5. Significance and Use

5.1 These test methods are used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils (see Practices D2487 and D3282) and to specify the fine-grained fraction of construction materials (see Specification D1241). The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, hydraulic conductivity (permeability), compactibility, shrink-swell, and shear strength. (See Section 6, Interferences.)

5.2 The liquid and plastic limits of a soil and its water content can be used to express its relative consistency or liquidity index. In addition, the plasticity index and the percentage finer than 2-µm particle size can be used to determine its activity number.

5.3 These methods are sometimes used to evaluate the weathering characteristics of clay-shale materials. When subjected to repeated wetting and drying cycles, the liquid limits of these materials tend to increase. The amount of increase is considered to be a measure of a shale's susceptibility to weathering.

5.4 The liquid limit of a soil containing substantial amounts of organic matter decreases dramatically when the soil is oven-dried before testing. Comparison of the liquid limit of a sample before and after oven-drying can therefore be used as a qualitative measure of organic matter content of a soil (see Practice D2487).

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740, generally, are considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Interferences

6.1 The liquid and plastic limits of many soils that have been allowed to dry before testing may be considerably different from values obtained on non-dried samples. If the liquid and plastic limits of soils are used to correlate or estimate the engineering behavior of soils in their natural moist state, samples should not be permitted to dry before testing unless data on dried samples are specifically desired. For this reason *Specimen Preparation Procedure 1 (Wet Preparation)* is used unless *Specimen Preparation Procedure 2 (Dry Preparation)* is specified by the requesting authority.

6.2 *The Liquid Limit Method A (Multipoint Method)* is generally more precise than the one-point method. It is recommended that the *Liquid Limit Method A (Multipoint Method)* be used in cases where test results may be subject to dispute, or where greater precision is required.

6.3 Because the *Liquid Limit Method B (One-Point Method)* requires the operator to judge when the test specimen is approximately at its liquid limit, it is particularly not recommended for use by inexperienced operators.

6.4 The correlation on which the calculations of the *Liquid Limit Method B (One-Point Method)* are based may not be valid for certain soils, such as organic soils or soils from a marine environment. It is strongly recommended that the liquid limit of these soils be determined by the *Liquid Limit Method A (Multipoint Method)*.

6.5 The composition and concentration of soluble salts in a soil affect the values of the liquid and plastic limits as well as the water content values of soils (see Test Method D4542).
Special consideration should therefore be given to soils from a marine environment or other sources where high soluble salt concentrations may be present. The degree to which the salts present in these soils are diluted or concentrated must be given careful consideration.

7. Apparatus

7.1 *Liquid Limit Device*—A mechanical device consisting of a brass cup suspended from a carriage designed to control its drop onto the surface of a block of resilient material that serves as the base of the device. Fig. 1 of the ASTM shows the essential features and dimensions of the device. The device may be operated by either a hand crank or electric motor.....
NOTE 2—The dimensions marked as essential in Fig. 1 are necessary to properly manufacture the liquid limit device. Laboratories are not expected to have the capability to confirm all of the essential dimensions. Laboratories should have the ability to check critical dimensions subject to wear as described in 10.1, Inspection of Wear.
7.1.1 *Base*—A block of resilient material having a resilience rebound of at least 77 % but no more than 90 %. Conduct resilience tests on the finished base with the feet attached. Details for measuring the resilience of the base are given in Annex A1 of the ASTM.....
7.1.2 *Rubber Feet,* supporting the base, designed to provide dynamic isolation of the base from the work surface.....
7.1.3 *Cup,* brass, with a mass, including cup hanger, of 185 to 215 g.....
7.1.4 *Cam*—Designed to raise the cup smoothly and continuously to its maximum height, over a distance of at least 180° of cam rotation, without developing an upward or downward velocity of the cup when the cam follower leaves the cam. (The preferred cam motion is a uniformly accelerated lift curve.)
NOTE 3—The cam and follower design in Fig. 1 is for uniformly accelerated (parabolic) motion after contact and assures that the cup has no velocity at drop off. Other cam designs also provide this feature and may be used. However, if the cam-follower lift pattern is not known, zero velocity at drop off can be assured by carefully filing or machining the cam and follower so that the cup height remains constant over the last 20 to 45° of cam rotation.
7.1.5 *Carriage,* constructed in a way that allows convenient but secure adjustment of the height-of-drop of the cup to 10 mm (0.394 in.), and designed such that the cup and cup hanger assembly is only attached to the carriage by means of a removable pin. See 10.2 and Fig. 2 of the ASTM for explanation and determination of the height-of-drop of the cup.....
7.1.6 *Motor Drive (Optional)*—As an alternative to the hand crank shown in Fig. 1, the device may be equipped with a motor to turn the cam. Such a motor must turn the cam at 2 ± 0.1 revolutions per second and must be isolated from the rest of the device by rubber mounts or in some other way that prevents vibration from the motor being transmitted to the rest of the apparatus. It must be equipped with an ON-OFF switch and a means of conveniently positioning the cam for height of-drop adjustments. The results obtained using a motor-driven device must not differ from those obtained using a manually operated device.....
7.1.7 *Counter (Optional)*—A mechanism to automatically count the number of drops of the cup during operation of the liquid limit device.....

