2021 Soil Mechanics II and Exercises Midterm Exam

2021/6/9 (Wed.) Test time 8:45-10:15, Submission by 10:30 on PandA

Attention:

- Stop writing answers at 10:15 at the latest and submit the answer sheets on PandA by 10:30.
- 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.
- 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, 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 consultation with others is strictly prohibited.
- Answer sharing and copying is academic dishonest. If the similarity in answers is observed among examinees, an extra oral examination may be conducted later for individual investigation. Close similarity in answers will result in failed credit of the course and serious penalties.
- Wherever necessary, specify the units in your answers.
- Use of calculators and rulers are permitted.

[Question 1] Answer all the following questions

(1) In Terzaghi's one-dimensional consolidation theory, it is assumed that the soil is fully saturated, and the solid particles and water are incompressible. Show the equation used for the derivation along with the reason why Terzaghi's one-dimensional consolidation equation cannot be derived without these assumptions.

(2) Sand drain method is a soil improvement method for soft ground.

(2-1) Explain the sand drain method by graphics.

(2-2) Explain the principle of the soil improvement by the sand drain method through the mathematical definition of a time factor.

(3) Kögler proposed an extremely simple formula by which the vertical stress in the ground is approximated when a uniformly distributed load is acting on a rectangular foundation. This approximation formula is based on the simple assumption that the distribution of vertical stress on the horizontal plane in the ground is uniformly distributed within a closed region. As shown in Fig. 1, when a rectangular load p [kN/m^2] (width: B, length: L) acts on the ground surface, the following equation can be obtained from the equilibrium condition by applying Kögler's assumption.

$$\Delta\sigma_z = \boxed{\quad (\mathrm{A}) \quad} \times p \qquad \text{Eq. (1)}$$

(3-1) Using symbols shown in Fig. 1, complete Eq. (1) by the equation that should replace the term (A).

(3-2) Based on Kögler's assumption, find the final consolidation settlement induced by the structural load p shown in Fig. 2. Here, it is assumed that the consolidation settlement of the clay layer can be calculated from the change in the effective overburden pressure at the center of the clay layer, and $\alpha = \pi/4$. The unit weight of water is 9.8 kN/m^3, and the consolidation settlement of sandy layers can be ignored.

(4) The vertical stress generated in an elastic ground by a trapezoidal strip load (Fig. 3), such as a levee or a road embankment, is calculated according to the following equation, given by Osterberg.

$$\sigma_v = \frac{p}{\pi}\left[\frac{a+b}{a}(\theta_1+\theta_2) - \frac{b}{a}\theta_2\right] = I_z \cdot p$$

Fig. 4 shows one such case when a triangular strip load acts on an elastic ground. Calculate the vertical stress increment at points A and B. You may use the chart shown in Fig. 5 to find the solution.

