| Final Exam for IPSE of CSE, 2018 | | 31st, Jan., Wed. | Time: 15:00 to 16:30 |
|---|---|---|---|
| Subject: **Soil Mechanics**<br>Department, Year: Civil and Environmental Engineering, 2nd year<br>Instructors: Dr. Konishi, Dr. Nakayama, Dr. Tsuno, Dr. Afshani | | | ● Free<br>● Nothing<br>● Partly permitted<br>· ~~Textbook~~<br>· ~~Reference book~~<br>· **Calculator** (OK)<br>· ~~PowerPoint handouts~~<br>· **Personal notes- max four A4 pages** (OK) |
| Student ID: | Student name: | Mark: | |

**Questions sheets (answer the questions in questions sheets)**

**Note that:** The density of water is $\rho_w$ = 1 g/cm$^3$ and the water unit weight is $\gamma_w$ = 9.81 kN/m$^3$.

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1. A water content tests was done on a soil sample and following results are obtained**: (20 points)**

Mass of the container: 50 g,

Mass of the specimen and container: 95 g,

Mass of the specimen and container after drying at oven: 80 g,

Volume of the solid grains ($V_s$): 10 cm$^3$,

Volume of the specimen ($V_{total}$): 25 cm$^3$,

Obtain the **A)** water content (ω), **B)** density of solid grains ($\rho_s$), and **C)** void ratio (e) and **D)** saturation ratio ($S_r$)?

Mass of water: 95 – 80 = 15 g, Mass of solid: 80 – 50 = 30 g, Mass of specimen: 95 – 50 = 45 g,
Volume of specimen = 25 cm$^3$, Volume of solid grains = 10 cm$^3$, Volume of void = 25 –10 ($V_V$) = 15 cm$^3$,
Volume of water = $m_w/\gamma_w$ = 15/ 1 = 15 cm$^3$ (8 points)

Water content $(\omega) = \frac{W_w}{W_s} \times 100 = \frac{15}{30} \times 100 = 50\%$ (3 points)

Dedsity of solid grains $(\rho_s) = \frac{30}{10} = 3\ (\frac{g}{cm^3})$ (3 points)

Void ratio $(e) = \frac{V_V}{V_S} = \frac{15}{10} = 1.5\ (\frac{g}{cm^3})$ (3 points)

Sturation ratio $(Sr) = \frac{V_w}{V_V} = \frac{15}{15} \times 100 = 100$ (3 points)

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2. Define each of the following items with enough explanation: **(15 point)**

(a) What is Hydrometer test:

A hydrometer is an instrument used to measure the specific gravity or relative density of liquids. Hydrometer test is used to measure the percentage of very fine particle in Soil Particle Size Distribution curve.

(b) What is Plasticity index:

The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL).

(c) What is Standard penetration test

The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. "Standard penetration resistance" or the "N-value" is decided by number of blow need for hammer to penetrate into soil 30 cm.

(d) What is Borehole horizontal load test?

Borehole horizontal load test is test to measure lateral K value, lateral resistant force of the ground, by measuring displacement of borehole wall after insert measurement pipe into the borehole and act pressure on horizontal direction.

3. Table 1 shows the results of consolidated-drained triaxial test (CD-test) at the time of specimen failure. Calculate cohesion $c_d$ and internal friction angle $\phi_d$ using Mohr-circle. **(15 point)**

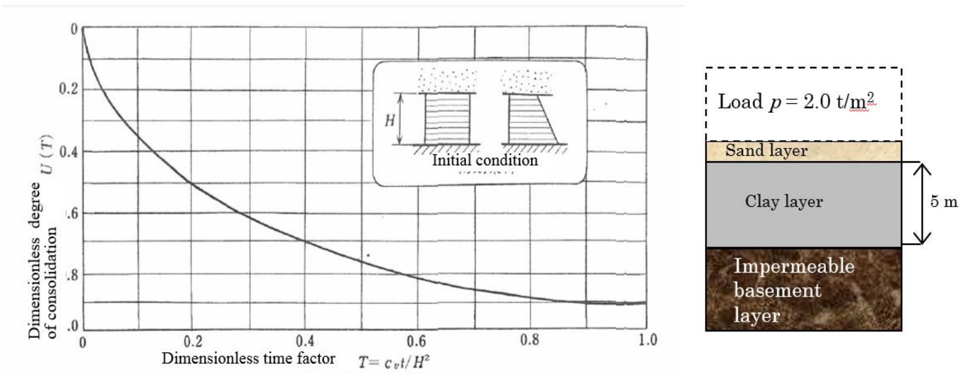
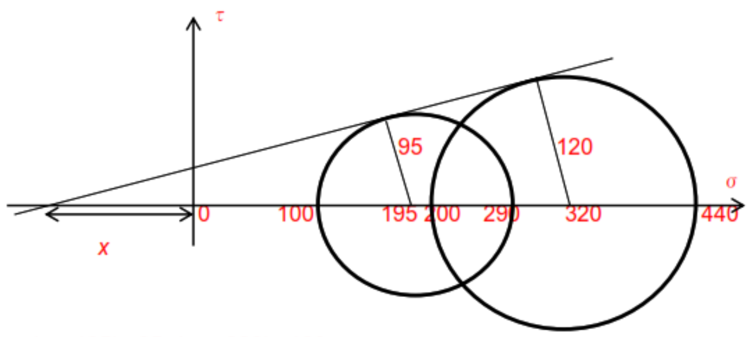



