Standard Method of Test for

Determining the Plastic Limit and Plasticity Index of Soils

AASHTO Designation: T 90-20

Technical Subcommittee: 1a, Soil and Unbound Recycled Materials

Release: Group 3 (July)

AASHTO

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1. SCOPE

1.1. The plastic limit of a soil is the lowest moisture content at which the soil remains plastic. The plasticity index of a soil is the range in moisture content, expressed as a percentage of the mass of the oven-dried soil, within which the material is in a plastic state. The plasticity index is calculated as the numerical difference between the liquid limit and plastic limit of the soil.

1.2. The following applies to all specified limits in this standard: For the purpose of determining conformance with these specifications, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value, in accordance with ASTM E29.

1.3. Two procedures for rolling out soil samples are provided in this method: the Hand Rolling Method and the Plastic Limit Device Method. The Hand Rolling Method shall be used as the referee procedure.

1.4. This test method is often conducted in conjunction with T 89, which is used to determine the liquid limit of soils.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 58, Dry Preparation of Disturbed Soil and Soil–Aggregate Samples for Test
- R 61, Establishing Requirements for Equipment Calibrations, Standardizations, and Checks
- R 74, Wet Preparation of Disturbed Soil Samples for Test
- T 89, Determining the Liquid Limit of Soils
- T 265, Laboratory Determination of Moisture Content of Soils

2.2. *ASTM Standard*:

- E29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. APPARATUS

3.1. *Dish*—A porcelain evaporating dish or similar mixing dish about 115 mm in diameter.

3.2. *Spatula*—A spatula or pill knife having a blade about 75 mm in length and about 20 mm in width.

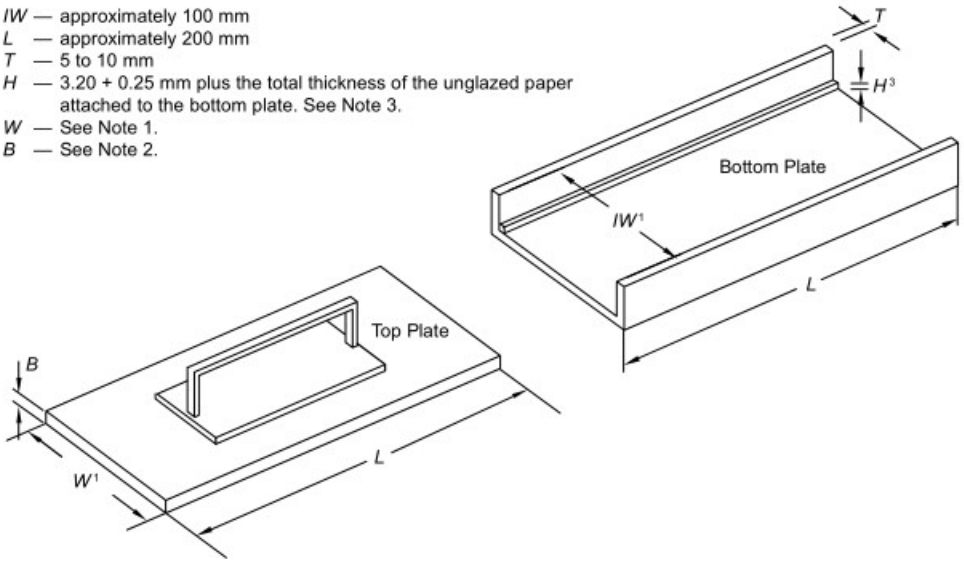
3.3. *Surface for Rolling*—Shall consist of one of the following:

3.3.1. A ground glass plate or piece of smooth, unglazed paper on which to roll the sample. Paper, if used, shall not add foreign matter (fibers, paper fragments, etc.) to the soil during the rolling process and shall lay flat on a smooth horizontal surface.

3.3.2. *Plastic Limit Rolling Device*[1,2]—A device made of acrylic conforming to the dimensions shown in Figure 1.

Dimensions:

IW — approximately 100 mm
L — approximately 200 mm
T — 5 to 10 mm
H — 3.20 + 0.25 mm plus the total thickness of the unglazed paper attached to the bottom plate. See Note 3.
W — See Note 1.
B — See Note 2.