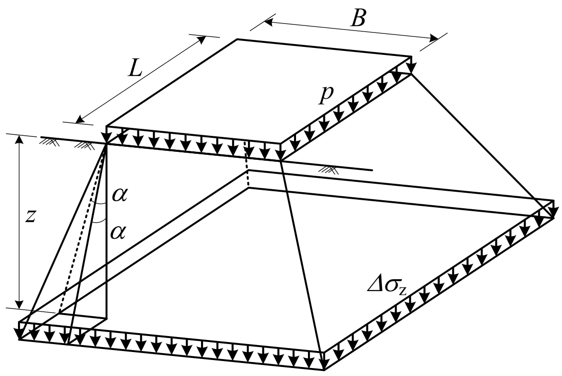


Fig. 1

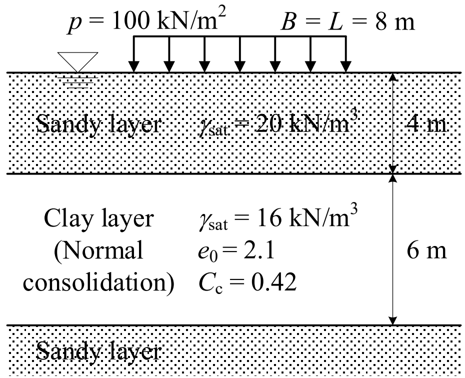


Fig. 2

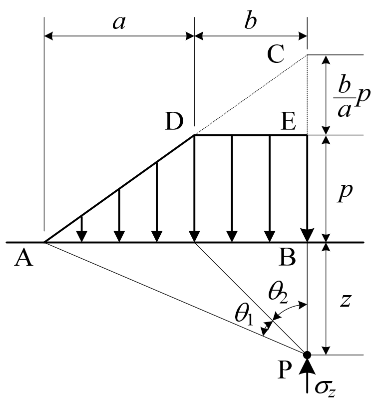


Fig. 3

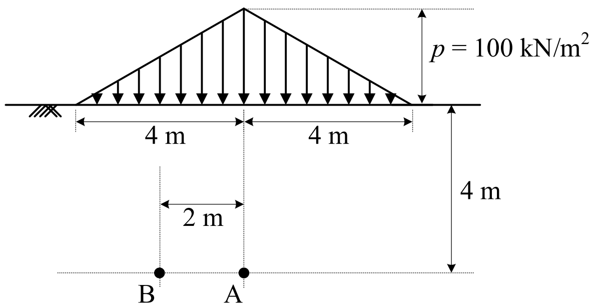
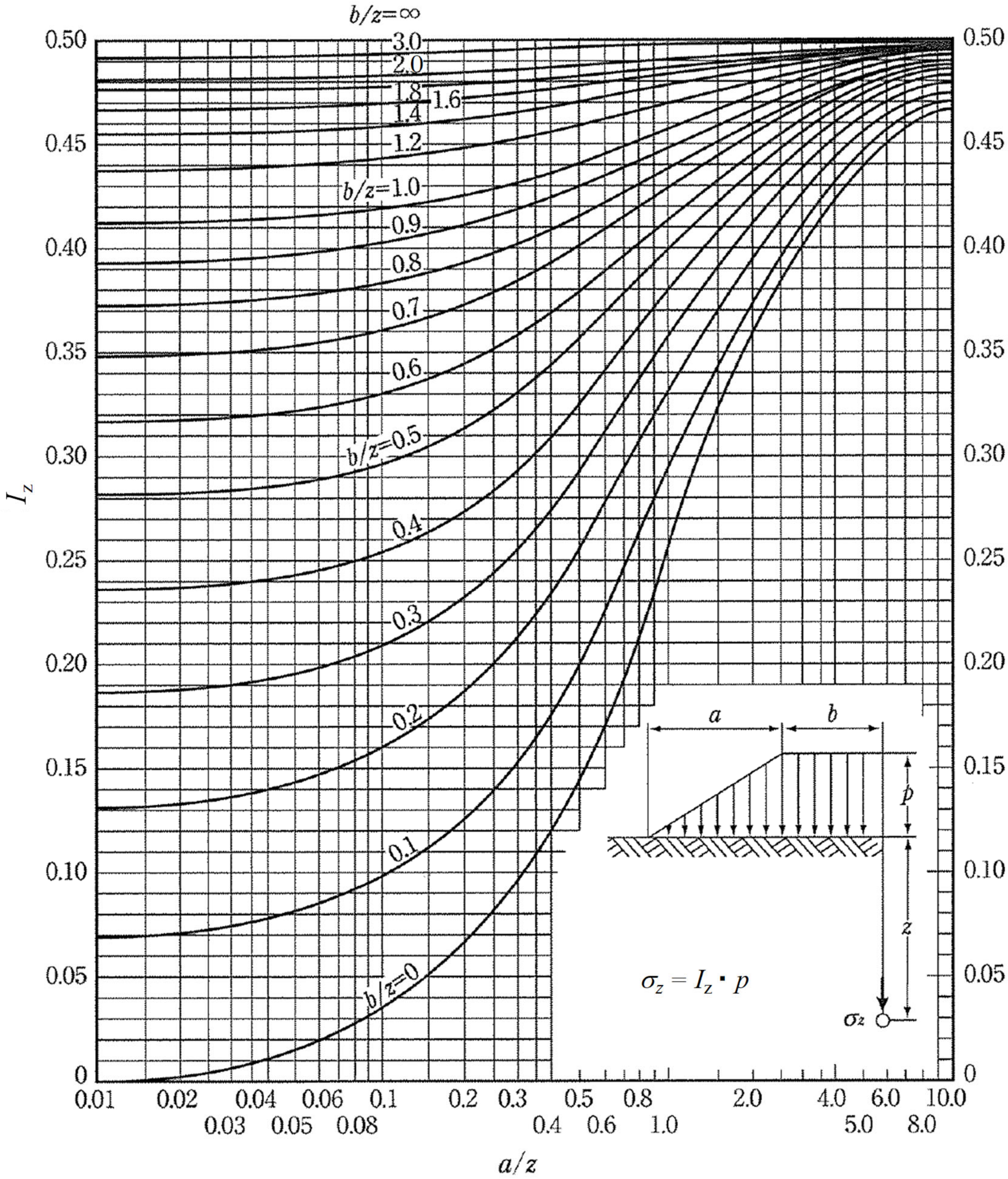


