Designation: D 7207 – 05

Standard Test Method for Determination of Unvegetated Rolled Erosion Control Product (RECP) Ability to Protect Sand from Hydraulically-Induced Shear Stresses under Bench-Scale Conditions[1]

1. Scope

1.1 This index test method establishes the guidelines, requirements and procedures for evaluating the ability of unvegetated Rolled Erosion Control Products (RECPs) to protect soil (sand) from hydraulically induced shear stress in a bench-scale apparatus.

1.2 This index test method utilizes bench-scale testing procedures and shall not be interpreted as indicative of field performance.

1.3 This index test is not intended to replace full-scale simulation or field testing in acquisition of performance values that are required in the design of erosion control measures utilizing unvegetated RECPs.

1.4 The values stated in SI units are to be regarded as standard. The inch-pound values given in parentheses are provided for information purposes 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort

D 4354 Practice for Sampling of Geosynthetics for Testing

D 6460 Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion

3. Terminology

3.1 For definitions of terms used in this method, see Terminology D 653.

4. Summary of Test Method

4.1 Soil cores consisting of containers with bare soil and/or RECP-protected soil are immersed in water and subjected to shear stresses caused by the rotation of an impeller with three blades. At a minimum, testing of containers with bare soil should be performed when a new or renewed soil stockpile is used.

4.2 The amount of soil that erodes at each of three shear stress levels is measured.

5. Significance and Use

5.1 This index test method indicates an unvegetated RECP's ability to reduce soil erosion caused by shear stress induced by moving water under bench-scale conditions. Only tangential shear is measured in this method. Radial and uplift forces generated by the circular motion of the water are not measured.

5.2 This test method is bench-scale and therefore, appropriate as an index test for general soil/product composite behavior under hydraulic shear conditions, and for product quality assurance/conformance testing. The results of this test shall not be interpreted as indicative of field performance.

6. Apparatus

6.1 The shear stress test apparatus includes a shear tank, false floor with test wells, transition cover plate, and motor-driven impeller. (See Fig. 1.)

6.1.1 *Shear Tank*—A cylindrical tank of sufficient diameter and depth to develop the desired shear levels. (See Fig. 1 for an example.)

6.1.2 *False Floor*—A false floor shall be positioned in the tank with at least three test wells cut into the false floor to hold soil cores. When soil cores are placed in the wells, the soil surfaces must be flush with the false floor surface. (See Fig. 1.)

6.1.3 *Motor-driven Impeller Assembly*—The impeller motor shall be capable of driving the impeller assembly at sufficient revolutions per minute (RPMs) to develop the necessary shear stresses. The blades of the three-blade impeller must be

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.25 on Erosion and Sediment Control Technology.

Current edition approved Nov. 1, 2005. Published December 2005.

[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.

