

## Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index

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### 1. Scope:

This test is for determining the liquid limit, plastic limit, and the plasticity index of soils and granular materials. Referee tests will be performed in accordance with AASHTO T 89 and AASHTO T 90.

The liquid limit is the water content at which a soil passes from a plastic to a liquid state.

The plastic limit is the lowest water content at which a soil remains plastic.

The plasticity index is the numerical difference between the liquid limit and the plastic limit.

The word "Soil" in these tests shall mean the - #40 sieve material.

### 2. Apparatus:

- 2.1 Balance having a capacity of at least 100 grams sensitive and readable to .01 gram.
- 2.2 Containers. Containers, such as metal cans with lids, which will prevent loss of moisture prior to and during weighing.
- 2.3 Drying oven. Ovens, hot plates or other suitable devices for drying the samples at  $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$ .
- 2.4 Evaporating dish. A porcelain dish used for mixing the soil and water.
- 2.5 Liquid limit device conforming to specifications as described in AASHTO T 89.
- 2.6 Grooving tool. A combined grooving tool and gauge as described in AASHTO T 89.
- 2.7 Gauge. 10mm x 25mm x 50mm (Optional).
- 2.8 Plastic wash bottle with jet opening for adding water to the soil.
- 2.9 Pulverizing apparatus shall be a mortar and rubber covered pestle or a mechanical device consisting of a mortar of suitable size and shape and a power-driven, rubber covered muller for breaking up soil particles without reducing individual grain size.
- 2.10 Splitter. Mechanical splitter capable of reducing the size of sample. (SD 213).

- 2.11 Sieves. Sieves shall conform to ASTM E11.
- 2.12 Spatula. A spatula having a flexible steel blade approximately 3" in length and 3/4" in width.
- 2.13 Spoon. An appropriate size spoon for mixing and transferring the dry soil.
- 2.14 Surface for rolling. A ground glass plate or a piece of smooth paper laying on a smooth, horizontal surface.

### 3. Procedure:

#### For Disturbed Soil Samples

- 3.1 Obtain a field sample in accordance with SD 201.

Obtain an approximate 500 gram dry sample of - #4 sieve material that is of adequate size to produce at least 100 grams of - #40 sieve material.

- 3.2 Sieve the material on a #40 sieve.

- 3.3 Pulverize the material retained on the #40 sieve using the mortar and rubber covered pestle or the power driven muller. If the sample contains brittle particles, the pulverizing operation shall be done carefully and with just enough pressure to free the finer material that adheres to the coarser particles.

#### For Aggregate Samples

- 3.4 Obtain an approximate 500 gram sample of -#4 material from SD 202.

Begin by weighing the sample to the nearest 0.1 gram and record it as "Wt. - #4" on the worksheet. Place the material on a #40 sieve with a pan below the sieve and agitate them for a period of time. (The use of a relief sieve, #20 or #30, is encouraged above the #40 to prevent overloading.) Place the material retained on the sieves into a pulverizing mechanism (Which shall consist of a mortar and rubber covered pestle or a power driven muller) and carefully pulverize the material.

Alternately sieve and pulverize the material until not more than 1% will pass the #40 sieve during 1 minute of sieving.

Weigh the material in the pan to the nearest 0.1 gram and record it as "Wt. - #40" on the worksheet. Calculate the percentage of the sample which passed through the sieve by dividing the "Wt. - #40" by the "Wt. - #4" and then multiplying this percentage by the accumulative percent passing the #4 sieve in the sieve analysis. Compare this percentage to the accumulative percentage of material that passed the #40 sieve in the sieve analysis. These should compare within  $\pm 3.0\%$ . If the difference is more than 3.0% above the

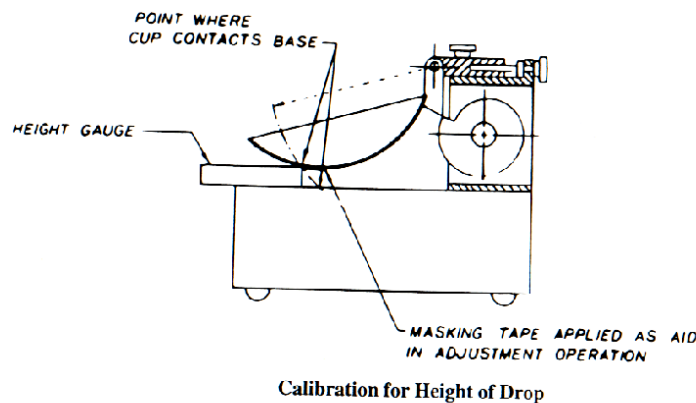
sieve analysis percentage, a new sample should be prepared and sieved, if it is more than 3.0% below the percentage passing in the sieve analysis, more pulverizing and sieving is required and the results recalculated.

