

NAME: KEY

CE 317

Introduction to Geotechnical Engineering

Fall 2009

Midterm I

Please read carefully all the questions before answering. This exam is open book and open notes, however, past exams and homework solutions are not allowed in the exam. THE QUESTIONS SHOULD ALL BE CLEAR AND ALL NECESSARY INFORMATION IS INCLUDED, however, if you believe that you must make some assumptions to answer a question, state those assumptions clearly. The exam time is 50 min. Good Luck.

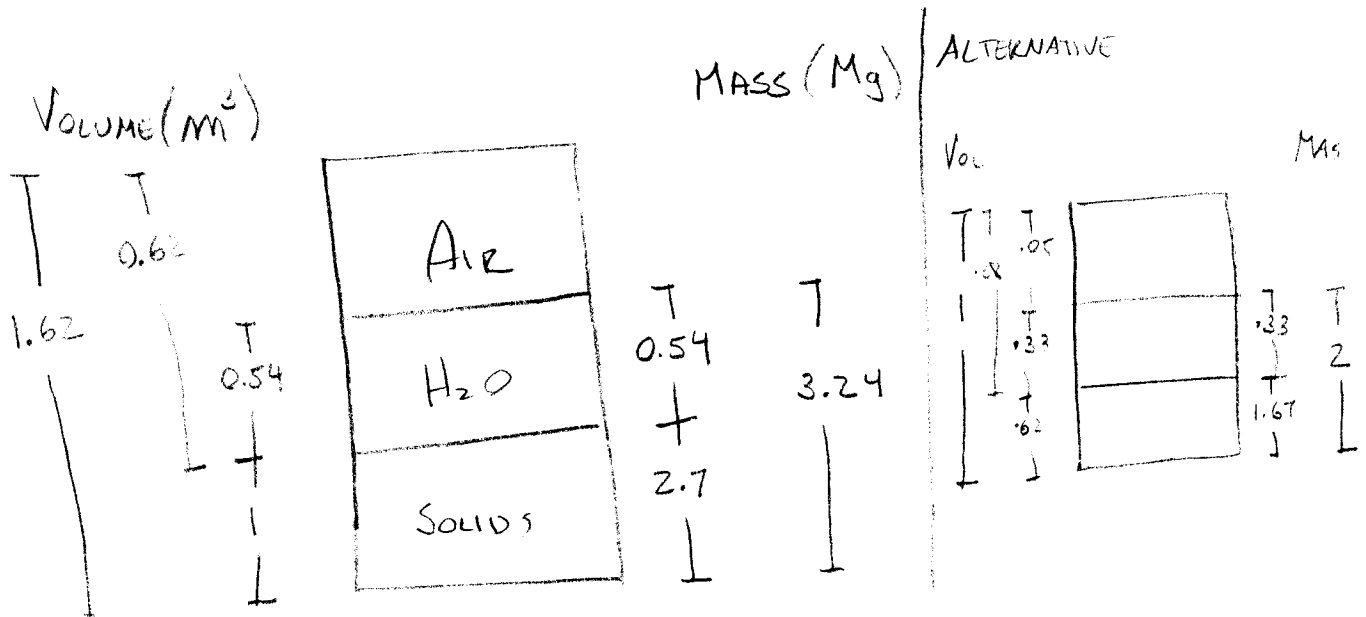
1	-	10 pts	_____
2	-	10 pts	_____
3	-	10 pts	_____
4		10 pts	_____
5		10 pts	_____
Total		50 pts	_____

Question 1.

The following ratios were measured for a sand sample in a laboratory test:

Water content	$\omega = 20\% = M_w/M_s$
Density of the solids	$\rho_s = 2.7 \text{ Mg/m}^3 = M_s/V_s$
Total Density	$\rho = 2.0 \text{ Mg/m}^3 = M_T/V_T$

Compute the degree of saturation and the saturated density of the soil



START WITH $V_s = 1 \text{ m}^3$ (see phase diagram)

$$V_s \rightarrow M_s \rightarrow M_w \begin{cases} M_T \\ V_w \end{cases} \rightarrow V_T \rightarrow V_v$$

$$S = \frac{V_w}{V_v} = \frac{0.54}{0.62} = 0.871 = 87.1\%$$

$$\rho_{SAT} = \frac{V_v \rho_w + M_s}{V_T} = \frac{0.62 \text{ m}^3 \cdot 1 \text{ Mg/m}^3 + 2.7 \text{ Mg}}{1.62 \text{ m}^3} = 2.05 \text{ Mg/m}^3$$

