

CIE-365 Spring 2022: Homework assignment 2

Due date: 02/07/2022 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:

$$\gamma_t = G_s \gamma_w (1 - n) + n S \gamma_w \quad (1)$$

$$\gamma_t = G_s \gamma_w (1 - n)(1 + w) \quad (2)$$

where γ_t is the total or moist unit weight, 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 $\gamma_t = 18.0 \text{ kN/m}^3$. 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 $\gamma_t = 20 \text{ kN/m}^3$ 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 $G_s = 2.67$.

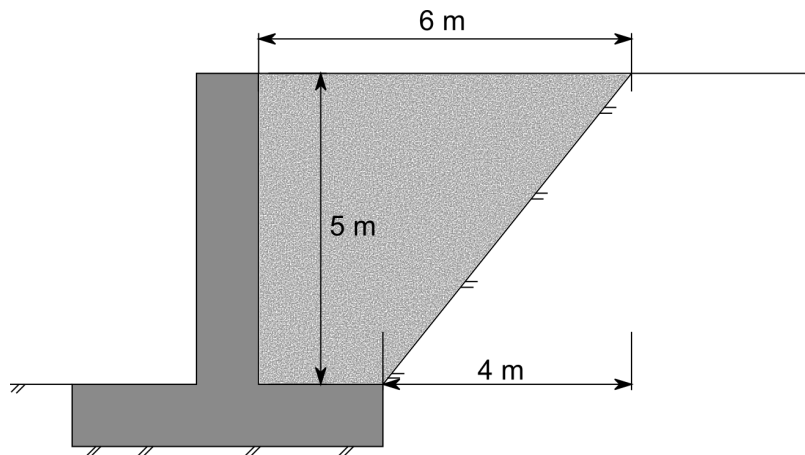


Figure 1: Sketch of retaining wall geometry for problem 4.

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.

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 through 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.

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		