7.2 *Flat Grooving Tool*—A tool made of plastic or noncorroding-metal having the dimensions shown in Fig. 3 of the ASTM.....
The design of the tool may vary as long as the essential dimensions are maintained.....
The tool may, but need not, incorporate the height gauge (shown as dimension K) for adjusting the height-of-drop of the liquid limit device.....
NOTE 4—Prior to the adoption of this test method, a curved grooving tool was specified as part of the apparatus for performing the liquid limit test. The curved tool is not considered to be as accurate as the flat tool described in 7.2 since it does not control the depth of the soil in the liquid limit cup. However, there are some data which indicate that typically the liquid limit is slightly increased when the flat tool is used instead of the curved tool.
NOTE 5—The dimensions marked as essential in Fig. 3 are necessary to properly manufacture the grooving tool. Laboratories are not expected to have the capability to confirm all of the essential dimensions. Laboratories should have the ability to check critical dimensions subject to wear as described in 10.1.2.
7.3 *Height Gauge*—A metal gauge block for adjusting the height-of-drop of the cup, having the dimensions shown in Fig.4 of the ASTM. The design of the tool may vary provided the gauge will rest securely on the base without being susceptible to rocking, and the edge which contacts the cup during adjustment is straight, at least 10 mm (3⁄8 in.) wide, and without bevel or radius.....
7.4 *Water Content Containers*—Small corrosion-resistant containers with snug-fitting lids for water content specimens. Aluminum or stainless steel cans 2.5 cm (1 in.) high by 5 cm (2 in.) in diameter are appropriate.....
7.5 *Balance,* conforming to Guide D4753, Class GP1 (readability of 0.01 g) .....
7.6 *Mixing and Storage Container or Dish*—A container to mix the soil specimen (material) and store the prepared material. During mixing and storage, the container shall not contaminate the material in any way, and prevent moisture loss during storage. A porcelain, glass, or plastic dish about 11.4 cm (41⁄2 in.) in diameter and a plastic bag large enough to enclose the dish and be folded over is adequate.....
7.7 *Plastic Limit:*
7.7.1 *Ground Glass Plate*—A ground glass plate of sufficient size for rolling plastic limit threads....
7.7.2 *Plastic Limit-Rolling Device (optional)*—A device made of acrylic conforming to the dimensions shown in Fig.5 of the ASTM. The type of unglazed paper attached to the top and bottom plate (see 17.2.2) shall be such that it does not add foreign matter (fibers, paper fragments, etc.) to the soil during the rolling process.....
7.8 *Spatula*—A spatula or pill knife having a blade about 2 cm (3⁄4 in.) wide, and about 10 to 13 cm (4 to 5 in.) long.....
7.9 *Sieve(s)*—A 200-mm (8-in.) diameter, 425-µm (No. 40) sieve conforming to the requirements of Specification E11 and having a rim at least 5 cm (2 in.) above the mesh. A 2.00-mm (No. 10) sieve meeting the same requirements may also be needed.....
7.10 *Wash Bottle*—Or similar container for adding controlled amounts of water to soil and washing fines from coarse particles.....
7.11 *Drying Oven*—Meeting the requirements of Test Methods D2216.....
7.12 *Washing Pan*—Round, flat-bottomed, at least 7.6 cm (3in.) deep, and slightly larger at the bottom than a 20.3-cm (8-in.) diameter sieve.....

