

1.103 CIVIL ENGINEERING MATERIALS LABORATORY (1-2-3)

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LABORATORY ASSIGNMENT NUMBER 8

SOIL CLASSIFICATION AND INDEX TESTING

Purpose: During this lab you will learn about:

- (1) The Unified Soil Classification System
- (2) Particle size analysis for coarse grained soils
- (3) Particle size analysis for fine grained soils
- (4) Plasticity of fine grained soils
- (5) Differences between coarse and fine grained soils

Reading:

Read this handout and know what will be done in the lab
ASTM Standards

- D2487 Identification and Classification
- D2488 Identification and Classification
- D821, 422, 1140, 2217 Grain size analysis
- D4318 Atterberg Limits
- D2216 Water content

Organization:

- Meeting A 110 minute *Group* exercise to conduct tests
- Meeting B 10 minutes *Individual* to measure water content
- Data Will be posted seven days after each Group meeting

Handouts:

- Sieve Analysis data sheet
- Hydrometer data sheet
- Grain size graph with USCS designations
- Atterberg limit data sheet
- Plasticity chart

Overview:

Today's lab will be very busy and loosely structured. You will be conducting three different types of tests. You need to do the mechanical sieve analysis on three soils. One is the coarse aggregate that you used to make the concrete. The second is the fine aggregate (sand) that you used to make the concrete. Remember that both of these materials have been processed for a particular application (making concrete) by the supplier. Therefore, the grain size distribution is

not that of a natural soil. The third material is a natural till (glacial deposit) from the Boston area.

You will also be working with two fine grained cohesive soils. For these materials you will measure the grain size distribution with the sedimentation test and the plasticity with the Atterberg Limit tests. The sedimentation experiments normally take several days to perform the entire test. The two sedimentation tests have been set up for the lab and all you need to do is take the time measurements during the class. We will supply you with the rest of the readings and the information required to complete the calculations. The Atterberg Limit measurements also take several days to complete. You can perform the Atterberg Limit physical test during the lab period but the water content measurements require the soil to be oven dried for 24 hours. This means that you need to return to the laboratory sometime during the week to measure the mass of the oven dried specimen. The following paragraphs outline the complete test procedures.

Procedure:

Particle Size Analysis

Mechanical Sieve for Coarse grained soils

1. Select the appropriate sieve sizes depending on the maximum particle size. See ASTM for guidelines.
2. Carefully clean each sieve (do not scrape across the sieve with hard objects because this will enlarge the holes).
3. Measure and record the mass of each empty sieve.
4. Measure the mass of the dry coarse grained soil.
5. Stack the largest five sieves on the pan.
6. Place the soil into the top sieve and cover.
7. Lock the sieve stack into the sieve shaker and shake for 5 minutes.
8. If more than 5 sieves are required assemble a second stack of five. You can include the smaller sieves of the first stack to create a complete second stack.
9. Place the soil from the pan into the first new sieve size of the second stack.
10. Place in the shaker and shake for 5 minutes.
11. Measure the mass of each sieve with the soil.
12. Examine the size, shape and color of the particles retained on each sieve. Add a short description to each size range.

Sedimentation for fine grained soils

1. Obtain the equivalent of 60 gm of dry soil.
2. Mix the soil to a thick slurry using 5.00 grams of sodium hexametaphosphate and distilled water as necessary.
3. Allow the solution to soak for 16 hrs.
4. Mix the slurry in a blender for 60 seconds.
5. Transfer to 1000 ml cylinder and fill with distilled water. Be sure to transfer all the soil.
6. Place in temperature bath.

7. *Everything up to this point has been completed prior to the class.*
8. Mix thoroughly with plunging rod and begin sedimentation experiment.
9. Obtain two sets of specific gravity readings (r_h) for the first two minutes of sedimentation with the hydrometer remaining in suspension. Obtain readings at 15, 30, 60, 90, 120 seconds.
10. Be sure to read the hydrometer to the nearest 0.2 division at top of meniscus.
11. Remix the slurry and obtain readings at 2, 4, 8, 16 minutes, etc.
12. We will take readings for at least two days or until suspension is clear and provide this data to you.
13. At the end of the experiment, obtain the final dry weight of soil with the sodium hexametaphosphate. *We will also provide you with this number.*

Hydrometer Calibration

1. Correct the hydrometer readings for temperature, the dispersing agent and the meniscus by taking the specific gravity reading (r_w) of a liquid composed of distilled water and dispersing agent in the same proportion as in the sedimentation test. Obtain this correction each time the sedimentation specific gravity is measured.