Fig. 4



b/z=∞
3.0
2.0
1.8
1.6
1.4
1.2
b/z=1.0
0.9
0.8
0.7
0.6
b/z=0.5
0.4
0.3
0.2
0.1
b/z=0
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
I_z
0.01 0.02 0.03 0.04 0.05 0.06 0.08 0.1 0.2 0.3 0.4 0.5 0.6 0.8 1.0 2.0 4.0 5.0 6.0 8.0 10.0
a/z
a
b
p
z
σz = Iz・p
σz

Fig. 5

[Question 2] Answer the following questions.

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

Soil dilatancy is defined as the change in volume caused by [①]. In the case of [②] triaxial compression tests, the volume of loose soil tends to [③], while the volume of dense soil tends to [④]. In the case of [⑤] triaxial compression test, the volume change of the specimen is negligible, and instead, [⑥] is generated due to the dilatancy characteristics. The value of [⑥] tends to be [⑦] in loose soils and [⑧] in dense soils.

(2) In triaxial compression tests, the principal stresses are controlled. Describe why the triaxial compression test can evaluate the shear strength of a soil even though the shear stress is zero on the principal planes.

(3) A consolidated undrained triaxial compression test was conducted on a sample of normally consolidated clay after isotropic consolidation with a confining pressure of 200 kN/m^2. At failure, the deviator stress q was 225 kN/m^2 and the excess pore water pressure u was 95 kN/m^2.

(3-1) Determine the mean effective stress at failure p', Skempton's pore pressure coefficient A_f, and the failure stress ratio M_f.

(3-2) Draw the total stress path of this test in the $p - q$ plane and the expected effective stress path in the $p' - q$ plane.

(3-3) Assuming that the cohesion c' is zero, find the internal friction angle ϕ' of this clay.

(4) Using the same sample as in (3), uniaxial compression test was conducted, and the uniaxial compressive strength q_f was 90 kN/m^2.

(4-1) Furthermore, an unconsolidated undrained triaxial compression test is conducted on the same specimen as in (3) with a confining pressure of 100 kN/m^2. Determine the estimated undrained shear strength c_u.

(4-2) Draw Mohr's stress circle at failure for the test (4-1).

(4-3) In general, excess pore water pressure is not measured in the unconsolidated undrained triaxial compression test. However, the excess pore water pressure at failure can be estimated using the Mohr-Coulomb failure criterion. Find the value of pore water pressure at failure estimated for the test (4-1).

【3】 Answer the following questions.