8. Reagents and Materials

8.1 *Purity of Water*—Where distilled water is referred to in this test method, either distilled or demineralized water may be used.....

8.1.1 In some cases, the cations of salts present in tap water will exchange with the natural cations in the soil and significantly alter the test results if tap water is used in the soaking and washing operations. Unless it is known that such cations are not present in the tap water, use distilled or demineralized water.....

NOTE 6—As a general rule, water containing more than 100 mg/L of dissolved solids should not be used for either the soaking or washing operations.

9. Sampling and Specimen

9.1 Samples may be taken from any location that satisfies testing needs. However, Practices C702 and D75 and Guide D420 should be used as guides for selecting and preserving samples from various types of sampling operations.....

Samples in which specimens will be prepared using the wet-preparation procedure (11.1) must be kept at their as-sampled water content prior to preparation.....

9.1.1 Where sampling operations have preserved the natural stratification of a sample, the various strata must be kept separated and tests performed on the particular stratum of interest with as little contamination as possible from other strata.....

Where a mixture of materials will be used in construction, combine the various components in such proportions that the resultant sample represents the actual construction case.....

9.1.2 Where data from these test methods are to be used for correlation with other laboratory or field test data, use the same material as used for those tests where possible.....

9.2 *Specimen*—Obtain a representative portion from the total sample sufficient to provide 150 to 200 g of material passing the 425-µm (No. 40) sieve.....

Free flowing samples (materials) may be reduced by the methods of quartering or splitting.....

Non-free flowing or cohesive materials shall be mixed thoroughly in a pan with a spatula or scoop and a representative portion scooped from the total mass by making one or more sweeps with a scoop through the mixed mass.....

10. Verification of Apparatus

10.1 *Inspection of Wear:*

10.1.1 *Liquid Limit Device*—Determine that the liquid limit device is clean and in good working order. Check the following specific points.....

10.1.1.1 *Wear of Base*—The spot on the base where the cup makes contact should be worn no greater than 10 mm (3⁄8 in.) in diameter.....

If the wear spot is greater than this, the base can be machined to remove the worn spot provided the resurfacing does not make the base thinner than specified in 7.1 and the other dimensional relationships are maintained.

10.1.1.2 *Wear of Cup*—Replace the cup when the grooving tool has worn a depression in the cup 0.1 mm (0.004 in.) deep or when the rim of the cup has been reduced to half its original thickness.....

Verify that the cup is firmly attached to the cup hanger.....

10.1.1.3 *Wear of Cup Hanger*—Verify that the cup hanger pivot does not bind and is not worn to an extent that allows more than 3 mm (1⁄8 in.) side-to-side movement of the lowest point on the rim_____
10.1.1.4 *Wear of Cam*—The cam shall not be worn to an extent that the cup drops before the cup hanger (cam follower) loses contact with the cam.....
10.1.1.5 *Rubber Feet*—The feet should prevent the base from bouncing or sliding on the work surface___
Replace rubber feet that become hard, cracked, or brittle from age.
10.1.2 *Grooving Tools*—Inspect grooving tools for wear on a frequent and regular basis.....
The rapidity of wear depends on the material from which the tool is made, and the types of soils being tested. Soils containing a large proportion of fine sand particles may cause rapid wear of grooving tools; therefore, when testing these materials, tools should be inspected more frequently than for other soils.
10.1.2.1 The critical grooving tool dimensions to be checked for wear are the width of the tip (dimension A in Fig.3) and the depth of the tip (dimension D in Fig. 3) .....
NOTE 7—The width of the tip of grooving tools is conveniently checked using a pocket-sized measuring magnifier equipped with a millimeter scale. Magnifiers of this type are available from most laboratory supply companies. The depth of the tip of grooving tools can be checked using the depth-measuring feature of vernier calipers.
10.2 *Adjustment of Height-of-Drop*—Adjust the height-of-drop of the cup so that the point on the cup that comes in contact with the base rises to a height of 10 ± 0.2 mm.....
See Fig.2 for proper location of the gauge relative to the cup during adjustment.
NOTE 8—A convenient procedure for adjusting the height-of-drop is as follows: place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot. The edge of the tape away from the cup hanger should bisect the spot on the cup that contacts the base. For new cups, placing a piece of carbon paper on the base and allowing the cup to drop several times will mark the contact spot. Attach the cup to the device and turn the crank until the cup is raised to its maximum height. Slide the height gauge under the cup from the front, and observe whether the gauge contacts the cup or the tape. (See Fig. 2.) If the tape and cup are both simultaneously contacted, the height-of-drop is ready to be checked. If not, adjust the cup until simultaneous contact is made. Check adjustment by turning the crank at 2 revolutions per second while holding the gauge in position against the tape and cup. If a faint ringing or clicking sound is heard without the cup rising from the gauge, the adjustment is correct. If no ringing is heard or if the cup rises from the gauge, readjust the height-of-drop. If the cup rocks on the gauge during this checking operation, the cam follower pivot is excessively worn and the worn parts should be replaced. Always remove tape after completion of adjustment operation.

