`Université d'Ottawa
Faculté de genie

Départment de
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University of Ottawa
Faculty of Engineering

Department of
Civil Engineering

uOttawa
L'Université canadienne
Canada's university

CVG 3109
SOIL MECHANICS - I
MIDTERM EXAM

Length of Examination: 1hr 20 min **17th Oct, 2011 (11:30 AM to 12:50 PM)**
Professor: Won Taek Oh

Family Name: ____

Other Names: ____

Student Number: ___________

Signature ___________________________

(i) This is a closed book exam. No textbooks are allowed
(ii) Formula sheet is available on last pages of this question paper
(iii) If you do not understand a question, clearly state an assumption and proceed.
(iv) Non programmable calculators are permitted
(v) Questions have the values shown next to the question.
(vi) Marks will be taken out for missing units and labels.
(vii) Answers should be succinct.

At the end of the exam, when time is up:
- Stop working and turn your exam upside down.
- Please remain silent.
- Do not move or speak until **ALL** exams have been picked up, and a TA or the Professor gives the go-ahead to leave.

Question	**Max Marks**	**Marks Awarded**
1	10	
2	30 (10 + 5 + 15)	
3	30 (15 + 15)	
4	15	
5	15	
Total	**100%**	

Question 1 (10 Marks)

A saturated soil (i.e. S = 100%) in a container that subjected to a total stress, σ is shown in Figure 1. The level of water in a piezometer is the same as the surface of the soil (i.e. hydrostatic pore-water pressure). What will be the **change in effective stress** if an additional stress, $\Delta\sigma$ is applied on top of the total stress σ under undrained condition? Briefly describe the **reason with calculation**. (u_s = hydrostatic pore-water pressure, u_e = excess pore-water pressure) (Hint: $\Delta\sigma = u_e$ for undrained condition).

Effective stress (σ') = Total stress (σ) – Pore water pressure (u)

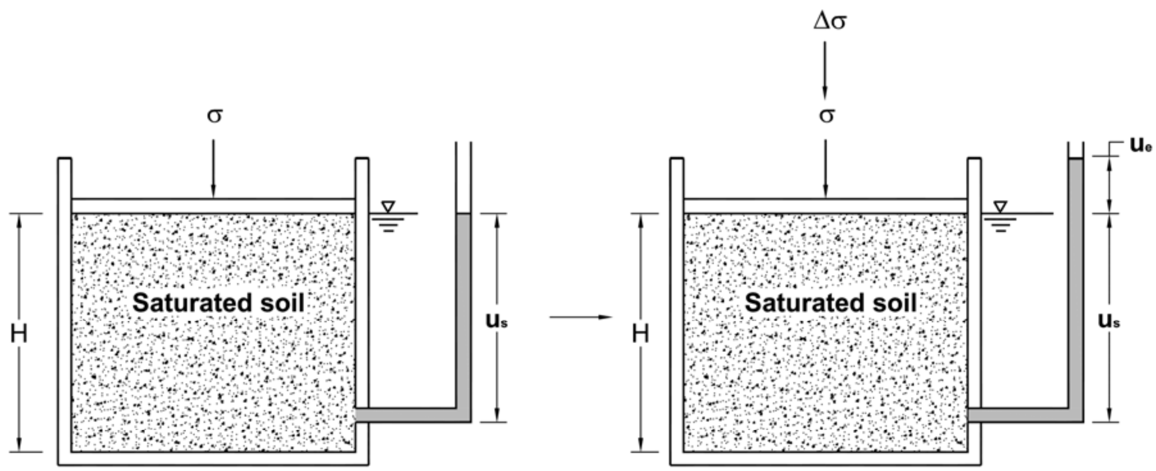

Figure 1

Question 2 (30 Marks)

The following results (Table 1) were obtained from a Standard Proctor test on a soil (G_S = 2.67) in a laboratory.

$$\gamma_t = \frac{W}{V} = \frac{(V_w + V_s G_S)\gamma_w}{1+e} = \frac{(Se + G_S)}{1+e}\gamma_w$$

$$\gamma_d = \frac{W_s}{V} = \frac{G_s}{1+e}\gamma_w = \frac{\gamma_t}{1+w}$$

$$Se = wG_s$$

Table 1. Standard Proctor test results

$w(\%)$	$\gamma_t (kN/m^3)$
6	15.70
8	18.80
9	20.20
11	21.00
12	20.70
14	19.30

a. Plot the **dry unit weight against water content** and determine the **maximum dry unit weight** and **optimum moisture content, OMC** (use the graph paper in page 4). **(10 Marks)**

b. Plot the **zero-air-voids line** (use the graph paper on page 4). **(5 Marks)**

c. A road is compacted at a water content which is equal to the OMC using a roller. The γ_d estimated from sand cone tests in the field was 90% of $\gamma_{d(max)}$ (= maximum dry unit weight from Standard Proctor test). If this road was fully saturated by rain infiltration, what would be the **volume of water** percolated into the compacted road for 1 m^3 of soil? (Neglect the volume change (i.e. void ratio) during infiltration). **(15 Marks)**