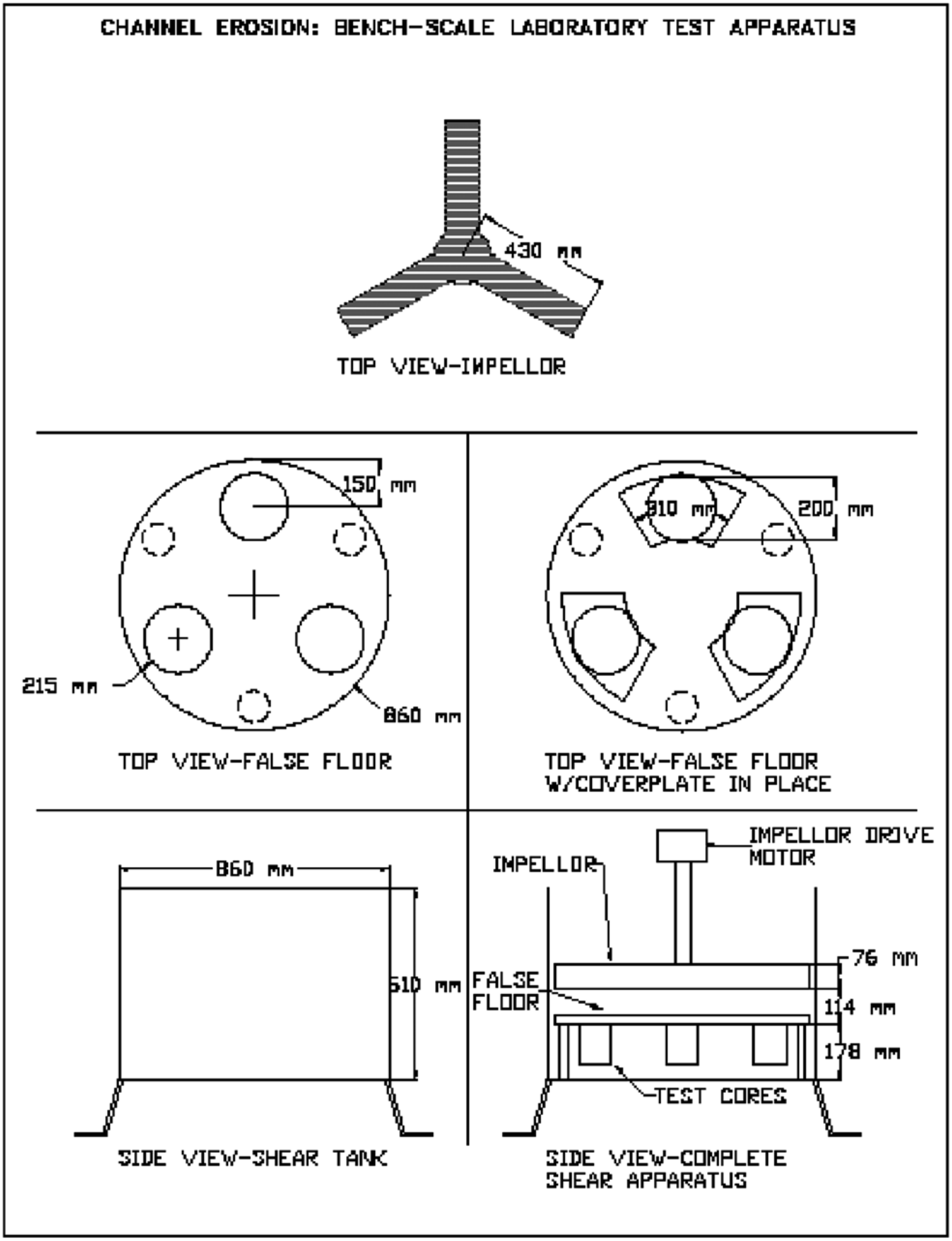

FIG. 1 Example of a Low-Shear Bench-Scale Laboratory Test Apparatus

sufficiently long enough to extend to within 25 mm (1 in.) of the side of the tank. The impeller is mounted in the tank so that the lower edge of the blades is 115 mm ± 1 cm (4.5 ± 0.4 in.) above the false floor of the tank in which the test cores are seated during testing. (See Fig. 1.) The apparatus should be capable of producing shear stresses in 24 Pascal (pa) (0.5 pounds/square foot (psf)) increments below, near, and above expected target shear stress levels.

NOTE 1—The shear stress apparatus shown in Fig. 1 has been found sufficient for achieving shear stresses between 24 and 72 pa (0.5 and 1.5 psf) using a 2 hp motor on many degradable RECPs. A larger tank, 1.83 m (6 ft) diameter with 0.6 (2 ft) depth of water over the pots has been able to achieve shear stresses as high as 0.4 kPa (8 psf) on rough RECPs.

6.1.4 *Soil Cores*—Consist of water-tight containers nominally 200 ± 10 mm (8 ± 0.4 in.) inside diameter plastic pipe section cylinders with height of 100 ± 10 mm (4 ± 0.4 in.) holding soil and test specimens.

7. Sampling

7.1 Take lot samples as directed in Practice D 4354. The laboratory sample should be at least 2 m^2 (6.5 ft^2).

7.2 Cut a single semi-circular specimen having a diameter 50 mm (2 in.) less than the tank diameter from the roll sample. This should be of sufficient size to cover half of the entire false floor and three soil cores when seated in the test wells. If a sufficiently large sample is not available, smaller specimens may be used as long as they completely cover the soil pot and extend far enough under the cover plate to be firmly secured so as not to pull free under anticipated shear forces.

8. Procedure

8.1 *Calibration of Test Apparatus*:

8.1.1 Calibration of the apparatus determines the impeller motor setting and associated revolutions per minute that exerts the desired tractive force on the test surfaces. See Annex A1 for calibration guidance.

8.1.2 At a minimum, calibration should be conducted for each RECP tested and each time a new soil stockpile is used.

8.2 *Test Set-up*:

8.2.1 Prepare nine soil cores for each RECP to be tested and nine bare-soil control cores.

8.2.1.1 Fill and compact the cores flush with soil. Unless otherwise requested, compact soil to 90 ± 3 % of Standard Proctor density, at a soil moisture within ±3 % of optimum moisture content per Test Method D 698. Submerge compacted cores in water for 24 hours to complete saturation. Each test should be conducted on freshly prepared cores. See A1.2 for sand details.

