Designation: D 6459 – 99

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

This standard is issued under the fixed designation D 6459; 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 hillslopes from rainfall-induced erosion. Critical elements of this protection are the ability of the ECB to:

1.1.1 Absorb the impact force of raindrops, thereby reducing soil particle loosening through "splash" mechanisms;

1.1.2 Slow runoff and encourage infiltration, thereby reducing soil particle displacement and transport through "overland flow" mechanisms;

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 baseline 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 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.* 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 Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils[3]

D 4318 Standard 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 D18.25 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 *temporary degradable*, *adj*—composed of biologically, photochemically or otherwise degradable materials that temporarily reduce soil erosion and enhance the establishment of vegetation.

4. Summary of Test Method

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

4.2 Key elements of the testing process include:

4.2.1 Calibration of the rainfall simulation equipment;

4.2.2 Preparation of the test plot;

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 runoff and associated sediment yield 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 rainfall intensity 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: highway 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 *Rainfall Simulators*—Rainfall simulators shall include sprinkler heads, sprinkler risers, valves and pressure gages. The sprinkler heads should be selected on their ability to model natural raindrop size and distribution (no more than 10 % greater than 6 mm (0.24 in.) and no more than 10 % smaller than 1 mm (0.04 in.)). To approximate the kinetic energy of natural rainfall, the sprinkler riser shall be constructed to position the sprinkler heads to achieve a minimum fall height (peak vertical trajectory) of 4.3 m (14 ft). A flow control valve and a pressure gauge capable of maintaining a uniform operating pressure shall be located on each riser. Fig. 1 shows an example of a rainfall simulator.

6.2 *Water Source*—Any water source shall be suitable for this use provided that it does not contain deleterious materials which could impair the operation of the rainfall simulators.

6.3 *Runoff and Sediment Collection System*—The runoff and sediment collection system includes flashing, collection apparatus and a holding tank. Flashing shall be fabricated to direct runoff from the plot into the collection apparatus. Once the runoff is on the flashing, it may be desirable to divert the flow to a single collection point. The flashing shall be continuous across the entire bottom edge of the plot. A holding tank(s) capable of temporarily containing all runoff shall be connected

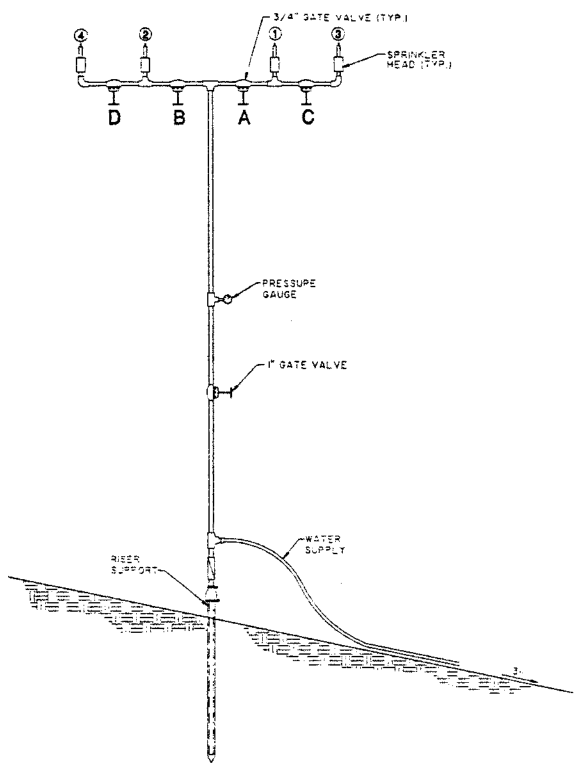


FIG. 1 Typical Rainfall Simulator

to the collection apparatus.

6.4 *Miscellaneous*—Other miscellaneous equipment includes: rain gauges (20), pie pans (3), sieve set (standard US sieves), evaporating dishes, a drying oven or microwave oven, balances, meteorological equipment (wind speed, temperature, precipitation), a surveyor's rod, sample bottles and bags, cooler and camera or video recorder.