Question 2

The borrow soil used in the compaction of a highway is tested using both a Modified and a Standard Proctor test. Results for the tests are shown below in Figure Q3. Based on these tests, compaction specifications for a job state:

- Relative Compaction of 95% with respect to the standard proctor
- water content within 2% of the optimum water content

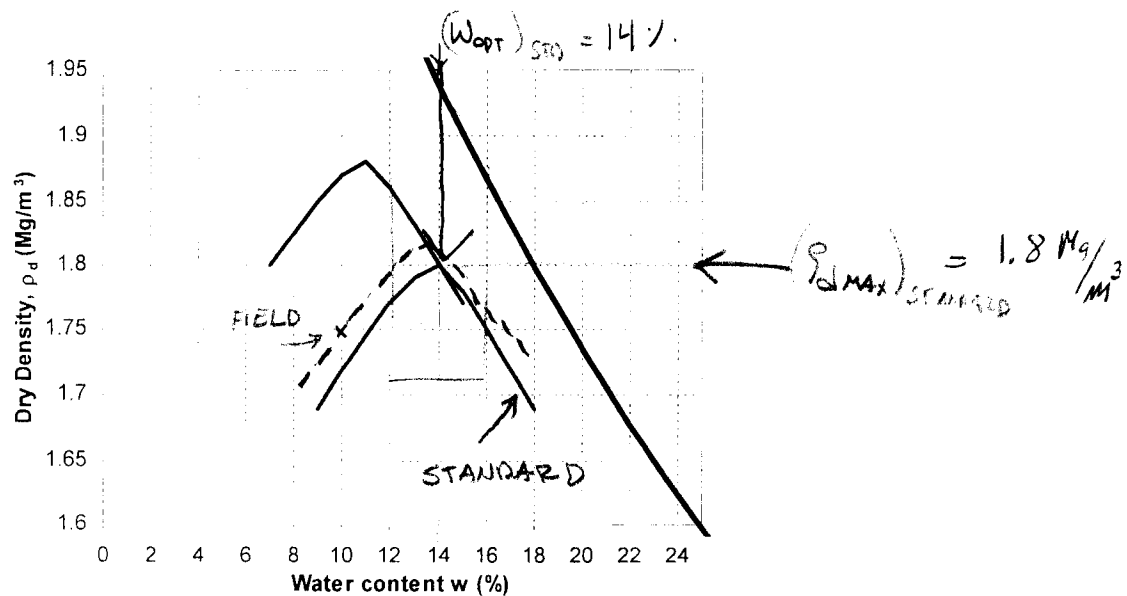


Figure Q3. Standard and modified proctor tests

A field compaction test yielded the following index properties:

$\omega = 10\%$
 $\rho = 1.93 \text{ Mg/m}^3$

a) Does this field test satisfy compaction specifications? Clearly justify your answer.

$RC = 95\% = \frac{\rho_{d, \text{field}}}{\rho_{d, \text{max}}} \Rightarrow (\rho_{d, \text{field}})_{\text{TARGET}} > 0.95 \rho_{d, \text{max}} = 0.95 (1.8) = 1.71 \text{ Mg/m}^3$

FROM TEST $\rho_{d, \text{field}} = \frac{\rho}{1 + \omega} = \frac{1.93}{1.1} = 1.75 \text{ Mg/m}^3 > 1.71 \text{ Mg/m}^3 \Rightarrow \text{OK, BUT } \omega_{\text{field}} = 10\% < \omega_{\text{opt}} - 2\%$

NOT ACCEPTABLE

b) If your answer to a is NO, how can the contractor achieve the target compaction? (circle ALL the correct answers)

- A. Add water to the soil ← THIS WOULD BE ENOUGH, ADD BETWEEN 2% TO < 6% WATER/UNIT MASS OF SOLIDS
- B. Use larger equipment
- C. Add water to the soil and use larger compaction equipment
 ↑ NOT THE MOST ECONOMICAL

Question 3

Give the USCS classification for a soil with the following characteristics:

% passing #4 sieve (by weight) = 90%
 % passing #200 sieve (by weight) = 9%
 $C_u = 7$
 $C_c = 2.1$
 $LL = 40, PL = 30$

% FINES = 9% (NOTE: $> 5\%$ AND $< 12\%$ \Rightarrow DUAL CLASS)

% GRAVEL = 10%

% SAND = 81% \leftarrow SOIL IS A SAND \Rightarrow S? - S?