11. Preparation Procedures for Test Specimens

11.1 *Specimen Preparation Procedure 1 (Wet Preparation Procedure)*—Except where *Specimen Preparation Procedure 2 (Dry Preparation Procedure)* is specified (11.2), prepare the specimen for testing as described in the following sections.....
11.1.1 *For Specimens Consisting of Material that Entirely Passes the 425-µm (No. 40) Sieve:* .....
11.1.1.1 Determine by visual and manual methods that the specimen from 9.2 has little or no material retained on a 425-µm (No. 40) sieve.....
If this is the case, prepare 150 to 200 g of material by mixing thoroughly with distilled or demineralized water on the glass plate or mixing dish using the spatula.....

If desired, soak the material in a mixing/storage dish with a small amount of water to soften the material before the start of mixing (see 8.1.1) .....
If using Liquid Limit Method A (Multipoint Method), adjust the water content of the material to bring it to a consistency that would require about 25 to 35 drops of the cup of the liquid limit device (commonly referred to as "blows") to close the groove.....
For Liquid Limit Method B (One-Point Method), the number of drops should be between about 20 and 30.....
11.1.1.2 If, during mixing, a small percentage of material is encountered that would be retained on a 425-µm (No. 40) sieve, remove these particles by hand (if possible) .....
If it is impractical to remove the coarser material by hand, remove small percentages (less than about 15 %) of coarser material by working the material (having the above consistency) through a 425-µm sieve. During this procedure, use a piece of rubber sheeting, rubber stopper, or other convenient device provided the procedure does not distort the sieve or degrade material that would be retained if the washing method described in 11.1.2 were used.....
If larger percentages of coarse material are encountered during mixing, or it is considered impractical to remove the coarser material by the procedures just described, wash the sample as described in 11.1.2.....
When the coarse particles found during mixing are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425-µm sieve, but remove by hand or by washing.....
11.1.1.3 Place the prepared material in the mixing/storage dish, check its consistency (adjust if required), cover to prevent loss of moisture, and allow to stand (cure) for at least 16 h (overnight)
After the standing period and immediately before starting the test, thoroughly remix the soil.....
NOTE 9—The time taken to adequately mix a soil will vary greatly, depending on the plasticity and initial water content. Initial mixing times of more than 30 min may be needed for stiff, fat clays.
11.1.2 *For Specimens Consisting of Material Containing Particles Retained on a 425-µm (No. 40) Sieve:*
.....
11.1.2.1 Place the specimen (see 9.2) in a pan or dish and add sufficient water to cover the material
Allow the material to soak until all lumps have softened and the fines no longer adhere to the surfaces of the coarse particles. (See 8.1.1.) .....
11.1.2.2 When the material contains a large percentage of particles retained on the 425-µm (No. 40) sieve, perform the following washing operation in increments, washing no more than 0.5 kg (1 lb) of material at one time.....
Place the 425-µm sieve in the bottom of the clean pan. Transfer, without any loss of material, the soil-water mixture onto the sieve.....
If gravel or coarse sand particles are present, rinse as many of these as possible with small quantities of water from a wash bottle, and discard.....
Alternatively, transfer the soil-water mixture over a 2.00-mm (No. 10) sieve nested atop the 425-µm sieve, rinse the fine material through and remove the 2.00-mm sieve.....
11.1.2.3 After washing and removing as much of the coarser material as possible, add sufficient water to the pan to bring the level to about 13 mm (1⁄2 in.) above the surface of the 425-µm sieve. Agitate the slurry by stirring with the fingers while raising and lowering the sieve in the pan and swirling the suspension so that fine material is washed from the coarser particles.....

