Mid-term Exam for IPSE of CSE, 2016		16th, Nov., Wednesday	From: 18:15 to 19:45
Subject: Soil Mechanics Department, Year: Civil & Env., 2nd year Instructors: Dr. Konishi, Dr. Nakayama, Dr. Tsuno, Dr. Afshani			● Free ● Nothing ● Partly permitted ・ ~~Textbook~~ ・ ~~Reference book~~ ・ Calculator ・ ~~PowerPoint handouts~~ ・ Personal notes
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. The results of the compaction and water content test is as follow: (24 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: 10 cm^3
   Volume of the specimen (V): 25 cm^3

Find the water content (ω), density of solid grains (ρ_s), wet density of grains (ρ_{wet}), dry density of grains (ρ_d), void ratio (e), and saturation ratio (S_r) of this soil sample.

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,

Water content $(\omega) = \frac{W_w}{W_s} \times 100 = \frac{15}{30} \times 100 = 50\%$ (4 points)

Dedsity of solid grains $(\rho_s) = \frac{30}{10} = 3\ (\frac{g}{cm^3})$ (4 points)

Wet density $(\rho_{wet}) = \frac{45}{25} = 1.8\ (\frac{g}{cm^3})$ (4 points)

Dry density $(\rho_d) = \frac{30}{25} = 1.2\ \left(\frac{g}{cm^3}\right)$ *or* Dry density $(\rho_d) = \frac{\rho_{wet}}{1+\omega} = \frac{1.8}{1+0.33} = 1.35\left(\frac{g}{cm^3}\right)$ (4 points)

Void ratio $(e) = \frac{V_V}{V_S} = \frac{15}{10} = 1.5\ (\frac{g}{cm^3})$ (4 points)

Volume of water = m/ρ = 15/1 = 15 cm^3 → Saturation ratio $(Sr) = \frac{V_W}{V_V} = \frac{15}{15} \times 100 = 100\%$ (4 points)

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2. Table 1 shows the sieves analysis test. a) Draw grading curve on the Fig. 1 with the given data in the table, b) find the uniformity coefficient Uc and then fine particle content. c) Is the soil well graded or poor graded? (16 points)

Table 1. Sieves analysis test results

Size (mm)	9.5	4.75	2.0	0.85	0.425	0.250	0.106	0.075	0.050	0.038	0.012	0.0025
Percentage finer than a given size P (%)	100	97.1	90.1	85.3	74.7	65.0	56.7	42.5	24.1	15.6	8.8	2.3

