~~Designation:D6638–07~~ Designation: D6638 – 11

Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)[1]

This standard is issued under the fixed designation D6638; 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 is used to determine the connection properties between a layer of geosynthetic reinforcement and segmental concrete block units used in construction of reinforced soil retaining walls. The test is carried out under conditions determined by the user that reproduce the connection system at full-scale. The results of a series of tests are used to define a relationship between connection strength for a segmental unit-geosynthetic connection system and normal load.

1.2 This is a performance test used to determine properties for design of retaining wall systems utilizing segmental concrete units and soil reinforcing geosynthetics, either geotextiles or geogrids. The test is performed on a full-scale construction of the connection and may be run in a laboratory or the field.

1.3 The values stated in SI units are regarded as the standard. The values stated in inch-pound units are provided for information only.

1.4 *This standard may involve hazardous materials, operations, and equipment. 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]

D448 Classification for Sizes of Aggregate for Road and Bridge Construction

D4354 Practice for Sampling of Geosynthetics for Testing

D4439 Terminology for Geosynthetics

D4495 Test Method for Impact Resistance of Poly(Vinyl Chloride) (PVC) Rigid Profiles by Means of a Falling Weight

D6637 Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

3. Terminology

3.1 *Definitions:*

3.1.1 *displacement criteria*, *n*—a user prescribed maximum movement, mm (in.), of the geosynthetic reinforcement out from the back of segmental concrete units.

3.1.2 *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. **(D4439)**

3.1.3 *granular infill*, *n*—coarse grained soil aggregate used to fill the voids in and between segmental concrete units.

3.1.4 *peak connection strength*, *n*—the maximum tensile capacity of the connection between geosynthetic reinforcement and segmental concrete units.

3.1.5 *segmental concrete unit (modular concrete block)*, *n*—a concrete unit manufactured specifically for mortarless, dry-stack retaining wall construction.

3.1.6 *segmental concrete unit width*, *n*—the segmental concrete unit dimension parallel to the wall face and coincident with the geosynthetic reinforcement test specimen width.

3.1.7 *service state connection strength*, *n*— the connection tensile capacity at a service state displacement criterion between geosynthetic reinforcement and segmental concrete units.

3.2 For definition of other terms relating to geosynthetics, refer to Terminology D4439.

---

[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

Current edition approved June 1, ~~2007.~~2011. Published July ~~2007.~~2011. Originally approved in 2001. Last previous edition approved in ~~2006~~2007 as D6638 – 0~~6~~7. DOI: ~~10.1520/D6638-07.~~10.1520/D6638-11.

[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.

4. Summary of Test Method

4.1 One end of a wide geosynthetic reinforcement test specimen is attached to dry stacked segmental concrete block units assembled as specified by the user. The other end of the test specimen is attached to a clamp, which is part of a constant rate of extension tensile loading machine. The top course of segmental concrete block units is then loaded vertically to a constant normal load and the geosynthetic is then tensioned under constant rate of displacement until a sustained loss of connection capacity and/or excessive movement (greater than 150 mm) of the reinforcement out from the connection.

4.1.1 Peak connection capacity, and tensile capacity after a user prescribed displacement criteria has occurred, is used to define connection strength based on peak and service state criteria respectively. Both these values may be obtained from each test that measures geosynthetic displacement. Tensile loads and strengths are reported per unit width of geosynthetic sample, kN/m (lb /ft). Generally a series of tests are performed to establish a mathematical relationship between connection strength and normal load on the connection.

5. Significance and Use

5.1 The connection strength between geosynthetic reinforcement and segmental concrete block units is used in design of reinforced soil retaining walls.

5.2 This test is used to determine the connection strength for the design of the connection system formed by segmental concrete block units and geosynthetic reinforcement layers in reinforced soil retaining walls. Performing a series of these connection tests at varying normal loads permits development of a relationship between connection strength and normal load. This relationship may be linear, bi-linear, or some other complex mathematical expression.

5.3 This connection strength test is meant to be a performance test (laboratory or field), therefore, it should be conducted using full-scale system components. The conditions for the test are selected by the user and are not for routine testing.

5.4 As a performance test on full-scale system components it accounts for some of the variables in construction procedures and materials tolerance normally present for these types of retaining wall systems.