Disaggregate fine soil lumps that have not slaked by gently rubbing them over the sieve with the fingertips.....
Complete the washing operation by raising the sieve above the water surface and rinsing the material retained with a small amount of clean water.....
Discard material retained on the 425-µm sieve.....
11.1.2.4 Reduce the water content of the material passing the 425-µm (No. 40) sieve until it approaches the liquid limit.....
Reduction of water content may be accomplished by one or a combination of the following methods:
(*a*) exposing to air currents at room temperature,
(*b*) exposing to warm air currents from a source such as an electric hair dryer,
(*c*) decanting clear water from surface of the suspension,
(*d*) filtering in a Büchner funnel or using filter candles, or
(*e*) draining in a colander or plaster of Paris dish lined with high retentivity, high wet strength filter paper. If a plaster of Paris dish is used, take care that the dish never becomes sufficiently saturated that it fails to absorb water into its surface. Thoroughly dry dish between uses.
During evaporation and cooling, stir the material often enough to prevent over-drying of the fringes and soil pinnacles on the surface of the mixture.....
For materials containing soluble salts, use a method of water reduction (*a* or *b*) that will not eliminate the soluble salts from the test specimen.....
11.1.2.5 If applicable, remove the material retained on the filter paper. Thoroughly mix this material or the above material on the glass plate or in the mixing dish using the spatula. .....
Adjust the water content of the mixture, if necessary, by adding small increments of distilled or demineralized water or by allowing the mixture to dry at room temperature while mixing on the glass plate.....
If using Liquid Limit Method A (Multipoint Method), the material should be at a water content that would require about 25 to 35 drops of the cup of the liquid limit device to close the groove.....
For Liquid Limit Method B (One-Point Method), the number of drops should be between about 20 and 30.....
Put, if necessary, the mixed material in the storage dish, cover to prevent loss of moisture, and allow to stand (cure) for at least 16 h.....
After the standing period and immediately before starting the test, thoroughly remix the specimen
11.2 *Specimen Preparation Procedure 2 (Dry Preparation Procedure):* .....
11.2.1 Dry the specimen from 9.2 at room temperature or in an oven at a temperature not exceeding 60°C until the soil clods will pulverize readily. (See Section 6, Interferences.) .....
Disaggregation is expedited if the material is not allowed to completely dry. However, the material should have a dry appearance when pulverized.....
11.2.2 Pulverize the material in a mortar with a rubber tipped pestle or in some other way that does not cause breakdown of individual particles.....
When the coarse particles found during pulverization are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425-µm (No. 40) sieve, but remove by hand or other suitable means, such as washing.....
If a washing procedure is used, follow 11.1.2.1 – 11.1.2.5.....

11.2.3 Separate the material on a 425-µm (No. 40) sieve, shaking the sieve by hand to assure thorough separation of the finer fraction.....
Return the material retained on the 425-µm sieve to the pulverizing apparatus and repeat the pulverizing and sieving operations. Stop this procedure when most of the fine material has been disaggregated and material retained on the 425-µm sieve consists of individual particles.....
11.2.4 Place material retained on the 425-µm (No. 40) sieve after the final pulverizing operations in a dish and soak in a small amount of water.....
Stir this mixture and transfer it to a 425-µm sieve, catching the water and any suspended fines in the washing pan.....
Pour this suspension into a dish containing the dry soil previously sieved through the 425-µm sieve
Discard material retained on the 425-µm sieve.....
11.2.5 Proceed as described in 11.1.2.4 and 11.1.2.5.....