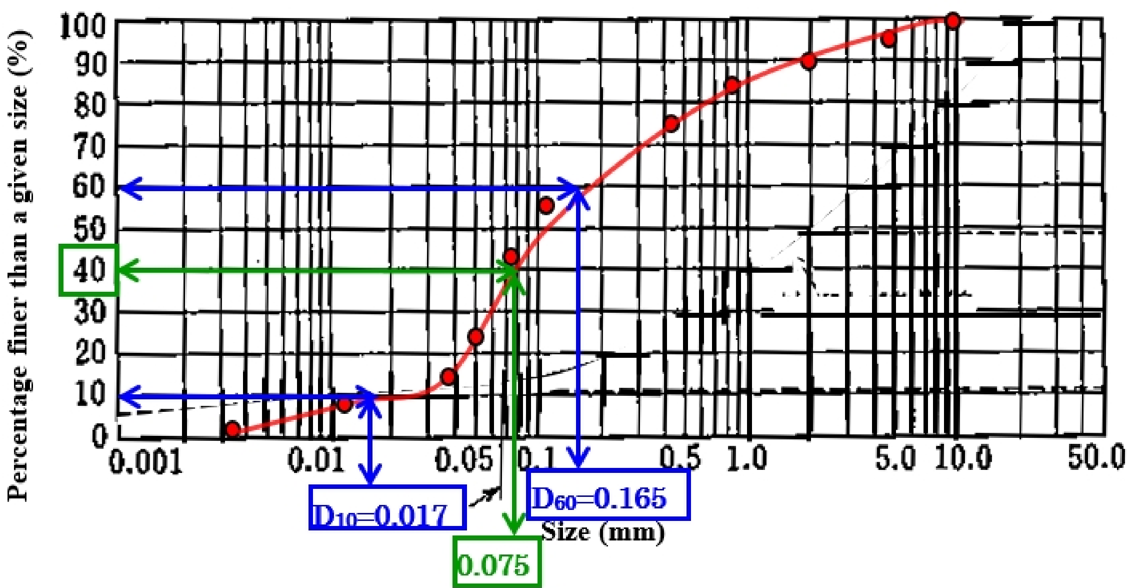


Figure 1

Graph (4 points)

Uniformity coefficient $U_c = D_{60}/D_{10} = 0.165/0.017 = 9.7$ (4 points)

Fine fraction content = 40% (4 points)

For a sand to be classified as well graded, the following criteria must be met:

Uc ≥ 6 and 1 < Cc < 3

$U_c = D_{60}/D_{10} = 9.7 > 6$ and $C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{0.06^2}{0.165 \times 0.017} = 1.28$ → Well graded (4 points)

3. The ground water flow net for a sheet pile in the soil is shown in Fig. 2. The flow lines and equipotential lines are also shown in it. The number of streamlines channels (flow channel= N_f) and number head drop (N_d) are 5, and 9 respectively. If the coefficient of permeability is k= 0.05 m/sec, and head difference of upstream and downstream is 5 meter, how much is the flow rate (Q)? (4 points)

$Q = k\,.H\,.\frac{N_f}{N_d} = 0.05 \times 5 \times \frac{5}{9} = 0.14\ \frac{m^3}{sec}$ (4 points)

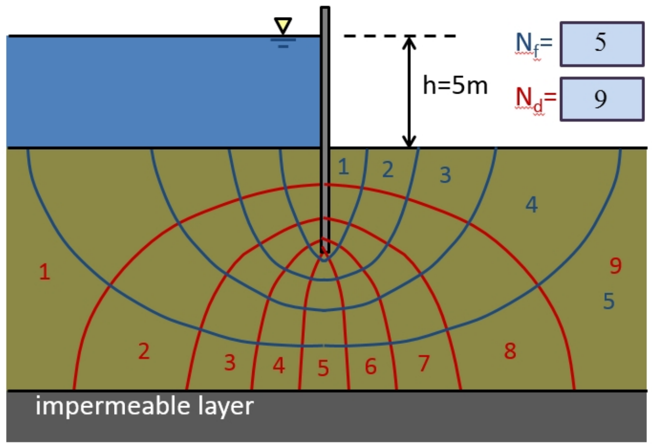


Fig. 2 Flow net diagram

4. In a flow water test through a soil sample, two following cases shown in Fig. 3 and 4 are set up. In case a, total discharge passing through the sample is Q_a and in case b, total discharge passing through the sample is Q_b. Test setup and soils in both cases are the same. a) If $Q_a = Q_1 + Q_2$ and $Q_b = Q_3 = Q_4$, what is ratio of $\frac{Q_a}{Q_b}$? b) In case b, how many cm is the water head at point c (h_c)? (22 points)

