Designation: D 6460 – 99

Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion[1]

This standard is issued under the fixed designation D 6460; 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 covers the guidelines, requirements and procedures for evaluating the ability of Erosion Control Blankets (ECBs) to protect earthen channels from stormwater-induced erosion. Critical elements of this protection are the ability of the ECB to:

1.1.1 Neutralize and absorb the hydraulic force of stormwater, thereby reducing soil particle loosening through "scour" mechanisms, and;

1.1.2 Slow runoff and encourage sedimentation, thereby reducing soil particle transport downstream;

1.1.3 Absorb shear forces of overland flow; and,

1.1.4 Trap soil particles beneath.

1.2 This test method utilizes full-scale testing procedures, rather than reduced-scale (bench-scale) simulation, and is patterned after conditions typically found on construction sites at the conclusion of earthwork operations, but prior to the start of revegetation work. Therefore this considers only unvegetated conditions.

NOTE 1—Future revisions may consider partial or fully vegetated conditions.

1.3 This test method provides a comparative evaluation of an ECB to base line bare soil conditions under controlled and documented conditions.

1.4 The values stated in SI units are to be regarded as standard. The inch-pound units 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.* Also, the user must comply with prevalent regulatory codes, such as OSHA (Occupational Health and Safety Administration) guidelines, while using the test method.

2. Referenced Documents

2.1 *ASTM Standards:*

C 136 Test Method for Sieve Analysis of Fine and Course Aggregates[2]

D 422 Test Method for Particle-Size Analysis of Soils[3]

D 698 Test Method for Laboratory Characteristics of Soil Using Standard Effort[4]

D 2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils[3]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *erosion control blanket (ECB), n*—a degradable material, composed primarily of processed natural organic materials, manufactured or fabricated into rolls designed to reduce soil erosion and assist in the growth, establishment and protection of vegetation.

3.1.2 *erosion control net (ECN), n*—a planar woven natural fiber or extruded synthetic mesh used as a component in the manufacture of ECBs.

3.1.3 *index test, n*—a test procedure which may contain a known bias, but which may be used to establish an order for a set of specimens with respect to the property of interest.

3.1.4 *lot, n*—a unit of production, or a group of other units or packages, taken for sampling or statistical examination, having one or more common properties and being readily separable from other similar units.

3.1.5 *natural, n*—a class name of various fibers of animal, mineral or vegetable origin.

3.1.6 *open weave textile (OWT), n*—a temporary degradable ECB composed of natural or polymer yarns woven into a matrix used to provide erosion control and facilitate vegetation establishment.

3.1.7 *polymer, n*—a chemical compound or mixture of compounds formed by polymerization and consisting essentially of repeating molecular structural units.

3.1.8 *sample, n*—a portion of material which is taken for testing or documentation and used in the laboratory as a source of individual specimens.

[1] This Test Method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock; Subcommittee D 18.25 on Erosion and Sediment Control Technology; and is the direct responsibility of Section .02 on Erosion Control Blankets (ECBs).

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

[4] *Annual Book of ASTM Standards*, Vol 15.09.

3.1.9 *shear stress, n*—the force of flowing water applied to the surface of a channel in Newtons per square metre (pounds per square foot); also, commonly referred to as "tractive force".

3.1.10 *temporary degradable* , *adj*—composed of biologically, photochemically or otherwise degradable materials that temporarily reduces soil erosion and enhances the establishment of vegetation.

4. Summary of Test Method

4.1 The performance of an erosion control blanket in reducing stormwater-induced erosion is determined by subjecting the material to simulated stormwater flow in a controlled and documented environment.

