

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

Scope

This procedure covers the determination of the plastic limit and plasticity index of soil in accordance with AASHTO T 90-22. 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. Two procedures, hand rolling and an alternate rolling method, are covered. The hand rolling method is to be used as the referee method.

Apparatus

- Dish: preferably unglazed porcelain or similar mixing dish, about 115 mm (4.5 in.) in diameter.
- Spatula: having a blade 75 to 100 mm (3 to 4 in.) long and about 20 mm (3/4 in.) wide.
- Rolling Surface:
 - A ground glass plate or piece of smooth, unglazed paper.
 - Plastic Limit Rolling Device: (Optional) A device made of acrylic conforming to the dimensions shown in AASHTO T 90 Figure 1.
 - Paper for Rolling Device: Unglazed paper that does not add foreign matter to the soil during the rolling process. Paper is attached to both the top and bottom plates of the rolling device by either spray-on adhesive or self-adhesive backing. Remove all adhesive from the rolling device after each test to prevent buildup.
- Containers: corrosion resistant, suitable for repeated heating and cooling, having close fitting lids to prevent the loss of moisture before initial mass determination and while sample is cooling before final mass determination. One container is needed for each moisture content determination.
- Balance: conforming to AASHTO M 231, class G1, sensitive to 0.01 g with a minimum capacity of 100 g.
- Oven: thermostatically controlled, capable of maintaining temperatures of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).
- Sieve: 0.425 mm (No. 40) sieve meeting the requirements of the FOP for AASHTO T 27/T 11.

Sample

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, FOP for AASHTO T 89, 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 10 g of soil to run the plastic limit test.

If the plastic limit only is to be determined, the sample must be prepared according to AASHTO R 58; Dry Preparation of Disturbed Soil and Soil-Aggregate Samples for Test or R 74; Wet Preparation of Disturbed Soil Samples for Test. Obtain about 20 g of material passing the 0.425 mm (No. 40) sieve. Mix the soil with distilled or demineralized water until the mass becomes plastic enough to be easily shaped into a ball. Use approximately 10 g of the soil ball 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.

Procedure

1. Determine and record the mass of the container and lid.
2. Pull a 1.5 to 2 g mass test sample from the initial 10 g.
3. Squeeze and form the test sample into an ellipsoidal-shape mass.
4. Use one of the following methods to roll the mass.
 - Hand Rolling Method—Roll the 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. The sample must be rolled into the 3 mm (1/8 in.) thread in no longer than 2 minutes.
 - Alternate Rolling Method, Plastic Limit Device Method—Place the soil mass on the bottom plate. Place the top plate in contact with the soil mass. Roll the mass between the plates with sufficient pressure to form the mass into a thread of uniform diameter along its length so that top plate contacts the side rails within 2 minutes. During this rolling process, do not allow the soil thread to contact the side rails. Rolling multiple threads at once is allowed.
5. Break the thread into six or eight pieces when the diameter of the thread reaches 3 mm (1/8 in.).
6. Squeeze the pieces together between the thumbs and fingers of both hands into an ellipsoidal-shape mass and reroll.

Continue this process of alternately rolling to a thread 3 mm (1/8 in.) 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 3 mm in diameter.

Crumbling may occur when the thread has a diameter greater than 3 mm (1/8 in.). This shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread 3 mm (1/8 in.) in diameter. At no time, shall the tester attempt to produce failure at exactly 3 mm (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 3 mm (1/8 in.) final diameter.

Note 2: 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 6 to 9 mm (1/4 to 3/8 in.) long.

7. Gather the portions of the crumbled soil together, place in the moisture content container and cover.
8. Repeat steps one through seven until 10 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) and record the results. (Remove lids and keep with containers during drying.)

Plastic Limit

The moisture content, as determined in Step 9 above, is the Plastic Limit.

Note 3: 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). If either the liquid limit or plastic limit cannot be determined, report the plasticity index as NP (non-plastic). If the plastic limit is equal to, or greater than the liquid limit, report the plasticity index as NP.

$$PI = LL - PL$$

Examples:

No. 1
LL = 34 and PL = 17
PI = 34 – 17 = 17

No. 2
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	25.21	10.77	23.62	9.18
2	14.18	24.84	10.66	23.90	9.72

Water Mass, g	Moisture Content	Plastic Limit
1.59	17.3%	17
0.94	9.7%	10

Report

- Results on forms approved by the agency
- PL and PI rounded to the nearest 1 percent and reported as a whole number.

WSDOT FOP for AASHTO T 90

Determining the Plastic Limit and Plasticity Index of Soils

WSDOT has adopted the published AASHTO T 90.

AASHTO Test Methods cannot be included in Materials Manual due to copyright infringement.

WSDOT employees can access AASHTO and ASTM test methods in the following web address:

<http://wwwi.wsdot.wa.gov/MatsLab/BusinessOperations/ASTMLogin.htm>

Non-WSDOT employees can order AASHTO's Standard Specifications for Transportation Materials and Methods of Sampling and Testing, using the following web address:

<https://store.transportation.org>

Performance Exam Checklist

FOP for AASHTO T 90

Determining the Plastic Limit and Plasticity Index of Soils

Participant Name: _____ Exam Date: _____

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

Preparation Element	Trial 1	Trial 2
1. The tester has a copy of the current procedure on hand?	_____	_____
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	_____	_____
3. Sample obtained using AASHTO R 58?	_____	_____
4. Minimum sample mass meets requirement of AASHTO T 90?	_____	_____
5. Sample mixed with distilled, demineralized, or de-ionized water until plastic enough to be easily shaped into a ball?	_____	_____
6. 10 g portion of ball taken from the moist sample material?	_____	_____
Procedure Element		
1. 1.5-2 g portion taken and formed into ellipsoidal mass?	_____	_____
2. Mass rolled at between 80-90 strokes per minute (using one of the techniques described in T 90) for no more than 2 minutes to form a 3 mm diameter thread?	_____	_____
3. Thread broken into six or eight pieces and pieces squeezed together into ellipsoidal shape and rerolled until thread crumbles and soil can no longer be rolled into a thread?	_____	_____
4. Tested material placed in a tared covered container and procedure steps 1-6 repeated until all 10 g of material is tested?	_____	_____
5. Sample dried in accordance with AASHTO T 265 to determine moisture content?	_____	_____
6. Were all calculations performed correctly?	_____	_____

Comments: First Attempt: Pass _____ Fail _____ Second Attempt: Pass _____ Fail _____

Examiner Signature: _____ WAQTC #: _____