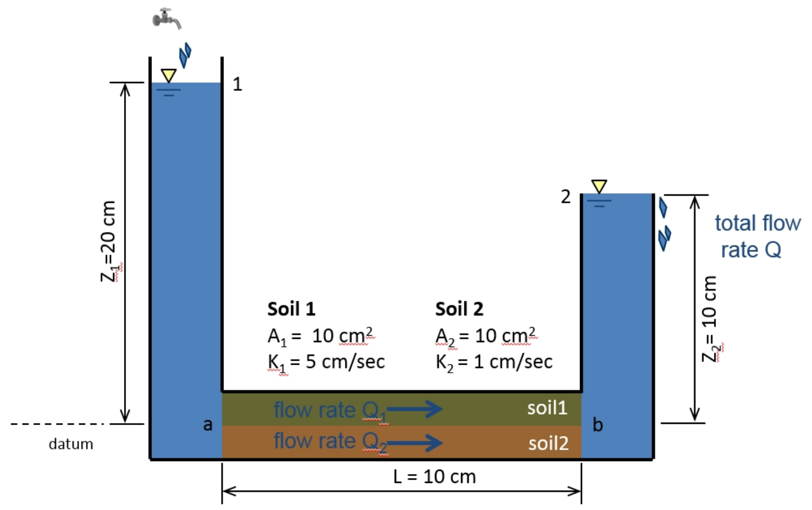


Fig. 3. Flow water test- Case a

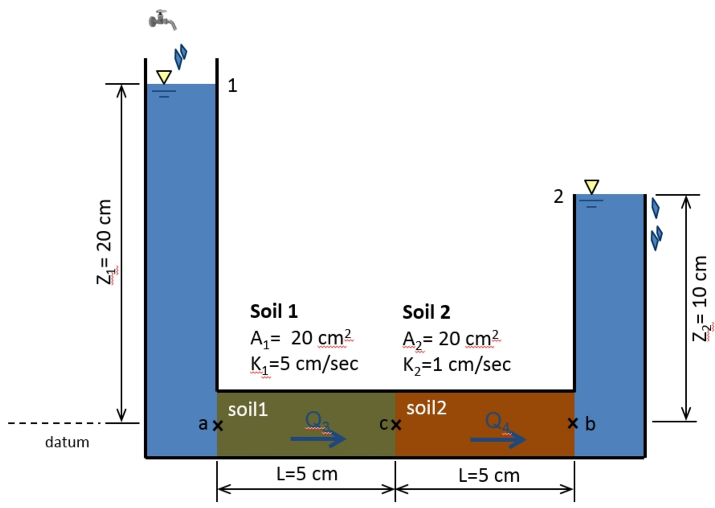


Fig. 4. Flow water test- Case b

$Q_m = k_m i_m A_m$

$i_{ab} = \dfrac{20-10}{10} = 1$

$Q_1 = kiA = 5 \times 1 \times 10 = 50(\frac{cm^3}{sec})$ (4 points)

$Q_2 = kiA = 1 \times 1 \times 10 = 10(\frac{cm^3}{sec})$ (4 points)

→ $Q_{case-a} = Q_1 + Q_2 = 60\ (\frac{cm^3}{sec})$

$Q_3 = Q_4 \rightarrow 5 \times \frac{20-h_c}{L=5\ cm} \times 20 = 1 \times \frac{h_c-10}{5} \times 20 \rightarrow h_c = 18.33\ cm$ (6 points)

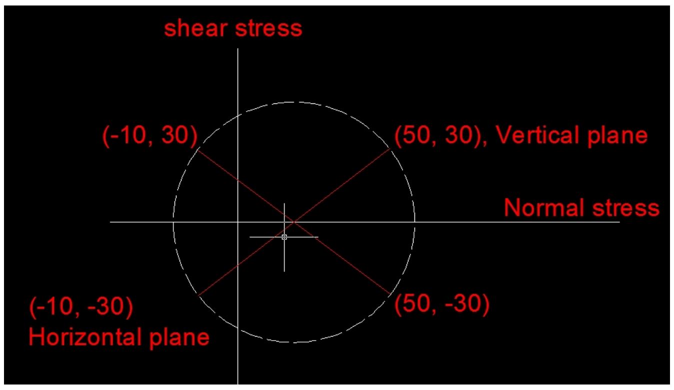
$Q_3 = kiA = 5 \times \frac{20-18.33}{5} \times 20 = 33.4\ (\frac{cm^3}{sec})$ (4 points)

$Q_4 = kiA = 1 \times \frac{18.33-10}{5} \times 20 = 33.4\ (\frac{cm^3}{sec})$ (4 points)

