Designation: D7499/D7499M – 09

Standard Test Method for Measuring Geosynthetic-Soil Resilient Interface Shear Stiffness[1]

This standard is issued under the fixed designation D7499/D7499M; 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 details how cyclic loading is applied to geosynthetics embedded in soil to determine the apparent stiffness of the soil–geosynthetic interface.

1.2 Resilient interface shear stiffness describes the shear stiffness between a geosynthetic and its surrounding soil under conditions of small cyclic loads.

1.3 This test method is intended to provide properties for design. The test method was developed for mechanistic empirical pavement design methods requiring input of the resilient interface shear stiffness. The use of this parameter from this test method for other applications involving cyclic loading should be evaluated on a case-by-case basis. It can also be used to compare different geosynthetics, soil types, etc., and thereby be used as a research and development test procedure.

1.4 The values stated in either SI units or inch-pound units 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.

1.5 *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. This standard may involve hazardous materials, and equipment.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D3080 Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
D4439 Terminology for Geosynthetics
D4354 Practice for Sampling of Geosynthetics for Testing

3. Terminology

3.1 For definitions of other terms used in this test method refer to Terminologies D123, D653, and D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *apertures, n*—the open spaces in geogrids which enable soil interlocking to occur.

3.2.2 *atmosphere for testing geosynthetics, n*—air maintained at a relative humidity of 60 ± 10 % and a temperature of 21 ± 2°C (70 ± 4°F).

3.2.3 *cross-machine direction, n*—the direction in the plane of the geosynthetic perpendicular to the direction of manufacture.

3.2.4 *failure, n*—an arbitrary point at which a material ceases to be functionally capable of its intended use.

3.2.5 *geosynthetic, n*—a planar 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.

3.2.6 *geosynthetic-soil resilient interface shear stiffness, n*—a parameter that describes the apparent stiffness of the interface between the soil and the geosynthetic determined by calculating the slope of the shear stress, shear displacement curve as the embedded geosynthetic is subjected to a cyclic load.

3.2.7 *junction, n*—the point where geogrid ribs are interconnected in order to provide structure and dimensional stability.

3.2.8 *machine direction, n*—the direction in the plane of the geosynthetic parallel to the direction of manufacture.

3.2.9 *pullout, n*—the movement of a geosynthetic over its entire embedded length, with initial pullout occurring when the back of the specimen moves, and ultimate pullout occurring when the movement is uniform over the entire embedded length.

3.2.10 *pullout force, (kN), , n*—force required to pull a geosynthetic out of the soil during a pullout test.

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

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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.

3.2.11 *pullout resistance, (kN/m), n*—the pullout force per width of geosynthetic measured at a specified condition of displacement.

3.2.12 *rib, n*—the continuous elements of a geogrid which are either in the machine or cross-machine direction as manufactured.

3.2.13 *wire gage, n*—a displacement gage consisting of a non extensible wire attached to the geosynthetic and monitored by connection to a dial extensometer, or electronic displacement transducer.

4. Summary of Test Method

4.1 In this test method, a horizontal layer of geosynthetic is embedded between two layers of soil. Six prescribed levels of horizontal cyclic force are applied to the geosynthetic at five specified levels of normal stress confinement. The maximum and minimum forces and corresponding displacements are recorded for the last ten cycles of each combination of normal stress and cyclic force (loading sequence).

4.2 The resilient interface shear stiffness (kPa/m or psi/in) of the test specimen can be calculated for any loading sequence by dividing the cyclic shear stress by the corresponding net recoverable horizontal displacement of the embedded geosynthetic

5. Significance and Use

5.1 This test method is intended as a performance test to provide the user with a set of design values for the test conditions examined.

5.1.1 The test method is applicable to all geosynthetics and all soils when loaded in a cyclic manner.

5.1.2 This test method produces test data, which can be used in the design of geosynthetic-reinforced pavement structures or in applications where geosynthetics are subjected to cyclic loads.

5.1.3 The test results may also provide information related to the in-soil stress-strain response of a geosynthetic under confined loading conditions.

5.2 Information derived from this test may be a function of soil gradation, plasticity, as-placed dry unit weight, moisture content, length and surface characteristics of the geosynthetic and other test parameters. Therefore, results are expressed in terms of the actual test conditions. The test measures the net effect of a combination of interface shear mechanisms, which may vary depending on type of geosynthetic specimen, embedment length, relative opening size, soil type, displacement rate, normal stress, and other factors.