4.2 Key elements of the testing process include:

4.2.1 Calibration of the stormwater simulation equipment;

4.2.2 Preparation of the test channel;

4.2.3 Documentation of the ECB to be tested;

4.2.4 Installation of the ECB;

4.2.5 Performance of the test;

4.2.6 Collection of hydraulic, topographical and associated data;

4.2.7 Analysis of the resultant data, and;

4.2.8 Reporting.

5. Significance and Use

5.1 This test method evaluates ECBs and their means of installation to:

5.1.1 Reduce soil loss and sediment concentrations in stormwater runoff under conditions of varying channel conditions and soil type, and;

5.1.2 Improve water quality exiting the area disturbed by earthwork activity by reducing suspended solids.

5.2 This test method models and examines conditions typically found on construction sites involving earthwork activities, including: highways and roads; airports; residential, commercial and industrial developments; pipelines, mines, and landfills; golf courses; etc.

5.3 This test method is a performance test, but can be used for quality control to determine product conformance to project specifications. Caution is advised since information about between-laboratory precision is incomplete. Unique project-specific conditions should be taken into consideration.

6. Apparatus

6.1 *Water Delivery System*—The water delivery system shall include pump(s), piping, channels, and water control structures, as necessary, to achieve the desired hydraulic conditions. The water control structures shall regulate the flow and to direct it into the desired test channel. The water delivery system shall be constructed such that turbulence at the entrance to the test channel is minimized. Use of flow straighteners (for example, tube racks or vanes) are recommended to reduce turbulence and achieve uniform flow conditions. A direct flow system (that is, controlled flow diverted from a natural waterway) may also be employed for this purpose. For maximum test conditions, a total discharge capability of approximately 0.9 m^3/s (30 ft^3/s) is recommended. The water delivery system in Fig. 1 shows an example of a closed-loop water delivery system.

6.2 *Water Source*—Any water source shall be suitable for this use provided that it is not sediment laden or contains deleterious materials which could impair the operation of the pumps.

6.3 *Total Station System*—The total station system is a standard surveying instrument which is capable of measuring vertical and horizontal angles, and distance, simultaneously to determine measurement point coordinates (that is, X, Y and Z axis) and which uses an internal data logger to store this information for future use. In lieu of a total station system, manual surveying equipment may be used provided that equivalent accuracy is achievable. Periodic calibration and certification of this equipment shall be performed.

6.4 *Velocity Probe*—A propeller-type probe shall be used to identify flow conditions during test operation. In lieu of a propeller-type probe, other velocity measurement devices may be used provided that equivalent accuracy is achievable. Periodic calibration and certification of this equipment shall be performed.

6.5 *Miscellaneous*—Other miscellaneous equipment includes: meteorological equipment (wind speed, temperature, precipitation), and cameras or video recorders.

7. Procedure

7.1 *Test Channel Preparation*:

7.1.1 Construct earthen test channels using conventional

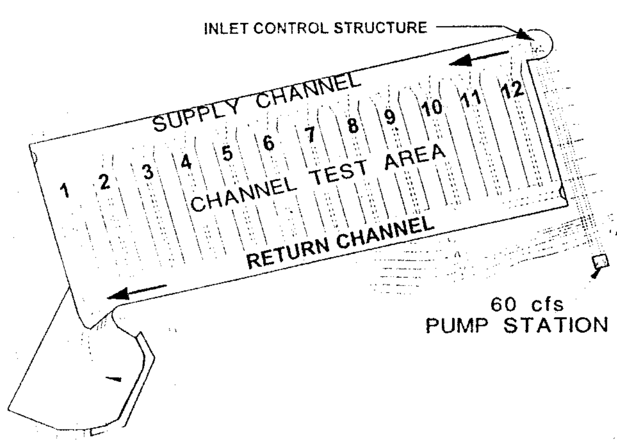


FIG. 1 Typical Closed Looped Water Delivery System

earthwork placement techniques. Perform compaction of channel bed material to create a geotechnically (structurally) stable subgrade.

7.1.2 Plate the channel surface with a minimum 45- cm (18– in.) thick veneer of soil. General soil types to be used for testing shall be loam, clay and sand. The target gradation curves for the loam and sand soil types are included in Fig. 2 and Fig. 3. The target Plastic Indices (PI) for the loam and clay soil types shall be approximately 4.5 and 15.0 ± 2.0 and 5.0, respectively. Place the veneer in 15– cm (6– in.) lifts and compact to approximately 90 to 95 % of standard Proctor density in accordance with Test Method D 698.