$Q_{case-b} = Q_4 = Q_3 = 33.4\ (\frac{cm^3}{sec})$

$\frac{Q_{case-a}}{Q_{case-b}} = \frac{60}{33.4} = 1.796$ (2 points)

5. Fig. 5 shows the stresses of a soil element (units in kPa). (**Positive angles indicate counterclockwise motion**.)
a) Using Mohr circle, calculate the maximum and minimum principal stresses.
b) Using Mohr circle, calculate the angle formed by the plane of the maximum principal stress and the horizontal plane.
c) The angle between plane A and horizontal plane is - 45° clockwise as shown in Fig. 5. Calculate normal and shear stresses acting on the planes of A and B and show it on the corresponding planes of soil element. (22 points)



Graph (4 points)

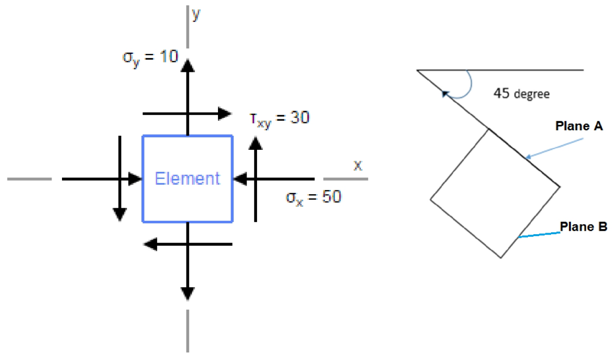


Fig. 5. Stress of a soil element

a) Center of Mohr-circle = 50 + (-10) / 2 = 20 → (20, 0) (2 points)

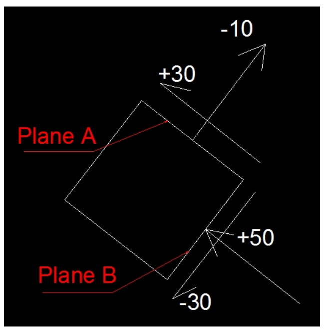
$\text{Radius} = \sqrt{(50-20)^2+(30-0)^2} = 30\sqrt{2} = 42.42\ m$ (2 points)

$Max\ \text{principal stresses} = 20 + 30\sqrt{2} = 62.42 \rightarrow (62.42, 0)$ (2 points)

$Min\ \text{principal stresses} = 20 - 30\sqrt{2} = -22.42 \rightarrow (-22.42, 0)$ (2 points)

b) $\tan 2\theta = \frac{30}{30} \rightarrow \theta = 22.5°$ (4 points)

c) $Plane\ A \rightarrow (-10, +30)$ $Plane\ B \rightarrow (+50, -30)$ (6 points)



6. Compute the vertical total stress, vertical effective stress and pore water pressure at a depth of 15 m below the bottom of a 6 meter deep lake. Unit weight of the soil at the bottom of lake is γ=17 kN/m³. (12 points)

$\sigma_t = 6 \times 9.81 + 15 \times 17 = 313.86\ kN/m^2$ (4 points)

$u = 21 \times 9.81 = 206\ kN/m^2$ (4 points)

$\sigma' = 313.86 - 206 = 107.86\ kN/m^2$ (4 points)

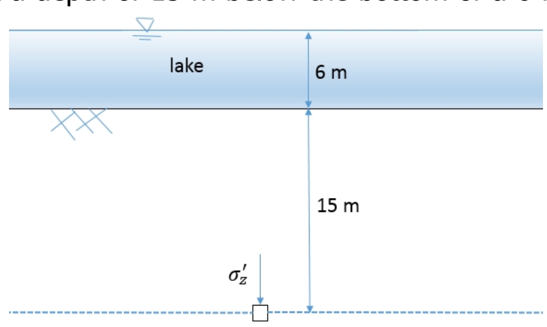


Fig. 6. The stress element of soil at the depth of a lake