5.3 Information between laboratories on precision is incomplete. In cases of dispute, comparative tests to determine if there is a statistical bias between laboratories may be advisable.

6. Apparatus

6.1 *Test Box*—An open rigid box consisting of two smooth parallel sides, a back wall, a horizontal split removable door, a bottom plate, and a load transfer sleeve. The door is at the front as defined by the direction of applied cyclic force. A typical box is shown in Fig. 1.

6.1.1 The box should be square or rectangular with minimum dimensions 457 mm (18 in.) long by 457 mm (18 in.) wide by 305 mm (12 in.) deep, if sidewall friction is minimized, otherwise the minimum width should be 760 mm (30 in.). The dimensions should be increased, if necessary, so that minimum width is the greater of 20 times the D85 of the soil or 6 times the maximum soil particle size, and the minimum length greater than 5 times the maximum geosynthetic aperture size. The box shall allow for a minimum depth of 150 mm (6 in.) above and below the geosynthetic. The depth of the soil in the box above or below the geosynthetic shall be a minimum of 6 times the D85 of the soil or 3 times the maximum particle size of the soil, whichever is greater. The box must allow for at least 305 mm (12 in.) embedment length beyond the load transfer sleeve.

NOTE 1—To remove side wall friction as much as possible a high density polyethylene (HDPE) geomembrane should be bonded to the inside surfaces of the pullout box. The sidewalls may also be covered with a layer of silk fabric, which has been shown to eliminate adhesion and has

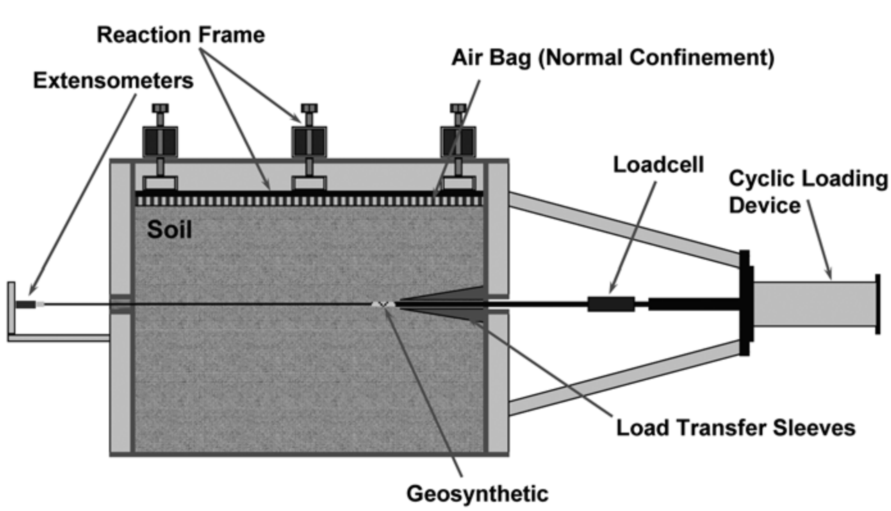

FIG. 1 Side View of a Typical Test Device

a very low friction value. Alternatively, a lubricant can be spread on the sidewalls of the box and thin sheets of polyethylene film used to minimize the side wall friction. It should be also noted that the effect of sidewall friction on the soil-geosynthetic interface can also be eliminated if a minimum distance is kept between the specimen and the side wall. This minimum distance is recommended to be 150 mm (6 in.).

6.1.2 The box shall be fitted with a pair of metal sleeves (load transfer sleeves) at the entrance of the box to transfer the force into the soil to a sufficient horizontal distance so as to significantly reduce the stress on the door of the box. The sleeves shall consist of two tapered (illustrated in Fig. 3) or non-tapered (no more than 13 mm (0.5 in.) thick) plates extending the full width of the pullout box and into the pullout box a minimum distance of 150 mm (6 in.), but it is recommended that this distance equal the total soil depth above or below the geosynthetic. Both design types must possess tapered edges at the point of load application in the soil that are no more then 3 mm (0.12 in.) thick. The plates shall be rigidly separated at the sides with spacers and be sufficiently stiff such that normal stress is not transferred to the geosynthetic between the plates.