7.1.3 Excavate the channels to a trapezoidal cross-section with a 0.61– m (2–ft) bottom width and 2H:1V side slopes. The test channels shall be a minimum of 24.4 m (80 ft) in length. A bed slope of approximately of 5 and 10 % is necessary to achieve the target shear stress. Fig. 4 shows a typical channel profile and Fig. 5 shows a typical channel cross-section.

7.1.4 Begin the test reach 6.1 m (20 ft) below the inlet to the channel and extend 12.2 m (40 ft) downstream from that point. Establish benchmarks on either side of the channel at each end of the test reach and at 1.5– m (5– ft) intermediate intervals (nine cross-sections total).

7.1.5 Loosen the soil veneer in the test reach and 1.5 m (5 ft) upstream and downstream of the test reach to a depth of approximately 10 cm (4 in.) using a tiller or other appropriate tools. Rake the tilled channel smooth with a steel hand rake and compact using a vibratory plate compactor. Repair depressions, voids, soft or uncompacted areas before testing can commence. Also, free the channel from obstruction or protrusions, such as roots, large stones or other foreign material.

7.1.6 If the channel has been used previously for a test series, discard the soil carried out of the channel, and obliterate any rills and gullies. Spread new soil of the same type across the channel and blend (rake or tilled) into the surface.

7.2 *Calibration*:

7.2.1 Perform determination of the water delivery system discharge (Q) using: the weir equation, and; velocity-area equation. Begin calibration of the water delivery system when a steady-state flow is achieved.

7.2.2 For open-channel water delivery systems, measure the depth of water flowing into the test channel. Measure the velocity in the supply channel using the velocity probe in the three-point measurement pattern shown in Fig. 5. Base calculation of total discharge on the weir equation and the velocity-area equation (see Section 8).

7.3 *Pre-Test Documentation*:

7.3.1 Maintain a test folder for each test cycle, including information on:

7.3.1.1 Site conditions;

7.3.1.2 Geotechnical and soil conditions;

7.3.1.3 Meteorological data;

7.3.1.4 ECB product type, description and installation procedure, and;

7.3.1.5 Photo documentation.

7.3.2 Include the following subjective site information: general visual conditions of the channel to be tested; general meteorological information; channel treatment; photographs or videotape, or both, and any supplemental information that is not included in the following sections, but is felt to be of interest to the test.

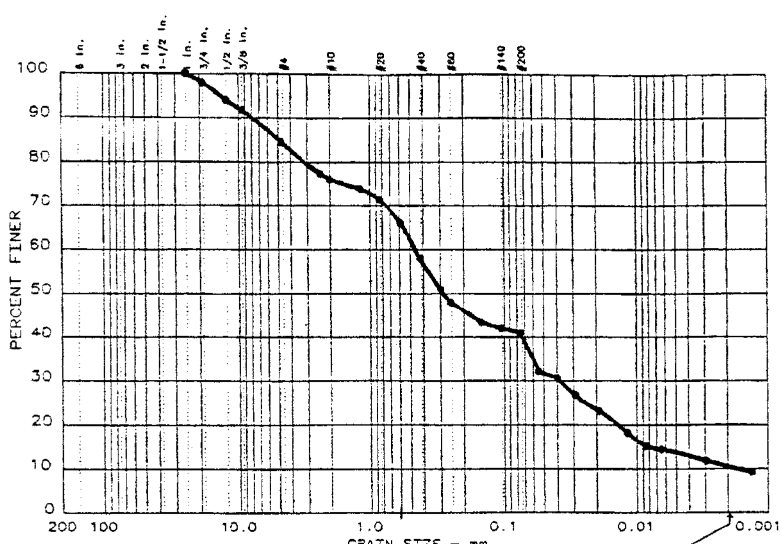
7.3.3 Include the following geotechnical and soils information : soil classification [Unified Soil Classification System (USCS) and USDA classification system.]; standard proctor moisture-density relationship; "K" factor; and; gradation (including hydrometer test for the P_{200} fraction).

