Final Exam for IPSE of CSE, 2017	1st, Feb., Wednesday	From: 15:00 to 16:30
Subject: Soil Mechanics Department, Year: Civil & Environmental Engineering,, 2nd year Instructors: Dr. Konishi, Dr. Nakayama, Dr. Tsuno, Dr. Afshani		• Free • Nothing • Partly permitted ~~・ Textbook~~ ~~・ Reference book~~ ・ Calculator (OK) ~~・ PowerPoint handouts~~ ・ Personal notes (OK)
Student ID: Student name:	Mark:	

Answer all the questions.

Note that: The density of water is ρ_w = 1 g/cm^3 and the water unit weight is γ_w = 9.81 kN/m^3.

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1. A sample of silty clay had a volume of 14.88 cm^3. Its weight at the natural water content was 28.81 g and after oven drying was 24.83 g. The specific gravity of the solid constituents was 2.70. Obtain (18 points):
   a) Natural water content (ω)
   b) Void ratio (e)
   c) Degree of saturation (S_r)
   d) Porosity (n)

Mass of water: 28.81 – 24.83= 3.98 g, Mass of solid: 24.83 g, Mass of specimen: 28.81 g
Volume of specimen: 14.88 cm^3, Volume of water: 3.98 cm^3, Volume of solid grains = 9.19 cm^3, Volume of void = 14.88 - 9.19 = 5.69 cm^3, (4 points)

a) Natural water content (ω)

$$\text{Water content } (\omega) = \frac{W_w}{W_s} \times 100 = \frac{3.98}{24.83} \times 100 = 16\%$$ (4 points)

b) Void ratio (e)

$$\text{Void ratio } (e) = \frac{V_V}{V_S} = \frac{5.69}{9.19} = 0.61$$ (4 points)

c) Degree of saturation (S_r)

$$\text{Saturation ratio } (Sr) = \frac{V_W}{V_V} = \frac{3.96}{5.96} \times 100 = 70\%$$ (4 points)

d) Porosity (n)

$$\text{Porosity } (n) = \frac{V_W}{V} = \frac{3.96}{14.88} = 0.38$$ (4 points)

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2. A pump is working to bring down the water table around a pumping well. Based on the Fig. 1, water level drops in well No. 1 to Z_1 = 10 m and in well No. 2 to Z_2 = 5 m. The distances of well No. 1 (r_1) and well No. 2 (r_2) from the pumping well are r_1 = 20 m and r_2 = 10 m respectively. If the soil permeability is $k = 0.05\frac{m}{sec}$, then how much is the flow rate (Q) ? (4 points)

$$z_2^2 - z_1^2 = \frac{Q}{\pi k} \ln\frac{r_2}{r_1} \rightarrow 25 - 100 = \frac{Q}{\pi \times 0.05} \ln\frac{10}{20}$$

$$Q = 17\frac{m^3}{sec}$$

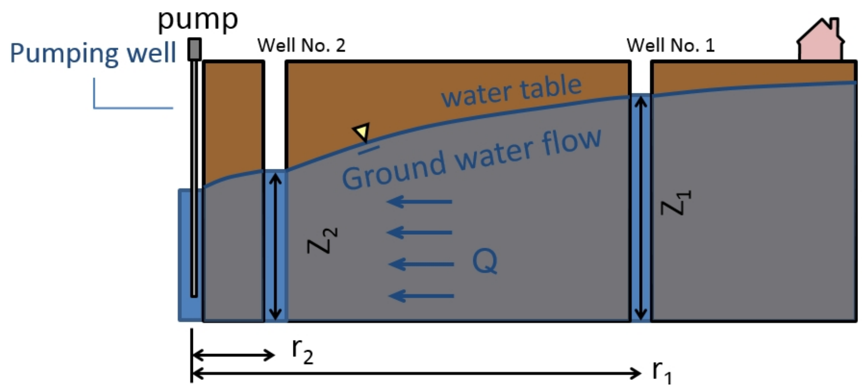

Fig. 1: Pumping well

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3. In the Fig. 2, water flows from left to right hand side in the soil layer below the sheet pile. The left hand side of the sheet water head is 5 meter higher than right hand side. Assume that the number between Streamlines lines (flow channels: N_f = 5) and the number between equipotential lines (number of drops in water head: N_d = 9). If the soil permeability is $k = 0.05\frac{m}{sec}$, then; (8 points)
   a) Draw the flow net (flowlines and equipotential lines) for the sheet pile driven in the soil. (4 points)
   b) How much is the flow rate which passes through the soil section under the sheet pile (Q)? (4 points)

$$Q = k \cdot H \cdot \frac{N_f}{N_d} = 0.05 \times 5 \times \frac{5}{9} = 0.14\ \frac{m^3}{sec}$$

