2022 Soil Mechanics I and Exercises Midterm Exam

2022/11/29 (Tue.) 13:15-14:15 Research Bldg. No.9 W2

Attention:

- The exam consists of two questions for which you are provided with two 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 page of an answer sheet is insufficient to complete your answer, use the back page of the same answer sheet after clearly indicating your intent.
- Scores for each question are equally weighted.
- In addition to personal writing instruments, non-programmable calculators are permitted. However, programmable calculators and calculator functions of mobile phones are prohibited. Any attempt 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] Using the specific gravity of soil particle $G_s = 2.69$ and the water density $\rho_w = 1.00$ g/cm^3, answer to the following questions. Graphics may be used if necessary.

(1) Particle size distribution curve of the soil is reported in Figure 1. Describe the test apparatuses and the methods used to obtain particle size distribution of soils.

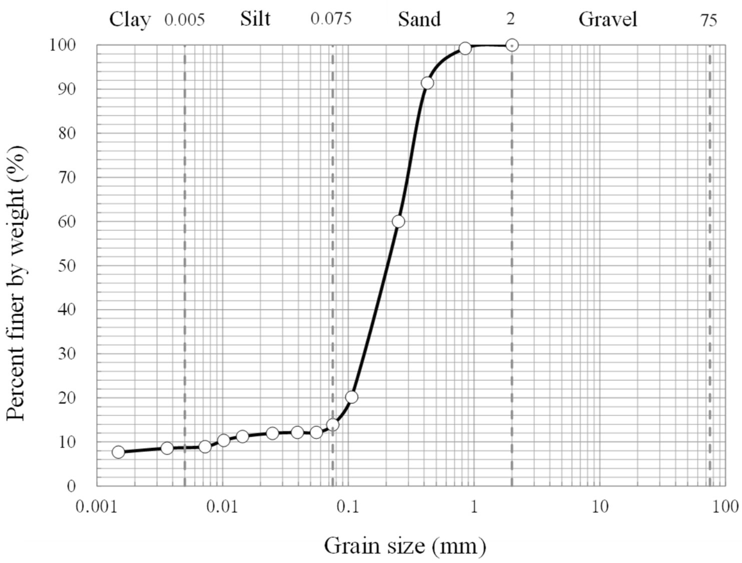


Figure 1 Particle size distribution curve (Edosaki sand)

(2) According to Fig. 1, find the average particle size D_{50} and the uniformity coefficient U_c.

(3) A soil compaction test was conducted for the soil and results are shown below. Draw the compaction curve for this soil.

Water content w (%)	10.2	12.6	14.3	15.4	17.0	19.8	21.5
Total density ρ_t (g/cm^3)	1.74	1.80	1.84	1.90	1.89	1.87	1.84

(4) From the definition of the zero-air void curve, express the relationship among the specific gravity of soil particle G_s, the dry density of soil ρ_d, the water density ρ_w, and the water content w. Also, add the zero-air void line along with the compaction curve obtained in (3).

(5) Determine the optimum water content and the maximum dry density of the soil from the compaction curve obtained in (3).

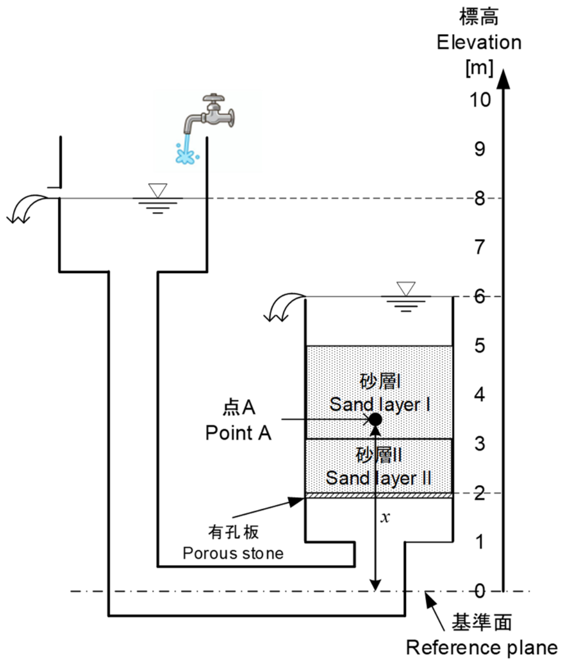
(6) The volumetric water content θ is defined as the ratio of the volume of water to the total volume (V_w/V). In regard to (5), find θ of this soil under the optimum water content.

(7) This soil is compacted with water content w = 10.0% to achieve the degree of compaction of 90.0%. Calculate the total density ρ_t and the degree of saturation S_r after compaction.

[Question 2]

The constant head permeability test on a sand column has been carried out as shown in the right figure. The cross-sectional area of the sand column is 1.00×10 [cm^2] and Point A is located at a distance of x [m] from the reference plane. Answer the following questions regarding the water flow in the sand column. Assume the sand column is saturated and the water flow is governed by the Darcy's law with steady state condition established for all cases below. Head loss due to friction and shape of pipes can be ignored. The reference plane is shown in the figure. The unit weight of water is 9.81 [kN/m^3] and the gravitational acceleration is 9.81 [m/s^2].

First, assume that both sand layers are composed of the same sand (specific gravity, G_s, is 2.60, void ratio, e, is 0.70 and hydraulic conductivity (coefficient of permeability), k_I is 1.0×10^{-5} [m/s]).



(1) Draw a distribution diagram of the elevation head, pressure head and piezometric head (total head) in the sand layer. For each hydraulic head, mark its value at the top and bottom of the sand column in the diagram.

(2) Show the pressure head ($2 \le x \le 5$), u, in the sand layer as a function of x.

(3) Determine the elevation head, pressure head, and piezometric head at the point A where x = 4.

(4) Determine the hydraulic gradient and flow rate per unit time.

(5) The total stress, σ, in the sand layer is $\sigma = -\gamma_t x + 5\gamma_t + \gamma_w$ ($2 \le x \le 5$). Determine the unit weight of the saturated sand, γ_t, and find the vertical effective stress, σ', at the bottom of the sand layer (x = 2).

(6) The drainage port of the upstream tank located 8 m above the reference plane is closed and the water level is gradually raised. Determine the water level (measured from the reference plane) when the sand layer becomes quicksand.

Next, the drainage port of the upstream tank is re-opened and fixed at 8 m from the reference plane. Assume the sandy column is composed of two sand layers as shown in the figure. The sand in layer I has specific gravity, G_s, of 2.60, void ratio, e, of 0.70 and hydraulic conductivity (coefficient of permeability), k_I, of 1.0×10^{-5} [m/s]. The sand in layer II has specific gravity, G_s, of 2.60, void ratio, e, of 0.80 and hydraulic conductivity (coefficient of permeability), k_{II}, of 2.0×10^{-5} [m/s].

(7) Show the piezometric head, h, of sand layer I ($3 \leq x \leq 5$) as a function of x.

(8) Show the pressure head, u, of sand layer II ($2 \leq x \leq 3$) as a function of x.