(1) As shown in Fig. 6, a rigid retaining wall with the heigh of H retains a flat backfill. The relationship between the displacement u of the retaining wall and the earth pressure p that acts on that wall can be drawn.

(1-1) Indicate the terminologies for which three representative earth pressures of p_a, p_0 and p_p are defined.

(1-2) In general, $p_a < p_0 < p_p$ as shown in the figure. Explain the reason briefly.

(1-3) The magnitude of displacement when $p = p_a$ is generally less than that when $p = p_p$ as shown in the figure. Explain the reason briefly.

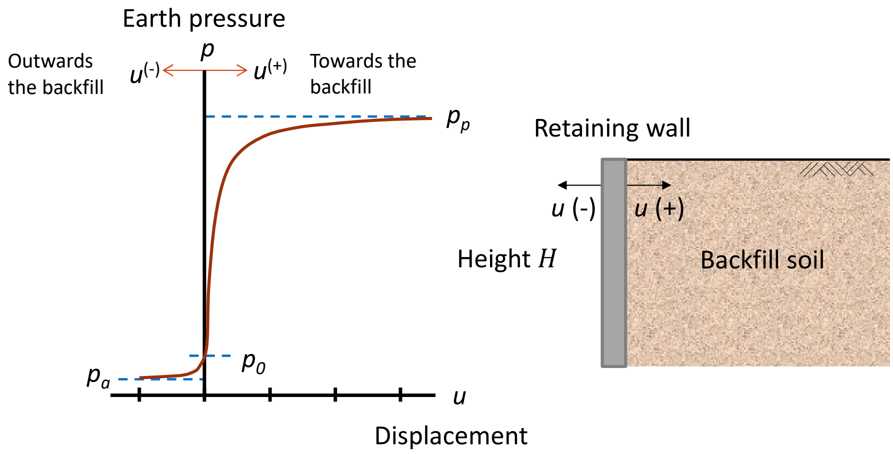


Fig. 6

(2) After installation of rigid sheet pile into a level ground in Fig. 7 (a), the left-side ground is excavated in Fig. 7 (b). Under the condition of (b), either active or passive state in the ground near the sheet pile can be assumed. Here, the unit weight of the ground is γ, the internal friction angle is ϕ', and the cohesion can be neglected.

(2-1) At depth z of point A, schematize Mohr's stress circles upon the conditions of (a) and (b).

(2-2) At depth z of point B, schematize Mohr's stress circles upon the conditions of (a) and (b).

(2-3) Coulomb's earth pressure along the left side of the sheet pile associated with (b) is discussed. Draw the rigid wedge and the forces acting on the wedge.

(2-4) Coulomb's earth pressure along the right side of the sheet pile associated with (b) is discussed. Draw the rigid wedge and the forces acting on the wedge.

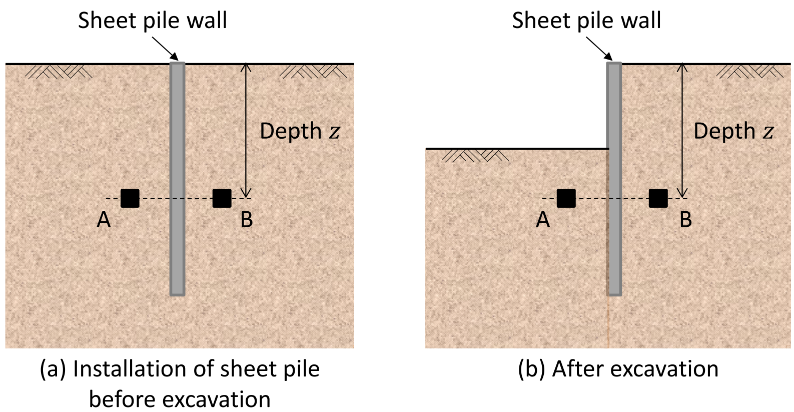


Fig. 7