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Standard Test Method for Cyclic Plate Load Tests to Evaluate the Structural Performance of Roadway Test Sections with Geosynthetics[1]

This standard is issued under the fixed designation D8462; 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 standard test method outlines the procedure used to determine the performance of unpaved and paved roadway cross sections, with and without geosynthetics, that are built in a controlled manner and tested using a stationary, cyclic load applied to the surface to simulate traffic.

1.2 Test section performance from these tests is normally calculated as a function of life extension, but can also be determined based on structural improvement. Life extension is related to the number of load cycles that can be accommodated by a particular configuration when compared to a similarly constructed control. Structural improvements are based on elemental or system-wide stiffness increases.

1.3 The cyclic plate load (CPL) test is intended to be a performance test conducted as closely as possible to as-built unpaved and paved roadway cross sections. It has been used as a tool to compare different geosynthetics; soil types, strengths, and thicknesses; and construction procedures for a variety of pavement applications.

1.4 *Units*—The values stated in SI units are to be regarded as standard. Values in parentheses are for information only.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4439 Terminology for Geosynthetics

2.2 *AASHTO Standards:*[3]

AASHTO R 50-09 Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures

3. Terminology

3.1 *Definitions*—For definitions of common geosynthetic terms used in this test method, refer to Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *equivalent single-axle load (ESAL), n*—the total number of repetitions of a standard design load of 80 kN (18 kips) applied to a single axle having two sets of dual wheels.

3.2.2 *stationary traffic benefit ratio (S-TBR), n*—the ratio of the number of load cycles of a pavement structure with geosynthetics to the number of load cycles for the same test section without geosynthetics to reach the same defined failure state, where the cyclic load is applied using a stationary plate.

3.2.3 *traffic benefit ratio (TBR), n*—the ratio of the number of load cycles of a pavement structure with geosynthetics to the number of load cycles for the same test section without geosynthetics to reach the same defined failure state.

4. Summary of Test Method

4.1 This test method covers the major considerations associated with cyclic plate load tests conducted on laboratory-constructed pavement test sections that are built inside a large, rigid test vessel and cyclically loaded to simulate traffic. Common configurations include paved and unpaved roads and other load support applications that include geosynthetics.

[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] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

4.2 Design and construction of individual test sections are intended to match as closely as possible the type and properties of those anticipated for use in the design situation of interest, and to be the same for tests that will be used to determine performance properties through direct comparisons to one another.

4.3 Testing is performed by loading the surface of the roadway using a stationary cyclic load representative of a typical truck to induce progressive vertical displacement of the surface (rut).

4.4 Benefit from the geosynthetic is determined by calculating the stationary traffic benefit ratio (S-TBR).

5. Significance and Use

5.1 The CPL test is intended as a performance test to quantify the benefits of geosynthetics in pavement structures, as recommended by AASHTO R 50-09. Performance is predominantly defined in terms of S-TBR.

5.2 The CPL test is a laboratory test used to accelerate rutting in a roadway cross section using a stationary cyclic plate. While the application of load differs from actual roads, the results from similarly constructed CPL tests are useful to evaluate and compare the performance of various products or designs. The results from these tests are most relevant to roads having similar design characteristics (material strengths and thicknesses).

NOTE 1—The extrapolation of cyclic plate results to designs that deviate significantly from the parameters tested may not be accurate, and performance calculations made at significantly different load cycle levels than the expected service life of an actual pavement may not provide an accurate estimate of the benefits actually realized.

5.3 The number of load cycles applied by the CPL device corresponds to the number of equivalent single-axle loads (ESALs) used in the AASHTO 1993 pavement design equation.

5.4 The test method is applicable to geosynthetics and soils used in typical pavement applications.

5.5 This test method produces test data that can be used to compare geosynthetic products, construction methods, and cross section configurations used in design of roads.

5.6 This test can be used to characterize specific behaviors of the geosynthetic under the conditions tested by including sensors to measure stresses and strains within the pavement cross section or on the geosynthetic itself. Sensors should be appropriately sized and installed to minimize their influence on the results of the test.

5.7 The relationship between load cycles and deformation is a function of the composite stiffness of the constructed system and the interdependence between the individual components of the design.

6. Apparatus

6.1 *Test Vessel*—The containment vessel or rigid box should be designed and constructed to encapsulate the constructed roadway test section without adversely affecting its response under load, and should be sufficiently strong to withstand forces from compaction equipment. If a square or rectangular shape is used, front and back walls can be designed to be incrementally added to account for the cumulative change in height as construction advances (refer to example box in Fig. 1). Many existing test tanks are rectangular, but can also be made in other shapes.

6.1.1 Placement of vertical boundaries should be more than 75 cm (29.5 in.) from the perimeter of the plate to minimize the influence of the boundary walls on the test results. The thickness of the subgrade shall be no less than 90 cm (35.5 in.) to minimize the influence of the floor.