**NOTE: The variation should not be more than 3.0%.**

### 3.5 Liquid Limit

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Adjust the cup of the liquid limit device to a 10 mm drop. Place a piece of masking tape across the wear spot on the bottom of the cup parallel with the axis of the cup hanger pivot. The tape must bisect the center of the wear spot, leaving the front half of the wear spot (away from the cup hanger pivot) exposed. From the front of the liquid limit device, slide the gauge under the cup until it comes in contact with the tape. Check the adjustment by turning the crank at 2 revolutions per second while holding gauge in position against the tape and cup. The adjustment is correct if a ringing or clicking sound is heard without the cup rising from the gauge.



Calibration for Height of Drop

Figure 1

- 3.6 Mix the sample of - #40 material thoroughly and transfer approximately 50 to 100 grams to the evaporating dish. If not enough material is produced from steps 3.3 or 3.4, repeat steps 3.3 or 3.4 until enough material is produced. Add 15 to 20 mL of water by alternately and repeatedly stirring, kneading and chopping with a spatula, allowing time for moisture to soak into the soil. (Allow 5 to 10 minutes, with the longer time used for material slow to absorb water.) Make further additions of water in increments of 1 to 3 mL. Mix each increment of water thoroughly as previously described before adding another increment. Once testing has begun, no additional dry soil shall be added to the moistened soil. The cup of the liquid limit device shall not be used for mixing.

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When sufficient water has been thoroughly mixed with the soil to form a uniform mass of stiff consistency, place an adequate quantity of this mixture in the cup above the spot where the cup rests on the base. Squeeze and spread this mixture with the spatula to level and at the same time trimmed to

a depth of approximately 10 mm at the point of maximum thickness. Use as few strokes of the spatula as possible, taking care to prevent entrapment of air bubbles within the mass.

Divide the soil in the cup of the mechanical device with a firm stroke of the grooving tool, along the diameter through the centerline of the cam follower, forming a clean sharp groove of the proper dimensions (Figure 2). To avoid tearing the sides of the groove or slipping of the soil cake within the cup, up to 6 strokes (From front to back or back to front, counting as 1 stroke) shall be permitted.

**NOTE: At this point, spilled portions of moistened soil shall be wiped from the edges of the cup and base of the machine to ensure a clean surface on which the cup will fall.**

Lift and drop the cup containing the soil by turning the crank at a rate of two revolutions per second until the sides of the groove come in contact at the bottom of the groove for a distance of 1/2", (Figure 3). Do not hold the base of the machine with the hand while turning the crank.

**NOTE: Some soils tend to slide on the surface of the cup instead of flowing. If this occurs, remove the material from the cup, add more water, remix and repeat the test. If the soil continues to slide on the cup at a lesser number of blows than 25, the material shall be considered non-controllable (N.C.) and a note should be made that the liquid limit could not be determined.**

Restrict the accepted number of blows for groove closure to between 22 and 28 blows. Record the number of blows for the accepted closure. Remove a slice of soil (8 grams minimum) approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to and including that portion of the groove where the closure took place, and place it in a container. Promptly weigh and record to the nearest 0.01 g, the weight of the can and wet soil. Dry to a constant weight as per SD 108.

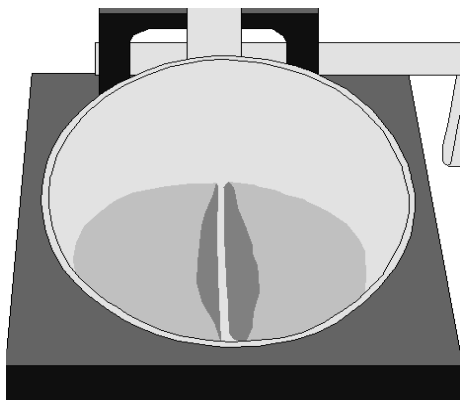


Figure 2  
(Soil cake grooved for the test)

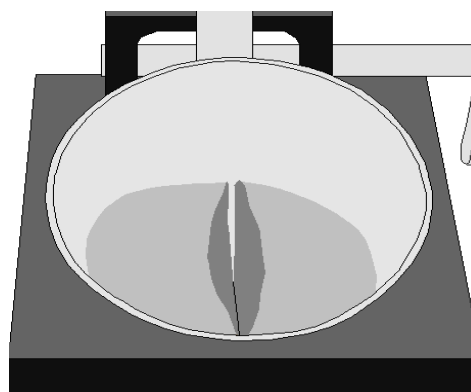


Figure 3  
(Soil cake after normal test)

### 3.7 Plastic limit.

Take a sample weighing a minimum of 8 grams from the wet material in the evaporating dish used for the liquid limit test. Take the sample at any stage of the mixing process when the material becomes plastic enough to be shaped without excessively sticking to the fingers when squeezed. Set this sample aside until the liquid limit test has been completed.