METHODS FOR LIQUID LIMIT—LIQUID LIMIT
METHOD A (MULTIPOINT METHOD)
12. Procedure for Liquid Limit Method A (Multipoint Method)

12.1 Thoroughly remix the specimen (soil) in its mixing dish, and, if necessary, adjust its water content until the consistency requires about 25 to 35 drops of the cup of the liquid limit device to close the groove.....
Using a spatula, place a portion(s) of the prepared soil in the cup of the liquid limit device at the point where the cup rests on the base, squeeze it down, and spread it into the cup to a depth of about 10 mm at its deepest point, tapering to form an approximately horizontal surface.....
Take care to eliminate air bubbles from the soil pat, but form the pat with as few strokes as possible
Keep the unused soil in the mixing/storage dish.....
Cover the dish with a wet towel (or use other means) to retain the moisture in the soil.....
12.2 Form a groove in the soil pat by drawing the tool, beveled edge forward, through the soil on a line joining the highest point to the lowest point on the rim of the cup.....
When cutting the groove, hold the grooving tool against the surface of the cup and draw in an arc, maintaining the tool perpendicular to the surface of the cup throughout its movement. See Fig. 6 of the ASTM.....
In soils where a groove cannot be made in one stroke without tearing the soil, cut the groove with several strokes of the grooving tool. Alternatively, cut the groove to slightly less than required dimensions with a spatula and use the grooving tool to bring the groove to final dimensions.....
Exercise extreme care to prevent sliding the soil pat relative to the surface of the cup.....
12.3 Verify that no crumbs of soil are present on the base or the underside of the cup.....
12.4 Lift and drop the cup by turning the crank at a rate of 1.9 to 2.1 drops per second until the two halves of the soil pat come in contact at the bottom of the groove along a distance of 13 mm (1⁄2 in.). See Fig. 7 and Fig. 8 of the ASTM.....
The base of the machine shall not be held with the hand, or hands, while the crank is turned.....
NOTE 10—Use of a scale is recommended to verify that the groove has closed 13 mm (1⁄2 in.).
12.5 Verify that an air bubble has not caused premature closing of the groove by observing that both sides of the groove have flowed together with approximately the same shape.....

If a bubble has caused premature closing of the groove, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving operation and repeat 12.1 – 12.4.....
If the soil slides on the surface of the cup, repeat 12.1 – 12.4 at a higher water content.....
If, after several trials at successively higher water contents, the soil pat continues to slide in the cup or if the number of drops required to close the groove is always less than 25, record that the liquid limit could not be determined, and report the soil as nonplastic without performing the plastic limit test
12.6 Record the number of drops, *N*, required to close the groove.....
12.7 Obtain a water content specimen by removing 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 container of known mass, and cover.....
12.8 Return the soil remaining in the cup to the dish.....
Wash and dry the cup and grooving tool and reattach the cup to the carriage in preparation for the next trial.....
12.9 Remix the entire soil specimen in the dish adding distilled water to increase the water content of the soil and decrease the number of drops required to close the groove.....
Repeat 12.1 – 12.8 for at least two additional trials producing successively lower numbers of drops to close the groove.....
One of the trials shall be for a closure requiring 25 to 35 drops, one for closure between 20 and 30 drops, and one trial for a closure requiring 15 to 25 drops.....
12.10 Determine the water content, *wn*, of the soil water content specimen from each trial, *n*, in accordance with Test Methods D2216.....
12.10.1 Determination of initial masses (container plus moist soil) should be performed immediately after completion of the test.....
If the test is to be interrupted for more than about 15 minutes, determine the mass of the water content specimens already obtained at the time of the interruption.....

13. Calculation for Liquid Limit Method A (Multipoint Method)

13.1 Plot the relationship between the water content, *wn*, and the corresponding numbers of drops, *Nn*, of the cup on a semilogarithmic graph with the water content as ordinates on the arithmetical scale, and the number of drops as abscissas on a logarithmic scale.....
Draw the best straight line through the three or more plotted points.....
13.2 Take the water content corresponding to the intersection of the line with the 25-drop abscissa as the liquid limit, *LL*, of the soil and round to the nearest whole number.....
Computational methods may be substituted for the graphical method for fitting a straight line to the data and determining the liquid limit.....

LIQUID LIMIT METHOD B (ONE-POINT METHOD)

14. Procedure for Liquid Limit Method B (One-Point Method)

14.1 Proceed as described in 12.1 – 12.6 except that the number of drops required to close the groove shall be 20 to 30.....
If less than 20 or more than 30 drops are required, return the soil in the cup to the mixing dish, adjust the water content of the soil and repeat the procedure.....

14.2 Immediately after removing the water content specimen as described in 12.6, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving and water content sampling processes.....