6. Apparatus

6.1 *Testing System*—An example of a test apparatus and setup is illustrated in Figs. 1 and 2. The principal components of the test apparatus are:

6.1.1 *loading frame*,

6.1.2 *normal load piston/actuator,*

6.1.3 *vertical loading platen,* with stiff rubber mat or airbag to apply uniform vertical pressure to top of concrete blocks

6.1.4 *vertical load cell,* to measure normal load

6.1.5 *geosynthetic loading clamp,*

6.1.6 *horizontal piston/actuator,* to load geosynthetic reinforcement in tension

6.1.7 *horizontal load cell* to measure geosynthetic tensile force, and

6.1.8 *two (2) horizontal displacement measurement devices,*to record displacement of the geosynthetic at the back of the segmental concrete blocks.

6.2 *Loading Frame*—The loading frame shall have sufficient capacity to resist the forces developed by the horizontal and vertical loading pistons/actuators.

6.3 *Tensile Loading Clamp and Loading Assemblies* —The geosynthetic is gripped at its free end with a clamp extending the full width of the specimen. The clamp shall be capable of applying a uniform force across the full width of the test specimen. A roller grip assembly may be used to apply the tensile load. For some geosynthetics it may be necessary to epoxy bond the geosynthetic to, or within, the clamp in order to obtain a uniform stress distribution across the entire width of the test specimen.

6.3.1 The tensile loading unit will generally be a constant rate of extension screw jack or hydraulic actuator that can be displacement rate controlled. The loading equipment shall have a capacity that is at least equal to 120 % of the wide strip tensile strength of the geosynthetic (Test Methods D4495 or D6637) multiplied by the specimen width. The piston shall be capable of at least 150 mm (6 inches) of movement in order to facilitate test set up and to ensure that there is adequate stroke to achieve failure of geosynthetic reinforcement specimens.

NOTE 1—Some systems (that is, modular concrete units with a depth greater than 0.5 m) may need more than 150 mm of movement to achieve failure of the connection.

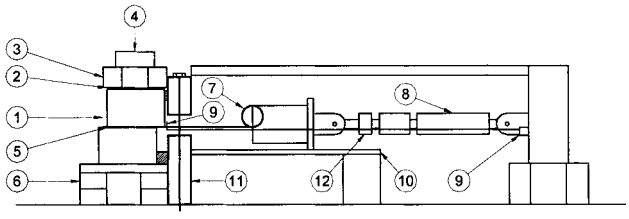

FIG. 1 Connection Strength Test System

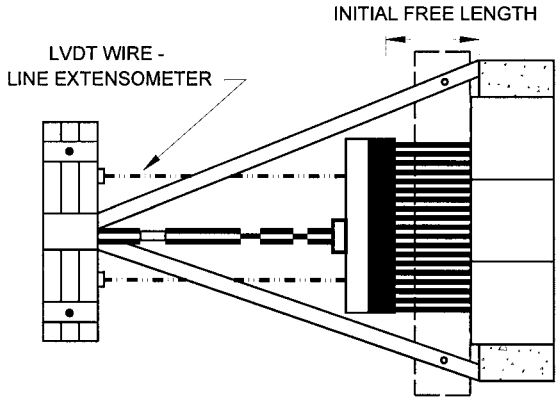

FIG. 2 Connection Test Apparatus (Plan View)

6.3.2 The orientation of the tensioning force shall be horizontal and perpendicular to the back of the segmental units and shall be applied at the elevation where the geosynthetic exits the back of the segmental units.

6.4 *Load Cells*—A calibrated load cell shall be used to measure the tensile connection force and normal load during the test. The load cell used for measuring tension shall have a capacity that is greater than or equal to 120 % of the wide strip tensile strength of the geosynthetic (Test Methods D4495 or D6637) multiplied by the specimen width. The load cell used for measuring the normal surcharge load shall have a capacity that is greater than or equal to 100 % of the maximum anticipated normal load. The load cells shall be accurate within ± 0.5 % of its full-scale range.