6.1.2 The sidewalls should be sufficiently smooth to allow for vertical movements from consolidation or settlement (or both) during testing.

NOTE 2—A high-density polyethylene (HDPE) geomembrane can be bonded to the inside surfaces of the test tank to reduce or prevent sidewall friction. The sidewalls may also be covered with a layer of silk fabric, which has been shown to eliminate adhesion and has 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 sidewall friction.

6.1.3 The height of the tank should be large enough to accommodate the minimum height for a roadway cross section subjected to typical axle loads.

6.2 *Cyclic Loading Apparatus*—The cyclic load system should be able to apply multiple load repetitions for extended periods of time (often several days). The loading system shall not significantly distort or otherwise displace the test tank during loading.

6.2.1 Surface loads shall be applied through a rigid 305 mm (12 in.) diameter steel plate. This size plate represents the dual-wheel footprint of a loaded truck.

6.2.2 A 6.4 mm (0.25 in.) thick nitrile rubber pad (40A durometer) shall be used beneath the load plate to reduce concentrated stresses from minor surface irregularities.

6.2.3 Maximum and minimum applied loads shall be consistent throughout the duration of the test.

6.3 *Measurements*—The maximum and minimum applied load and accumulated surface deformation as a function of the number of applied load pulses shall be measured to characterize performance. The displacement of other positions within the cross section may be used to ensure proper performance and behaviors.

6.3.1 The maximum and minimum applied load shall be measured and confirmed throughout the duration of the test to ensure that it remains constant. The load measurement device must be accurate within ±0.5 % of the maximum applied load.

6.3.2 Displacement can be monitored using extensometers, linear variable differential transducers (LVDTs), or other electronic displacement transducers. The datum for the displacement measurements shall be stable and unaffected by movements caused by loading system.

6.3.3 Displacement measurements shall be used to characterize the shape of the depression bowl caused by the applied load at the test surface. Multiple sensors shall be positioned along a line extending through the center and on both sides of the load plate, as illustrated in Fig. 2. If displacement of the load plate is made using sensors external to the loading system and the load plate is attached to the end of the actuator using

FIG. 1 Example CPL Test Vessel

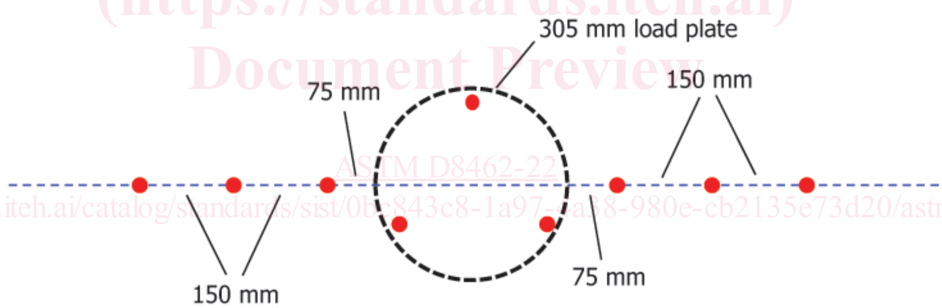

FIG. 2 Plan View of Surface Displacement Sensor Layout

a clevis or swivel joint, then at least three sensors, triangularly arranged, shall be used to determine the average displacement of the load plate.

6.3.4 Vertical displacement measurements within the cross section of the test section may be used to evaluate load transfer through the various layers. Load transfer may also be characterized using sensors attached to the geosynthetic to monitor displacement or strain (or both) during testing.

6.3.5 All electronic displacement measurement devices must be accurate within ±0.5 % of the full scale. Position, location, and orientation of all measurement devices shall be accurately measured and recorded. The ranges of the sensors shall be sufficient to remain within their calibrated limit throughout the duration of the test.

7. Materials

7.1 Construction materials (for example, subgrade soil, geosynthetic, subbase and base aggregate, and asphalt) should match as closely as possible the type and properties of those anticipated for use in the design situation of interest, and should be the same for tests that will be used to determine performance properties through direct comparisons to one another. Given the difficulty of matching material properties and characteristics for situations where test section materials come from geographic locations other than those for the design of interest, allowances are provided for adjusting asphalt concrete and aggregate base and subbase thicknesses for materials of somewhat different material properties.

7.1.1 At a minimum the particle size distribution, Atterberg limits, classification, and moisture/density relationship shall be measured and documented for the subgrade, subbase, and base course materials.

7.1.2 Other soil properties may also include stiffness, resilient modulus, density, shear strength, bearing strength, moisture susceptibility, and permeability, as appropriate.

