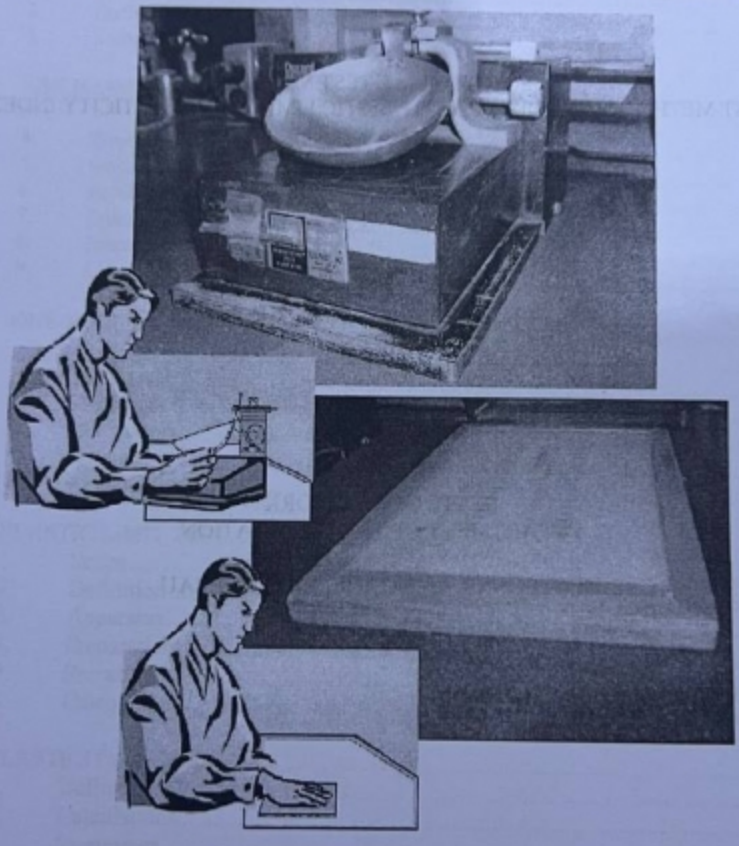
GTM-7

TEST METHOD FOR LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX



GEOTECHNICAL TEST METHOD
GTM-7
Revision #2

AUGUST 2015

NEW YORK STATE OF OPPORTUNITY. Department of Transportation | Office of Technical Services | Geotechnical Engineering Bureau

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II. LIQUID LIMIT TEST PROCEDURE

1. SCOPE

1.1 This section describes the laboratory procedure for determining the liquid limit of soils using the device specified in Section 3.8, securing the results of at least three trials, and the plotting of a flow curve. Provision is also made for a one point method requiring the calculation of the liquid limit value from data obtained from a single trial.

The method described herein is based upon AASHTO Designation T89 which has been modified for New York State Department of Transportation use.

2. DEFINITION

2.1 The liquid limit of a soil is the moisture content, expressed as a percentage of the weight of the oven-dried soil, at the boundary between the liquid and plastic states of consistency. The moisture content at this boundary is arbitrarily defined as the water content at which two halves of a soil cake will flow together, for a distance of ½ in. (12.7 mm) along the bottom of a groove of standard dimensions separating the two halves, when the cup of a standard liquid limit apparatus is dropped 25 times from a height of 0.3937 in. (10 mm) at the rate of two drops/second.

3. APPARATUS

3.1 Porcelain evaporating dishes or similar mixing dishes approximately 4½ in. (114 mm) in diameter.

3.2 Pulverizing apparatus - mortar and rubber-covered pestle.

3.3 U.S. No. 40 (0.425 mm) sieve.

3.4 Spatula, about 3 in. (75 mm) long and approximately ¾ in. (19 mm) wide.

3.5 Balance sensitive to 0.01 g.

3.6 Watering bottle, with distilled, demineralized or tap water.

3.7 Drying tares with covers, such as metal cans with lids, which will prevent moisture loss. The tares and covers should be marked and weighed as matched pairs.

