Atterberg Limits

Geotechnical Engineering Laboratory 3

1. General Notes

- All equipment must be cleaned and returned to the proper location before anyone leaves. All stations, benches, and tables must be cleaned before group leaves the lab.
- DO NOT share data with other groups or compare data.
- DO NOT fudge your data to make results “better”. If there are problems with the data or results, discuss what went wrong and why in the report. If you are not sure why, make an educated guess.
- Be careful when removing samples from ovens - always use appropriate gloves.

2. Lab Procedures

2.1 Enter names onto the data sheet (attached).

2.2 Preparatory work

2.2.1 A sample has been prepared for each group. Locate the sample. The sample has been hydrated for 24h to distribute moisture. The sample has also been screened over the #40 sieve.

2.2.2 Weigh out the four sample cups provided. Also, write down the label of the cups for identification upon removal from the oven.

2.2.3 Obtain a liquid limit device, a bowl, a container of distilled water, and a spatula. Also get a good spoon.

2.2.4 Obtain a glass plate for the plastic limit test.

2.2.5 See the TA to continue

2.3 Plastic Limit

2.3.1 See the text on p. 43 of the textbook (Holtz, Kovacs, and Sheahan 2011) and Fig 2.10d on p. 42 for further details.

2.3.2 Begin by taking about 1/3 of you entire sample and placing it on the glass plate. Divide the one-third portion of the sample into two equal sized balls. You will do the test on each of the balls and then average the result. Each ball should have a mass of about 20 g.

2.3.3 Take one ball and roll it gently with your fingertips on the glass plate to make a long, skinny thread of soil. If the thread breaks into ¼-in. long pieces when the thread is about 1/8-in. thick, place the pieces in a sample cup you have weighed. Weigh the sample and cup. Record the weight and cup label. Place in the oven for 24 hr. Remove from oven after 24 hr and reweigh. Calculate the water content of the soil ball.
2.3.4 If the thread breaks apart into pieces before it is only 1/8-in. thick, remold into a ball and add a SMALL amount of water (3 or 4 drops) to the ball and re-work it to distribute the moisture throughout the ball. Then repeat process until the thread breaks into pieces 1/8-in. thick.

2.3.5 If the thread rolls out to very thin without breaking up into pieces, it is too wet. If this is the case, you will need to remold into a ball and re-roll the sample until it dries out and breaks as previously described.

2.3.6 Figure 2.10d in the textbook shows how the pieces will look.

2.3.7 Repeat the whole procedure for the second ball of soil.

2.3.8 Average the water content of the two samples; this water content (in percent) is the Plastic Limit, PL.

2.4 Liquid Limit

2.4.1 See pp. 40 and 43 of the textbook and Figure 2.10a-c for further information.

2.4.2 Turn the crank on your liquid limit (LL) device and check the height of fall of the cup, which should be 10 mm exactly. (Use the grooving tool to measure the 10 mm height. The TA can show you how.) If the height of fall is not correct, adjust the device until it is.

2.4.3 The LL test will be conducted by turning the crank at the rate of two blows per second. (Each blow consists of one fall of the cup.) Practice turning the crank and timing the rate of blows until you feel comfortable that you can perform the test at the proper rate.

2.4.4 Take the remaining 2/3 of your total sample. Add a little water to the soil and mix with a spatula. Mix in the porcelain bowl. You want the soil to look like thick and dry peanut butter at this stage. The idea is to start on the dry side of the liquid limit and add water. It is easy to add more water, but very difficult to take it out, so be careful not to get it too wet at this stage.

2.4.5 Take some of the soil and place it on the CLEAN brass cup of your LL device. Use the spatula to smooth out the soil. You want the deepest portion of the soil to be about 8-mm thick.