7.1.3 At a minimum the gradation, asphalt content, air void content, and Rice specific gravity shall be measured and documented for the asphalt, as appropriate. The stiffness-temperature relationship of the asphalt should also be measured and documented.

7.1.4 At a minimum the 2 %, 5 %, and ultimate tensile strength in the principal strength directions, nominal opening size, and mass per unit area shall be measured and documented for the geosynthetic for material identification purposes.

8. Construction

8.1 Preparation and construction of geomaterials should be done as closely as possible to full-scale actual construction to ensure that they are uniform and resemble design or field conditions. The size and energy of the construction equipment should be optimized as much as possible to achieve the most realistic result.

8.2 Densification of geomaterials can be achieved using vibrating plate (most appropriate for granular soils, aggregate base course materials, and asphalt), "jumping jack," or hand compaction hammers (most appropriate for fine-grained and cohesive soils). The thickness of the individual layers depends on the energy that can be imparted into the soil from the compaction equipment, and should be optimized to achieve uniform conditions.

8.3 Conditioning of geomaterials should be done in such a way to produce uniformity of properties throughout the pavement cross section.

8.4 *Quality Assurance / Quality Control Measures:*

8.4.1 Correlations between various soil properties of interest should be made prior to construction to establish target values. Common relationships include: moisture/density, moisture/shear strength, moisture/bearing strength, and bearing strength/stiffness. Any relationships used to determine key material properties shall be periodically checked to ensure validity.

8.4.2 In-situ measurements shall be made during construction to maintain adequate consistency within and between test sections. Typical in-situ measurements include: shear strength, density/unit weight, moisture content, bearing capacity, and stiffness.

8.4.3 The thicknesses of individual layers shall be measured during construction. The upper surface of the subgrade, subbase, base course, and asphalt layers shall be level and have uniform thickness within and between test sections.

8.4.4 A series of test sections that will be used to determine relative performance shall be constructed to meet the target strengths and thicknesses and shall be similar to one another. Constructed subgrade strength; density and/or stiffness of the subbase and base; and stiffness of the asphalt layers should be within ±5 % of the design target and between test sections. Final constructed thicknesses of the subgrade, subbase, base, and asphalt layers should be within ±2 % of the design target and between test sections.

8.4.5 The initial thickness of the base course shall be constructed 10 % greater than the design thickness to facilitate deformation or loss of thickness (or both) that may occur during the conditioning step described in 8.8.

8.4.6 Coverings or other protection should be used to minimize unwanted changes in material properties during and after construction. When coverings are used, all sections used for direct calculation of performance shall be covered or cured (or both) for the same amount of time within ±4 h. Refer to Note 3.

NOTE 3—Differences in moisture content within the base course layer are known to significantly affect the performance of test sections.

8.4.7 The elapsed construction time shall be within ±3 days between test sections within a series to minimize changes in the properties of subgrade, subbase, and base materials. Likewise, the elapsed time from construction to loading shall be within ±3 days for tests within a series to minimize differences in performance due to curing, drying, aging, or combinations thereof.

8.5 Tests should be conducted at similar temperatures to one another. The ambient temperature during loading for test sections with asphalt should be within ±1 °C (±2 °F) of one another for all comparison tests.

NOTE 4—A reasonable temperature range for this test is 25 ± 5 °C (77 ± 9 °F).

8.6 Each test section shall be constructed and tested separately, including complete reconstruction of subgrade materials, to minimize possible residual effects from previous loading or due to curing, drying, aging, or combinations thereof.

8.7 The use of virgin materials to construct test sections minimizes potential changes in material properties between equivalent test sections. Because this may not always be feasible or efficient, the reuse of materials that are known to vary significantly from test to test should be evaluated to ensure that these changes do not substantially affect behavior and performance. For example, the structural characteristics of subgrade soils may change with repeated drying, wetting, and remolding; and aggregate particles may break down from moisture conditioning and compaction. Note 5 outlines specific concerns related to hot-mix asphalt. Refer to the tolerances outlined in 8.4.4 for guidance.

NOTE 5—Because the reuse of hot-mix asphalt is known to cause significant increases in stiffness and breakdown of the aggregates forming the mix, virgin hot-mix asphalt should be used for each test. Stiffer materials distribute applied loads differently than softer materials.

8.8 *Conditioning:*

8.8.1 A conditioning step shall be employed to simulate light construction traffic on the exposed base course layer prior to construction of the asphalt layer or the application of the full 40 kN (9 kips) cyclic loading.

8.8.2 A cyclic load having a maximum of 20 kN (4.5 kips) and minimum of 0.5 kN (0.1 kips) and the shape described in 9.1 shall be applied to a 400 mm (16 in.) diameter steel plate. Load cycles shall be applied until surface displacement reaches equilibrium (defined as less than 0.01 mm (0.0004 in.) accumulated permanent displacement per applied load pulse).