Department of
Civil and Environmental Engineering

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 3

Due date: 02/21/2022 at 10:00 AM
Possible points: 50

Answer the following questions based on the contents of Module 4.

1. [O2] (8 points) Watch the this video and answer the following questions:
   (a) What is needed for frozen heave to occur?
   (b) Using a schematic figure, explain the mechanism of frost-heaving and thaw deformations in frost-susceptible soils.
   (c) What are the consequences of frost-susceptible soils in pavements.
   (d) List three mitigation techniques to prevent distress from frost-susceptible soils.

2. [O1] (6 points) During the shrinkage limit test on a silty clay, the volume of the dry soil pat was found to be 10.76 cm^3 and its dry mass was 22.68 g. If the shrinkage limit was 11.1 %, what is the density of the soil solids?

3. [O1] (6 points) Estimate the swelling potential of soils A-F with poperties in Tables 1 and 2 using Figure 1.

Table 1: 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

4. [O2] (12 points) The soil profile shown in Figure 2 illustrates three cases:
   (a) The water table is at $h = 10$ m.
   (b) The water table is at the surface $h = 0$ m.
   (c) A case in which the water table is at $h = 36$ m.

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

Table 2: 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

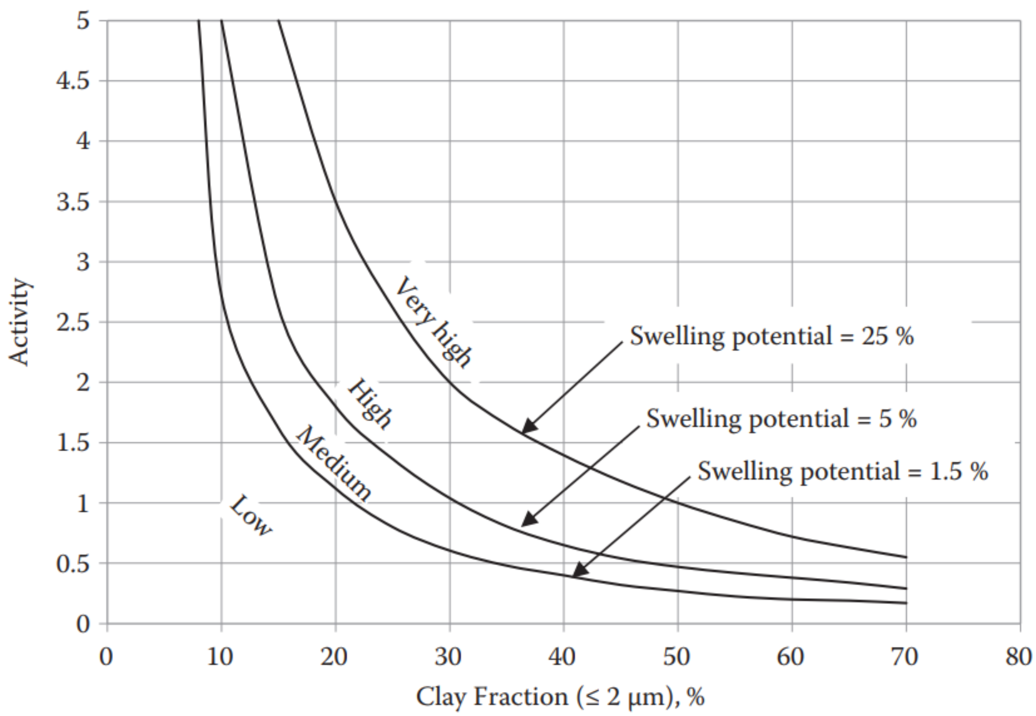

Figure 1: Classification chart for swelling potential. (Reproduced from Ishibashi and Hazarika 2010 after Seed et. al, 1962).

The depth of points A, B, and C are $z_A = 20$ m, $z_B = 45$ m, and $z_C = 70$ m respectively. In all cases compute:

- The total vertical stress at points A, B, and C
- The effective vertical stress at points A, B, and C.
- Draw the profile of vertical total stress (σ_v vs. z).
- Draw the profile of vertical effective stresses (σ_v' vs. z).
- What is the effect of a rising water table on the vertical effective stresses (i.e., comparison between case a) and b))?
- What is the effect of dewatering the soil profile on the vertical effective stresses (i.e., comparison between soil profile a) and c))?