Notes:

1. The tolerance between the width of the top plate (*W*) and the inside width of the bottom plate *(IW)* shall be such that the top plate slides freely on the rails without wobbling.
2. The top plate shall be rigid enough so that the thickness of the soil threads is not influenced by flexure of the top plate.
3. The width of the side rails shall be between 3 and 6 mm.

Figure 1—Plastic Limit Rolling Device

3.3.2.1. *Paper for Rolling Device*—Unglazed paper that does not add foreign matter (fibers, paper fragments, etc.) to the soil during the rolling process. Attach the unglazed paper to the top and bottom plates of the device either by a spray-on adhesive or by use of a self-adhesive backing.

Note 1—Take special care to remove the adhesive that remains on the plastic limit rolling device after testing. Repeated tests without such removal will result in a buildup of the residual adhesive and a decreased soil thread diameter.

3.4. *Moisture Content Container*—Made of material resistant to corrosion and not subject to change in mass or disintegration on repeated heating and cooling. The container shall have a close-fitting lid

to prevent loss of moisture from samples before initial mass determination and to prevent absorption of moisture from the atmosphere following drying and before final mass determination. One container is needed for each moisture content determination.

3.5. *Balance*—A class G1 balance meeting the accuracy requirements of M 231.

3.6. *Oven*—Thermostatically controlled and capable of maintaining temperatures of 110 ± 5ºC for drying samples.

4. CALIBRATIONS, STANDARDIZATIONS, AND CHECKS

4.1. Unless otherwise specified, follow the requirements and intervals for equipment calibrations, standardizations, and checks in R 18.

4.2. Follow the procedures for performing equipment calibrations, standardizations, and checks found in R 61.

5. SAMPLE

5.1. *If only the plastic limit is to be determined*—Take a quantity of soil with a mass of about 20 g from the thoroughly mixed portion of the material passing the 0.425-mm (No. 40) sieve, obtained in accordance with R 58 or R 74. Place the air-dried soil in a mixing dish and thoroughly mix with distilled, demineralized, or de-ionized water until the mass becomes plastic enough to be easily shaped into a ball (Notes 2 and 3). Take a portion of this ball with a mass of about 10 g for the test sample.

Note 2—Tap water may be used for routine testing if comparative tests indicate no differences in results between using tap water and distilled, demineralized, or de-ionized water. However, use distilled, demineralized, or de-ionized water for referee or disputed tests.

Note 3—The objective is to add enough moisture to a plastic soil sample so that the 3-mm thread described in Section 6 does not crumble on the first roll. For a nonplastic soil, this will not be possible.

5.2. *If the plasticity index (both liquid and plastic limit) is to be determined*—Take a test sample with a mass of about 10 g from the thoroughly wet and mixed portion of the soil prepared in accordance with T 89. Take the sample at any stage of the mixing process at which the mass becomes plastic enough to be easily shaped into a ball without sticking to the fingers excessively when squeezed. If the sample is taken before completion of the liquid limit test, set it aside and allow to season in air until the liquid limit test has been completed. If the sample taken during the liquid limit test is too dry to permit rolling to a 3-mm thread as described in Section 6, add more water and remix (Note 3).

6. PROCEDURE

6.1. Determine and record the mass of the moisture content container.

6.2. Select a 1.5- to 2.0-g portion from the 10-g mass of soil prepared in accordance with Section 5. Form the selected portion into an ellipsoidal mass.

6.3. Use one of the following methods to roll the soil mass into a 3-mm-diameter thread at a rate of 80 to 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position again.

6.3.1. *Hand Rolling Method*—Roll the mass between the palm or fingers and the ground-glass plate or unglazed paper with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. Deform the thread further on each stroke until its diameter reaches 3 mm. Take no more than 2 min to roll the soil mass to the 3-mm diameter.

Note 4—The amount of hand or finger pressure required will vary greatly, according to the soil. Fragile soils of low plasticity are best rolled under the outer edge of the palm or at the base of the thumb.