7. Procedure

7.1 *Test Plot Preparation*:

7.1.1 Construct an earthen embankment using conventional earthwork placement techniques. Perform compaction of the embankment to create a geotechnically (structurally) stable embankment with a surface slope of 3H:1V having a slope length of 12 m (40 ft). Fig. 2 shows a typical embankment cross-section.

7.1.2 Plate the top surface of the embarkment with a minimum 15 cm (6 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 is included in Fig. 3 and Fig. 4. 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 Locate test plots on the embankment using a plot size of 2.4 m (8 ft) in width (cross-slope) and of 12 m (40 ft) in length (downslope). Separate the test plots such that overspray from the rainfall simulators does not impact adjacent plots.

NOTE 2—The slope width, length and steepness were selected as being representative of conditions typically found on construction sites. This test plot configuration was chosen to assure uniformity and consistence of testing activities.

7.1.4 Isolate the top edge and sides of each test plot by a water barrier which forms the boundary of the test plot. Bury the bottom edge of the barrier approximately 10 cm (4 in.) to divert surface flow such that no intrusion of outside surface water onto the test plot ("run-on") occurs. The barrier shall be continuous such that joints do not allow outside flow to enter the plot. Commercially available lawn edging is suitable for this purpose.

7.1.5 Loosen the soil veneer to a depth of approximately 10 cm (4 in.) using a tiller or other appropriate tools. Rake the tilled plot smooth with a steel hand rake and lightly compact using a turf roller. Repair depressions, voids, soft, or uncompacted areas before testing commences. Also, free the plot from obstruction or protrusions, such as roots, large stones, or other foreign material.

7.1.6 If the plots have been used for previous test series, discard the soil carried of the plot and obliterate any rills and gullies. Spread new soil of the same type across the plot and blend (rake or till) into the surface. If the soil loss of the control plot differs significantly from the base line calibration test reevaluate the soil properties.

7.2 *Calibration*:

7.2.1 Calibration of the rainfall simulation equipment includes:

7.2.1.1 Rainfall intensity;

7.2.1.2 Uniformity of rainfall application across the plot, and;

7.2.1.3 Drop size distribution for each intensity.

7.2.2 To ensure uniform distribution, do not conduct calibration and testing when the wind velocity is greater than 8 km/h (5 mph).

7.2.3 At a minimum, conduct calibration annually or following equipment maintenance work. Conduct one intensity/ uniformity check every 90 days, or after no more than four test series, whichever comes first.

7.2.4 Place sprinkler risers around the perimeter of the test plot to provide uniform distribution. The precise location of the risers to provide uniform rainfall distribution will be determined by the calibration process and the nuances of any given simulator system (See Fig. 5 for typical sprinkler riser configuration.).

7.2.5 Place the rain gages on the plot surface following the pattern shown in Fig. 5. Duration of the calibration test shall be 15 min, recorded to the nearest second. Perform calibrations at uniform pressure for each intensity. Adjust riser locations until an acceptable uniform rainfall distribution pattern is achieved, as defined in Section 8.

7.2.6 Calculate the rainfall intensity uniformity using the Christiansen uniformity coefficient (see Section 8).

7.2.7 To measure drop size distribution, completely fill three labeled pie pans with sifted flour, struck off with a ruler to produce a smooth, uncompacted surface. Locate three supports approximately 20-cm (8- in.) high (for example, 1-gal cans) along the vertical centerline of the test plot, and at the horizontal quarter points. Place the filled pie pans on the supports (horizontal, not parallel to the ground) and cover. At the desired test intensity, remove the cover briefly so that drops impinge on the flour to form pellets. Recover the pans after only a few seconds and before the drops start to touch each other. Repeat this procedure at each desired intensity. Air-dry the flour pellets for a minimum of 12 h. Screen each sample of these semi-dry pellets by emptying the entire contents of the pan onto a 70 mesh sieve to carefully remove as much loose

