Designation: D3080/D3080M – 11

Standard Test Method for

Direct Shear Test of Soils Under Consolidated Drained Conditions[1]

This standard is issued under the fixed designation D3080/D3080M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of the consolidated drained shear strength of one specimen of a soil material under direct shear boundary conditions. The specimen is deformed at a controlled rate on or near a single shear plane determined by the configuration of the apparatus.

1.2 Shear stresses and displacements are nonuniformly distributed within the specimen. An appropriate height cannot be defined for calculation of shear strains. Therefore, stress-strain relationships or any associated quantity such as the shear modulus, cannot be determined from this test.

1.3 The determination of strength envelopes and the development of criteria to interpret and evaluate test results are left to the engineer or office requesting the test.

1.4 The results of the test may be affected by the presence of coarse-grained soil or rock particles, or both, (see Section 7).

1.5 Test conditions, including normal stress and moisture environment, should be selected to represent the field conditions being investigated. The rate of shearing must be slow enough to ensure drained conditions.

1.6 Generally, three or more tests are performed on specimens from one soil sample, each under a different normal load, to determine the effects upon shear resistance and displacement. Results from a test series are combined to determine strength properties such as Mohr strength envelopes. Interpretation of multiple tests requires engineering judgment and is beyond the scope of this test method. This test method pertains to the requirements for a single test.

1.7 There may be instances when the gap between the shear box halves should be increased to accommodate sand sized particles greater than the specified gap. Presently there is insufficient information available for specifying the gap dimension based on particle size distribution.

1.8 *Units*—The values stated in either inch-pound units or SI units [given in brackets] are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.8.1 The gravitational system of inch-pound units is used. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The slug unit is not given, unless dynamic (F = ma) calculations are involved.

1.9 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.9.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.10 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D422 Test Method for Particle-Size Analysis of Soils

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Strength and Compressibility of Soils.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2435 Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4220 Practices for Preserving and Transporting Soil Samples

D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D6026 Practice for Using Significant Digits in Geotechnical Data

D6027 Practice for Calibrating Linear Displacement Transducers for Geotechnical Purposes (Withdrawn 2013)[3]

3. Terminology

3.1 *Definitions*—For definitions of common technical terms used in this test method, refer to Terminology D653.

3.2 *Description of Terms Specific to This Standard:*

3.2.1 *Failure*—The stress condition at failure for a test specimen. Failure is often taken as the maximum shear stress attained, or in the absence of a peak condition, the shear stress at 10 percent relative lateral displacement. Depending on soil behavior and field application, other suitable criteria may be defined at the direction of the requesting agency.

3.2.2 *Nominal Normal Stress*—In the direct shear test, the applied normal (vertical) force divided by the area of the shear box. The contact area of the specimen on the imposed shear plane decreases during shear and hence the true normal stress is unknown.

3.2.3 *Nominal Shear Stress*—In the direct shear test, the applied shear force divided by the area of the shear box. The contact area of the specimen on the imposed shear plane decreases during shear and hence the true shear stress is unknown.

3.2.4 *Percent Relative Lateral Displacement*—The ratio, in percent, of the relative lateral displacement to the diameter or lateral dimension of the specimen in the direction of shear.

3.2.5 *Preshear*—In strength testing, the stage of a test after the specimen has stabilized under the consolidation loading condition and just prior to starting the shearing phase. It is used as an adjective to modify phase relations or stress conditions.

3.2.6 *Relative Lateral Displacement*—The displacement between the top and bottom shear box halves.

[3] The last approved version of this historical standard is referenced on www.astm.org.

4. Summary of Test Method

4.1 This test method consists of placing the test specimen in the direct shear device, applying a predetermined normal stress, providing for wetting or draining of the test specimen, or both, consolidating the specimen under the normal stress, unlocking the shear box halves that hold the test specimen, and shearing the specimen by displacing one shear box half laterally with respect to the other at a constant rate of shearing deformation while measuring the shearing force, relative lateral displacement, and normal displacement (Fig. 1). The shearing rate must be slow enough to allow nearly complete dissipation of excess pore pressure.