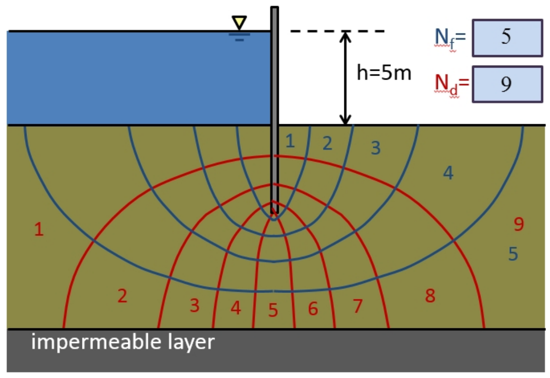

Fig. 2: Water flow in the soil below the sheet pile

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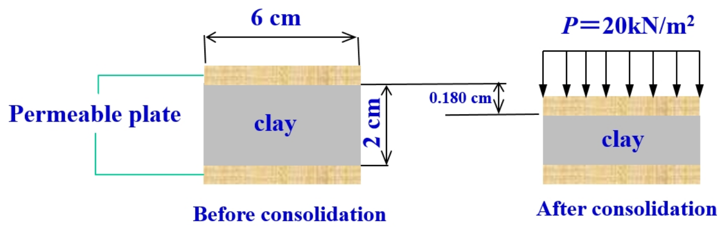
4. Undisturbed saturated clay was placed in the consolidation ring of which inside diameter is 6 cm and height is 2 cm. Then, permeable plates were set on upper-and-lower surface and acted on consolidation pressure P=20 kN/m^2 .
Then, the specimen was consolidated and the settlement was 0.180 cm. Mass of the specimen after dried is 34.65 g and density of the soil grains ρ_s=2.630 g/cm^3.
a) Find the initial void ratio e_0.
b) Find the void ratio after consolidation e_1.
c) Find the coefficient of compressibility m_v. (18 points)



$P = 20\ \frac{KN}{m^2},\ m_s = 34.65\ g,\ \Delta h = 0.108\ cm, \rho_s = 2.63\ \frac{g}{cm^3}$

$A = \frac{\pi \times 6^2}{4} = 28.27\ cm^2\ ,\ h_s = \frac{m_s}{\rho \times A} = \frac{34.65}{2.630 \times 28.27} = \boxed{0.466\ cm}$ (4 points)

a)
$h = 2\ cm;\ h_s = 0.466\ cm$

$e_0 = \frac{h}{h_s} - 1 = \frac{2}{0.466} - 1 = \boxed{3.292}$ (4 points)

b)
$\Delta h = 0.180\ cm;\ h_1 = h - \Delta h = 1.820\ cm$

$e_1 = \frac{h_1}{h_s} - 1 = \frac{1.820}{0.466} - 1 = \boxed{2.906}$ (4 points)

c)
$\varepsilon = \frac{\Delta V}{V} = \frac{\Delta h}{h} = \frac{0.18}{2} = 0.090\ ,\ m_v = \frac{\varepsilon}{\Delta P} = \frac{0.09}{20} = \boxed{0.0045\ \frac{m^2}{KN}}$ (6 points)

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5. Fig. 4 shows relationship between dimensionless degree of consolidation U and dimensionless time factor T. The clay layer lies on the impermeable basement layer. The clay layer is five meter in thickness. The drainage has one-way to the upper surface. The coefficient of consolidation c_v is 0.2 cm^2/min and coefficient of compressibility m_v is 0.05 m^2/ton. The load p = 2.0 ton/m^2 acts on the ground surface. Find time and settlement value to finish 80% of consolidation. (24 points)

