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| **No and Title of Test:** 3 (a) Atterberg Limit Tests | |
| **Year and Section:** 3rd year – Section 4 | **Lab. Group:** 3 |
| **SURNAME, Other names of student:** | |

**Atterberg Limit Tests**

1. **Liquid Limit Test**

**Object of the Experiment:** To determine the liquid limit of the air-dried soil by Casagrande liquid limit device.

**Apparatus:**



Figure 1 – Casagrande Liquid Limit Device

**Theory:**

The Atterberg limits are the basic measure of the nature of the fine-grained soils. Depending on the water content of the soil, it may appear in four states, which are solid, semi-solid, plastic and liquid. In each state the consistency and behavior of a soil is different. Thus, the boundary between each state can be defined by three limits.

* Shrinkage limit

The shrinkage limit (SL) is the water content where further loss of moisture will not result in any more volume reduction.

### Plastic limit

The plastic limit (PL) is the water content where soil starts to show plastic behavior.

* Liquid limit

The liquid limit (LL) is the water content where a soil changes from plastic to liquid behavior.

By looking at the graph below, one can determine the liquid limit, plastic limit and shrinkage limit values and calculate the corresponding plasticity index value.

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Figure 2 - Atterberg Limits and soil volume relationships

**Method of Test:**

1) The height that the liquid limit device’s cup is lifted adjusted. Thus, at the time the cup is raised to its maximum height, the 10 mm gauge shall just pass between it and the base.

2) An amount of (at least) 200 g air-dried soil ((-) 400 micron sieve) is taken and placed on the plate. Then, distilled water is added slowly and soil is mixed via palette knife until it turns into a thick uniform paste.(addition of excess water should be avoided.)

3) A portion of water-soil mixture is placed in the cup and the surface of paste is leveled (parallel to the base) using the palette knife.

4) By drawing the grooving tool, the soil is divided in the cup along the diameter.

5) The crank is turned at a rate of two revolutions/second till the two soil parts come together along a line of 13 mm length. Provided that the number of drops being between 40 and 60 by that time, 10 g of soil is taken from the flowing parts by the knife and placed in a container in order to determine the water content.

6) The steps from 2 to 5 are repeated several times using the same sample each time adding more water and care should be taken in order not to obtain blows out of a range 10-50 blows. One of the most important things is that the test should always be carried out from the drier to the wetter condition of soil.

7) Each time the test is repeated the cup and grooving tool should be cleaned and the left sample should be covered with a damp cloth to prevent rapid drying.

**Calculations:**

* Mass of moisture = (mass of cont. + wet soil) - (mass of cont. + dry soil)

For 59 drops: 37.1 – 30.5 = 6.6 g

For 33 drops: 36.1 – 29.8 = 6.3 g

For 16 drops: 36.1 – 29.2 = 6.9 g

* Mass of dry soil = (mass of container + dry soil) – (mass of container)

For 59 drops: 30.5 – 13.8 = 16.7 g

For 33 drops: 29.8 – 14.8 = 15.0 g

For 16 drops: 29.2 – 14.0 = 15.2 g

* Moisture Content = 100 \* (mass of moisture/mass of dry soil)

For 59 drops: 100 \* (6.6/16.7) = 39.5%

For 33 drops: 100 \* (6.3/15.0) = 42.0%

For 16 drops: 100 \* (6.9/15.2) = 45.4%

**Reporting of Results:**

By considering the flow curve, we can determine the water content value which corresponds to 25 number of drops as 43.6 % , which is called liquid limit (WL).

1. **Plastic Limit Test**

**Object of the Experiment:** To determine the plastic limit of the soil, i.e., the minimum moisture content at which the soil can be rolled into a thread 3 mm in diameter without breaking.

**Apparatus:**

- A glass plate.

- A palette knife.

- Moisture content apparatus.

- 400-micron sieve.

- A non – corrodible airtight container.

**Method of Test:**

1) Take about 20 g of the air-dried soil passing the 400 micron sieve, and mix it with distilled water until it can be formed into two balls. Place one of the balls and about three-quarters of the second ball in the airtight container. Apply the following operations to the remaining quarter.

2) By using the first finger and thumb of each hand, form the quarter of the ball into a thread, about 6 mm in diameter. Then place this thread on the glass plate, and roll it with the tips of the fingers of one hand until its diameter is reduced to 3mm, keeping the rolling pressure constant throughout the test.

3) Remould the thread between the fingers, and repeat Step (2), until the thread shears both longitudinally and transversely when it has been rolled to a diameter of 3 mm. Place the crumbled soil thread into a suitable container for moisture content determination.

4) Repeat steps (2) and (3) for each quarter of the same ball, placing the crumbled soil into the same container, and determine the moisture content as a whole.

5) Repeat steps (2) to (4) for the second ball.

**Calculations:**

* Mass of moisture = (mass of container + wet soil) – (mass of container + dry soil)

For container no 3: 23.3 – 21.7 = 1.6 g

For container no 4: 225.4 – 23.5 = 1.9 g

* Mass of dry soil = (mass of container + dry soil) – (mass of container)

For container no 3: 21.7 – 13.9 = 7.8 g

For container no 4: 23.5 – 14.2 = 9.3 g

* Moisture Content = 100 \* (mass of moisture/mass of dry soil)

For container no 3: 100 \* (1.6/7.8) = 20.51 %

For container no 4: 100 \* (1.9/9.3) = 20.43 %

* Plastic Limit (Wp) = (20.51 + 20.43) / 2 = 20.47%

1. **Determination of the Plasticity Index**

**Object:** To calculate the plasticity index of a soil.

**Procedure:** Determine the liquid limit (WL) and plasticity limit (WP) by the method of tests given in part A and part B.

**Calculations:**

Plasticity index (Ip) = WL - WP = 43.6 – 20.47 = 23.13 %

**Discussion of Results:**

For the first part of the experiment, we found the liquid limit as 43.6 % from the flow curve for the soil specimen we used. Thus, we can conclude that this sample has low plasticity according to the Casagandre’s method since the value of liquid limit is smaller than 50%.

For the second part of the experiment, we calculated the plastic limit as 20.47 % by simply taking the average of two moisture content values. The two moisture contents do not differ by more than 0.5 % from the average moisture content value, so the test was not repeated.

In these parts human factor plays an important role in errors. By reducing the human factors, we can increase the accuracy of the experiment and get more accurate results.

**Conclusion:**

We found the two Atterberg limits which are liquid limit and plastic limit for our soil sample as 43.6 % and 20.47 % respectively. Furthermore, we calculated the plasticity index as 23.13 %, and define our soil as clay with low plasticity (CL) according to Casagrande’s Plasticity Chart.

**References**

Mirata T. (1980) , Laboratory Instructions for Soil Mechanics Students, METU Press, Ankara (reprinted in 2009)

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