6.5 *Displacement Measuring Devices*— Two linear variable displacement transducers (LVDTs) or similar electronic displacement measuring devices are recommended to continuously monitor the displacement of the geosynthetic out from the back of the concrete units. Alternatively, dial gauges may be read and recorded manually at regular intervals not greater than one minute. LVDTs, dial gauges or similar measuring devices shall be accurate to ± 0.1 mm (±0.005 in.).

7. Sampling

7.1 *Segmental Concrete Units*

7.1.1 Segmental concrete units shall be full-size blocks and meet the manufacturer's material and dimensional specifications. Model or prototype units shall not be used unless it can be demonstrated that they are equivalent to production units.

7.1.2 The user shall specify and/or collect a sufficient sample of representative segmental units, from a standard production lot, to construct the anticipated number of test configurations for the connection system within the testing agency's load frame and testing system.

7.1.3 The wall for connection testing shall be constructed using randomly selected full-size (that is, full width) segmental units from the users sampling of a standard production lot, see section 7.1.2. A maximum of two half width segmental concrete units may be used on only one course of the units being tested in a confined width test apparatus. Segmental concrete units may be re-used in testing if there is no cracking, abrasion or wearing of the concrete surfaces between tests.

7.1.4 *Wall Width*—The wall for testing shall be constructed to a minimum of 750 mm (29.5 in.) in width and contain at least one typical segmental concrete unit running bond joint. The segmental wall width for testing shall be at least as wide as the geosynthetic test specimen width (see 7.2.3). Testing of segmental concrete unit widths greater than 500 mm, may be represented in this test by limiting the test wall to 1000 mm (39.4 in.) in width.

NOTE 2—Narrower wall widths may be used for testing, provided the connection strength is proven to be unaffected by this reduction (see section 7.2.3).

7.1.5 *Conditioning*—The segmental concrete unit test specimen shall be brought to standard temperature and relative humidity conditions for testing in a laboratory. The temperature is to be 21 ± 2°C (70 ± 4°F) and the relative humidity of 65 ± 10 %. For field-testing the specimen shall be brought to ambient conditions for not less than one hour. The temperature and humidity at the start and end of the test shall be recorded for field-testing.

7.2 *Geosynthetic*

7.2.1 *Sampling Requirements*—The latest version of ASTM sampling protocol for geotextiles (Practice D4354) shall be used for the geosynthetic reinforcement material.

7.2.2 *Conditioning*—The geosynthetic reinforcement test specimen shall be brought to standard temperature and relative humidity conditions for testing in a laboratory. The temperature is to be 21 ± 2°C (70 ± 4°F) and the relative humidity of 60 ± 10 %. For field-testing the specimen shall be brought to ambient conditions for not less than one hour. The temperature and humidity at the start and end of the test shall be recorded for field-testing.

7.2.3 *Specimen Width*—The geosynthetic reinforcement test specimen shall be a minimum of 750 mm (29.5 in.) in width. For tests that use two or more full segmental retaining wall units on the bottom course, the geosynthetic shall be an exact multiple of the segmental retaining wall unit width totaling closest to, but exceeding 750 mm (29.5 in.) in width. For segmental retaining wall unit widths greater than 500 mm (19.7 in.) a geosynthetic specimen width of 1000 mm (39.4 in.) may be used.

NOTE 3—Narrower geosynthetic reinforcement specimen widths may be used for a specific concrete unit, provided that sufficient testing demonstrates that narrower samples provide an evaluation of connection performance that is equivalent to the minimum 750 mm (29.5 in.) width sample. This procedure may be appropriate for wall connections that are primarily mechanical (non-frictional) in nature.

7.2.4 *Specimen Length*—The geosynthetic specimen shall have sufficient length to cover the interface surface as specified by the user. The specimen must be trimmed to provide sufficient anchorage at the geosynthetic loading clamp and a free length between the back of the concrete blocks and loading clamp ranging from a minimum of 200 mm (7.9 in.) to a maximum of 600 mm (23.6 in.), The geosynthetic reinforcement specimen shall be placed between the stacked segmental concrete units to cover the same area that will be used in field construction of the connection or as determined by the user.

