Designation: D 3080 – 98

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

This standard is issued under the fixed designation D 3080; 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 a soil material in direct shear. The test is performed by deforming a specimen at a controlled strain rate on or near a single shear plane determined by the configuration of the apparatus. Generally, three or more specimens are tested, each under a different normal load, to determine the effects upon shear resistance and displacement, and strength properties such as Mohr strength envelopes.

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 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 soil or rock particles, or both, (see Section 7).

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

1.6 The values stated in inch-pound units are to be regarded as the standard. Within this test method the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of each other.

1.7 *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:*

D 422 Method for Particle-Size Analysis of Soils[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft)[2]

D 854 Test Method for Specific Gravity of Soils[2]

D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56 000 ft-lbf/ft)[2]

D 1587 Practice for Thin-Walled Geotechnical Tube Sampling of Soils[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[2]

D 2435 Test Method for One Dimensional Consolidation Properties of Soils[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]

D 4753 Specifications for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil Rock and Construction Materials Testing[2]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D 653.

3.2 *Description of Terms Specific to This Standard:*

3.2.1 *Relative Lateral Displacement*—The horizontal displacement of the top and bottom shear box halves.

3.2.2 *Failure*—The stress condition at failure for a test specimen. Failure is often taken to correspond to the maximum shear stress attained, or the shear stress at 15 to 20 percent relative lateral displacement. Depending on soil behavior and field application, other suitable criteria may be defined.

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

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Structural Properties of Soils.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

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

stress, providing for wetting or draining of the test specimen, or both, consolidating the specimen under the normal stress, unlocking the frames that hold the test specimen, and displacing one frame horizontally with respect to the other at a constant rate of shearing deformation and measuring the shearing force and horizontal displacements as the specimen is sheared (Fig. 1).

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, thereby allowing excess pore pressure to be dissipated more rapidly than with other drained stress tests. The test can be made on all soil materials and undisturbed, remolded or compacted materials. There is however, a limitation on maximum particle size (see 7.2).

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 results from several tests may be used to express the relationship between consolidation stress and drained shear strength.

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 weak plane since failure is forced to occur on or near a horizontal plane at 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. Care should be taken to ensure that the testing conditions represent those conditions being investigated.

5.5 The range in normal stresses, rate of shearing, and general test conditions should be selected to approximate the specific soil conditions being investigated.

NOTE 1—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 D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means of evaluating some of these factors.

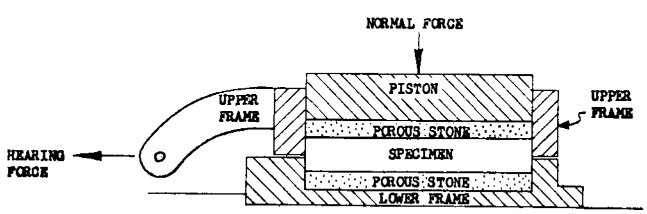

FIG. 1 Test Specimens in (*a*) Single and (*b*) Double Shear

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 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 vertically by a horizontal plane into two halves of equal thickness which are fitted together with alignment screws. The shear box is also fitted with gap screws, which control the space (gap) between the top and bottom halves of the shear box.

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 horizontal 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 permeability 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 ring. If the insert functions to transfer the horizontal stress to the soil, it 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.

NOTE 2—Exact criteria for insert texture and permeability have not been established. For normal soil testing, medium grade inserts with a permeability 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 permeability 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 permeability of the porous insert is not reduced by the collection of soil particles in the pores of the insert; hence frequent checking and cleaning (by flushing and boiling, or by ultrasonic cleaning) are required to ensure the necessary permeability.

6.4 *Loading Devices*:

6.4.1 *Device for Applying and Measuring the Normal*

Force—The normal force is applied by a lever loading yoke which is activated by dead weights (masses) or by a pneumatic loading device. The device shall be capable of maintaining the normal force to within ±1 percent of the specified force quickly without exceeding it.

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, and should permit adjustment of the rate of displacement from 0.0001 to 0.04 in./min (.0025 to 1.0 mm/min). The rate to be applied depends upon the consolidation characteristics of the soils (see 9.12.1). The rate is usually maintained with an electric motor and gear box arrangement and the shear force is determined by a load indicating device such as a proving ring or load cell.

6.4.3 The weight of the top shear box should be less than 1 percent of the applied normal force: this may require that the top shear box be modified and supported by counter force.