3.8 Mechanical Liquid Limit Device(s)

3.8.1 Manually operated - consisting of a brass cup and carriage, constructed according to the plan and dimensions shown in Figure 1.

exercised to insure that the pulverizing apparatus does not reduce the natural size of the individual grains. If the sample contains brittle particles, the pulverizing operation shall be done carefully and with just enough pressure to free the finer material adhering to the coarser particles. The ground soil shall then be separated into two fractions by means of the No. 40 (0.425 mm) sieve. The plus No. 40 (0.425 mm) component shall be reground as before. When repeated grinding produces only a minimal quantity of minus No. 40 (0.425 mm) soil, the material retained on the No. 40 (0.425 mm) sieve shall be discarded and further pulverization of this fraction should be suspended.

4.4 The material passing the No. 40 (0.425 mm) sieve obtained from the grinding and sieving operations described above shall be thoroughly mixed together and set aside for use in performing the physical tests. Approximately 0.3 lb. (150 g) would generally suffice for the liquid limit test.

5. ADJUSTMENT OF MECHANICAL DEVICE

5.1 Inspect the liquid limit device to determine that it is in proper adjustment prior to each use, each day. Check the drop of the brass cup. See that the pin connecting the cup is not worn excessively to permit side play, that the screws connecting the cup to the hanger arm are tight, and that a groove has not been worn in the cup through long usage. Inspect the grooving tool to determine that the critical dimensions are as shown in Figure 1. Replace grooving tool tips that become worn. Replace cup when it becomes grooved by wear from the grooving tool.

5.2 By means of the gauge on the handle of the grooving tool and the adjustment plate H, Figure 1, adjust the height to which the cup C is lifted so that the point on the cup that comes in contact with the base is exactly 0.3937 in. (10 mm) above the base. Secure the adjustment plate H by tightening the screws, I. With the gauge still in place, check the adjustment by revolving the crank rapidly several times. If the adjustment is correct, a slight ringing sound will be heard when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard, further adjustments are required.

6. PROCEDURE

6.1 If the soil is organic or fine-grained containing no plus No. 40 (0.425 mm) material, and is in its natural state, proceed without adding water. Chopping, stirring and kneading may be necessary to attain a uniform consistency. Then proceed as described in Sections 6.3 through 6.9 below.

6.2 The soil sample prepared under 4.3 shall be placed in an evaporating dish, covered, and cured, and then thoroughly mixed with the addition of distilled, demineralized or tap water by alternately and repeatedly stirring, cutting and kneading with a spatula. If needed, further additions of water shall be made in increments of 1 to 3 mL; each increment of water shall be thoroughly mixed with the soil. The cup of

not been properly mixed or sufficiently cured. Then remixing is necessary and the test should be redone.

6.5 A sample of the soil is now taken to determine its moisture content. Remove a slice of soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together. Place in a moisture tight tared container. Weigh to the nearest 0.01 g and record.

6.6 The soil remaining in the cup shall be transferred to the mixing dish. The cup and grooving tool shall then be washed and dried in preparation for the next trial.

6.7 The foregoing operations shall be repeated for at least two different determinations on the soil sample to which sufficient water has been added (see 6.8 for wet natural soil) to change the soil to a fluid state, and then a more fluid state. The object of this procedure is to obtain samples of such consistency that at least one determination will be made in each of the following range of drops: 25-35, 20-30, 15-25, so the range in the three determinations is at least 10 drops. The number of drops required to close the groove should be above and below 25.

6.8 The test shall proceed from the drier to the wetter condition of the soil. However, when the soil in its natural state (see 6.1) is of such consistency that closure occurs at less than 25 drops (sample wet), the process must be reversed so as to obtain determinations in each of the aforementioned range of drops (see 6.7). Drying of the soil shall be accomplished by a combination of air-drying and manipulation by kneading. In no case shall dried soil be added to the natural soil being tested.

6.9 Oven-dry all the soil samples in the tared, uncovered containers to constant weight at 230±9° F (110±5° C), place samples in a desiccator (1) and allow to cool. Replace the covers on the containers, and weigh before hygroscopic moisture can be absorbed. Weigh (2) to the nearest 0.01 g and record. The loss in weight of the soil in each tare, due to drying, is recorded as the weight of water.