5. Significance and Use

5.1 The direct shear test is suited to the relatively rapid determination of consolidated drained strength properties because the drainage paths through the test specimen are short, allowing excess pore pressure to dissipate more rapidly than other drained stress tests. The test can be made on any type of soil material. It is applicable for testing intact, remolded, or reconstituted specimens. There is however, a limitation on the maximum particle size (see 6.2).

5.2 The test results are applicable to assessing strength in a field situation where complete consolidation has occurred under the existing normal stresses. Failure is reached slowly under drained conditions so that excess pore pressures are dissipated. The shear rate must meet the requirements of 9.10. The results from several tests may be used to express the relationship between consolidation stress and drained shear strength.

NOTE 1—The equipment specified in this standard method is not appropriate for performing undrained shear tests. Using a fast displacement rate without proper control of the volume of the specimen will result in partial drainage and incorrect measurements of shear parameters.

5.3 During the direct shear test, there is rotation of principal stresses, which may or may not model field conditions. Moreover, failure may not occur on the weakest plane since failure is forced to occur on or near a plane through the middle of the specimen. The fixed location of the plane in the test can be an advantage in determining the shear resistance along recognizable weak planes within the soil material and for testing interfaces between dissimilar materials.

5.4 Shear stresses and displacements are nonuniformly distributed within the specimen, and an appropriate height is not defined for calculating shear strains or any associated engineering quantity. The slow rate of displacement provides for dissipation of excess pore pressures, but it also permits plastic flow of soft cohesive soils.

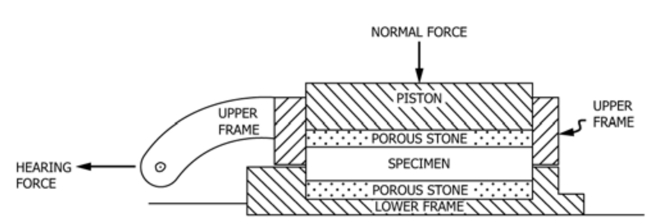

FIG. 1 Test Specimens in Single Shear Apparatus

5.5 The number of tests in a series normal stress level, rate of shearing, and general test conditions should be selected to approximate the specific soil conditions being investigated.

5.6 The area of the shear surface decreases during the test. This area reduction creates uncertainty in the actual value of the shear and normal stress on the shear plane but should not affect the ratio of these stresses.

NOTE 2—Notwithstanding the statement on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing the test and the suitability of the equipment and facilities used. Agencies which meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D3740 provides a means of evaluating some of these factors.

6. Apparatus

6.1 *Shear Device*—A device to hold the specimen securely between two porous inserts in such a way that torque is not applied to the specimen. The shear device shall provide a means of applying a normal stress to the faces of the specimen, for measuring change in thickness of the specimen, for permitting drainage of water through the porous inserts at the top and bottom boundaries of the specimen, and for submerging the specimen in water. The device shall be capable of applying a shear force to the specimen along a predetermined shear plane (single shear) parallel to the faces of the specimen. The frames that hold the specimen shall be sufficiently rigid to prevent their distortion during shearing. The various parts of the shear device shall be made of material not subject to corrosion by moisture or substances within the soil, for example, stainless steel, bronze, or aluminum, etc. Dissimilar metals, which may cause galvanic action, are not permitted.

6.2 *Shear Box,* a shear box, either circular or square, made of stainless steel, bronze, or aluminum, with provisions for drainage through the top and bottom. The box is divided by a straight plane into two halves of equal thickness which are fitted together with alignment screws. The shear box is also fitted with gap screws, which create the space (gap) between the top and bottom halves of the shear box prior to shear. The two halves should provide a bearing surface for the specimen along the shear plane during relative lateral displacement.