Select a 1.5 to 2.0 gram portion from the 8 gram sample and squeeze and form this into an ellipsoidal-shaped mass. Roll this mass between the fingers and the ground-glass plate or a piece of smooth paper (do not use paper towels) laying on a smooth horizontal surface with just sufficient pressure to roll the mass into a uniform thread approximately 1/8" in diameter throughout its length (Figure 4). When the diameter of the thread reaches 1/8", break it into 6 or 8 pieces, squeeze the pieces together into a uniform mass roughly ellipsoidal in shape and re-roll. The rate of rolling shall be between 80 and 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position.

**NOTE: If 1/8" cannot be attained after repeated rolldown attempts, sample is considered non-plastic (NP).**

Continue this alternate rolling to a thread, gathering together, kneading and re-rolling until the thread crumbles under the pressure required for rolling (Figure 5).

The crumbling may occur when the thread has a diameter greater than 1/8". This shall be a satisfactory end point, provided the soil has been previously rolled into a 1/8" diameter thread.

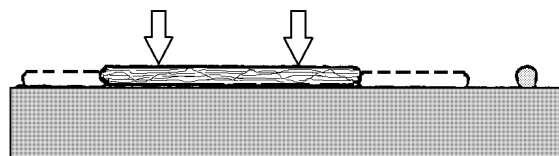


Figure 4

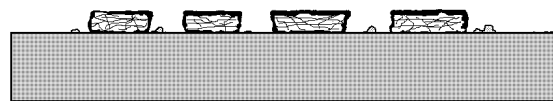


Figure 5

- 3.8 Gather all the crumbled soil together and place it in a tared container for weighing. This requires an additional sample to be taken and the steps in

paragraph 3.7 followed again. Be sure the lid is on the container to prevent evaporation while the additional material is prepared.

Weigh and record the weight of the container and wet soil to the nearest 0.01 gram. Dry the sample to a constant weight as per SD 108.

#### 4. Report:

##### 4.1 Calculation of the liquid limit.

- A. Calculate the moisture content to the nearest 0.1% of the oven-dried weight as follows:

$$\% \text{ moisture} = \frac{\text{Weight of water}}{\text{Weight of oven-dried material}} \times 100$$

- B. Convert the percent of moisture to the Liquid Limit using the following conversion factors.

# of blows x factor		# of blows x factor	
22 =	0.9846	26 =	1.0050
23 =	0.9899	27 =	1.0100
24 =	0.9952	28 =	1.0138
25 =	<b>1.0000</b>		

- C. Record the liquid limit to the nearest 0.1% on the worksheet.

##### 4.2 Calculation of the plastic limit.

- A. Calculate the plastic limit as follows:

$$\text{Plastic limit} = \frac{\text{Weight of water}}{\text{Weight of oven-dried material}} \times 100$$

- B. Record the plastic limit to the nearest 0.1% on the worksheet.

##### 4.3 Calculation of the plasticity index.

- A. Calculate the plasticity index as follows:

$$\text{Plasticity index} = \text{liquid limit} - \text{plastic limit}$$

- B. Record the plasticity index to the nearest 0.1% on the worksheet.

##### 4.4 Report the liquid limit and plasticity index to the whole number or decimal required by the specifications.

**5. References:**

AASHTO T 89  
AASHTO T 90  
ASTM E11  
SD 108  
SD 202  
SD 213  
DOT-3

Sample ID 2203565

# Sieve Analysis and P.I. Worksheet

DOT-3

File No.

3-19

PROJECT PH 0066(00)15

COUNTY Aurora, Ziebach

PCN B015

Charge to (if not above project)

Field No. 01

Date Sampled 03/10/2019

Date Tested 03/10/2019

Sampled By Brown, Benjamin

Tested By Tester, One

Checked By Tester, Two

Material Type Base Course

Source

Lot No.

Sublot No.

