



Designation: D 5321 – 92 (Reapproved 1997)

Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method¹

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1. Scope

1.1 This test method covers a procedure for determining the shear resistance of a geosynthetic against soil, another geosynthetic, or a soil and geosynthetic in any combination.

1.1.1 The test method is intended to indicate the performance of the selected specimen by attempting to model certain field conditions.

1.2 The test method is applicable for all geosynthetics. Remolded or undisturbed soil samples can be used in the test device.

1.3 The test method is not suited for the development of exact stress-strain relationships within the test specimen due to the non-uniform distribution of shearing forces and displacement.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all 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 653 Terminology Relating to Soil, Rock and Contained Fluids²

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN/m/m³))²

D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56 000 ft-lbf/ft³ (2700 kN/m/m³))²

D 3080 Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions²

D 4354 Practice for Sampling of Geotextiles for Testing³

¹ This test method is under the jurisdiction of ASTM Committee D-35 on Geosynthetics and is the direct responsibility of Subcommittee D35.01 on Mechanical Properties.

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² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 04.09.

D 4439 Terminology for Geosynthetics³

3. Terminology

3.1 Definitions—For definitions of terms relating to soil and rock, refer to Terminology D 653. For definitions of terms relating to geosynthetics, refer to Terminology D 4439.

3.2 Descriptions of Terms Specific to This Standard:

3.2.1 *adhesion*, c_a (FL⁻²), n —the shearing resistance between soil and another material under zero externally applied pressure. (D 653, D-18)

3.2.2 *angle of friction*, n —(angle of friction between solid bodies) (degrees) the angle whose tangent is the ratio between the maximum value of the shear stress that resists slippage between two solid bodies at rest with respect to each other and the normal stress across the contact surface. (D 653, D-18)

3.2.3 *atmosphere for testing geosynthetics*, n —air maintained at a relative humidity of $65 \pm 5\%$ and temperature of $21 \pm 2^\circ\text{C}$ ($70 \pm 4^\circ\text{F}$). (D 4439)

3.2.4 *coefficient of friction*, n —a constant proportionality factor, relating normal stress and the corresponding critical shear stress, at which sliding starts between two surfaces. (D 653, D-18)

3.2.5 *direct shear friction test*, n —for geosynthetics, a procedure in which the interface between a geosynthetic and any other surface, under a range of normal stresses specified by the user, is stressed to failure by the horizontal movement of one surface against the other.

3.2.6 *geosynthetic*, n —a planar synthetic product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering-related material as an integral part of a man-made project, structure, or system. (D 4439)

4. Summary of Test Method

4.1 The coefficient of friction between a geosynthetic and soil, or between any geosynthetic combination selected by the user, is determined by placing the geosynthetic and one or more contact surfaces, such as soil, within a direct shear box. A constant normal compressive stress is applied to the specimen, and a tangential (shear) force is applied to the apparatus so that one section of the box moves in relation to the other section. The shear force is recorded as a function of the horizontal displacement of the moving section of the shear box.

The test is performed for a minimum of three different normal stresses, selected by the user, to model appropriate field conditions. The peak (or alternatively, the residual) shear stresses recorded are plotted against the applied normal compressive stresses used for testing. The test data are generally represented by a best fit straight line whose slope is the coefficient of friction between the two materials where the shearing occurred. The y-intercept of the straight line is the adhesion.

5. Significance and Use

5.1 The procedure described in this test method for determination of the coefficient of soil and geosynthetic or geosynthetic and geosynthetic friction by the direct shear method is intended as a performance test to provide the user with a set of design values for the test conditions examined. The test specimens and parameters are generally selected by the user.

5.2 This test method may be used for acceptance testing of commercial shipments of geosynthetics, but caution is advised as outlined below.

5.2.1 The coefficient of soil and geosynthetic friction can be expressed only in terms of the soil used in testing (see Notes 1 and 2). The coefficient of friction is a function of the applied normal compressive stress, soil gradation, plasticity, in-place density, moisture content, and other parameters.

NOTE 1—In the case of acceptance testing requiring the use of soil, the user must furnish the soil sample, soil parameters, and direct shear test parameters.

