

**Carleton University**  
**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**CIVE3208/ERTH4107 Geotechnical Mechanics**

Midterm Oct. 23, 2009 (1.5 hours)

Closed book, calculators permitted

Question # 1 (30 marks)

- a) Give the name of two commonly used soil classification systems. (4)
- b) Define two common clay fabrics and their general physical properties. (5)
- c) What is the most distinguishing characteristic of a Montmorillonite clay? (3)
- d) What is the optimum water content of a soil? (3)
- e) Define permeability and state that which of the following soils have higher permeability? SC, CL (5)
- f) Why during the construction of a clay landfill liner is it specified that the clay be compacted 1-3 % wet of the optimum water content? (5)
- g) The capillary fringe is the tension saturated zone above the watertable. Why doesn't gravity drainage occur in the capillary fringe and how does the capillary fringe in a sand compare to the capillary fringe in a clay. (5)

Question # 2 (10 marks)

The minimum and maximum void ratios for typical silica sands are 0.46 and 0.66, respectively. What is the corresponding range of saturated unit weights in  $\text{kN/m}^3$ ? ( $G_s = 2.70$ )  
What is the volume of water contained in a cubic metre of this soil if the soil is compacted to its minimum void ratio (0.46) and the degree of saturation is 50 percent?

Question # 3 (10 marks)

Prove the following relationship: 
$$\gamma = \frac{G_s(1+w)}{1+e} \gamma_w$$

Question # 4 (20 marks)

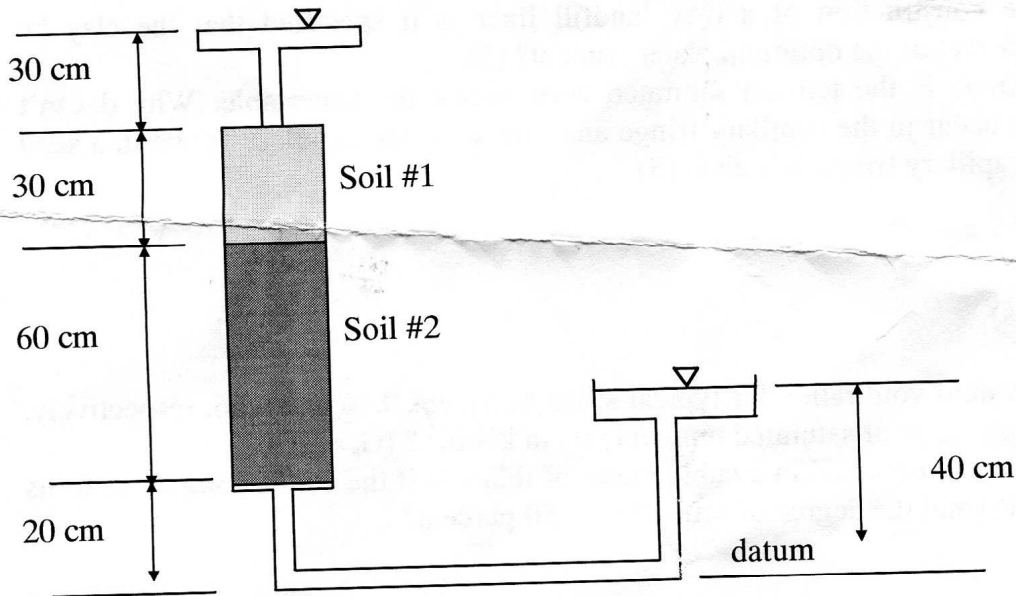
A city inspector checked the field compaction of a soil layer using the sand cone method to determine the volume of the soil excavated. The contract specifications call for the soil to be compacted to at least 95 % of the maximum laboratory value and within  $\pm 2$  % of the optimum water content. The maximum dry density of the soil from compaction test in the lab was 1.9

$\text{g}/\text{cm}^3$ . The volume of the soil excavated was  $1153 \text{ cm}^3$  and its mass was  $2209 \text{ g}$ . The dry mass of the soil was later determined to be  $1879 \text{ g}$ . ( $G_s = 2.70$ )

- What is the dry density of the soil layer?
- What is the relative compaction?
- Does the test meet specifications?
- If the soil sample were saturated, what would be the water content?

Question #5 (20 marks)

Two reservoirs are connected to the soil column given below. If the cross-sectional area of the soil column is  $10 \text{ cm}^2$ ,  $k_1$  is  $3 \times 10^{-2} \text{ cm/s}$  and  $k_2$  is  $1 \times 10^{-5} \text{ cm/s}$  and the soil porosity for both soils is  $0.333$ , determine the flow through the column, the darcy velocity and the seepage velocity.



Question #6 (10 marks)

Calculate the vertical effective stress at a depth of  $5 \text{ m}$  at a site where there is a deep and homogeneous deposit of gravel and the water table is  $2 \text{ m}$  below the soil surface. The bulk and saturated unit weights of the gravel are  $\gamma = 19 \text{ kN/m}^3$  and  $\gamma_{\text{sat}} = 20 \text{ kN/m}^3$ .