Question 3 (30 Marks)

For a cutoff wall shown in Figure 2

a. Establish the **flow nets** (i.e. flow and equipotential lines) following all the rules (draw on Figure 2). **(15 marks)**

b. Calculate the **effective stress** at point **A** (back of the piling) (γ_{sat} = 20 kN/m^3). **(15 marks)**

Effective stress (σ') = Total stress (σ) – Pore water pressure (u)

$u = (h - z)\gamma_w$

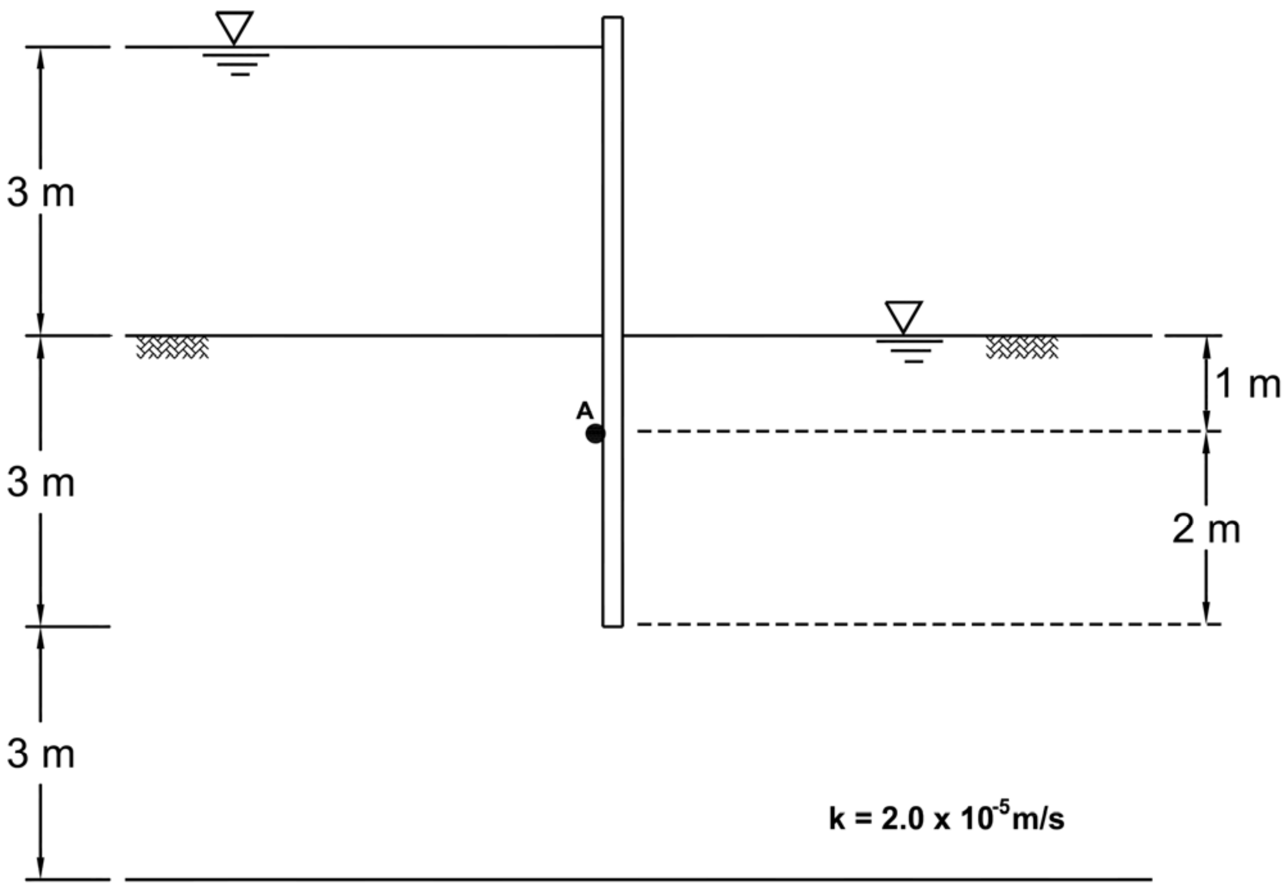

Figure 2

Question 4 (15 Marks)

For a soil profile given below (Figure 3) calculate the **effective stress** at the depths of **EL -2 m**, **EL -3.5 m** and **EL -6.5m**. (Assume that G_S = 2.7 for both sand and clay)