7.3.4 Include the following meteorological information: all data from the on-site weather station at the time of the test (that is, ambient air temperature, wind speed and precipitation).

7.3.5 Include the following product type and description information: manufacturer name; product name; description; specifications; size, and; a sample of the material, if practical.

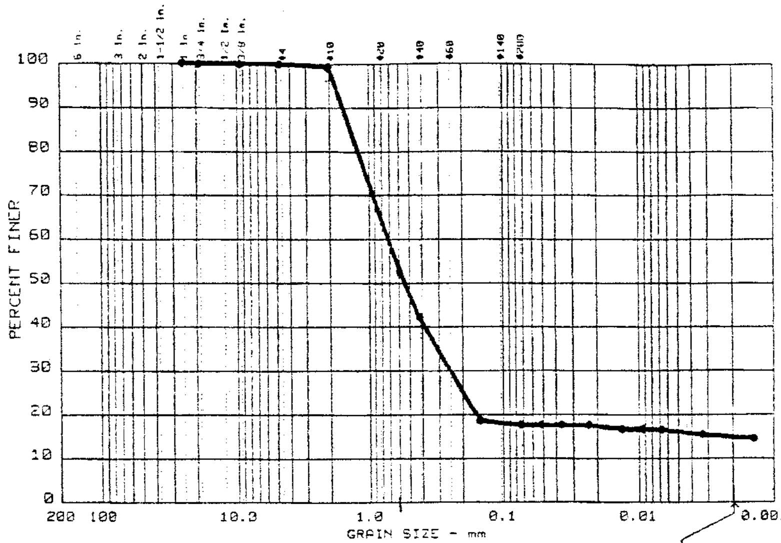
7.4 *Test Set-Up*

7.4.1 Install the ECB in the channel after calibration has



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
20	0.0	15.5	43.6	30.4	10.5

FIG. 2 Typical Loam Grain Size Distribution



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
1	0.0	0.1	82.3	2.8	14.8

FIG. 3 Typical Sand Grain Size Distribution

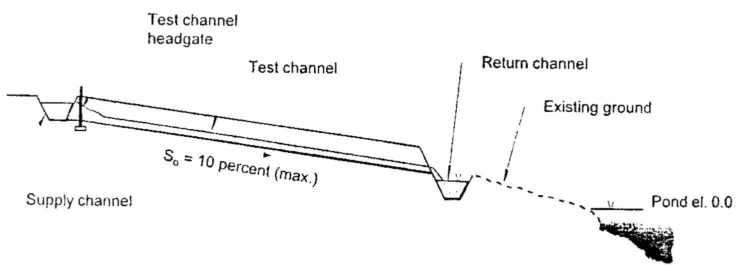


FIG. 4 Typical Channel Profile

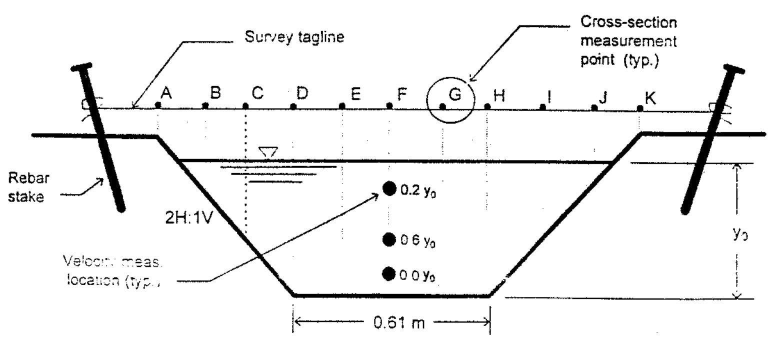


FIG. 5 Typical Channel Cross-Section

been completed and the test plot has been prepared,. Document the installation methodology for the ECB including: orientation on the bed and side slopes (longitudinal or lateral); placement (which side faces up); termination details; joint details, and; anchor type and installation pattern. Place the ECB over the entire length of the test channel and extend it up the side slopes to above the maximum anticipated flow depth.