Note: Wash the hydrometer between readings.

2. Calculate (and plot) the effective depth (H) of the hydrometer versus the hydrometer reading.
 - a) Determine the center of volume as the midpoint of the bulb.
 - b) Calculate the reading depth (H_r) as the distance from a particular reading and the center of volume.
 - c) During the first 2 minutes of a test, the effective depth is the reading depth plus the meniscus correction (c_m = top to bottom of meniscus).
 - d) Calculate the area of the cylinder (A_j) from the volume and distance between calibration marks.
 - e) Measure the volume of the hydrometer (V_h) by water displacement.
 - f) For readings after 2 minutes, the effective depth is

$$H = H_r - (V_h/2A_j) + c_m$$

Plasticity and the Atterberg Limits

Liquid Limit by the Casagrande Cup

1. Never oven dry soil prior to tests.
2. Sieve soil through US #40 sieve and obtain natural water content ω_N .
3. Mix about 100 gm soil to about 15 drop consistency and place covered bowl in humid room for 24 hrs to temper.
4. Place soil in clean calibrated Casagrande cup to maximum depth of 1/2 inch. Be sure to remove entrapped air and have surface smooth.
5. Groove soil with tool perpendicular to the cup at the point of contact.
6. Turn crank at 2 blows/second until groove closes for a length of 1/2 inch and record number of blows.
7. Mix soil in dish and repeat steps 4, 5 and 6 until two consistent blow counts (± 1) are measured.

8. Obtain water content of soil by removing 10 gm of paste perpendicular and across closed groove.
9. Obtain four separate water content determinations between 15 and 35 blows by drying the soil slightly and repeating steps 4 through 8.
10. Plot the water content against log of blows, draw the flow curve and select the liquid limit as the intersection of this curve and the 25 blow line.

Plastic Limit by Hand Rolling

1. Separate about 20 gm of the tempered soil before starting the liquid limit experiment and set aside to dry.
2. Roll 1/3 of soil into 1/8" strand on glass plate.
3. Repeat step 2 until the strand shows signs of crumbling when it reaches 1/8" diameter. This is the plastic limit.
4. Obtain water content.
5. Repeat steps 2 through 4 for the remaining two-thirds.

Calculations:

Grain size

- a) Mechanical Method

The opening size is printed on each sieve.

- b) Sedimentation Method

The maximum diameter still in solution at and/or above the center of volume of the hydrometer is

$$D = \{ 18\eta H / t(\gamma_s - \gamma_w) \}^{1/2}$$

where η = viscosity of water
 t = elapsed time
 γ_s = unit weight of soil
 γ_w = unit weight of water

Quantity of soil less than given size

- a) Mechanical Method

$$N(\%) = \{ (\text{Total mass.} - \Sigma \text{ mass. on larger sieves}) / \text{Total mass} \} \times 100$$

- b) Sedimentation Method

$$N(\%) = \{ V G_s \gamma_c (r_h - r_w) / M_s (G_s - 1) \} \times 100$$

where V = volume of suspension
 M_s = total dry mass of soil

γ_c = unit weight of water at hydrometer calibration temp.
 r_h = hydrometer reading in suspension
 r_w = hydrometer reading in calibration liquid
 G_s = specific gravity (use 2.7)

Report:

Your report should include the following information:

- All the hand recorded data sheets.
- Grain size curves (% passing vs log particle diameter) for each of the five soils. These can all be presented on one graph or separately.
- Tabulated data for grain size analysis of each soil.
- Example calculation for the mechanical and sedimentation analysis.
- Calculate the coefficient of curvature and coefficient of uniformity of each coarse grained soil. Give the USCS classification symbol.
- A graph of the flow curve (water content vs number of blows to close the groove) for each of the fine grained soils. Show on each graph your determination of the liquid limit.
- The Plasticity Chart (plasticity index Vs liquid limit) showing the location of the two fine grained soils. Indicate the four major classification groupings.
- A table giving the liquid limit, plastic limit, plasticity index, % clay fraction, activity, and USCS classification for each of the fine grained soils. Include a short description of the soil.