NOTE 2—Soil and geosynthetic friction tests should be performed by laboratories experienced in the friction testing of soils, especially since the test results may be dependent on site-specific soil conditions.

5.2.2 This test method measures the total resistance to sliding of a geosynthetic with a supporting material (substratum) or an overlying material (superstratum). Total sliding resistance may be a combination of sliding, rolling, interlocking of soil particles and geosynthetic surfaces, and shear strain within the geosynthetic specimen.

5.2.3 The test method does not distinguish between individual mechanisms, which may be a function of the soil used, method of soil placement, normal and shear stresses applied, rate of horizontal displacement, and other factors. Every effort should be made to identify, as closely as is practicable, the sheared area and failure mode of the specimen so that comparison tests can be performed. Care should be taken, including close visual inspection of the specimen after testing, to ensure that the testing conditions are representative of those being investigated.

5.2.4 Information on precision between laboratories is incomplete. In cases of dispute, comparative tests to determine whether a statistical bias exists between laboratories may be advisable.

5.3 The test method produces test data that can be used as follows: in the design of geosynthetic-reinforced retaining walls, embankments, and base courses; in applications in which the geosynthetic is placed on a slope; for determination of geosynthetic overlap requirements; or in other applications in which soil/geosynthetic or geosynthetic/geosynthetic friction is critical to design.

6. Apparatus

6.1 *Shear Device*—A rigid device to hold the specimen securely and in such a manner that a uniform force without torque can be applied to the specimen. The device consists of both a stationary and moving container, both of which are capable of containing dry or wet soil and are rigid enough to prevent distortion during shearing of the specimen. The traveling container must be placed on firm bearings and rack to ensure that the movement of the container is only in a direction parallel to that of the applied shear force.

NOTE 3—One container should be adjustable to compensate for deformation of the soil.

6.1.1 Square or rectangular containers are recommended; they should have a minimum dimension that is the greater of 300 mm (12 in.), 15 times the d_{85} of the coarser soil used in the test, or a minimum of five times the maximum opening size (in plan) of the geosynthetic tested. The depth of each container should be 50 mm (2 in.) or six times the maximum particle size of the coarser soil tested, whichever is greater. The minimum specimen to width to thickness ratio is 2:1.

NOTE 4—The minimum container dimensions given in 6.1.1 are guidelines based on requirements for testing most combinations of geosynthetics and soils. Containers smaller than those specified in 6.1.1 can be used if it can be shown that data generated by the smaller devices contain no scale or edge effects bias when compared to the minimum size devices specified in 6.1.1. The user should conduct comparative testing prior to the acceptance of data produced on smaller devices. For direct shear testing involving soils, competent geotechnical review is recommended to evaluate the compatibility of the minimum and smaller direct shear devices.

6.2 *Normal Stress Loading Device*, capable of applying and maintaining a constant uniform normal stress on the specimen for the duration of the test. Careful control and accuracy ($\pm 2\%$) of the normal stress is important. Normal stress loading devices include, but are not limited to, weights, pneumatic or hydraulic bellows, or piston-applied stresses. For jacking systems, the tilting of loading plates must be limited to 10 mm (0.4 in.) from the center to the edge of the plate during operation of the test device.

6.3 *Shear Force Loading Device*, capable of applying a shearing force to the specimen at a constant rate of displacement (strain controlled) in a direction parallel to the direction of travel of the soil container. The rate of displacement should be controlled to an accuracy of $\pm 10\%$ over a wide range of displacements. The system must allow constant measurement and readout of the shear force applied. An electronic load cell or proving ring arrangement is generally used. The shear force loading device should be connected to the test apparatus in such a fashion that the point of the load application to the traveling container is in the plane of the shearing interface and remains the same for all tests.

6.4 *Displacement Indicators*, for providing continuous readout of the horizontal shear displacement and, if desired, vertical displacement of the specimen during the consolidation or shear phase. Dial indicators, or linear variable differential transformers (LVDT), capable of measuring a displacement of at least 75 mm (3 in.) for horizontal displacement and 25 mm (1 in.) for vertical displacement are recommended. The sensitivity of displacement indicators should be 0.02 mm (0.001 in.) for