2015 Soil Mechanics II and Exercises Midterm Exam

2015/6/10 (Wed.) 8:45-10:15 Kyotsu 4 Lecture room

Attention:

- The exam consists of three questions for which you are provided with three 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 attempts 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] Answer the following questions

(1) Write a flow chart showing the derivation of the one-dimensional consolidation equation from the following four assumptions and conditions:

(a) Darcy's law $v = -\frac{k}{\gamma_w}\frac{\partial u}{\partial z}$

(b) Continuity equation for the water (mass conservation law) $\frac{\partial v}{\partial z} = \frac{\partial \varepsilon}{\partial t}$

(c) Effective stress - strain relationship of the soil $d\varepsilon = m_v d\sigma'$

(d) Constant total stress $\frac{\partial \sigma}{\partial t} = \frac{\partial \sigma'}{\partial t} + \frac{\partial u}{\partial t} = 0$

where v is pore water velocity, k is coefficient of permeability, γ_w is unit weight of water, u is excess pore water pressure, ε is volumetric strain, m_v is coefficient of volume compressibility, σ' is effective stress, σ is total stress, t is time and z is the position coordinate.

(2) In the ground condition shown in Figure 1, the groundwater level has dropped from 1 m to 5 m as a result of groundwater pumping over time. Determine the consolidation settlement S of the clay layer induced by the groundwater drawdown. It is assumed that the unit weight of the soil where groundwater level has dropped is γ_{t1}=19.0 kN/m^3, same as that above the initial groundwater level. Also, the unit weight of water is taken as γ_w=9.81 kN/m^3. Stress state at the middle of the layer can be used as the representative stress state of the clay layer.

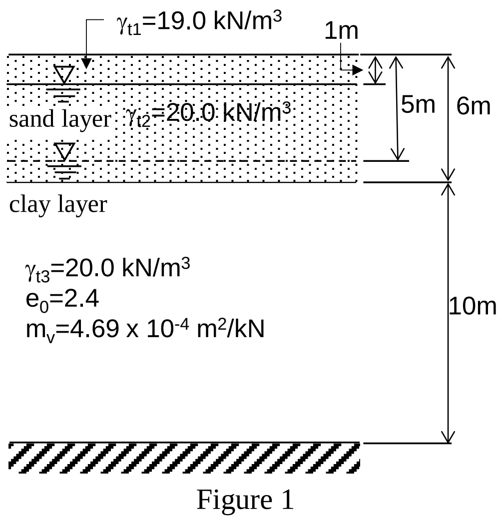

Figure 1

(3) According to clay layers having a thickness of H or 2H as depicted in Figure 2 from ① to ⑨, arrange them in the ascending order of time required to complete one-dimensional consolidation.

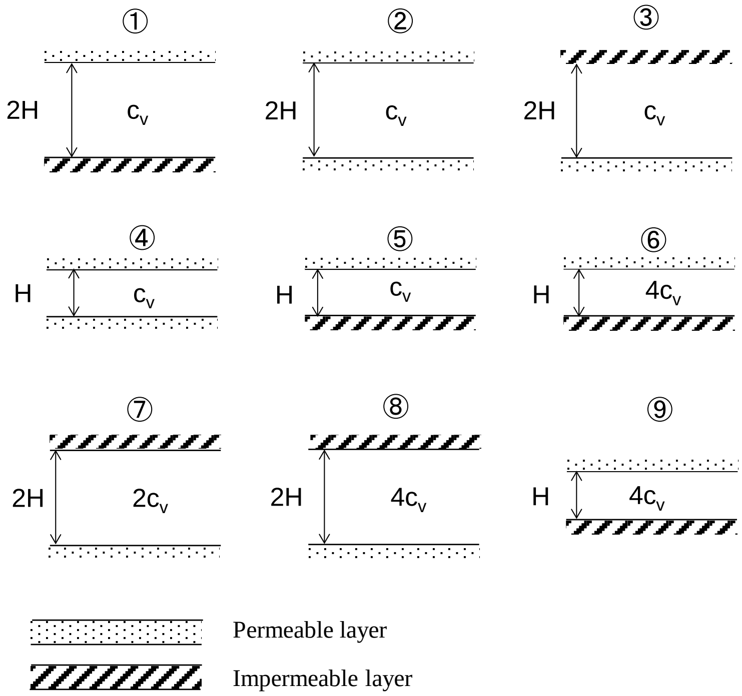

Figure 2

(4) The vertical stress in the ground beneath the corner of a rectangular area caused by a uniformly distributed load q is calculated as follows by Newmark's equation.