**Fig. 3: Undisturbed saturated clay before and after**

Table1: results of consolidated-drained triaxial test (CD-test)

| | | |
|---|---|---|
| Cell pressure [kPa] | 100 | 200 |
| Principal stress deviations $\sigma_1 - \sigma_3$ [kPa] | 190 | 240 |




$(x + 195) : 95 = (x + 320) : 120$

$x = 280$

$\sin\phi_d = 95/(280+195) = 0.2$

$\phi_d = 11.5^\circ$

$\cos\phi_d = \sqrt{1-0.2^2} = \sqrt{0.96}$

$\tan\phi_d = \frac{0.2}{\sqrt{0.96}} = \frac{0.2}{0.4\sqrt{6}} = \frac{1}{2\sqrt{6}}$

$c = 280 \times \tan\phi_d = 280 \times \frac{1}{2\times\sqrt{3}\times\sqrt{2}} = 57\text{kN/m}^2$

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4. **Fig. 1** shows a dam built on a top of soil with coefficient of permeability k= 0.05 m/sec, and water head difference between upstream and downstream of the sheet pile is h = 10 meter. Draw proper flow net in the soil beneath dam and obtain flow rate (Q)? (6 points)

$Q = k \,.\, H \,.\, \frac{N_f}{N_d} = 0.05 \times 5 \times \frac{5}{8} = 0.156 \ \frac{m^3}{sec}$ (5 points)

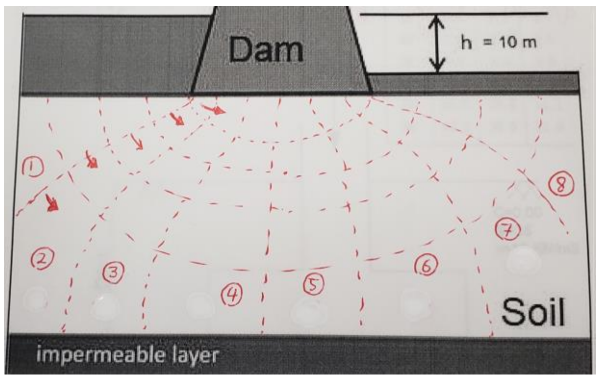


**Fig. 1: Draw flow net in soil layer**

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5. **Fig. 3** shows relationship between dimensionless degree of consolidation U and dimensionless time factor T. The clay layer lies on the impermeable basement layer. The thickness of clay layer is 5 meter. The drainage has one-way to the upper surface. The coefficient of consolidation $c_v$ is 0.2 cm²/min and coefficient of compressibility mv is 0.05 m²/ton. The load P = 2.0 ton/m² acts on the ground surface. (25 points)

**A, B**) Find time and settlement value to finish 80% of consolidation.

**C**) How much should be the P load, If the 80% settlement $S_{80}$ (that obtained in the A, B) is wanted to be reached in 200 days?

A, B) $U = 80\,\% \rightarrow T = 0.57 = \frac{c_v t}{H^2}$

$c_v = 0.2$ cm²/min $= 2 \times 10^{-5}$ m²/min

One-way drainage → H = 5 m

$0.57 = \frac{c_v t}{H^2} \rightarrow t = 712500 \min = 494.8\ days$ (7.5 points)

mv = 0.05 $m^2$/ton

$S_{100}$ = mv × H × Δσ = 0.05 × 5 × 2 = 0.5 m

$S_{80}$ = 0.8 × 0.5 = 0.4 m (5 points)

C)

$t_{80} = 200\ days \rightarrow T_{80} = \frac{c_v \times t_{80}}{H^2} = \frac{0.2 \times 200 \times 24 \times 60}{500^2} = 0.23$ (5 points)

$By\ the\ Fig.\ 2,\ we\ know\ that: T_{80} = 0.23 \rightarrow U = 0.53$

$p = \frac{S_0}{m_v \times H} = \frac{0.4}{0.05 \times 5 \times 0.53} = 3.018 \frac{ton}{m^2}$ (7.5 points)