NOTE 2—The standard sand used in this test procedure has been found to be successful for general product comparison purposes. However, site-specific and/or user-defined soils may be used based on user needs. If non-standard soils are used, agreement should be established between the testing laboratory and the user of the test.

8.2.1.2 Weigh each prepared soil core in its submerged state to determine its Initial Submerged Mass (SM_i) and record to ±0.01 grams (g).

NOTE 3—Typically a balance is supported above the water level of the tank with a device to reach down and hold the soil core below the water level during weighing. A similar weighing is done at the end of the test to facilitate the determination of soil loss during the test.

8.2.1.3 Calculate the Submerged Mass of the Soil (SM_s) in each core by subtracting the submerged weight of the empty core from the submerged weight of the soil-filled core and record to ±0.01 g.

8.2.1.4 Calculate the Core linear Density (C_d) by dividing the SM_s by the unit length of the core and record in g/mm).

8.3 *Test Operation and Data Collection*:

8.3.1 Place three prepared and weighed soil cores in the test wells of the false floor. When soil cores are placed in the wells, the soil surfaces must be flush with the false floor surface.

8.3.2 For RECP testing, place the RECP over the entire false floor and hold it in place on the soil core surfaces by covering it with a 1.0 mm (0.038 in.) cover plate. The cover plate shall have arc or trapezoidal-shaped openings approximately equal to the diameter of the test cores in width (the radial direction) and approximately 75 mm (3.0 in.) larger in length (both upstream and downstream circumferentially) than the diameter of the test cores to completely expose the protected soil surfaces of the cores. (See Fig. 1.) Firmly secure the cover plate to the false floor to prevent the RECP from being pulled out from beyond the exposed surface. The specimen should be marked to facilitate identification of any slippage from beneath the cover plate. Any slippage shall be noted.

8.3.3 Fill the tank with water so that the impeller blades are covered. A line should designate the initial height of water. Fill in such a way that the water does not disturb the surface of the RECP/soil.

8.3.4 Activate the shear stress apparatus to rotate the impeller assembly at the RPM level determined from the calibration procedures necessary to achieve the target shear stress. Unless otherwise agreed to between the testing laboratory and user of the test, the RECP / bare soil control cores shall be subjected to a minimum of three flow tests at three different shear stress levels to encompass the shear stress at which 13 mm (0.5 in.) of soil loss will occur in the test cores.

NOTE 4—Commonly in channel erosion testing, 13 mm (0.5 in.) of soil loss is considered a point of maximum allowable soil loss. Therefore, it is recommended that the first test run be at a shear stress level sufficient to invoke approximately 13 mm (0.5 in.) of soil loss from the soil core. This may be accomplished by selecting a shear stress at or near the RECP's advertised and/or published permissible shear stress. After determining soil loss achieved during the first test, a minimum of two additional tests shall be performed, one at a higher level of shear stress and one at lower level of shear stress at a minimum of 24 pa (0.5 psf) above/below the initial target shear stress.

8.3.5 Allow test to run for 30 minutes.

8.3.6 Remove each soil core from its test well, being careful to retain all the remaining soil, and determine its Final Submerged Mass (SM_f).

8.3.7 Repeat 30-minute test on new RECP-protected cores at higher/lower shear stress levels.

8.3.8 Conduct a similar set of tests for the bare soil control cores at a minimum, when a new or renewed soil stockpile is used.

9. Calculations

9.1 Record the Final Submerged Mass (SM_f) of soil for each of the three cores for the RECP and bare soil control sets at each shear stress level.

9.2 Calculate the average depth of Soil Loss (mm) for each Core (SL_c) as follows:

$$SL_c = \frac{(SM_i - SM_f)}{Cd} \quad (1)$$

where:

SM_i = initial submerged mass of core (g),
SM_f = final submerged mass of core (g), and
Cd = core linear density (g/mm).

9.3 Calculate the Mean Soil Loss (SL_{avg}) in mm for each set of three cores by averaging the SL_c values of all three cores.

9.4 Plot SL_{avg} versus shear stress (in Pa and (lb/sf)) for each 30 minute test. All SL_c data points should be shown and used for curve fitting. On the graph, note the point at which the soil loss curve crosses 13 mm (0.5 in.) of soil loss.

