T 90

DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

FOP FOR AASHTO

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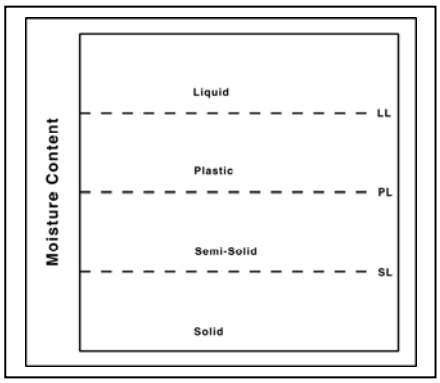

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Material phase and moisture content

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Significance

Fine-grained soils, particularly clays, exhibit different properties at different moisture contents. At very low moisture contents, the material acts like a solid. As the moisture content rises, the material moves from solid to semi-solid to plastic to liquid form.

The moisture content at the boundary between semi-solid and plastic states is known as the plastic limit (PL). The moisture content between the plastic and liquid states is known as the liquid limit (LL). The difference between the plastic and liquid limits is called the plasticity index (PI), and indicates the size of the range over which the material acts as a plastic – capable of being deformed under stress, but maintaining its form when unstressed.

Fine-grained soils also exhibit shrinking and swelling as the moisture content changes. As water content increases from dry to wet, no change in volume occurs below a certain moisture content, known as the shrinkage limit (SL). Above the SL, volume increases as moisture content increases.

For these reasons, knowledge of the LL, PL, and PI, and sometimes the SL, are important to quality assurance in roadway construction.

Scope

This procedure covers the determination of the plastic limit and plasticity index of soil in accordance with AASHTO T 90. It is used in conjunction with the FOP for AASHTO T 89, Determining the Liquid Limit of Soils. The three values are used for soil classification and other purposes. This FOP will cover the hand rolling method only. If the plastic limit device method is approved by the agency, see the FOP for AASHTO T 90 for that procedure.

Apparatus

- Dish: preferably unglazed porcelain or similar mixing dish, of approximately 4.5 inch diameter.
- Spatula: having a blade 3 to 4 in. long and about 3/4 in. wide.
- Rolling Surface: a ground glass plate or piece of smooth, unglazed paper.
- Containers: corrosion resistant, suitable for repeated heating and cooling, having close fitting lids to prevent the loss of moisture. One container is needed for each moisture content determination.
- Balance: conforming to AASHTO M 231, class G1, sensitive to 0.01 g with a 1200 g capacity.
- Oven: thermostatically controlled, capable of maintaining temperatures of 230 ±9°F.

Sample

05 The plastic limit procedure is often run in conjunction with the liquid limit procedure. If this is the case, the plastic limit sample should be obtained from the soil prepared for the liquid limit test at any point in the process at which the soil is plastic enough to be easily shaped into a ball without sticking to the fingers excessively when squeezed. Obtain approximately 8 g of soil to run the plastic limit test.

If only the plastic limit is to be determined, the sample must be prepared per AASHTO T 87 or T 146. Obtain about 20 g of material passing the No. 40 sieve. Mix the soil with distilled or demineralized water until the mass becomes plastic enough to be easily shaped into a ball. Obtain approximately 8 g of soil to run the plastic limit test.

Note 1: Tap water may be used for routine testing if comparative tests indicate no differences in results between using tap water and distilled or demineralized water.

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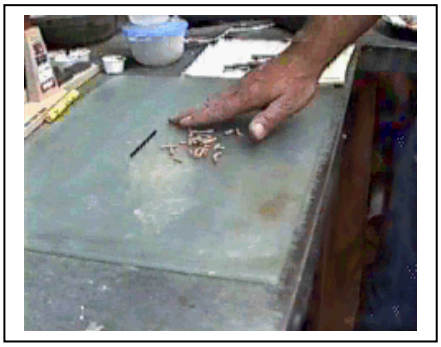
Rolling the thread



Breaking the thread

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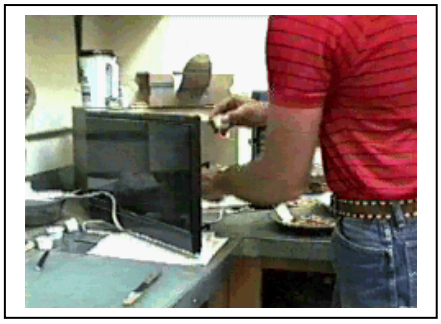
Procedure (Hand Rolling Method)

1. From the sample pull a 1.5 to 2 g mass.
2. Squeeze and form the test sample into an ellipsoidal-shape mass.
3. Roll this mass between the fingers or palm and the rolling surface with just sufficient pressure to roll the mass into a thread of uniform diameter along its length. Roll out between 80 and 90 strokes per minute, counting a stroke as one back and forth motion. The sample must be rolled into the 1/8 in. thread in no longer than 2 minutes.
4. Break the thread into six or eight pieces when the diameter of the thread reaches 1/8 in.
5. Squeeze the pieces together between the thumbs and fingers of both hands into an ellipsoidal-shape mass and reroll.
6. Continue this process of alternately rolling to a thread of 1/8 in. diameter, cutting into pieces, gathering together, kneading and rerolling until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a thread.