6.2.1 The minimum specimen diameter for circular specimens, or width for square specimens, shall be 2.0 in. [50 mm], or not less than ten (10) times the maximum particle size diameter, whichever is larger.

6.2.2 The minimum initial specimen thickness shall be 0.5 in. [13 mm], but not less than six (6) times the maximum particle diameter.

6.2.3 The minimum specimen diameter to thickness or width to thickness ratio shall be 2:1.

NOTE 3—A light coating of grease applied to the inside of the shear box may be used to reduce friction between the specimen and shear box. TFE-fluorocarbon coating may also be used on these surfaces instead of grease to reduce friction.

6.3 *Porous Inserts,* Porous inserts function to allow drainage from the soil specimen along the top and bottom boundaries. They also function to transfer shear stress from the insert to the top and bottom boundaries of the specimen. Porous inserts shall consist of silicon carbide, aluminum oxide, or metal which is not subject to corrosion by soil substances or soil moisture. The proper grade of insert depends on the soil being tested. The hydraulic conductivity of the insert should be substantially greater than that of the soil, but should be textured fine enough to prevent excessive intrusion of the soil into the pores of the insert. The diameter or width of the top porous insert or plate shall be 0.01 to 0.02 in. (0.2 to 0.5 mm) less than that of the inside of the shear box. The insert functions to transfer the shear stress to the soil and must be sufficiently coarse to develop interlock. Sandblasting or tooling the insert may help, but the surface of the insert should not be so irregular as to cause substantial stress concentrations in the soil. Porous inserts should be checked for clogging on a regular basis.

NOTE 4—Exact criteria for insert texture and hydraulic conductivity have not been established. For normal soil testing, medium grade inserts with a hydraulic conductivity of about 0.5 to 1.0×10^{3} ft/yr [5.0×10^{-4} to 1.0×10^{-3} cm/s] are appropriate for testing silts and clays, and coarse grade inserts with a hydraulic conductivity of about 0.5 to 1.0×10^{5} ft/yr [0.05 to 0.10 cm/s] are appropriate for sands. It is important that the hydraulic conductivity of the porous insert is not reduced by the collection of soil particles in the pores of the insert. Storing the porous inserts in a water filled container between uses will slow clogging. The inserts can be cleaned by flushing, boiling, or ultrasonic agitation.

6.4 *Loading Devices:*

6.4.1 *Device for Applying the Normal Force*—The normal force is typically applied by dead weights, a lever loading yoke activated by dead weights (masses), a pneumatic force cylinder, or a screw driven actuator. The device shall be capable of maintaining the normal force to within ± 1 percent of the specified force. It should apply the load quickly without significantly exceeding the steady value. Dead weight systems should be checked on a regular schedule. All systems with adjustable force application (e.g. pneumatic regulator or motor driven screw) require a force indicating device such as a proving ring, load cell, or pressure sensor.

6.4.2 *Device for Shearing the Specimen*—The device shall be capable of shearing the specimen at a uniform rate of displacement, with less than ±5 percent deviation. The rate to be applied depends upon the consolidation characteristics of the test material as specified in 9.10. The rate is usually maintained with an electric motor and gear box arrangement and the shear force is determined by a force indicating device such as a proving ring or load cell.

NOTE 5—In order to test a wide range of soils the apparatus should permit adjustment of the rate of displacement from 0.0001 to 0.04 in./min [0.0025 to 1.0 mm/min].

NOTE 6—Shearing the test specimen at a rate greater than specified may produce partially drained shear results that will differ from the drained strength of the material. The specimen must be sheared slowly enough to allow pore pressures to dissipate.

6.4.3 *Top Half of Shear Box*—The weight of the top half of shear box supported by the specimen shall be less than 1 percent of the applied normal force during shear: this will most likely require that the top shear box be supported by a counter force, the equipment modified or the specimen sheared under a greater applied normal force.

6.5 *Normal Force Measurement Device*—A proving ring or load cell (or calibrated pressure sensor when using a pneumatic