(1) A desiccator is used to cool the dried soil samples before weighing. The hot samples, if placed immediately on the balance, cause convection currents in the air which can cause serious weighing errors. Weigh within 15 minutes, at which time the samples should be cool.

(2) Always weigh on the same balance previously used.

13. PROCEDURE

13.1 Proceed in accordance with 6.1 through 6.6, except that a moisture content sample shall be taken only for the accepted trial. The accepted trial shall require between 15 and 30 drops of the cup to close the groove, and at least two consistent consecutive closures shall be observed before taking the moisture content sample for calculation of the liquid limit.

14. CALCULATIONS

14.1 Calculate the moisture content, W, for the accepted trial, expressed as a percentage of the oven-dried weight. (Same as 7.1)

14.2 Determine the liquid limit LL, using the following formula, in which the moisture content (W) expressed as a percent is multiplied by $(N/25)^{0.12}$ calculated for specific number of drops:

$$LL = W\,(N/25)^{0.12}$$

Where:

N =Number of drops of the cup required to close the groove at the moisture content, W.

14.3 Values of $(N/25)^{0.12}$ are given in Table 1.

TABLE 1 - VALUES OF $(N/25)^{0.12}$

N	$(N/25)^{0.12}$	N	$(N/25)^{0.12}$
15	0.941	23	0.990
16	0.948	24	0.995
17	0.955	25	1.000
18	0.961	26	1.005
19	0.967	27	1.009
20	0.974	28	1.014
21	0.979	29	1.018
22	0.985	30	1.022

3.11 Desiccator.

4. PREPARATION OF TEST SAMPLE

4.1 The test may be performed using material left over from the thoroughly mixed portion of the soil prepared for the liquid limit test, which normally is at a moisture content higher than the plastic limit. Set the sample aside and allow to air dry until the liquid limit test has been completed. However, if the sample is too dry to permit rolling to a ⅛ in. (3 mm) thread, add water, thoroughly remix and season in air prior to doing the test.

4.2 Where no leftover soil is available from the liquid limit test and the soil is granular and/or contains sand sizes, it shall be prepared as outlined above under Liquid Limit (4.3 and 4.4).

4.3 Where no leftover soil is available from the liquid limit test and it is determined that the soil is organic or fine-grained, containing no plus No. 40 (0.425 mm) material, the plastic limits shall be run on the natural soil, brought to the approximate moisture content for plastic limit determinations.

5. PROCEDURE

5.1 Squeeze and roll a 0.3 oz. (8 g) test sample into an ellipsoidal shaped mass. Roll this mass between the fingers or palm of hand and the ground glass plate or satisfactory paper on a smooth horizontal surface with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling should be between 80 and 90 strokes/min., counting a stroke as one complete motion of the hand forward and back to the starting position again.

5.2 When the diameter of the thread becomes ⅛ in. (3 mm), break the thread into six or eight pieces. Squeeze the pieces together between the thumbs and fingers into a uniform mass roughly ellipsoidal in shape, and reroll.

5.3 Continue this alternate rolling to a thread ⅛ in. (3 mm) in diameter, 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.

5.4 Crumbling may occur when the thread has a diameter greater than ⅛ in. (3 mm). This shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread ⅛ in. (3 mm) in diameter.

5.5 The crumbling will manifest itself differently with various soil types: 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 progresses toward the middle, and finally the thread falls apart in many small platy particles. Heavy clay soils require much pressure to deform the thread, particularly as they approach the

6.2 The two moisture contents are averaged to obtain the plastic limit. If the test results vary appreciably, retest, because reproducibility of results is mandatory to obtain the correct plastic limit.

IV. PLASTICITY INDEX

1. DEFINITION

1.1 The plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit, and is a dimensionless number. Both the liquid and plastic limits are moisture contents.

