Method of

DETERMINING THE ATTERBERG LIMITS OF SOILS

DOTD DESIGNATION: TR 428

I. Scope

This method covers procedures for determining the liquid limit, plastic limit and plasticity index of soils. This method should not be used to determine the PL, LL & PI of soils to be used in the design of Geotechnical Structural elements (Piles, Footings, Retention Structures etc…). ASTM D4318-17 should be used for that purpose.

For test procedure, refer to AASHTO T 89 and AASHTO T 90 with the following modifications:

II. Sample

A. A sample weighing about 25 grams shall be taken from the thoroughly mixed portion of the material passing the No. 40 sieve which has been obtained in accordance with the Method of Dry Preparation of Disturbed Samples for Test (DOTD Designation TR 411). Place the dried and prepared soil in an evaporating dish and thoroughly mix with distilled water (See Note 1) until the mass becomes sufficiently plastic to be kneaded and shaped into a ball slightly wetter than at its plastic limit. Set aside (See Note 2).

B. A sample weighing about 50 grams, taken as in Section 2 (A), shall be placed in an evaporating dish and thoroughly mixed with sufficient distilled water (See Note 1), by alternately and repeatedly stirring, kneading and chopping with a spatula, so that the soil is slightly drier than at its liquid limit. Set aside (See Note 2).

Note 1: In lieu of distilled water, water from a municipal source may be substituted provided:

A. A sample has been submitted to the Materials & Testing Section and approved for this use.
B. A series of not less than ten samples have been run using both distilled water and tap water; and the Laboratory Engineer is assured of no variations due to the use of the tap water.

Note 2: After water has once been introduced into the sample, no dry soil shall be added to the moist mixture.

III. Procedure

A. Squeeze and form an easily handled portion of the test sample taken in accordance with Section 2 (A) into an ellipsoidal mass. Roll this soil mass between the fingers or palm of hand and the ground glass plate or a piece of paper lying 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 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.

B. When the diameter of the thread becomes 1/8 inch, break the thread into six or eight pieces. Squeeze the pieces together between the thumbs and fingers of both hands into a uniform mass roughly ellipsoidal in shape, and reroll. Continue this alternate rolling to a thread 1/8 inch 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. The crumbling may occur when the thread has a diameter greater than 1/8 inch. This shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread 1/8 inch in diameter. The crumbling will manifest itself differently with the 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 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 plastic limit and, finally, thread breaks into a series of barrel-shaped segments each about 1/4 to 3/8 in. in length. At no time shall the operator attempt to produce failure at 1/8 in. diameter by allowing the thread to reach 1/8 in., then reducing the rate of rolling or the hand pressure and continuing the rolling without further deformation until the thread falls apart. It is permissible, however, to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal mass nearer to the required 1/8 in. final diameter.

C. Gather the portions of the crumbled soil together and place in a suitable tared container. Cover and repeat until about 25 grams of crumbled soil have been collected. Weigh the container and the soil and record the weight. Oven dry the soil in the container to constant weight at 230° F. ± 9°F and weigh. Record this weight. Record the loss in weight as the weight of water for calculation of the plastic limit.

D. The test sample taken in accordance with Section 2 (B) shall be further moistened as necessary by small additions of water. Each increment of water shall be thoroughly mixed with the soil as previously described before another increment of water is added. The cup of the liquid limit device should not be used for mixing soil and water.

Note 5: Some soils are slow to absorb water; therefore, it is possible to add the increments of water so fast that a false liquid limit value is obtained. This can be avoided if more mixing and/or time is allowed.

E. When sufficient water has been thoroughly mixed with the soil to form a uniform mass of stiff consistency, a sufficient quantity of this mixture shall be placed in the brass cup above the spot where the cup rests on the base and shall then be squeezed and spread into the position shown in Figure 1A with as few strokes of the spatula as possible, care being taken to prevent the entrapment of air bubbles within the mass. With the spatula the soil shall be leveled and at the same time trimmed to a depth of 1 cm. at the point of maximum thickness. The excess soil shall be returned to the evaporating dish. The soil in the cup of the mechanical device shall be divided by a firm stroke of the grooving tool along the diameter through the centerline of the cam follower so that a clean, sharp groove of the proper dimensions will be formed. To avoid tearing of the sides of the groove or slipping of the soil cake on the cup, up to six strokes, from front to back or from back to front counting as one stroke, shall be permitted. The depth of the groove should be increased with each stroke and only the last stroke should scrape the bottom of the cup.