Note: For soils above and below the water table, the dry and saturated unit weights are given. You can use the water content above the water table to calculate the total unit weight at that location.

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

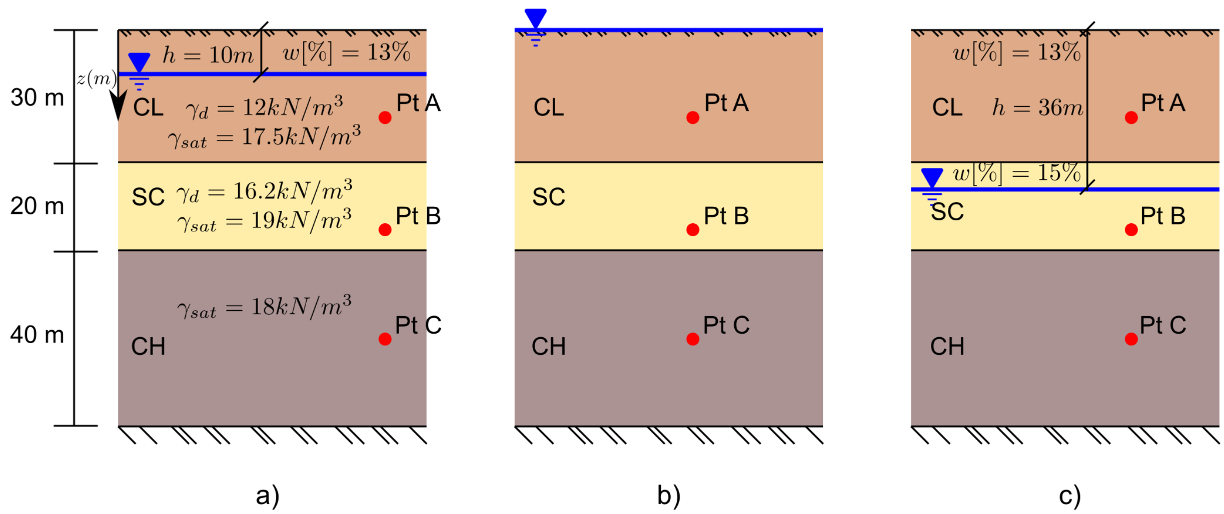

Figure 2: Soil profiles for problem 4

5. [O2] (10 points) A falling-head permeability test is to be performed on a soil whose permeability is estimated to be 3×10^{-7} m/s. What diameter standpipe should you use if you want the head to drop from 27.5 cm to 20 cm in about 5 min? The sample's cross section is 15 cm^2 and its length is 8.5 cm. (Afte Taylor, 1948.)

6. [O2] (8 points) A canal is dug parallel to a river, as illustrated in figure 3. The soil profile consists of silty sand surrounded by an impermeable high plasticity clay. The average thickness of the sand layer is $d_{av} = 0.5$ m, and it has a width of $W = 30$ m. The elevations of the entrance, exit points, canal, and river water table are marked in the figure 3. Determine:

   (a) The total head at the canal's entrance point and the exit point in the river.

   (b) The hydraulic gradient between the canal and the river.

   (c) The flow per unit of length from the canal to the river.

   (d) If the sand layer has a specific gravity $G_s = 2.65$, and saturated unit weight $\gamma_{sat} = 17.5$ kN/m^3. Determine the Darcy and the true flow velocity in the sand layer.

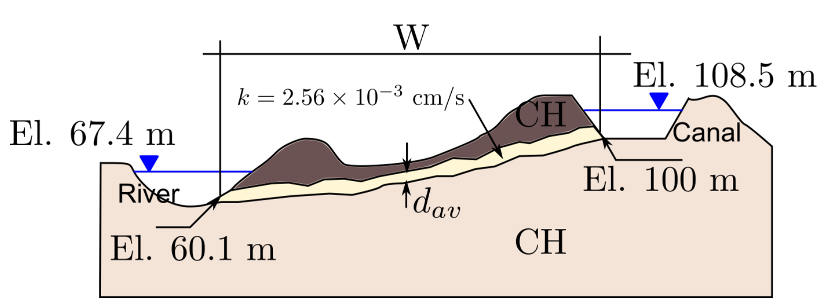

Figure 3: Cross-sectional profile for problem 6.

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