$$\sigma_z = \frac{q}{2\pi}\left[\frac{mn\left(m^2+n^2+2\right)}{\left(m^2+1\right)\left(n^2+1\right)\sqrt{m^2+n^2+1}} + \sin^{-1}\frac{mn}{\sqrt{m^2+1}\sqrt{n^2+1}}\right]$$
$$= qf_B(m,n)$$

Now, consider a rectangular load being exerted on the ground surface as shown in Figure 3. Calculate the vertical stress increases $\Delta\sigma_{zO}$ and $\Delta\sigma_{zG}$ that occur at a depth z=6 m just below points O and G, respectively. In order to obtain the solutions, Figure 4 may be used.

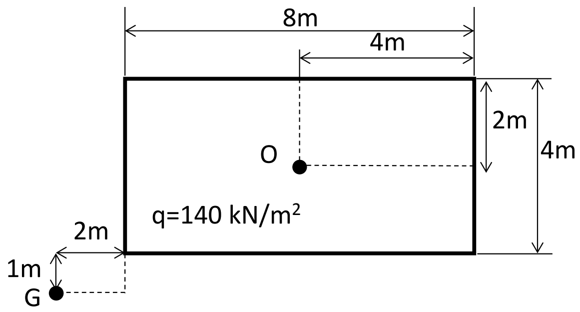

Figure 3

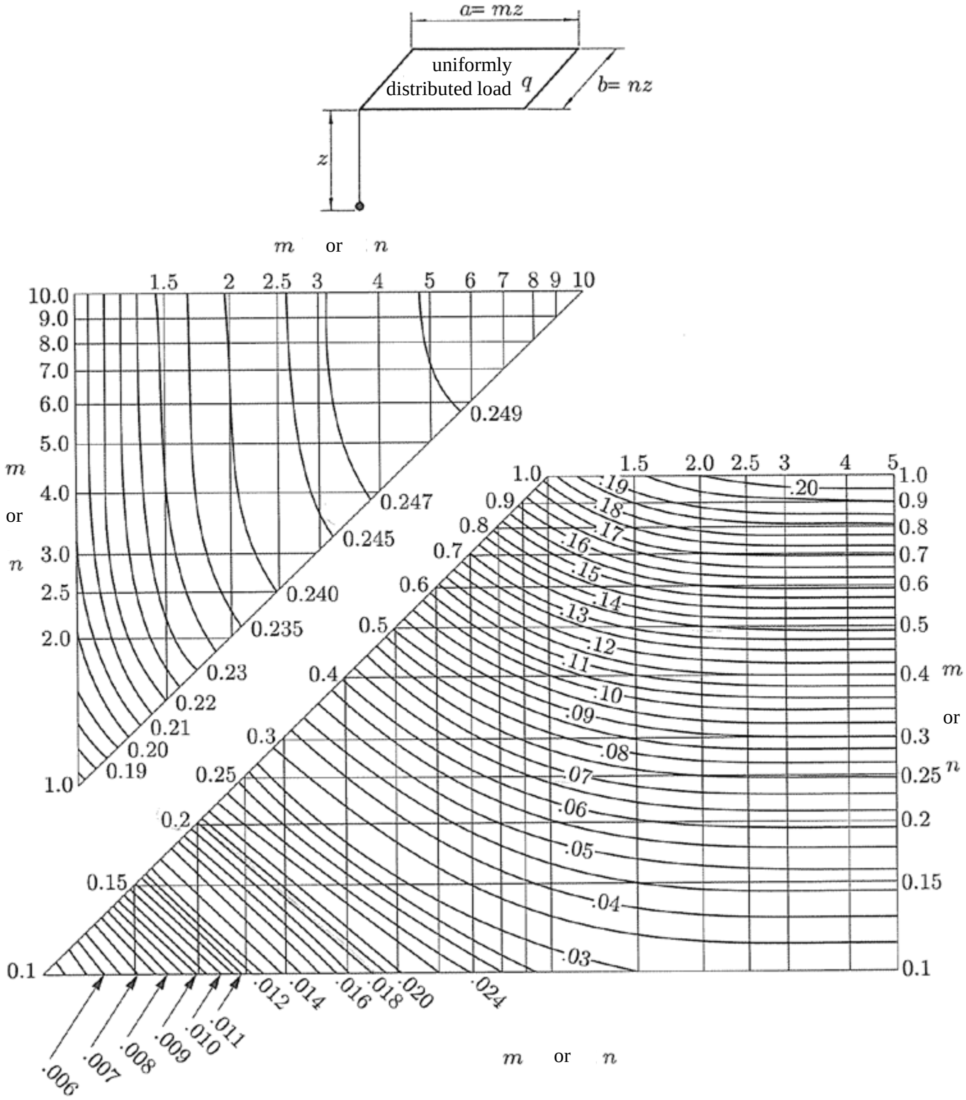
a= mz
uniformly
distributed load
q
b= nz
z
m or n
m or n
m or n
m or n
0.249
0.247
0.245
0.240
0.235
0.23
0.22
0.21
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Figure 4