NOTE 3—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.

6.5 *Shear Force Measurement Device*—A proving ring or load cell accurate to 0.5 lbf (2.5 *N*), or 1 percent of the shear force at failure, whichever is greater.

6.6 *Shear Box Bowl*—A metallic box which supports the shear box and provides either a reaction against which one half of the shear box is restrained, or a solid base with provisions for aligning one half of the shear box, which is free to move coincident with applied shear force in a horizontal plane.

6.7 *Controlled High Humidity Room*, if required, for preparing specimens, such that water content gain or loss during specimen preparation is minimized.

6.8 *Trimmer or Cutting Ring*, for trimming oversized samples to the inside dimensions of the shear box with a minimum of disturbance. An exterior jig may be needed to maintain the shear box alignment.

6.9 *Balances*—in accordance with Test Method D 2216.

6.10 *Deformation Indicators*—Either dial gages or displacement transformers capable of measuring the change in thickness of the specimen, with a sensitivity of at least 0.0001 in. (0.0025 mm) and to measure horizontal displacement with sensitivity of at least 0.001 in. (0.025 mm).

6.11 *Apparatus for Determination of Water Content*, as specified in Test Method D 2216.

6.12 *Equipment for Remolding or Compacting Specimens*, if applicable.

6.13 Miscellaneous Equipment, including timing device with a second hand, distilled or demineralized water, spatulas, knives, straightedge, wire saws, etc., used in preparing the specimen.

7. Test Specimen

7.1 The sample used for specimen preparation should be sufficiently large so that a minimum of three similar specimens can be prepared. Prepare the specimens in a controlled temperature and humidity environment to minimize moisture loss or gain.

7.1.1 Extreme care should be taken in preparing undisturbed specimens of sensitive soils to prevent disturbance to the natural soil structure. Determine the initial mass of the wet specimen for use in calculating the initial water content and unit weight of the specimen.

7.2 The minimum specimen diameter for circular specimens, or width for square specimens, shall be 2.0 in. (50 mm), or not less than 10 times the maximum particle size diameter, whichever is larger, and conform to the width to thickness ratio specified in 7.4.

7.3 The minimum initial specimen thickness shall be 0.5 in. (12 mm), but not less than six times the maximum particle diameter.

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

NOTE 4—If large soil particles are found in the soil after testing, a particle size analysis should be performed in accordance with Method D 422 to confirm the visual observations, and the result should be provided with the test report.

7.5 *Specimen Preparation*:

7.5.1 *Undisturbed Specimens*—Prepare undisturbed specimens from large undisturbed samples or from samples secured in accordance with Practice D 1587, or other undisturbed tube sampling procedures. Undisturbed samples shall be preserved and transported as outlined for Group C or D samples in Practice D 4220. Handle specimens carefully to minimize disturbance, changes in cross section, or loss of water content. If compression or any type of noticeable disturbance would be caused by the extrusion device, split the sample tube lengthwise or cut it off in small sections to facilitate removal of the specimen with minimum disturbance. Prepare trimmed specimens, whenever possible, in an environment which will minimize the gain or loss of specimen moisture.

NOTE 5—A controlled high-humidity room is desirable for this purpose.

7.5.2 *Compacted Specimens*—Specimens shall be prepared using the compaction method, water content, and unit weight prescribed by the individual assigning the test. Assemble and secure the shear box. Place a moist porous insert in the bottom of the shear box. Specimens may be molded by either kneading or tamping each layer until the accumulative mass of the soil placed in the shear box is compacted to a known volume, or by adjusting the number of layers, the number of tamps per layer, and the force per tamp. The top of each layer shall be scarified prior to the addition of material for the next layer. The compacted layer boundaries should be positioned so they are not coincident with the shear plane defined by the shear box halves, unless this is the stated purpose for a particular test. The tamper used to compact the material shall have an area in contact with the soil equal to or less than ½ the area of the mold. Determine the mass of wet soil required for a single compacted lift and place it in the shear box. Compact the soil until the desired unit weight is obtained. Continue placing and compacting soil until the entire specimen is compacted.

NOTE 6—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 during consolidation. However, the upper ring in some shear devices requires friction to support the ring after the shear plates have been gapped. A light coating of grease applied between the halves of the shear box may be used to reduce friction between the halves of the shear box during shear.