9.5 Calculate the Shear Stress Ratio (*SSR*) for the test RECP as follows:

$$SSR = \frac{tp_{(0.5\ in\ SLavg)}}{tc_{(0.5\ in\ SLavg)}} \quad (2)$$

where:

$tp_{(0.5\ in\ SLavg)}$ = shear stress on RECP-protected cores at 0.5 in. average soil loss, and
$tc_{(0.5\ in\ SLavg)}$ = shear Stress on bare soil control cores at 0.5 in. average soil loss.

10. Report

10.1 The report shall at a minimum include the following:

10.1.1 General information, including test facility location, date, time, and dimensions of test apparatus.

10.1.2 Calibration data and analysis for each RECP tested.

10.1.3 Test set-up activities, including *(1)* test conditions (shear stress levels); *(2)* soil type and conditions; and *(3)* RECP product type and description.

10.1.4 The sand gradation and standard proctor moisture-density relationship shall be reported. If other soils are used, the soils information shall include: soil type/texture (that is, sandy loam, silt loam, clay); standard proctor moisture-density relationship; gradation (including hydrometer test for the P200 fraction); organic matter content; plasticity indices; and pH.

10.1.5 Raw data, initial and final submerged masses, core densities and depth of soil loss for each core.

10.1.6 Graph displaying SL_{avg} in mm (in.) versus shear stress in Pa (lb/sf) for all three RECP and bare soil tests. Denote on graph the shear stress level at which 13 mm (0.5 in.) of soil loss would be expected. All data points shall be plotted.

10.1.7 The calculated Shear Stress Ratio (SSR) for each RECP.

11. Precision and Bias

11.1 *Precision*—The precision of this test method is being established.

11.2 *Bias*—The true ability of an RECP to protect soil from hydraulic shear can be defined only in terms of a test method. Within this limitation, the procedure described herein has no known bias and, since there is not an accepted referee test method, the procedures of this test method have no inherent bias.

12. Keywords

12.1 erosion control; RECP; rolled erosion control product; shear stress; shear stress ratio

ANNEX

(Mandatory Information)

A1. Test Calibration and Soils

A1.1 Calibration of Flow/Shear Simulator

A1.1.1 Due to inherent differences in surface roughness characteristics of various unvegetated RECPs, each RECP tested in the shear stress apparatus will have its own shear stress versus impeller speed (RPM) relationship. For this reason, it is necessary to calibrate the shear tank for each RECP and soil tested within it. Procedural guidelines for calibration of the shear tank are provided below.

A1.1.2 Mount the top of a solid aluminum calibration block onto the bottom of a 203 mm (7.95 in.) diameter plastic calibration disk having a thickness of 3 mm (0.125 in.). The aluminum column should have dimensions no less than 25 mm (1 in.) square by 150 mm (6 in.) in height.

A1.1.3 Attach a 200 mm (8 in.) diameter specimen of the RECP to the top (exposed) surface of the calibration disk. The use of glues, small wire braces, etc. are acceptable to attach the RECP to the calibration disk as long as the attachment mechanism does not contribute hydraulic shear resistance during calibration testing.

A1.1.4 Mount a similar aluminum calibration block onto the bottom of the shear tank in a position 25 mm (1 in.) offset on the "downstream" side of a position directly beneath the center of a sample well in the false floor.

A1.1.5 Insert the RECP covered plastic calibration disk equipped with the aluminum calibration block into one of the sample wells so that the column extends downward towards the floor of the tank, a short distance away from the reaction column. Assure that the calibration disk moves freely around the sample well and is not wedged into a locked position. If the disk is too tight, remove any sand from around the edges to achieve a loose fit within the sample well. Cover the other sample wells with a similar plastic disk with the same RECP attached.

A1.1.6 Mount a water-resistant load cell with calibrated stress readout between the stress and reaction columns. Be careful to seal the electrical connections to and from the load cell with an appropriate water-proof gel.

A1.1.7 Fill the shear tank with water and activate the impeller assembly. Slowly increase the RPMs of the impeller and record the RPM reading at each 4.8 pa (0.1 psf) increment of increasing shear stress. Allow no less than 2 minutes at each RPM reading to establish an accurate and consistent reading from the load cell.

A1.1.8 The index limiting shear stress shall be calculated as follows:

$$\tau_i = \frac{\text{Load cell reading, kg (lb)}}{A} \quad \text{(A1.1)}$$

where:
τ_i = index limiting shear stress, Pa (lb/ft^2), and
A = surface area of sample, cm^2 (ft^2).