2. CALCULATIONS

2.1 Plasticity Index = Liquid Limit - Plastic Limit

$$PI = LL - PL$$

3. COMMENTS

3.1 Report the calculated difference as indicated in 2.1 as the plasticity index.

3.2 There are certain circumstances under which the plasticity index cannot be determined.

a) When either the liquid limit or plastic limit cannot be determined, report the plasticity index as NP (non-plastic).

b) When the soil is extremely sandy, the plastic limit test shall be done before the liquid limit test. If the plastic limit cannot be determined, then report the plasticity index as NP (non-plastic).

c) When the plastic limit is equal to or greater than the liquid limit, report the plasticity index as NP (non-plastic).

3.3 The plasticity index gives an indication of, among other things, the reduction in moisture content required to convert a soil from a liquid to a semisolid state. It gives the range in moisture at which a soil is in a plastic state. The plasticity index may be considered as a measure of the cohesion possessed by a soil.

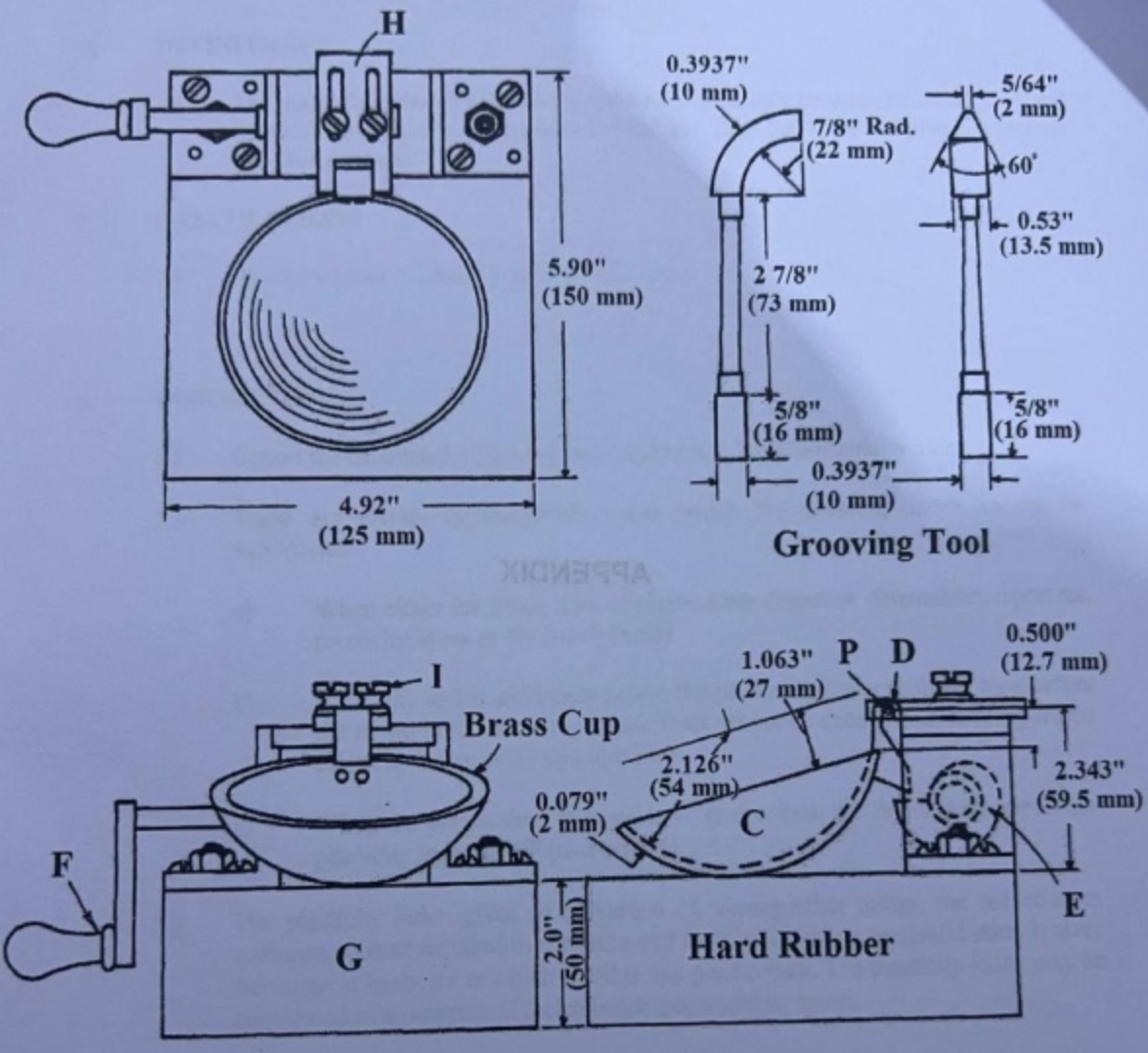
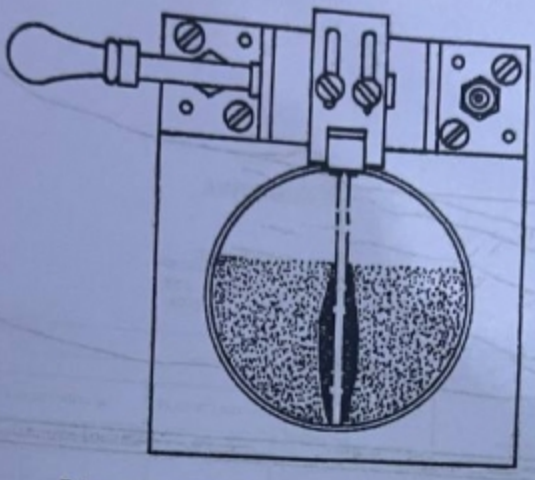
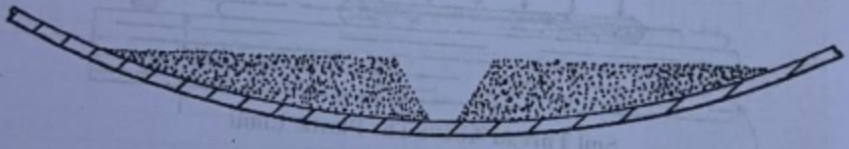