14.2.1 As an alternative to reforming the soil in the brass cup after removing the water content specimen, the soil remaining in the cup can be removed from the cup, remixed with the soil in the mixing container and a new specimen placed in the cup as described in 12.1.....

14.3 Repeat 12.2 – 12.6.....

14.4 If the second closing of the groove requires the same number of drops or no more than two drops difference, secure another water content specimen as described in 12.6.....

If the difference of the number of drops between the first and second closings of the groove is greater than two, remix the entire specimen and repeat the procedure, beginning at 14.1, until two successive closures having the same number of drops or no more than two drops difference are obtained....

NOTE 11—Excessive drying or inadequate mixing will cause the number of drops to vary.

14.5 Determine water contents of the two water content specimens in accordance with 12.10 and 12.10.1.....

15. Calculations for Liquid Limit Method B (One-Point Method)

15.1 Determine the trial liquid limit, *LLn*, for each water content specimen using one of the following equations: .....

$$LLn = wn \cdot (Nn / 25)^{0.121} \quad (1)$$

or

$$LLn = k \cdot wn \quad (2)$$

where:

LLn = one point liquid limit for given trial "*n*", %,
Nn = number of drops causing closure of the groove for given trial,
wn = water content for given trial, %, and
k = factor given in Table 1.

TABLE 1 Factors for Obtaining Liquid Limit from Water Content and Number of Drops Causing Closure of Groove

N (Number of Drops)	k (Factor for Liquid Limit)
20	0.973
21	0.979
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014
29	1.018
30	1.022

15.1.1 The liquid limit, *LL*, is the average of the two trial liquid-limit values, to the nearest whole number (without the percent designation) .....
15.2 If the difference between the two trial liquid-limit values is greater than one percentage point, repeat the test as described in 14.1 through 15.1.1.....

METHOD FOR PLASTIC LIMIT

16. Preparation of Plastic Limit Test Specimen

16.1 Select a 20-g or more portion of soil from the material prepared for the liquid limit test; either, after the second mixing before the test, or from the soil remaining after completion of the liquid limit test.....
16.2 Reduce the water content of the soil to a consistency at which it can be rolled without sticking to the hands by spreading or mixing continuously on the glass plate or in the mixing/storage dish.....
The drying process may be accelerated by exposing the soil to the air current from an electric fan, or by blotting with paper, that does not add any fiber to the soil.....
Paper such as hard surface paper toweling or high wet-strength filter paper is adequate.....
Do not use blotting for materials containing soluble salts; use a method of water reduction that will not eliminate the soluble salts from the test specimen.....

17. Procedures for Plastic Limit

17.1 From this plastic-limit specimen, select a 1.5 to 2.0 g portion. Form the selected portion into an ellipsoidal mass.....
17.2 Roll the soil mass by one of the following procedures:
Plastic Limit Rolling Procedure 1 (Hand Rolling) or *Plastic Limit Rolling Procedure 2 (Using the Rolling Device)*
17.2.1 *Plastic Limit Rolling Procedure 1 (Hand Rolling)* .....
Roll the mass between the palm or fingers and the ground-glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length (see Note 12) .....
The thread shall be further deformed on each stroke so that its diameter reaches 3.2 mm (1⁄8 in.), taking no more than 2 minutes (see Note 13) .....
The amount of hand or finger pressure required will vary greatly according to the soil being tested, that is, the required pressure typically increases with increasing plasticity.....
Fragile soils of low plasticity are best rolled under the outer edge of the palm or at the base of the thumb.....
NOTE 12—A normal rate of rolling for most soils should be 80 to 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position. This rate of rolling may have to be decreased for very fragile soils.
NOTE 13—A 3.2-mm (1⁄8-in.) diameter rod or tube is useful for frequent comparison with the soil thread to ascertain when the thread has reached the proper diameter.
17.2.2 *Plastic Limit Rolling Procedure 2 (Using the Rolling Device)* .....
Attach smooth unglazed paper to both the top and bottom plates of the plastic limit-rolling device
Place the soil mass on the bottom plate at the midpoint between the slide rails.....
Place the top plate in contact with the soil mass(es) .....