2.4.6 Take the grooving tool and cut a groove (gently) down the center of the soil in the brass cup. Turn the crank at the proper rate of two blows per second until the groove in the soil closes the width of the reference mark on the grooving tool (the TA can show you what that is). Make sure to count your blows! If you forget to count, you must start over again. Record the number of blows on your data sheet. You want blows of about 40, 30, 20, and 15, meaning you have to repeat the process at least four times.

2.4.7 If you have conducted the test at least four times with the appropriate number of blows within the desired range of 15 to 40, place the entire soil within the brass cup in a sample cup you have weighed, weigh the sample and cup, and place into the oven for 24 hr. After 24 hr, remove the sample, weigh, and record.
2.4.8 If your number of blows is too high, add a little water and repeat. Better to go slowly and add water in small increments. Your patience will be rewarded.

2.4.9 If your number of blows is below 15, dry the sample out as best you can, and repeat. This process is difficult and time-consuming, so do not add too much water at a time. Your patience will be rewarded.

2.4.10 Repeat the cycle until you have 4 samples that have produced blows close to the desired values of 15, 20, 30, and 40.

2.4.11 You should have 4 cups of soil that have been dried when you are finished. Calculate the water content of the soil in each cup. You will need these water contents to calculate the LL.

2.5 CLEAN bench top and all equipment. Return all equipment neatly to where they were obtained. TA will approve your cleaning and dismiss you.

2.6 Discard all dried samples into the appropriate bin as designated by the TA.

3.0 Calculations

- Calculate the LL of your soil, as explained on p. 43 of the textbook. (See also Example 2.12 on pp. 44-45, including Fig. Ex. 2.12 on p. 45.) Use the attached plot to find the water content corresponding to 25 blows. Plot the four pairs of data (water contents and blows). Connect the data points with one best-fit line. (In your report, you may want to plot the data using a computer program and draw a linear regression line using the program.) The water content where the line crosses 25 blows is the LL.
- Calculate the PL of your soil as described in 2.3.8.
- Calculate the Plasticity Index, PI of the sample (Eq. 2.39 on p. 46 of the textbook).
- Calculate the Liquidity Index of the sample (Eq. 2.40 on p. 46). The TA will need to tell you the natural water content $w_n$ of the soil.
- What is the Activity of your sample? Assume the percent passing the #200 sieve is 22%.
- Use Fig. 4.14 (p. 132) and Table 4.1 (p. 33) to determine the type of clay mineral of which your sample was composed.
- Classify the soil you have if percent passing the #200 is 22%. Classify by both AASHTO and USCS.
- Classify the soil you have if percent passing the #200 is 37.5%. Classify by both AASHTO and USCS.
- Classify the soil you have if percent passing the #200 is 95.8%. Classify by both AASHTO and USCS.
- All calculations must conform to departmental report guidelines. Present in the results section of your report.
4.0 Questions

- Answer all questions in the discussion portion of your laboratory report.
- Discuss why roads are built with soils with PI = 0, if possible.
- Of the three soils in classified in the calculations section of this document, which is the best to use as a foundation material? Which is the best to use as a landfill cap? Discuss.
- Why is it important to screen the sample over the # 40 sieve before conducting a test to find the Atterberg limits?
- What are the sources of error in the procedures for the Atterberg limits?
- What is the source of the cohesive soil used in these experiments? (Ask the TA)
Atterberg Limits Data Sheet

Group Member Names: 

Test Date: 

Soil Description: 

<table>
<thead>
<tr>
<th>TEST</th>
<th>PLASTIC LIMIT</th>
<th>LIQUID LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cup Number =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass of Wet Soil + Cup =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass of Dry Soil + Cup =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass Of Cup =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass of Dry Soil =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Content (%) =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Blows =</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Liquid Limit Plot

Blows (Log Scale)

Water Content (%)
Photographs Courtesy of Susan E. Burns and Georgia Institute of Technology

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Casagrande Liquid Limit

Plastic Limit

These photographs can be viewed at larger scale from the JPG files included in the ZIP file for this laboratory experiment.