6.2 *Normal Stress Loading Device*—Normal stress applied to the upper layer of soil above the geosynthetic must be constant and uniform for the duration of the load step. To maintain a uniform normal stress, a flexible pneumatic or hydraulic diaphragm-loading device which is continuous over the entire test box area should be used and capable of maintaining the applied normal stress within ±2% of the required normal stress. Normal stresses utilized will depend on testing requirements; however, stresses up to 250 kPa (35 psi) should be anticipated. A recommended normal stress-loading device is an air bag.

6.3 *Cyclic Force Loading Device*—— Horizontal cyclic force must be supplied by a device with the ability to apply cyclic load in the direction of the opening of the box. The force must be at the same level with the specimen.

6.3.1 The cyclic force system must be able to apply multiple load repetitions using a haversine-shaped load pulse consisting of a 0.2 second load followed by a 0.80 second rest period. The loading system must also be able to simultaneously maintain a minimum seating load on the material during cyclic loading.

6.3.2 Also, a device to measure the cyclic force (i.e., a load cell) must be incorporated into the system and shall be accurate within ±0.5 % of its full-scale range.

6.4 *Displacement Indicators*— — Horizontal displacement of the geosynthetic is measured at the entrance of the box and at several locations on the embedded portion of the specimen. Measurements outside the door at the box entrance are made by electronic displacement transducers (e.g., linear variable differential transformers (LVDTs) can be used) mounted to the box frame to read against a plate attached to the specimen near the door.

6.4.1 Displacement measurements within the box may employ any of several methods, which place sensors or gauge connectors directly on the geosynthetic and monitor their change in location remotely. One such device utilizes wire gages, which are protected from normal stress by a surrounding tube, which runs from a location mounted on the specimen to the outside of the box where displacements are measured by displacement transducers.

6.4.2 All electronic measurement devices must be accurate to ± 0.01 mm. Locations of the devices must be accurately determined and recorded. Minimum extension capabilities of 50 mm (2 in.) are recommended.

6.4.3 Determine the displacement of the geosynthetic at the front (leading end) and the rear (embedded end) of the geosynthetic at several locations along its width; suggested layout is shown in Fig. 2

6.5 *Geosynthetic Clamping Devices*—Clamps which connect the specimen to the cyclic force system without slipping, causing clamp breaks or weakening the material may be used, see Note 2. The clamps shall be swiveled to allow the cyclic forces to be distributed evenly throughout the width of the sample. The clamps must allow the specimen to remain horizontal during loading and not interfere with the interface shear surface. Gluing, bonding, or otherwise molding of a geosynthetic within the clamp area is acceptable and recommended whenever slippage might occur. Thin metal rods or tubes may be used to reduce friction between the geosynthetic clamp/sample and the top edge of the lower load transfer sleeve (Fig. 3).

NOTE 2— A suggested method of clamping is shown in Fig. 4 and includes a simple clamp consisting of two pieces of 22 gauge sheet metal glued to both sides of the geosynthetic sample. The sheet metal plates should be at least the same width as the geosynthetic being tested. Special precautions should be taken to ensure that geotextile samples adhere to the sheet metal – such as making holes for the epoxy to flow through the fabric, however; all such modifications to the fabric to facilitate bonding should not interfere with the remainder of the geosynthetic protruding from the front edge of the sheet metal.

6.6 *Soil Preparation Equipment* —Use equipment as necessary for the placement of soils at desired conditions. This may include compaction devices such as vibratory or "jumping-jack" type compaction, or hand compaction hammers. Soil

