Department of
Civil and Environmental Engineering

1865 THE UNIVERSITY OF MAINE

308 Boardman Hall
Orono, Maine 04469-5711
Tel: 207.581.1277
Fax: 207.581.3888
Email: luis.zambranocruzatty@maine.edu

CIE-365 Spring 2022: Homework assignment 2

Due date: 02/09/2022 at 10:00 AM
Possible points: 80

Answer the following questions based on the contents of Module 2.

1. [O1] (10 points) Using phase diagrams derive equations 1, and 2:

$$\gamma_t = G_s\gamma_w(1-n) + nS\gamma_w \tag{1}$$

$$\gamma_t = G_s\gamma_w(1-n)(1+w) \tag{2}$$

where γ_t is the total or moist unit weigh, G_s is the specific gravity, γ_w is the water unit weight, n is the porosity, S is the degree of saturation, and w is the water content.

2. [O1] (5 points) A sand has a natural water content of 5% and a total unit weight of $\gamma_t = 18.0$ kN/m^3. The void ratios corresponding to the densest and loosest state of this soil are $e_{min} = 0.51$ and $e_{max} = 0.87$ respectively. Find the relative density and degree of saturation.

3. [O1] (5 points) A saturated clay encountered in a deep excavation has a water content of $w = 25\%$. Determine the void ratio and saturated unit weight, knowing that $G_s = 2.70$.

4. [O1] (15 points) A laboratory test determined that the minimum and maximum void ratios of some gravel are $e_{min} = 0.2$ and $e_{max} = 0.95$ respectively. In a construction site, the gravel was used as fill for a 20m long retaining wall shown in figure 1. It was determined that the in-situ moist unit weight was $\gamma_t = 20$kN/m^3 with a moisture content of $w = 8\%$. a) Determine the in-situ void ratio of the gravel, b) its relative density, c) minimum and maximum dry densities. d) If the gravel is transported from its source with a relative density of $D_r = 23\%$ and moisture content of $w = 1\%$, what is the volume of gravel transported from its source to the site?. Use $G_s = 2.67$.

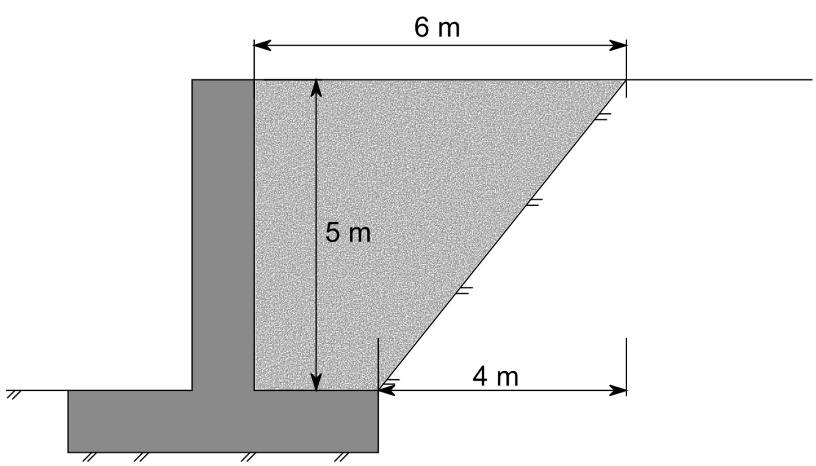

Figure 1: Sketch of retaining wall geometry for problem 4.

5. [O1] (3 points) Table 1 shows results obtained from a liquid limit test on a clay using the Casagrande cup device.

   (a) Determine the liquid limit of this clay.

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Table 1: Test results for problem 5.

Number of blows	6	12	20	28	32
Water content (%)	52.5	47.1	43.2	38.6	37

(b) If the natural water content is 38% and the plastic limit is 23%, calculate the liquidity index.

6. [O1] (6 points) Table 2 shows the data recorded from a liquid limit test on a clay using the Casagrande cup device.

Table 2: Test results for problem 6.

Test number	**Container (g)**	**Cont. and wet soil (g)**	**Cont. and dry soil (g)**	**Blow count**
	W_c	W_w	W_d	N
1	45.3	57.1	54.4	28
2	43.0	59.8	56.0	31
3	45.2	61.7	57.9	22
4	45.6	58.4	55.3	18

(a) Determine the liquid limit.

(b) If the plastic limit is 15% and the soil contains 45% clay, calculate the activity.

(c) Is the soil active?. Do you expect swelling with moisture content changes?.

7. [O1] (26 points) Base on the results of sieve analysis shown in Table 3 and 4 perform the following tasks:

(a) Plot the GSD curves for soils A trough F in 5-cycle semilogarithmic space.

(b) For each of the soils determine the effective size as well as the uniformity coefficient and the coefficient of curvature.

(c) Determine the percentages of gravel, sand, silt, and clay according to the USCS.

(d) Determine the plastic index, liquidity index, and activity when possible.

(e) Classify each soil according to the USCS

8. [O1] (10 points) For the data in Table 5 ($G_s = 2.64$):

(a) Plot the compaction curves.

(b) Establish the maximum dry density and optimum water content for each test.

(c) Compute the degree of saturation at the optimum point for data in column A.

(d) Plot the 100% saturation (ZAV) curve. Also plot the 70, 80, and 90% saturation curves. Plot the line of optimums.

Note: [O1] indicates the course objective that is partially covered by this assignment.

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Table 3: Sieve and hydrometer analysis results for problem 7.

U.S. Standard Sieve No. or Particle Size	Percent Passing by Weight					
	Soil A	Soil B	Soil C	Soil D	Soil E	Soil F
75 mm (3 in)	100		100			
38 (1-1/2)	70		-			
19 (3/4)	49	100	91			
9.5 (3/8)	36	-	87			
No. 4	27	88	81		100	
No. 10	20	82	70	100	89	
No. 20	-	80	-	99	-	
No. 40	8	78	49	91	63	
No. 60	-	74	-	37	-	
No. 100	5	-	-	9	-	
No. 140	-	65	35	4	60	
No. 200	4	55	32	-	57	100
40 μm	3	31	27		41	99
20 μm	2	19	22		35	92
10 μm	1	13	18		20	82
5 μm	<1	10	14		8	71
2 μm	-	-	11		-	52
1 μm	-	2	10		-	39

Table 4: Atterberg limits conducted on soil samples for problem 7.

Property	Soil A	Soil B	Soil C	Soil D	Soil E	Soil F
w_n [%]	27	14	11	8	72	
LL [%]	13	35	35	-	28	60
PL [%]	8	29	18	NP	NP	28

Table 5: Results of compaction tests for problem 8.

A: modified		B: standard		C: low energy	
γ_d [kN/m^3]	w [%]	γ_d [kN/m^3]	w [%]	γ_d [kN/m^3]	w [%]
18.37	9.3	16.59	9.3	15.96	10.9
18.73	12.8	16.82	11.8	16.08	12.3
17.69	15.5	17.22	14.3	17.07	16.3
16.67	18.7	17.14	17.6	16.75	20.1
16.10	21.1	16.53	20.8	16.16	22.4
		15.88	23		