7.4.2 Measure the elevation of the channel surface (that is, soil, not ECB) with the total station equipment using the reference benchmarks and a stringline between opposing benchmarks,. Take elevation measurements for each test cross-section (nine total) at the locations shown in Fig. 5. To allow measurement of the channel surface, a 0.6– cm (0.25– in.) diameter steel tip extension ("stinger") may need to be attached to the base of the surveyor's rod. Perform rod placement from an above channel platform, so that the rodman does not walk on the ECB. The rodman must use care in positioning the rod, so that the measurements are indicative of the channel surface. The rod shall not rest on the ECB above nor penetrate into the channel surface below.

7.4.3 Take photographs or videotape of the lined channel, or both prior to testing.

7.5 *Test Operation and Data Collection*:

7.5.1 Include the following test data: operator name and title; time flow began; time flow stopped; time runoff stopped; flow depths, and; measured velocities.

7.5.2 Make water surface elevation measurements at the centerline point of each test cross-section using the total station equipment as soon as the flow reaches a steady-state, uniform condition,. Make velocity measurements at the centerline point of each test cross-section using the velocity probe (see Fig. 5). If the depth of flow is less than 20 cm (8 in.), take only the six-tenths depth reading. Take photographs or videotapes, or both, during the test.

7.5.3 Perform testing at shear stresses of 48, 96, 144, and 192 Newtons/m^2 (1.0, 2.0, 3.0 and 4.0 lb/ft^2) or until catastrophic channel erosion is observed. Determine the appropriate discharge to achieve each shear stress threshold from the necessary depth of flow, based on the test channel (energy) gradient.

7.5.4 Test duration for each target shear stress shall be 30 min in length or until catastrophic channel erosion is observed. After completion of data collection for a given shear stress, commence the next higher shear stress test. As soon as practical, but not more than 2 h, after completion of data collection for a given shear stress, commence the next higher shear stress test. Do not remove the lining material or otherwise disturb between runs.

7.5.5 At the conclusion of the test, take channel surface elevation measurements again at the same locations as the pre-test measurements. As with the previous test data collection, take the rodman elevation measurements from above and do not walk on the lined channel surface.

7.5.6 Record general observations regarding the condition of the tested ECB at the conclusion of the data collection.

7.5.7 Carefully remove the ECB from the channel, with as little disturbance of the soil as possible. Note general observations regarding the condition and scour patterns. Take photographs and or videotape to record the condition of the test channel. Markers may be used to identify any scour patterns for the pictorial documentation.

7.5.8 Include a minimum of three test cycles (test cycle is a sequence of stepped shear stress) for each test series.

8. Calculation

8.1 *Calibration Data*:

8.1.1 *Weir Equation*—The elevation difference between the measured water surface and the bottom of the weir is the total head. With supercritical flow in the steep test channel downstream from the weir, the total discharge is computed as:

$$Q = 1.65(L)(H)^{3/2} \tag{1}$$

where:
Q = discharge, m^3/ s,
L = width of weir, m, and
H = total head, m.

8.1.2 *Velocity-Area Equation*—Based on the trapezoidal cross-section and the three-point cross-section velocity measurements, the discharge in the channel is computed as:

$$Q = V_1 A_1 + V_2 A_2 + V_3 A_3 \tag{2}$$

Q = discharge, m^3/ s,
V_n = measured velocity at each location, m / s,
A_1, A_3 = flow area, m^2 (@ B = 1.83m, SS = 2H:1V ⇒ $0.45y_0 + y_0^2$), and
A_2 = flow area, m^2 (@ B = 1.83 m ⇒ $0.9y_0$).

8.2 *Test Data*:

8.2.1 Analysis of the test data involves the following variables: total discharge, velocity, flow depth, energy slope, resistance coefficient (Manning *n*-value) and boundary shear stress.