[Question 2] Answer the following questions

(1) Clay samples in undisturbed and remolded conditions were subjected to unconfined compression tests. The corresponding values for unconfined compression strength obtained for each one are expressed by q_u (undisturbed) and q_{ur} (remolded).

1) Draw the schematic plot of stress-strain relationship obtained from undisturbed and remolded clay samples. Clearly indicate in the figure the unconfined compression strength for both the undisturbed (q_u) and the remolded (q_{ur}) samples.

2) Express the formula to obtain the degree of sensitivity from the results of this test.

(2) A saturated and normally consolidated clay sample is consolidated to a stress p', and then subjected to an undrained triaxial compression test. As a result, the deviator stress and the pore water pressure obtained at failure are q_f and u_f, respectively.

1) Draw the Mohr's Circle for total stress. Clearly specify in the figure the major and minor principal stresses.

2) Draw the Mohr's Circle for effective stress. Clearly specify in the figure the major and minor principal stresses.

3) Express the formula that defines the pore pressure coefficient at failure (A_f).

4) Draw the expected total and effective stress paths in the $\sigma_m - q$ and $\sigma'_m - q$ spaces, where $\sigma_m = (\sigma_1 + 2\sigma_3)/3$ and $\sigma'_m = (\sigma'_1 + 2\sigma'_3)/3$

[Question 3] Answer the following questions

(1) A retaining wall with a vertical back face is shown in Figure 5. Its frictionless face with a height H retains a horizontal backfill made of dry sand. The unit weight and the internal friction angle of the backfill are γ and ϕ, respectively. Once the wall moving outward of the backfill exceeds the limit, a backfill wedge is formed and slips along a failure plane with an angle θ measured from the horizontal. Based on Coulomb's earth pressure theory, answer the following questions by considering forces per unit width of the retaining wall:

(a) Draw the vector diagram of forces that act on the backfill wedge sliding along the failure plane.

(b) Determine the resultant force acting on the retaining wall by optimizing it with respective to the angle θ.

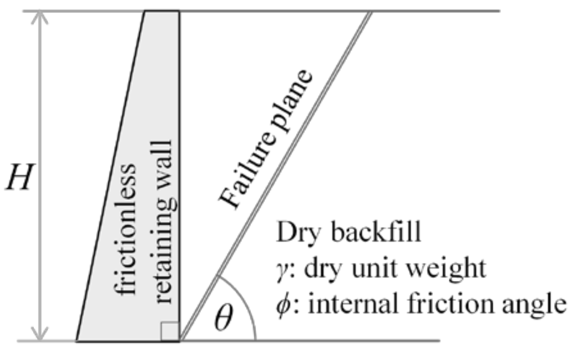

Figure 5