**Formula Sheet**

$$e = \frac{n}{1-n} \quad , \quad n = \frac{e}{1+e} \quad , \quad \rho = \frac{G_s(1+w)}{1+e} \rho_w \quad , \quad \gamma = \frac{G_s(1+w)}{1+e} \gamma_w$$

$$\gamma_{sat} = \frac{G_s + e}{1+e} \gamma_w \quad , \quad \gamma_d = \frac{G_s}{1+e} \gamma_w \quad , \quad \gamma_d = \frac{\gamma}{1+w} \quad , \quad \gamma' = \gamma_{sat} - \gamma_w$$

$$S = \frac{G_s w}{e} \quad i_c = \frac{\gamma'}{\gamma_w}$$

$$PI = LL - PL \quad , \quad LI = \frac{w_n - PL}{PI} \quad , \quad A = \frac{PI}{\% \text{ finer than } 2 \mu\text{m, by weight}}$$

$$v = ki \quad , \quad Q = Aki \quad \bar{K}_{x(\text{Horizontal})} = \frac{K_1 Z_1 + K_2 Z_2}{Z_1 + Z_2} \quad \bar{K}_{z(\text{Vertical})} = \frac{Z_1 + Z_2}{\frac{Z_1}{K_1} + \frac{Z_2}{K_2}}$$

$$e = \frac{V_{vs}}{V_w}$$

$$n = \frac{V_w}{V_v}$$

Test 1

Time: 1 hour 20 minutes

Answer all three questions.

[MARKS]

Question 1

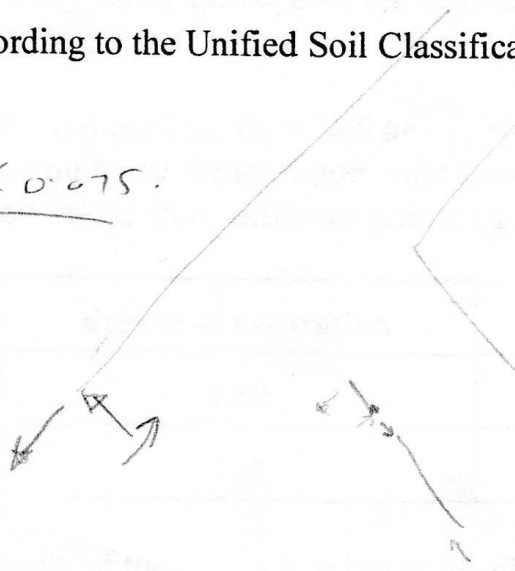
[25] Given the sieve analysis and plasticity data for the following two inorganic soils:

Sieve Size	Opening mm	Soil 1, % Finer	Soil 2, % Finer
No. 4	4.75	100.0	97
No. 10	2.00	93.2	90
No. 40	0.425	81.0	40
No. 100	0.15	69.0	8
No. 200	0.075	60.2	4
LL		42	-
PL		24	-
PI			NP*

\* Nonplastic.

classify the two soils according to the Unified Soil Classification System.

4% < 0.075.



**Question 2**

A  $1.2 \text{ m}^3$  soil sample weighs 20 kN. Its moisture content is 35%. With reference to the phase diagram in Figure 1, determine the following for this soil sample: (take  $\gamma_w = 9.81 \text{ kN/m}^3$ ,  $G_s = 2.71$ ).

- [2] (a)  $W_w$  ✓
- [2] (b)  $W_s$  ✓
- [2] (c)  $V_w$  ✓
- [2] (d)  $V_s$  ✓
- [2] (e)  $V_a$  ✓
- [2] (f) void ratio ✓
- [2] (g) degree of saturation ✓
- [2] (h) dry unit weight ✓
- [4] (i) how much water in kN is needed to saturate  $1.0 \text{ m}^3$  of the sample
- [2] (j) the liquidity index if the liquid limit = 50% and the plastic limit = 25%

Handwritten calculations:  
 $\frac{5.815}{5.87}$   
 $V_w = 0.53$   
 $V =$   
 $0.1 = \frac{V_s}{V_s}$

Phase Diagram

Volume			Weight	
$V_a$		air	$W_a$	
$V_w$		water	$W_w$	
$V_s$		solid	$W_s$	

**Question 3**

[20] Relative density tests on a dry sandy gravel give the densest unit weight and loosest unit weight of  $20.1$  and  $14.5 \text{ kN/m}^3$ , respectively.

If the specific gravity of the soil particle,  $G_s = 2.65$  and  $\gamma_w = 9.81$ ,

- (a) Determine the maximum and the minimum void ratios of the soil.
- (b) Samples of the soil taken from different points in the field show the following characteristics.

Location	degree of saturation	moisture content
1	0.50	0.13
2	1.0	0.15

Determine the relative density of the soil as it exists at the above two locations.