the advantage of using curvilinear squares in the flow net.

(2-3) Let u, v and $h(x, y)$ be the flow velocity in the x and y directions and the total head at any point. Applying the velocity potential function (or the total head), $\phi\,(= -k \cdot h(x, y))$, and Darcy's law, express u and v and derive the governing equation which is known as Laplace's equation for two-dimensional flow.