Effective stress (σ') = Total stress (σ) – Pore water pressure (u)

$$\gamma_t = \frac{W}{V} = \frac{(V_w + V_s G_S)\gamma_w}{1+e} = \frac{(Se + G_S)}{1+e}\gamma_w$$

$$\gamma_d = \frac{W_s}{V} = \frac{G_s}{1+e}\gamma_w = \frac{\gamma_t}{1+w}$$

$$Se = wG_s$$

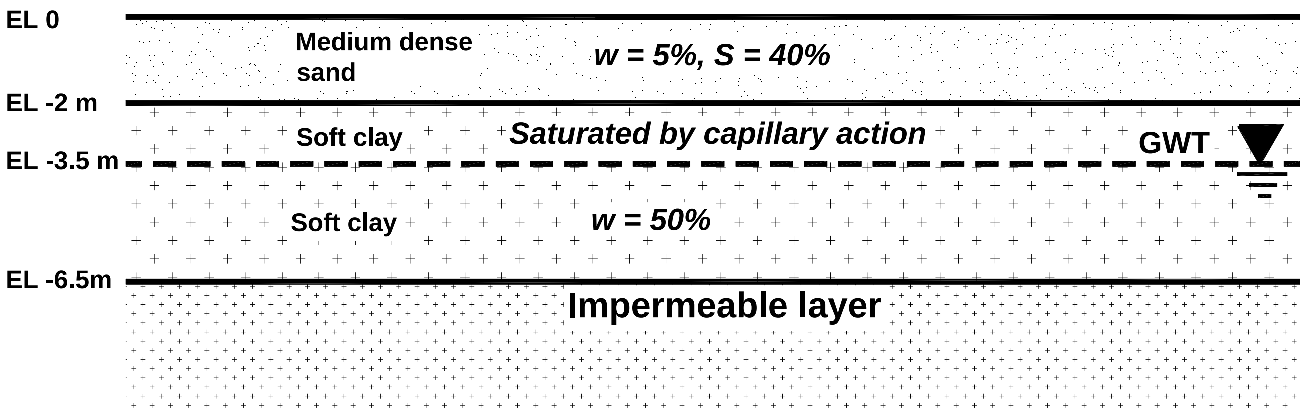

Figure 3

Question 5 (15 Marks)

Determine the total stress, pore-water pressure and effective stress on plane x - x for the test setup shown in Figure 4. (γ_{sat} = 19.5 kN/m^3).

Effective stress (σ') = Total stress (σ) – Pore water pressure (u)

Effective stress on downward seepage:

$$\sigma' = \gamma_{sub} z + jz = \gamma_{sub} z + iz\gamma_w$$

Effective stress on upwards seepage:

$$\sigma' = \gamma_{sub} z - jz = \gamma_{sub} z - iz\gamma_w$$

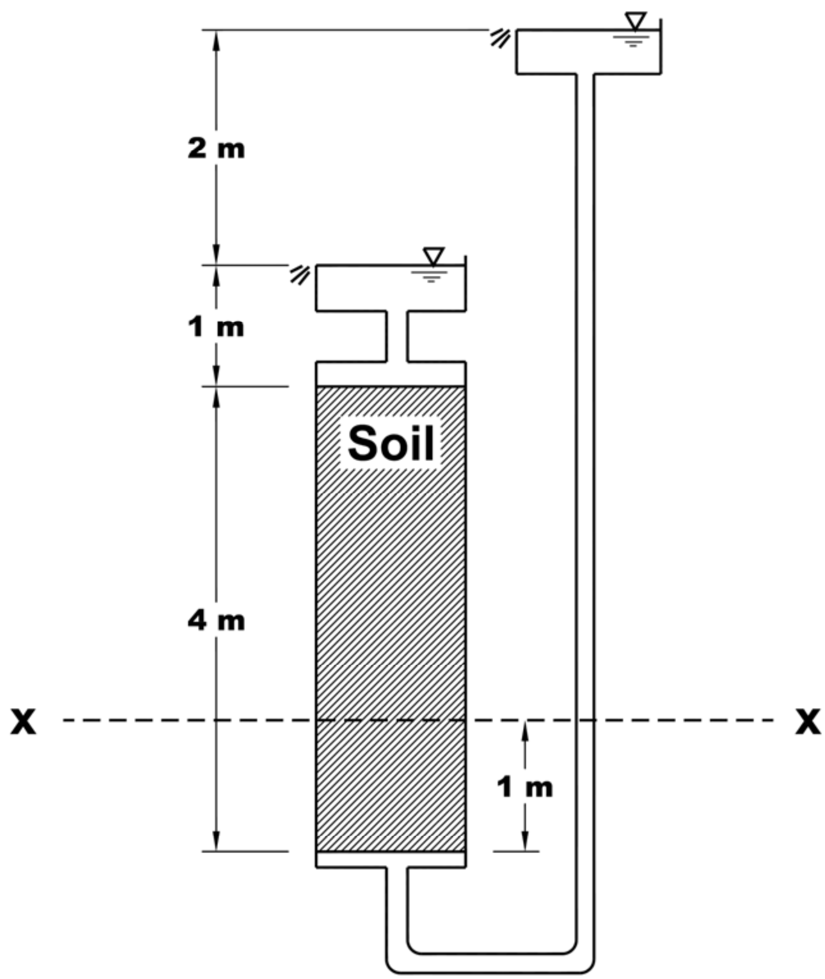

Figure 4