Weight Ticket Number or Station

Lift of

[Wet Sample Weight (0.1g) - Original Dry Sample Weight (0.1g) 7,318.0] / dry weight x 100 = % moisture

Sieve Size	Fineness Modulus	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.		0.0	0.0	100.0	100	100 - 100
3/4 in.		167.6	2.3	97.7	98	80 - 100
5/8 in.		240.6	3.3	94.4	94	
1/2 in.		351.7	4.8	89.6	90	68 - 91
3/8 in.	* 15.0	338.8	4.6	85.0	85	
1/4 in.		625.2	8.5	76.5	77	
#4	* 31.5	586.2	8.0	68.5	69	46 - 70
Pan		5008.1	68.4			
Total		7,318.2				

**+ #4 Gradation Check**

within 0.3% of original dry weight 0.00

**Dust Check**

wt. before washing (0.1g) \_\_\_\_\_

wt. after washing (0.1g) \_\_\_\_\_

loss from washing \_\_\_\_\_

% - #200 \_\_\_\_\_

## Liquid Limit & Plastic Limit

	Liquid Limit	Plastic Limit
A. Can number	45	19
B. Weight of can + wet soil (0.01g)	29.87	28.34
C. Weight of can + dry soil (0.01g)	28.14	27.11
D. Weight of water (B - C) (0.01g)	1.73	1.23
E. Weight of can (0.01g)	19.82	20.17
F. Weight of dry soil (C - E) (0.01g)	8.22	6.94
G. Liquid Limit (D / F x J x 100) (0.1g)	21.2	N.P. <input type="checkbox"/>
H. Plastic Limit (D / F x 100) (0.1g)		17.7
I. Plasticity Index (G - H) (0.1g)	3.5	Specification
Liquid Limit N.C. <input type="checkbox"/> (G rounded)	21	0 - 25
Plasticity Index (I rounded)	4	0 - 6
J. Correction # Blows	26	

22=0.9846, 23=0.9899, 24=0.9952, 25=1.0000, 26=1.0050, 27=1.0100, 28=1.0138

weight - #40 181.40 / weight - #4 611.20 x % passing #4 = 20.3

(±0.3% VARIABLE of accumulative % passing (0.1%) on the #40)

Sieve Size	Fineness Modulus	Retained (.1g)	% total ret. (0.1g)	% total x % pass. #4	% passing (0.1g)	% passing (rounded)	Spec Req.
#6							
#8	* 46.3	136.5	21.6	14.8	53.7	54	34 - 58
#10		28.2	4.5	3.1	50.6	51	
#12							
#16	* 56.7	67.1	10.6	7.3	43.3	43	
#20		62.7	9.9	6.8	36.5	37	
#30	* 71.7	75.8	12.0	8.2	28.3	28	
#40		61.4	9.7	6.6	21.7	22	13 - 35
#50	* 84.3	55.6	8.8	6.0	15.7	16	
#80		34.4	5.4	3.7	12.0	12	
#100	* 88.5	4.8	0.8	0.5	11.5	12	
#200		10.6	1.7	1.2	10.3	10.3	3.0 - 12.0
Pan dry		1.7	95.1	10.3	wt before washing (0.1g)	631.9	
Pan wash		93.4	15.0		wt after washing (0.1g)	538.5	
Total		3.94	632.2		loss from washing(-#200)	93.4	

**Coarse** \_\_\_\_\_ % x % Retain/Design \_\_\_\_\_ = \_\_\_\_\_

**Fine** 15.05 % x % Passing/Design \_\_\_\_\_ = \_\_\_\_\_

**Total/Combined -#200** \_\_\_\_\_

**- #4 Gradation Check**

within 0.3% of original dry weight 0.05

## Crushed Particles Test

Weight of crushed particles	447.0
Weight of total + #4 sample	1,015.9
Percent of crushed pieces	44
Specification	1 or more FF, min. 30 - 100

**- #4 % Particles less than 1.95 Specific Gravity**

Specific gravity of solution (1.95 ± 0.01) \_\_\_\_\_

Weight of lightweight particles \_\_\_\_\_

Weight of - #4 material \_\_\_\_\_

% lightweight particles \_\_\_\_\_

Specification \_\_\_\_\_

**+ #4 % Particles less than 1.95 Specific Gravity**

Specific gravity of solution (1.95 ± 0.01) \_\_\_\_\_

Weight of lightweight particles (0.1g) \_\_\_\_\_

Weight of + #4 material (0.1g) \_\_\_\_\_

% lightweight particles \_\_\_\_\_

Specification \_\_\_\_\_

Comments

Figure 6