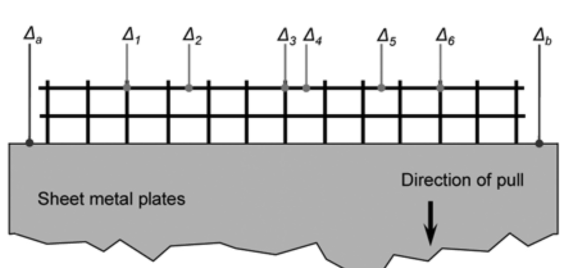

FIG. 2 Example Instrumentation Layout

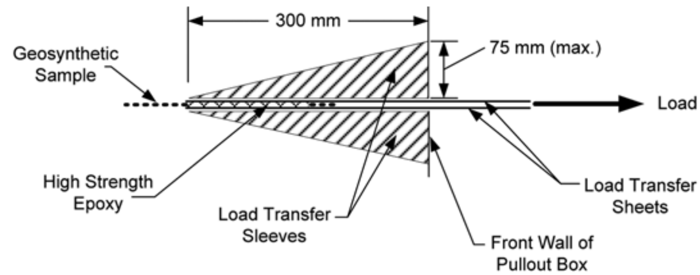

FIG. 3 Side View of Load Transfer Sleeve Arrangement

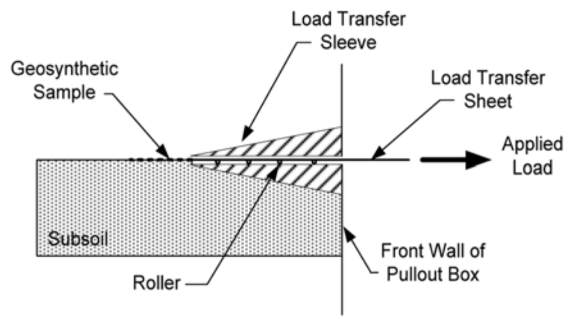

FIG. 4 Geosynthetic Clamping Detail

container or hopper, leveling tools and soil placement/removal tools may be required.

6.7 *Miscellaneous Equipment*— Measurement and trimming equipment as necessary for geosynthetic preparation, a timing device and soil property testing equipment if desired.

7. Geosynthetic Sampling

7.1 *Lot Sample*—Divide the product into lots and for any lot to be tested, take the lot samples as directed in Practice D4354D4354, see Note 3

NOTE 3—Lots of geosynthetics are usually designated by the producer during manufacture. While this test method does not attempt to establish a frequency of testing for determination of design oriented data, the lot number of the laboratory sample should be identified. The lot number should be unique to the raw material and manufacturing process for a specific number of units (for example, rolls, panel, etc.) designated by the producer.

7.2 *Laboratory Sample*—Consider the units in the lot sample as the units in the laboratory sample for the lot to be tested. Take for a laboratory sample, a sample extending the full width of the geosynthetic production unit, of sufficient length along the selvage or edge from each sample roll so that the requirement of 7.3 can be met. Take a sample that will exclude material from the outer wrap unless the sample is taken at the production site, at which point inner and outer wrap material may be used.

7.3 *Test Specimens*—For each unit in the laboratory sample, remove the required number of specimens.

7.3.1 Remove the minimum of specimens for testing in a required direction, see Note 4. The length of the embedded geosynthetic should be between 51 mm (2 in.) and 102 mm (4 in.) and contain two full grid apertures. Samples that do not meet these criteria should follow the guidelines outlined in Note 5. The width of the specimen shall be at least 305 mm (12 in.) and must allow for a minimum of 75 mm (3 in.) clearance on each side of the test specimen from the side walls of the test box if the side wall friction is minimized (see Note 1), otherwise the minimum clearance should be 150 mm (6 in.) on each side. The length of the test specimen shall be of sufficient size to facilitate clamping and maintain the required length and width specifications. The minimum width of the test specimen shall be 305 mm (12 in.) and should include a minimum of five tensile elements (i.e., ribs/strands). All specimens should be free of surface defects, etc., not typical of the laboratory sample. Take no specimens nearer the selvage edge of the geosynthetic production unit than 1/10 the width of the unit.

NOTE 4—The interface interaction characteristics of some geosynthetics may depend on the direction tested. In some applications, it may be necessary to perform tests in both the machine and the cross-machine directions. In all cases, the direction of cyclic load of the geosynthetic specimen(s) should be clearly noted.

NOTE 5—The sample length is relatively short when compared to traditional pullout tests to ensure that strain and shear stress along the length of the geosynthetic are generally uniform when loaded. The length of the geosynthetic should be reduced if the strain in the first 1.0 cm of embedded length is greater than 5 percent. However, the length of geogrids should not be less than one aperture or contain partial apertures. Specimen sizes that are longer than specified or contain more than two grid apertures are permissible provided shear stress and strain remain relatively uniform along the entire embedded specimen length throughout the test.

8. Conditioning

8.1 When soil is included in the test specimen, the method of conditioning is selected by the user or mutually agreed upon by the user and testing agency. In the absence of specified conditioning criteria, the test should be performed in the atmosphere for testing geotextiles defined in 3.1.2.