Drying sample

Note 2: Crumbling may occur when the thread has a diameter greater than 1/8 in. This shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread of 1/8 in. diameter. The crumbling will manifest itself differently with various types of soil. Some soils fall apart in many pieces; others form an outside tubular layer that splits at both ends; splitting progresses toward the middle, and the thread falls apart in small platy particles. Heavy clay requires much pressure to deform the thread, particularly as it approaches the plastic limit, and the thread breaks into a series of barrel-shaped segments each 1/4 to 3/8 in. long. At no time shall the tester attempt to produce failure at exactly 1/8 in. diameter. It is permissible, however, to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal-shaped mass nearer to the required 1/8 in. final diameter.

7. Gather the portions of the crumbled soil together and place in a suitable, tared container and cover.
8. Repeat steps one through seven until 8 g of sample have been tested and placed in the covered container.
9. Determine the moisture content of the sample in accordance with the FOP for AASHTO T 255/T 265 (Soil).

Plastic Limit

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The moisture content, as determined in Step 9 above, is the Plastic Limit. It is advisable to run several trials on the same material to ensure a proper determination of the Plastic Limit of the soil.

Plasticity Index

The Plasticity Index (PI) of the soil is equal to the difference between the Liquid Limit (LL) and the Plastic Limit (PL).

PI = LL – PL

Examples: **#1** **#2**

LL = 34 and PL = 17
PI = 34 – 17 = 17

LL = 16 and PL = 10
PI = 16 – 10 = 6

Example Calculation

Container	Container Mass, g	Container and Wet Soil Mass, g	Wet Soil Mass, g	Container and Dry Soil Mass, g	Dry Soil Mass, g
1	14.44	22.65	8.21	21.45	7.01
2	14.18	23.69	9.51	22.81	8.63

Water Mass, g	Moisture Content	Plastic Limit
1.20	17.1	17
0.88	10.2	10

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Report

Results shall be reported on standard forms approved by the agency. Report the PL and PI to the nearest whole number.

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Tips!

- Some soils, such as sandy silts, require very light pressure when rolling.
- If the sample flattens rather than rolling into a thread, it may be too wet.

REVIEW QUESTIONS

1. Describe how to obtain the plastic limit sample if done in conjunction with the liquid limit procedure.

2. Describe the process for determining the plastic limit.

3. What does the plastic limit represent?

4. How is the plastic limit used with the liquid limit?

5. What does the plasticity index represent?

6. Approximately how much soil should be prepared to run the plastic limit test?

7. What is the approximate mass of the ellipsoidal sample?

8. What change in the procedure is permissible for feeble plastic soils?

PERFORMANCE EXAM CHECKLIST

DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS FOP FOR AASHTO T 90

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Describe the preparation of the plastic limit sample:	_____	_____
a. Sample may be obtained from preparations for liquid limit test sample?	_____	_____
b. Sample mass approximately 20 g of minus #40?	_____	_____
c. Mix in dish with enough distilled or demineralized water until easily shaped into ball?	_____	_____
d. Approximately 8 g sample obtained?	_____	_____
2. 1.5 to 2.0 mass obtained from ball?	_____	_____
3. Sample squeezed into ellipsoidal mass?	_____	_____
4. Mass rolled into 1/8" thread at rate of 80-90/min?	_____	_____
5. Thread broken into six or eight pieces, recombined, and rolling repeated?	_____	_____
6. Moisture sample obtained when thread just begins to crumble?	_____	_____
7. Tare mass of moisture container determined?	_____	_____
8. Moisture sample properly taken and wet mass determined?	_____	_____
9. Moisture content determined by the FOP for AASHTO T 265?	_____	_____
10. Multiple tries conducted until 8 g of original sample used?	_____	_____
11. Plastic limit correctly calculated and rounded to nearest whole number?	_____	_____
12. Plasticity index determined by subtracting plastic limit from liquid limit?	_____	_____
13. Plasticity index reported to the whole number?	_____	_____
14. Reported on standard agency form?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

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Signature of Examiner _____