FOR A SAND W IF $C_u > 6$ \checkmark
 $1 < C_c < 5$ \checkmark \Rightarrow Well sorted

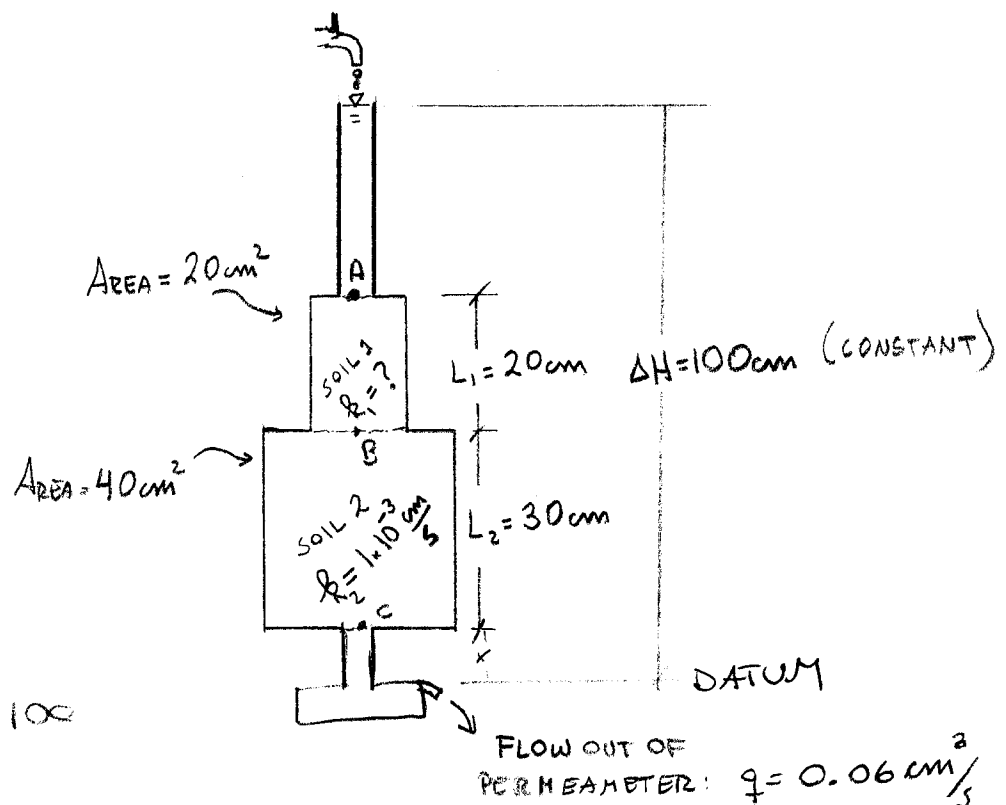
$LL = 40$
 $PL = 30$ $\Rightarrow PI = 10 \Rightarrow OL$ or ML (NO MENTION OF ORGANIC MATERIAL)

HENCE

SW - SM

Question 4

Consider the permeameter shown below. The flow in the permeameter is maintained at a steady state and the measured flow rate is $0.06 \text{ cm}^3/\text{s}$. What is the permeability of soil 1?



$$\text{@ A} \rightarrow \left. \begin{array}{l} z_A = 50 \\ p = 50 \end{array} \right\} h_A = 100$$

$$\text{@ C} \rightarrow \left. \begin{array}{l} z_C = x \\ h_f = 100 - x \end{array} \right\} h_C = 0$$