Figure 1 Mechanical Liquid Limit Device



Liquid Limit Device with Soil Sample in Place



Divided Soil Cake Before Test

Soil Cake After Test

Figure 2 Diagrams Illustrating Liquid Limit Test

SM 309 (4/66)

APPENDIX C

ATTERBERG LIMIT TESTS

Project Allegany State Park, Dam Site

District 9 County: Cattaraugus Contract

Done 10/22/73
Test by Ernst
Comp. by Mpilynn
Check by Mmlin

Sample No. / Depth - Ft.		LIQUID LIMIT - %			PLASTIC LIMIT - %	
1.	Tare No.	2	4	5	25	18
2.	Tare Plus Wet Soil	32.78	31.89	32.49	24.06	24.16
3.	Tare Plus Dry Soil	27.44	27.10	27.69	22.63	22.60
4.	Wt. of Tare	13.75	14.12	14.10	16.79	16.78
5.	Moisture Loss (2 - 3)	5.34	4.79	4.80	1.43	1.64
6.	Wt. Dry Soil (3 - 4)	13.69	13.98	13.59	5.84	5.82
7.	% M. C. (5) ÷ (6) x 100	39.0	36.9	35.3	24.5	28.7
8.	No. of Blows	17	26	35		

$\frac{200}{40}$ = ——%

Liquid Limit 37.2
Plastic Limit 24.6
Plastic Index 12.6

Sample No. / Depth - Ft.		LIQUID LIMIT - %			PLASTIC LIMIT - %	
1.	Tare No.					
2.	Tare Plus Wet Soil					
3.	Tare Plus Dry Soil					
4.	Wt. of Tare					
5.	Moisture Loss (2 - 3)					
6	Wt. Dry Soil (3 - 4)					
7.	% M. C. (5) ÷ (6) x 100					
8	No. of Blows					

$\frac{200}{40}$ = ——%

Liquid Limit
Plastic Limit
Plastic Index