NOTE A1.1—The RPMs of the impeller will be measured using a procedure consistent with its drive mechanism. For pneumatic units, a record of air pressure may be recorded at each shear stress increment. For electrical drive mechanisms, a record of resistance may be recorded. All such recordings should be correlated to the shear stress as measured by the load cell assembly.

A1.1.9 Plot index limiting shear stress versus impeller RPMs (or indicator unit: for example, psi) specific to the RECP tested and use this relationship to determine shear stress levels during subsequent testing of the same RECP material.

A1.2 Standard Soils

A1.2.1 General soil type to be used for testing shall be sand. The sand shall comply with the sand gradation given in Test Method D 6460. The target gradation curves for the sand is included in Fig. A1.1. The sand layers shall be compacted to 90 ± 3 % of Standard Proctor density, at a soil moisture within ±3 % of optimum moisture content per Test Method D 698.

A1.2.2 If the RECP is to be soil filled, the additional cover soil is placed and compacted after the RECP placement. Calibration should be performed on the soil filled RECP.

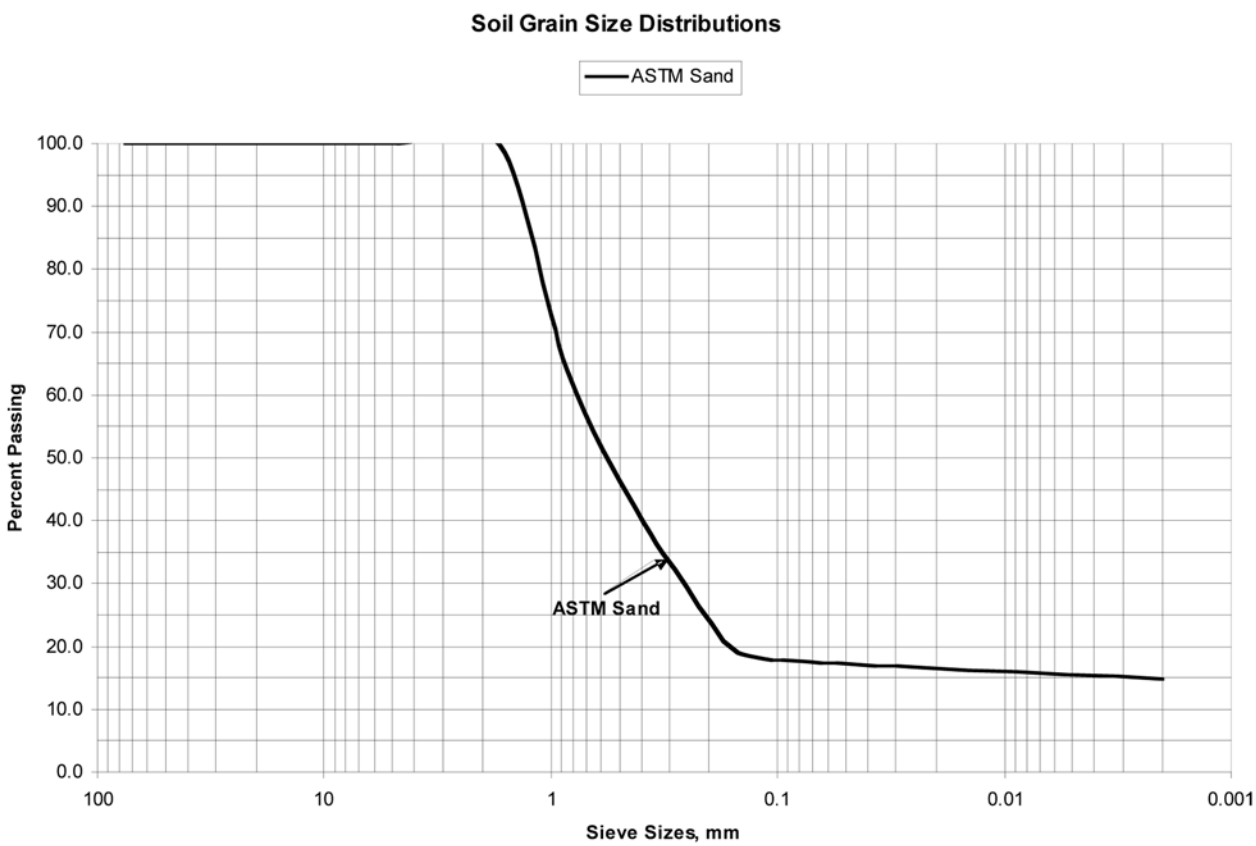

FIG. A1.1 Target Sand Gradation