7.2.5 A new geosynthetic reinforcement test specimen shall be used for each test.

7.2.6 *Number of Tests*—A sufficient number of tests shall be conducted to adequately define a relationship between connection strength and normal load applied to the connection. Tests shall be conducted at a minimum of five (5) unique normal loads within the range of loads typical of wall design, as directed by the user. Additionally, at least two more tests at one normal load will be necessary to verify repeatability (see section 7.2.7).

7.2.7 *Repeatability of Test Results*—The testing agency shall provide evidence of test results repeatability by conducting at least three tests at one normal load level for a specific segmental concrete units and geosynthetic reinforcement system. The general range for repeatability of peak connection strength of these three nominally identical tests is ± 10 % from the mean of the three tests (see reference in X1.1). If the test results are outside of this range it shall be duly noted on the report.

8. Test Procedure

8.1 Install and brace lower course of concrete segmental units. Place the units such that a running joint will be coincident with the center of pull for the geosynthetic reinforcement test specimen, on either this course or the course above.

8.1.1 The connection shall be constructed using the geosynthetic reinforcement, granular infill, full-scale segmental concrete block units and connectors specified by the user. The number, type and arrangement of mechanical connectors shall also be specified by the user.

8.1.2 A single course of segmental units shall be placed on a rigid base. A second course of segmental units will later (see 8.5) be placed over the bottom course of units, with the geosynthetic reinforcement located and placed between these courses as described by the user or in the same manner anticipated for field construction. Both courses of segmental concrete units shall be rigidly braced to prevent lateral movement of the units during geosynthetic tension testing.

8.1.3 The minimum width of the bottom course of concrete units shall be at least the geosynthetic reinforcement specimen width (see 7.2.3) and it must fully support the top course of segmental concrete units. Small wall widths are permissible (see 7.1.4 and 7.2.3). Reducing the width of segmental concrete units by cutting with a concrete/masonry saw is permissible, provided that the cut (rough) edges are located beyond the edge of the geosynthetic sample.

8.1.4 Arrange the lower course units such that a minimum of one “as manufactured” running bond joint shall be located at the centerline of pull for the geosynthetic reinforcement test specimen on either the top or bottom course of segmental units.

NOTE 4—It is recommended that the lower course units should be level from front-to-back and side-to-side. Adjacent units should be level and a uniform surface should be established across the entire top surface of the units, prior to placement and compaction of core fill and/or placement of the geosynthetic. Only the geosynthetic, connection or alignment devices, and unit core fill (as required by the unit system) should be placed within the connection test interface. No other material should be placed within the test interface unless specifically directed by the user or segmental concrete unit system supplier.

8.2 Place and compact granular infill within (if required) and between the segmental concrete units to the density specified by the user.

8.2.1 The granular infill for testing shall be specified by the user.

NOTE ~~4—A~~ 5—A typical granular infill would be crushed stone conforming to the size number 57 or 67 gradations in Classification D448.

8.3 Center geosynthetic reinforcement with respect to the centerline of the horizontal tension loading piston/actuator. Place the geosynthetic reinforcement test specimen in the user-specified position with respect to concrete keys, mechanical connectors, and the wall face. Record the geosynthetic reinforcement test specimen width, length, and position on the concrete units.

8.4 For concrete segmental wall widths greater than the geosynthetic reinforcement specimen width, trim two pieces of the same geosynthetic reinforcement to cover the interface between courses of concrete units on either side of the geosynthetic test specimen width. These pieces are required to ensure that the top course of concrete units remain level to receive uniform distribution of the normal load. Leave 10 mm (0.4 in.) between these pieces of geosynthetic and the edge of the geosynthetic test specimen.

8.5 Place the top course of concrete segmental units over the geosynthetic sample using the drystack jointing arrangement as described by the user or in the same manner anticipated for field construction. The number, type and arrangement of mechanical connectors must also be specified by the user.

8.5.1 The top course of segmental concrete units shall be level and rigidly braced to prevent lateral movement of the units during geosynthetic tension testing.

8.5.2 The minimum width of the top course of segmental concrete units shall be 750 mm (29.5 in.) and shall be fully supported by the bottom course. Reducing the width of segmental concrete units by cutting with a concrete/masonry saw is permissible, provided that the cut (rough) edges are located beyond the edge of the geosynthetic sample.