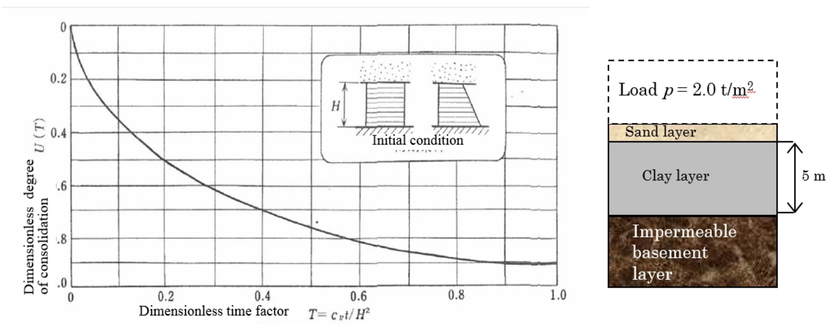

Fig. 4: Relationship between dimensionless degree of consolidation U and dimensionless time factor T

a, b)
$By\ Fig.\ 2,\ we\ know\ that:\ U = 80\% \rightarrow T_{80} = \boxed{0.567}$ (2 points)

$t_{80} = \frac{T_{80} \times H^2}{c_v} = \frac{0.567 \times 500^2}{0.2} = \boxed{492\ days}$ (4 points)

$\Delta p = 2.0 \frac{t}{m^2} \rightarrow S_0 = m_v \times H \times \Delta p = 0.05 \times 5.0 \times 2.0 = \boxed{0.5\ m}$
(4 points)

$S_{80} = S_0 \times U = 0.5 \times 0.8 = \boxed{0.4\ m}$ (2 points)

c, d)
$t_{80} = 200\ days \rightarrow T_{80} = \frac{c_v \times t_{80}}{H^2} = \frac{0.2 \times 200 \times 24 \times 60}{500^2} = \boxed{0.23}$ (4 points)

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

$p = \frac{S_0}{m_v \times H} = \frac{0.4}{0.05 \times 5 \times 0.53} = \boxed{3.018 \frac{ton}{m^2}}$ (6 points)

6. The layer of soil is sliding down in the slope with angle of the β. 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 γ. The cohesion and internal friction angle of the all soil layers are c and $\emptyset$.

<u>Using the parameters (γ, z, β, c, $\emptyset$)</u>, obtain (16 points):

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

b) Normal and shear component of the weight on the sliding slip "bd", (σ and τ).

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

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

Fig. 5: Retaining wall

a)

$W = \gamma.z.cos\beta \times 1 \times 1 = \gamma.z.cos\beta$

b)

$\sigma = W.cos\beta = \gamma.z.cos^2\beta;\ \tau = W.sin\beta = \gamma.z.sin\beta\ cos\beta.$

c)

$s = c + \sigma tan\varphi = c + \gamma.z.cos^2\beta tan\varphi$

d)

$$FS = \frac{s}{\tau} = \frac{c + \gamma.z.cos^2\beta tan\varphi}{\gamma.z.sin\beta\ cos\beta} = \frac{c}{\gamma.z.sin\beta\ cos\beta} + \frac{cos\beta tan\varphi}{sin\beta} = \frac{2c}{\gamma.z.sin2\beta} + \frac{tan\varphi}{tan\beta}$$

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7. About negative shaft friction, answer the following questions (10 points):

a) Define the negative shaft friction in piles and explain why it happens (use figures and drawing to support your explanation). ?

b) What is the effect of this negative shaft friction in pile settlement?

a) Normally, if the load applies to the top of the pile, the shear stresses on the pile skin is upward. When the soil around the pile is soft compressible, the soil may consolidate after the pile installation. The compressible soil go downward relative to the pile. The downward movement of soil develops skin friction between the pile and the surrounding soil and it is termed as negative skin friction. (4 points)

b) The negative shaft friction applies downward shear stress on the pile and pushes the pile downward, as a result, the pile settlement **increases**. (4 points)

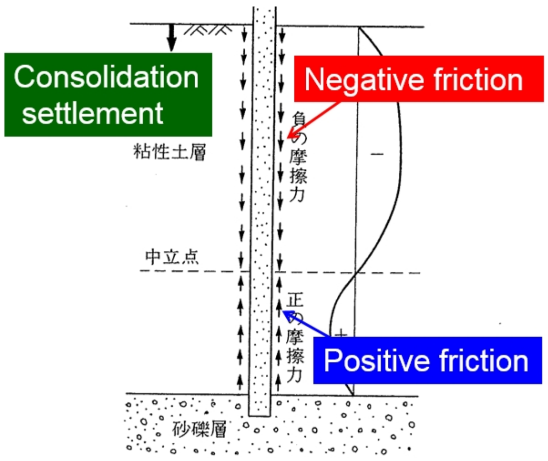

Figure: (2 points)