Simultaneously apply a slight downward force and back and forth motion to the top plate so that the top plate comes into contact with the side rails within 2 min (see Notes 12 and 14) .....
During this rolling process, the end(s) the soil thread(s) shall not contact the side rail(s) .....
If this occurs, roll a smaller mass of soil (even if it is less than that mentioned in Section 17.1) .....
NOTE 14—In most cases, two soil masses (threads) can be rolled simultaneously in the plastic limit-rolling device.

17.3 When the diameter of the thread becomes 3.2 mm, break the thread into several pieces. Squeeze the pieces together, knead between the thumb and first finger of each hand, reform into an ellipsoidal mass, and re-roll.....

17.4 Continue this alternate rolling to a thread 3.2 mm in diameter, gathering together, kneading and re-rolling, until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a 3.2-mm diameter thread (see Fig. 9 of the ASTM and Note 15) .....

17.4.1 It has no significance if the thread breaks into threads of shorter length. Roll each of these shorter threads to 3.2 mm in diameter. The only requirement for continuing the test is that these threads can be reformed into an ellipsoidal mass and rolled out again.....

17.4.2 The operator shall at no time attempt to produce failure at exactly 3.2-mm diameter by allowing the thread to reach 3.2 mm, then reducing the rate of rolling or the hand pressure, or both, while continuing the rolling without further deformation until the thread falls apart.....

17.4.3 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 3.2-mm final diameter..

17.4.4 If crumbling occurs when the thread has a diameter greater than 3.2 mm, this shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread 3.2 mm in diameter.....

NOTE 15—Crumbling of the thread 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. Fat clay soils require much pressure to deform the thread, particularly as they approach the plastic limit. With these soils, the thread breaks into a series of barrel-shaped segments about 3.2 to 9.5 mm (1⁄8 to 3⁄8 in.) in length. (See Appendix X2 of the ASTM for additional examples of soils at the Plastic Limit.)

17.5 Gather the portions of the crumbled thread together and place in a container of known mass. Immediately cover the container.....

17.6 Select another 1.5 to 2.0-g portion of soil from the plastic-limit specimen.....
Form the selected portion into an ellipsoidal mass and repeat the operations described in 17.1 – 17.5 until the container has at least 6 g of soil.....

17.7 Repeat 17.1 – 17.6 to make another container holding at least 6 g of soil.....

17.8 Determine the water content of the soil contained in the containers in accordance with Test Methods D2216. See 12.10.1.....

18. Calculation for Plastic Limit

18.1 Compute the average of the two water contents (trial plastic limits) and round to the nearest whole number. This value is the plastic limit, *PL*.....

18.2 Repeat the test if the difference between the two trial plastic limits is greater than the acceptable range of two results listed in Table 2 of the ASTM for single-operator results.....

PLASTICITY INDEX

19. Calculation for Plasticity Index

19.1 Calculate the plasticity index, *PI*, as follows:

$$PI = LL - PL \quad (3)$$

where:
LL = liquid limit (whole number), and
PL = plastic limit (whole number).

19.2 Both *LL* and *PL* are whole numbers.....

If either the liquid limit or plastic limit could not be determined, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, *NP*.....

20. Report: Test Data Sheet(s)/Form(s)

20.1 The terminology used to specify how data are recorded on the test data sheet(s)/form(s), as given below, is covered in 1.9 of the ASTM.

20.2 Record as a minimum the following information: .....

20.2.1 Sample/specimen identifying information, such as location, project name, project number, boring number, depth (m or ft) .....

20.2.2 Description of sample, such as approximate maximum grain size, estimate of the percentage of sample retained on the 425-µm (No. 40) sieve, as-received water content.....

20.2.3 Details of specimen preparation, such as wet or dry (air-dried or oven-dried), method of removing particles larger than the 425-µm (No. 40) sieve.....

20.2.4 Any special specimen selection process used, such as removal of sand lenses from an intact (undisturbed) sample.....

20.2.5 Equipment used, such as hand rolled (Plastic Limit Rolling Procedure 1) or rolling device (Plastic Limit Rolling Procedure 2) for plastic limit, manual or mechanical liquid limit device, metal or plastic grooving tool.....

20.2.6 Liquid limit, plastic limit, and plasticity index to the nearest whole number, omitting the percent designation. .....

If the liquid limit or plastic limit tests could not be performed, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP.....

20.2.7 Method by which liquid limit was performed, if it differs from the multipoint method.....

Comments