F. The cup containing the sample shall be lifted and dropped by turning the crank F (Figure 1), at the rate of two revolutions per second until the two sides of the sample come in contact at the bottom of the groove along a distance of about ½ in. One closure of the groove is sufficient unless inspection indicates premature closure due to air bubble or lump, in which case the soil shall be remixed and a second groove closure shall be observed before one is accepted for the record, so as to assure that the accepted number of blows is truly characteristic of the soil under test. The number of blows required to close the groove the required 1/2 in. shall be recorded. The accepted number of blows shall be restricted to between 20 and 30 blows. The base of the machine shall not be held with the free hand while the crank F is turned.

G. A slice of soil approximately twice the width of the spatula, extending from edge to edge of the soil cake at right angles to the grove and including that portion of the groove in which the soil flowed together, shall be removed and placed in a suitable tared container. The container and soil shall then be weighed and the weight recorded. The soil in the container shall be oven-dried to constant weight at 230°F. ± 9°F and weighed. This weight shall be recorded and the loss in weight due to drying shall be recorded as the weight of the water and is to be used in the determination of the liquid limit.

IV. Calculations

A. The water content of the soil shall be expressed as the moisture content in percentage of the weight of the oven dried soil and shall be obtained as follows:

$$Percent\ Moisture = \frac{Weight\ of\ water}{Weight\ of\ oven\ dried\ soil} \times 100$$

V. Determination of Plastic Limit, Liquid Limit and Plasticity Index

A. Plastic Limit. The plastic limit expressed as the water content in percentage of the weight of the oven- dry soil using weights as obtained in Section 3 (C) shall be calculated in accordance with Section 4 (Calculations) and shall be reported to the nearest whole number.

B. Liquid Limit.

1. The water content of the soil at the time of the accepted closure expressed in percentage of the weight of the oven-dry soil using weights as obtained in Section 3 (G) shall be calculated in accordance with Section 4 (Calculations) and shall be recorded to the nearest 0.1 percent.
2. The Liquid Limit shall then be determined by the Mean Slope Nomograph shown in Figure 4 by plotting the number of blows, as obtained in Section 3 (F), and the water content of the soil as obtained in Section 4 (A), against the liquid limit. Alternatively, it can be obtained by means of the chart shown in Figure 3 by computing suitable factors from the nomograph, and shall be reported to the nearest whole number.
3. Plasticity Index. Determine the plasticity index of a soil as the difference between its liquid limit and its plastic limit as follows:

$$Plasticity\ Index = Liquid\ Limit - Plastic\ Limit$$

When the plastic limit is equal to, or greater than, the liquid limit, or when the liquid limit or plastic limit cannot be determined, report the plasticity index as NP (non-plastic).