6.3.2. *Alternate Procedure, Plastic Limit Device Method*—Place the soil mass on the bottom plate. Place the top plate in contact with the soil mass. Simultaneously apply a slight downward force and back and forth motion to the top plate so the plate comes in contact with the side rails within 2 min. During this rolling process, do not allow the soil thread to contact the side rails.

Note 5—In most cases, more than one soil mass (thread) can be rolled simultaneously in the plastic limit rolling device.

6.4. The soil shall roll to a thread diameter of 3 mm at least one time to be considered plastic. When the diameter of the thread reaches 3 mm, squeeze the thread between the thumb and fingers and form the mass back into a roughly ellipsoidal shape. Repeat the rolling and re-forming process as described in Section 6.3 until the soil can no longer be rolled into a thread and begins to crumble. The crumbling may occur when the thread has a diameter greater than 3 mm, provided the soil has been previously rolled into a thread 3 mm in diameter (Note 6). This is considered a satisfactory end point. If unsure a satisfactory end point has been reached, verify by attempting to reform the soil into an ellipsoidal mass and, if possible, repeat the rolling process until the soil can no longer hold a thread shape when a slight amount of pressure is applied to the ellipsoidal mass. Do not attempt to produce failure at an exact 3-mm diameter by purposely reducing the rate of rolling or the hand pressure, or both (Note 7).

Note 6—The crumbling will manifest itself differently with various types of soil. Some soils fall apart in numerous small aggregations of particles; others may form an outside tubular layer that starts splitting at both ends. The splitting may progress toward the middle, and the thread may finally fall apart in many small platy particles. Heavy clay soils require much pressure to deform the thread, particularly as they approach the plastic limit. These types of soils may break into a series of barrel-shaped segments each about 6 to 9 mm in length.

Note 7—For feebly plastic soils, it may be necessary to reduce the total amount of deformation by making the initial diameter of the ellipsoidal-shaped mass nearer to the required 3-mm final diameter.

6.5. Gather the portions of the crumbled soil together and place in the moisture content container. Immediately cover the container with a close-fitting lid to prevent additional loss of moisture.

6.6. Repeat the operations described in Sections 6.3 through 6.5 until the entire 10-g specimen is tested. Place all of the crumbled portions into the same moisture content container.

6.7. Determine the moisture content of the soil in the container in accordance with T 265, and record the results.

7. CALCULATIONS

7.1. The plastic limit of the soil is the moisture content determined in Section 6.7, expressed as a percentage of the oven-dry mass, and determined in accordance with T 265. Report the plastic limit to the nearest whole number.

7.2. If applicable, calculate the plasticity index of a soil as the difference between its liquid limit and its plastic limit, as follows:

plasticity index = liquid limit – plastic limit *(1)*

7.3. Report the results as calculated in Section 7.2 as the plasticity index, except under the following conditions:

7.3.1. When the liquid limit or plastic limit cannot be determined, report the plasticity index as NP (nonplastic).

7.3.2. When the plastic limit is equal to, or greater than, the liquid limit, report the plasticity index as NP.

8. PRECISION STATEMENT

8.1. This precision statement applies to soils with a plastic limit range between 15 and 32, tested using the hand rolling method.

8.2. *Repeatability (Single Operator)*—Two results obtained by the same operator on the same sample in the same laboratory using the same apparatus should be considered suspect if they differ by more than 10 percent of their mean.

8.3. *Reproducibility (Multilaboratory)*—Two results obtained by different operators in different laboratories should be considered suspect if they differ from each other by more than 18 percent of their mean.

9. KEYWORDS

9.1. Atterberg; clay soil; plastic limit; plasticity index.

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[1] The plastic limit rolling device is covered by a patent (U.S. Patent No. 5,027,660). Interested parties are invited to submit information regarding the identification of an alternative(s) to this patent to AASHTO Headquarters. Your comments will receive careful consideration at a meeting of AASHTO Technical Section 1a on Soil Materials Tests.
[2] Bobrowski, L. J., Jr. and D. M. Griekspoor, "Determination of the Plastic Limit of a Soil by Means of a Rolling Device," *Geotechnical Testing Journal*, GTJODJ, Vol. 15, No. 3, September 1992, pp. 284–287.