# Soil Mechanics I and Exercises [Midterm Exam]

November 26, 2024 (Tue.) 13:15–14:15 @W2 Lecture Room

Notes:

- The examination consists of two questions for which you are provided with two answer sheets.
- Write down your name and student ID number on every 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, continue your answer on the back side of the same sheet of paper, and be careful not to spread the answer to a single question across multiple sheets of paper.
- In addition to personal writing instruments, use of non-programmable calculators and rulers are permitted. However, programmable calculators and calculator functions of mobile phones are prohibited.
- Wherever necessary, specify the units in your answers.
- Any attempt at cheating on the exam will result in failed credit of the course and serious penalties.

[Question 1]

(1) The ground consists of a sand layer 2.0 [m] thick and a fine-grained soil layer 6.0 [m] thick, as shown in Fig. 1. The groundwater table is located 2.0 [m] below the ground surface; it can be regarded that the sand layer shallower than the groundwater table is unsaturated, and the fine-grained soil layer deeper than the groundwater table is saturated. Geotechnical investigations were conducted on the sand and fine-grained soil layers, respectively, and the results are shown in Table 1. Note that the density of water $\rho_w$ is $1.0\times10^3$ [kg/m$^3$] and the magnitude of gravitational acceleration g is 9.8 [m/s$^2$].

Table 2

| | Specific gravity $G_s$ | Water content $w$ | Saturation $S_r$ | Conditions |
|---|---|---|---|---|
| Sand layer | 2.7 | 10 % | 30 % | Unsaturated |
| Fine grained layer | 2.6 | 50 % | 100 % | Saturated |

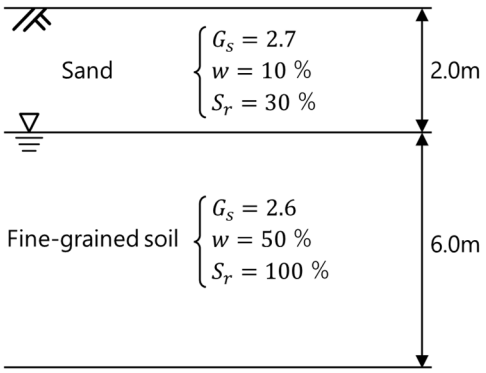


Fig.1 Target ground

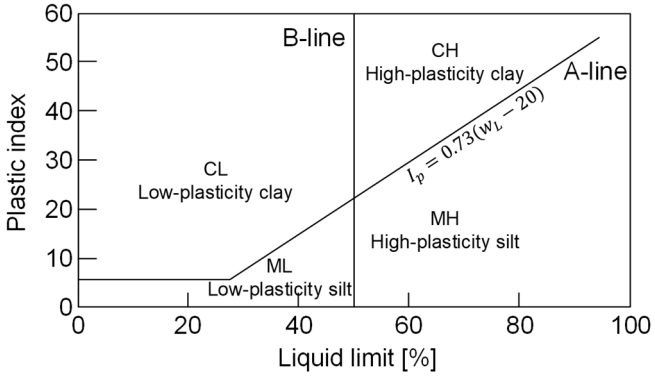


Fig.2 Plasticity chart

(1-1) Briefly explain “liquid limit” in about 30 words.

(1-2) The consistency limits of a sample taken from the fine-grained soil were determined to be 60% for the liquid limit, and 20% for the plastic limit. Find the plasticity index $I_p$ of the fine-grained soil sample.

(1-3) Answer the most appropriate engineering classification for the fine-grained soil sample using the plasticity chart as shown in Figure 2,

(1-4) Find the void ratio both of the sand and fine-grained soil layers.

(1-5) Find the wet unit volume weight of the sand layer $\gamma_t$, and the saturated unit volume weight of the fine-grained soil layer $\gamma_{sat}$, respectively.

(1-6) Find the total stress, pore water pressure, and effective stress in the center of the fine-grained soil layer (5.0 m depth from the ground surface).

(2) Explain the following terms using the keywords in parentheses ( ).

(a) Particle size distribution

(Keywords：particle size test, particle size distribution curve, coefficient of uniformity)

(b) Degree of compaction

(Keywords：compaction curve, maximum dry density, optimum water content)

[Question 2]

Answer the following questions. For (2) to (6), use the physical quantities indicated in the figures and the questions. The water flow in the soil follows Darcy's law. The soil specimen is supported by a mesh and is assumed not to deform. The water is assumed to be incompressible, and the unit weight of water is $\gamma_w$ [kN/m$^3$].

(1) List the factors that affect hydraulic conductivity of soil and briefly explain how each factor affects it.

(2) A constant-head hydraulic conductivity test was conducted as shown in Figure 3. Define the hydraulic gradient $i$.

(3) Water flowed out from the right-side container at a flow rate of $q$ [m$^3$/s]. Define the hydraulic conductivity $k$ of this soil specimen.

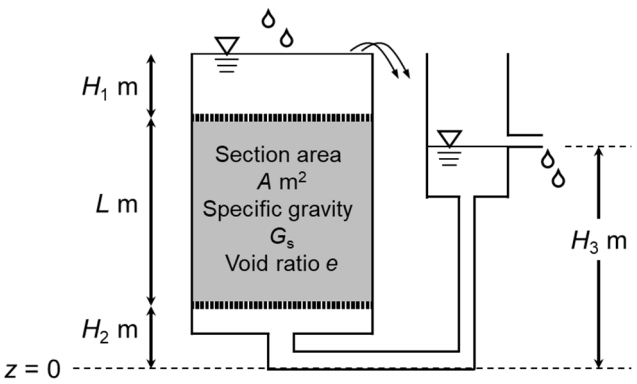


Figure 3

(4) Draw the vertical distribution of the elevation head, pressure head, and piezoelectric head (= total head) from the datum to the top surface of water for the left-side container. Indicate the intercepts and any necessary values.

(5) Next, as shown in Figure 4, the right-side container is covered with maintaining the water level, and an air pressure $P_1$ [kPa = kN/m$^2$] is applied. The applied air pressure acts isotropically as an increment in the water pressure in the right-side container. Define the air pressure $P_1$ [kPa] that should be applied not to cause seepage in the soil specimen.

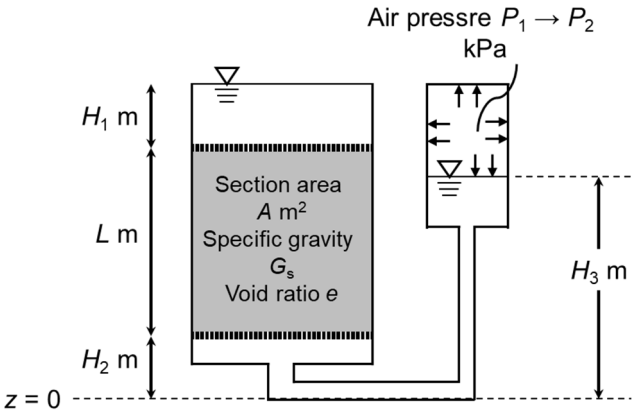


Figure 4

(6) When the air pressure is further increased to $P_2$ [kPa] from (5), show the condition of $P_2$ in order for the specimen to avoid quicksand.