8.2.2 Determine total discharge by the calibration activity and also compute at each of the nine measurement cross-sections by the continuity equation, as follows:

$$Q = V_{avg} A \tag{3}$$

where:
Q = discharge, m^3/ s,
V_{avg} = average of the three centerline velocity measurements, m / s, and
A = cross-sectional area of flow, m^2.

8.2.3 Determine the energy slope, S_f, by fitting a regression line through the energy grade line elevation determined at each of the nine measurement cross-sections, as follows:

$$S_f = WSE + V_{\text{avg}}^2 / 2\,g \tag{4}$$

where:
S_f = energy slope,
WSE = water surface elevation,
V_{avg} = average velocity, m / s, and
g = gravitational constant, 9.8m / s^2.

8.2.4 Calculate the Manning resistance coefficient, n, for each test as follows:

$$n = R^{2/3} S_f^{1/2} / V_{\text{avg}} \tag{5}$$

where:
n = Manning resistance coefficient,
R = hydraulic radius, m
S_f = energy slope, and
V_{avg} = average velocity, m / s.

The hydraulic radius is the flow area (m^2) divided by the wetted perimeter (*m*).

8.2.5 The average and maximum boundary shear stresses shall be determined, as follows:

$$\tau_{\text{avg}} = \gamma \times R \times S_f \text{ and } \tau_0 = \gamma \times y_0 \times S_f \tag{6}$$

where:
τ_{avg} and τ_0 = average and maximum shear stress, respectively, N / m^2, and
γ = unit weight of water (1001.6 kg / m^3)

8.2.6 Calculate the Clopper Soil Loss Index (CSLI) from the topographic data gathered before and after test flows using the total station equipment. Use the change in channel topography to define the performance of the ECB. Quantify areas of degradation (soil loss) as "cut" and quantify areas of aggradation (sediment deposition) as "fill". Use commercially-available earthworks software to evaluate the channel topographies and determine areas of cut and fill. Calculate the CSLI as follows:

$$CSLI = C_T / A_T \times 100 \tag{7}$$

where:

CSLI = Clopper Soil Loss Index, cm,
C_T = total cut, m^3, and
A_T = Wetted channel area, m^2.

NOTE 2—The CSLI evaluates channel lining materials only on their ability to reduce soil loss (erosion). It neither nor penalize the lining material on its ability to capture soil (sedimentation).

9. Report

9.1 Report at a minimum the following information:

9.1.1 General information, including test facility location, date, time and operator(s),

9.1.2 Test channel preparation,

9.1.3 Calibration data and analysis,

9.1.4 Materials documentation including blanket material and anchor description,

9.1.5 Test set-up activities including roll out pattern of blanket(s), anchor pattern and average anchor density (anchor per unit area),

9.1.6 Test operation and data collection (including "raw" data), and

9.1.7 Analysis (including hydraulic conditions and CSLI).

9.2 *Reporting of Significant Digits*:

9.2.1 Round off values from computation to the number of decimal places justified by the data. All calculations and reporting of experimental results shall adhere to the procedures described in "Experimental Methods for Engineers" (Holman 1984).[5]

9.2.2 *Examples of Significant Digits*:

Number as Written	Number of Significant Digits	Implied Range
341	3	340.5 to 341.5
34.1	3	34.05 to 34.15
.00341	3	0.003405 to 0.003415
3410.	4	3409.5 to 3410.5
341 EE7	3	340.5 EE7 to 341.5 EE7
3.41 EE-2	3	3.405 EE-2 to 3.415 EE-2

10. Precision and Bias

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

10.2 *Bias*—The true value of erosion control performance of ECBs 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.

11. Keywords

11.1 channel lining; ECB; erosion control; erosion control blanket; rolled erosion control product; scour; sediment; soil loss

[5] Holman, J.P., Experimental Methods for Engineers, McGraw-Hill Book Company, Fourth Edition, 1984.

APPENDIX

(Nonmandatory Information)

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