CONTINUITY

$$q_1 = q_2$$

$$k_1 \frac{h_A - h_B}{20} A_1 = k_2 \frac{h_B - h_C}{30} A_2$$

USE THIS

FLOW THROUGH SOIL 2

$$q_2 = k_2 \frac{h_B - h_C}{30 \text{ cm}} A_2 = 0.06 \frac{\text{cm}^3}{\text{s}}$$

$$h_B = \frac{0.06 \text{ cm}^3/\text{s} \cdot 30 \text{ cm}}{\frac{1}{1.10} \text{ cm/s} \cdot 40 \text{ cm}^2} + 0 \quad h_C$$

$$h_B = 45 \text{ cm}$$

$$k_1 = \frac{k_2}{A_1} \frac{h_A - h_B}{L_1} \frac{A_2}{L_2}$$

$$k_1 = 1.10 \frac{\text{cm}^2}{\text{s}} \frac{(45 - 0)/20}{(100 - 45)} = 1.1 \times 10^{-2} \text{ cm/s}$$

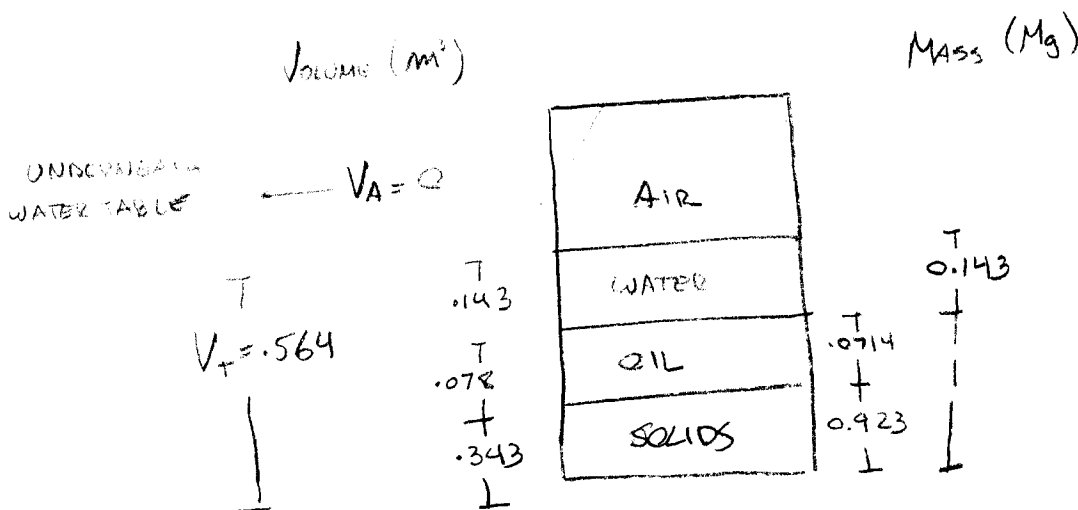
Question 5

A soil underneath the water table has been contaminated with oil. The density of the oil is 0.92 Mg/m^3 and the density of the soil solids is 2.71 Mg/m^3 . A water content test was conducted at a relatively low temperature such that after heating the sample, only the water had evaporated. The measures taken during the test are:

$$\left. \begin{array}{l} \text{Mass of can} = 200 \text{ g} \\ \text{Mass of can + soil sample (before heating)} = 280 \text{ g} \\ \text{Mass of can + soil sample (after heating)} = 270 \text{ g} \end{array} \right\} \begin{array}{l} M_{oil} + M_{water} + M_c = 80 \text{ g} \\ M_s + M_{oil} = 70 \text{ g} \\ M_w = 10 \text{ g} \end{array}$$

A separate test indicated that the proportion of water to oil is 2:1 (by mass).

Compute the density of the contaminated soil



FROM TEST

$$\frac{M_w}{M_s + M_{oil}} = \frac{1}{7}$$

$$\text{Let } (M_{oil}, M_{sol}) = 1 \text{ Mg} \rightarrow M_w = \frac{1}{7} = 0.143 \rightarrow M_o = \frac{M_w}{2} = 0.0714$$

$$M_s = 1 - 0.0714 = 0.928 \text{ Mg} \rightarrow V_s = \frac{M_s}{\rho_s} =$$

$$V_o = \frac{M_o}{\rho_o} = \frac{0.0714}{0.92}$$

$$\rho = \frac{M_T}{V_T} = \frac{1.143 \text{ Mg}}{.564 \text{ m}^3} = 2.03 \text{ Mg/m}^3$$