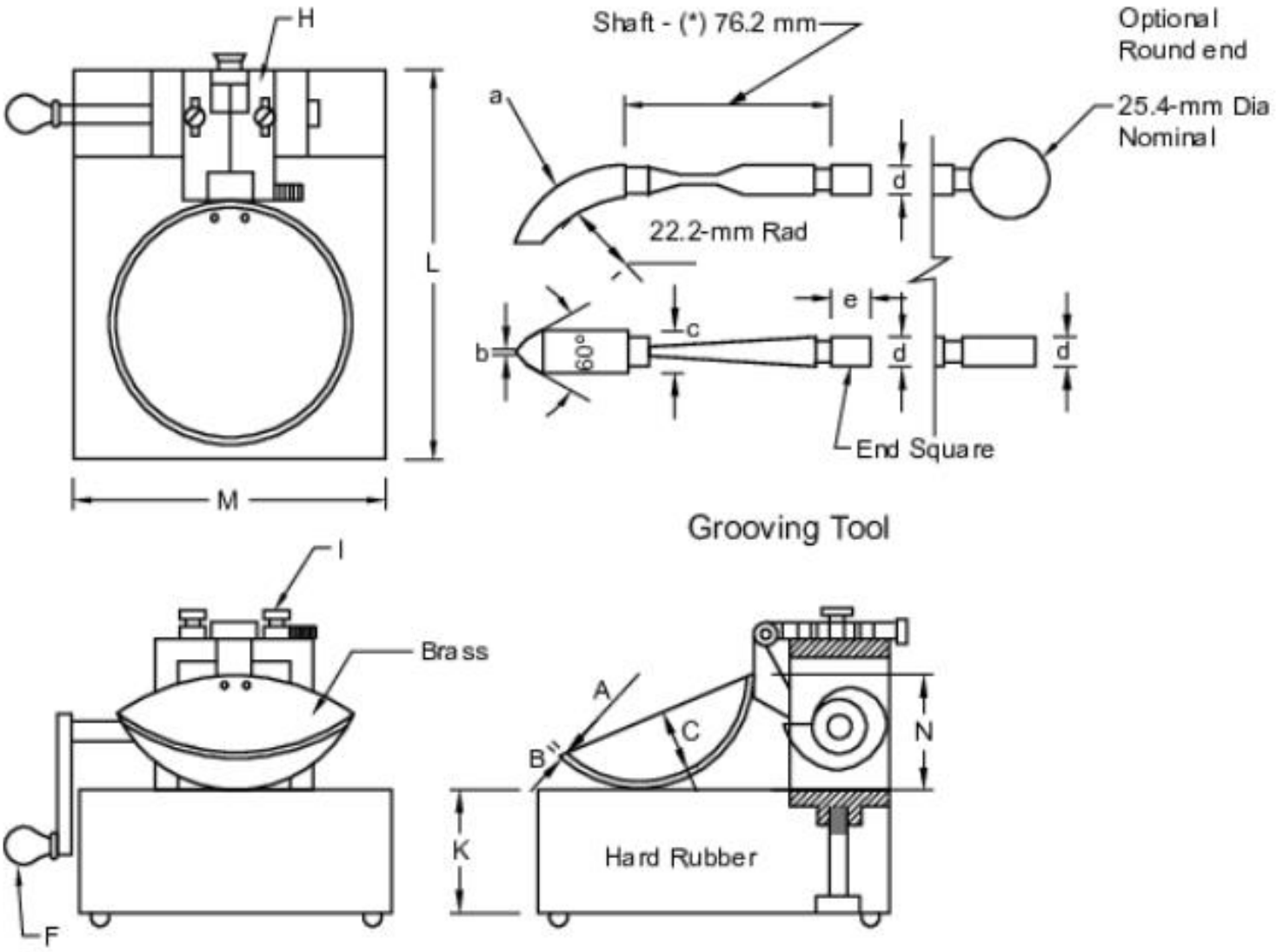

Figure 1

Mechanical Liquid Limit Device

Taken from Standard Method of Determining the Liquid Limit of Soils

AASHTO T 89

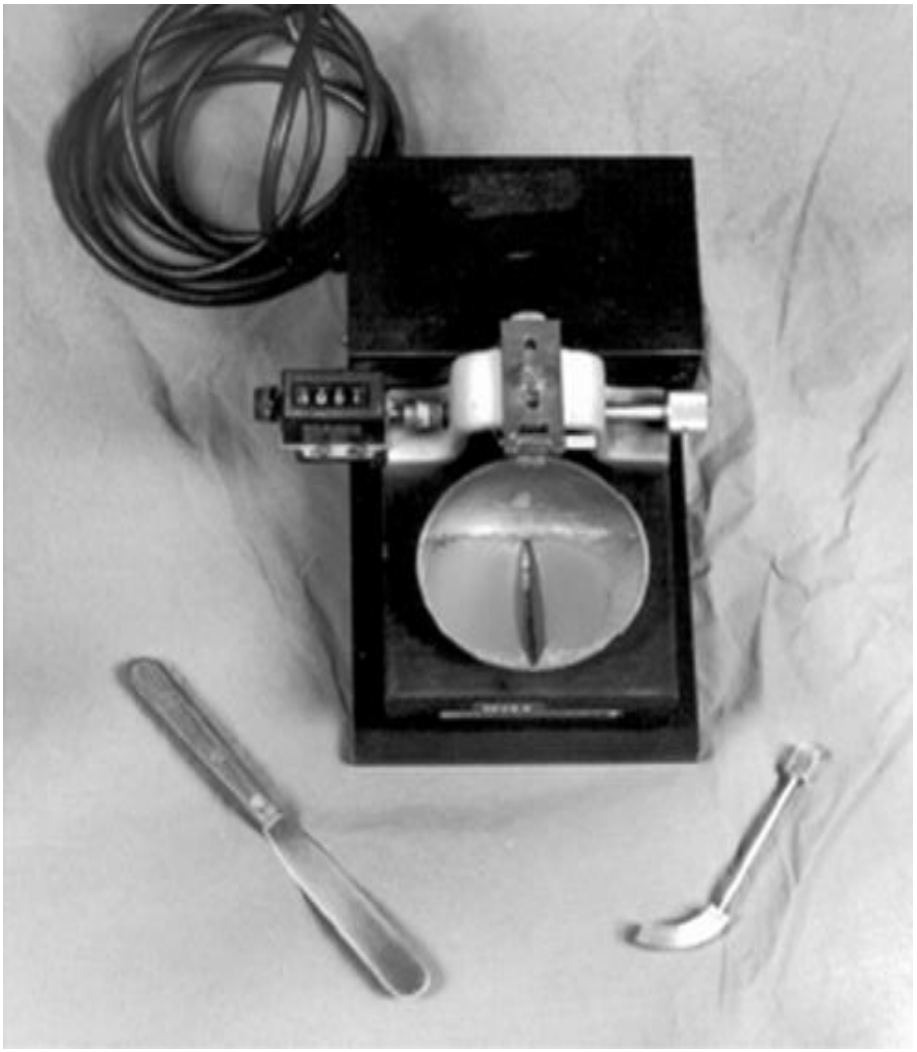

Figure 1-A – Liquid limit device with soil sample in place

	Liquid Limit Device							Groving Tool				
	Cup Assembly				Base			Curved End			Gauge	
Dimension	A	B	C	N	K	L	M	a	b	c	d	e*
Description	Radius of Cup	Thickness of Cup	Depth of Cup	Cup at Cam Follower to Base	Thickness	Length	Width	Thickness	Cutting Edge	Width	Depth	Length