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6. The layer of soil is sliding down in the slope with angle of the $\beta$. The section "abcd" is assumes to slips on sliding slip "bd". The thickness of the sliding layer is z, and unit weight of it is $\gamma$. The cohesion and internal friction angle of the soil layer is c and $\emptyset$. **Using the shown parameters ($\gamma$, z, $\beta$, c, $\emptyset$) (and not actual values),** obtain (16 points):

a) Weight of the section "abcd", (W).

b) Normal and shear component of the weight on the sliding slip "bd", ($\sigma$ and $\tau$).

c) Shear strength on the sliding slip "bd", (S).

d) Safety factor of this sliding, (SF).

a) $W = \gamma z \cos\beta$

b) $\sigma = W \cdot \cos\beta = \gamma z \cos^2\beta$ , $\tau = W \sin\beta = \gamma z \cos\beta \sin\beta$

c) $S = c + \sigma \tan\varphi = c + \gamma z \cos^2\beta \tan\varphi$

d) $F_s = \frac{2c}{\gamma z \sin 2\beta} + \frac{\tan\varphi}{\tan\beta}$

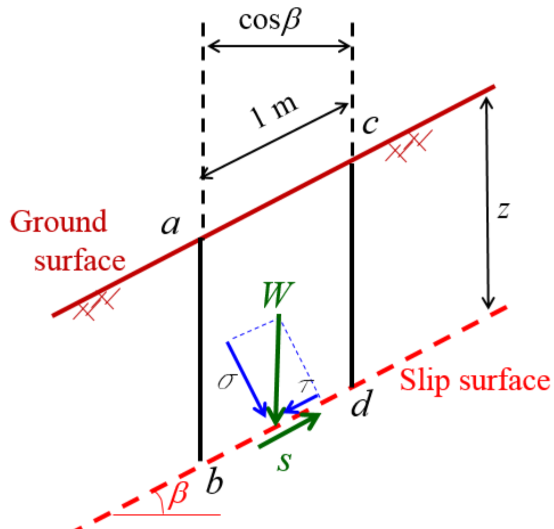


Fig. 5: Sliding soil layer

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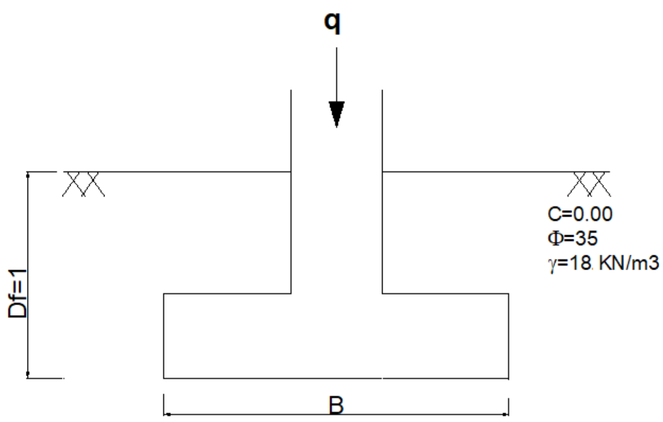
7. **Fig. 5** shows a square foundation in sandy soil. The sand has cohesion C = 0 kPa, internal friction angle Φ = 32° and unit weight γ = 18 kN/m³. The width of foundation is B = 1 m and depth of foundation base is $D_f$ = 1 m. If factor of safety is 3, determine bearing capacity ($q_u$) and allowable bearing capacity ($q_a$) of this square foundation? (10 point)




| $\phi$ | $N_c$ | $N_\gamma$ | $N_q$ |
|---|---|---|---|
| 0° | 5.3 | 0 | 1.0 |
| 5° | 5.3 | 0 | 1.4 |
| 10° | 5.3 | 0 | 1.9 |
| 15° | 6.5 | 1.2 | 2.7 |
| 20° | 7.9 | 2.0 | 3.9 |
| 25° | 9.9 | 3.3 | 5.6 |
| 28° | 11.4 | 4.4 | 7.1 |
| 32° | 20.9 | 10.6 | 14.1 |
| 36° | 42.2 | 30.5 | 31.6 |

* $q_u = 1.3cN_c + \gamma DN_q + 0.4\gamma BN_\gamma$ ,

$q_a = \left[1.3cN_c + \gamma D(N_q - 1) + 0.4\gamma BN_\gamma\right]\frac{1}{F} + \gamma D$

$q_u = 0 + \gamma DN_q + 0.4\gamma BN_\gamma = 18 \times 1 \times 14.1 + 0.4 \times 18 \times 1 \times 10.6 = 330kPa$

$q_a = 1/3\left[0 + \gamma D(N_q - 1) + 0.4\gamma BN_\gamma\right] + \gamma D = 1/3(18 \times 1 \times 13.1 + 0.4 \times 18 \times 1 \times 10.6) + 18 \times 1 = 121kPa$

**End of Questions.**