US standard, in.	2.12	0.078	1.062	1.85	1.968	5.905	4.921	0.393	0.078	0.531	0.393	0.625
Tolerance, in.	0.078	0.003	0.039	0.059	0.196	0.196	0.196	0.003	0.003	0.003	0.007	----

Figure 2

LL = MOISTURE CONTENT x FACTOR			
BLOWS	FACTOR	BLOWS	FACTOR
20	0.973	26	1.005
21	0.979	27	1.009
22	0.985	28	1.014
23	0.990	29	1.018
24	0.995	30	1.022
25	1.000		

Figure 3

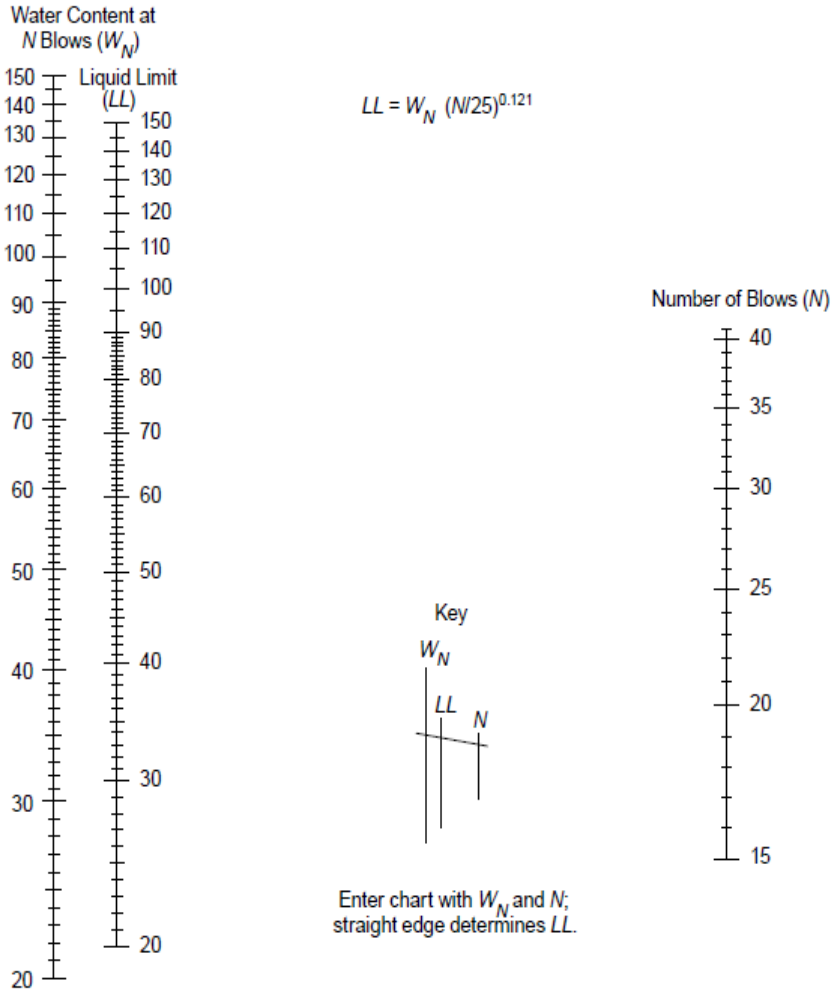

Figure 4—Nomographic Chart Developed by the Waterways Experiment Station, Corps of Engineers, U.S. Army, to Determine Liquid Limit Using Mean Slope Method

Figure 4