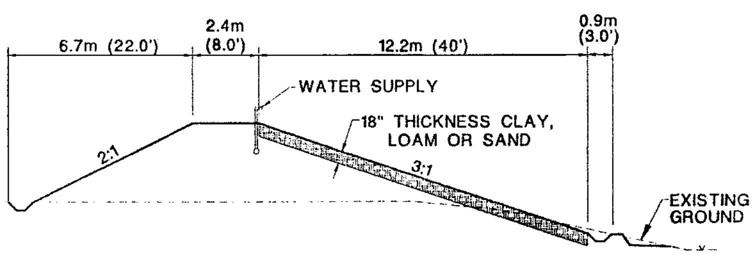
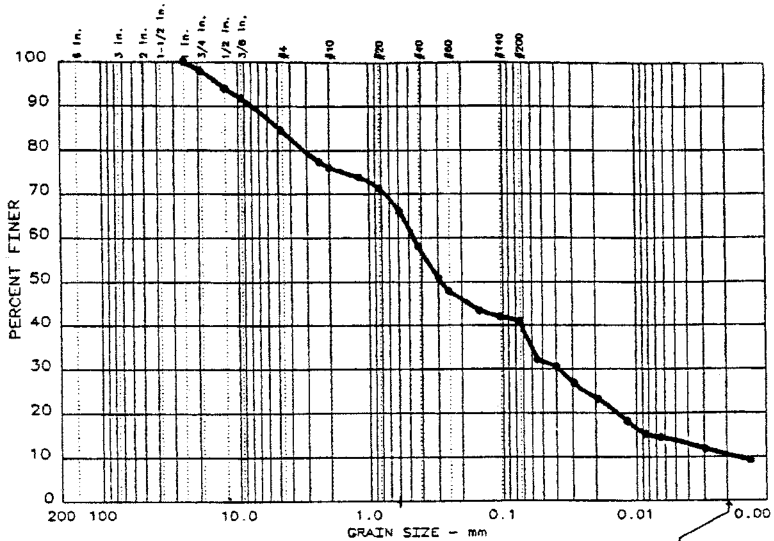
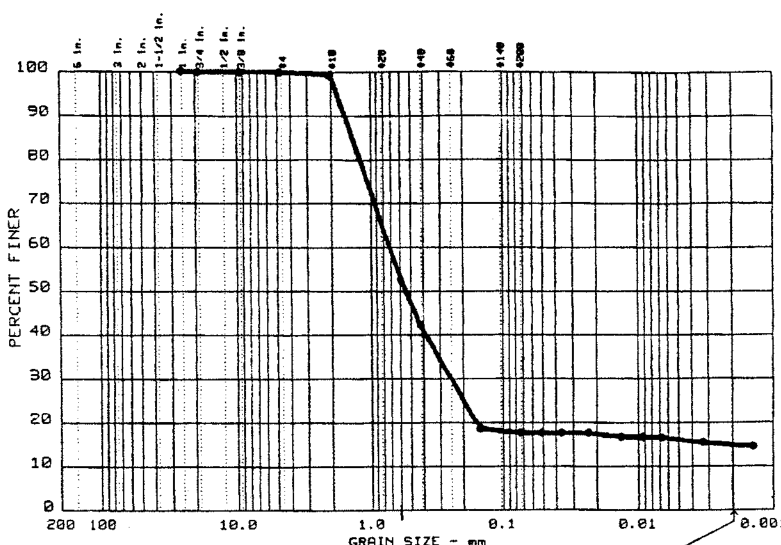


FIG. 2 Typical Embankment Cross Section



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

FIG. 3 Typical Loam Grain Size Distribution



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

FIG. 4 Typical Sand Grain Size Distribution

flour as possible. Then transfer the remaining pellets to evaporating dishes and heat in an oven at approximately 43°C (110°F) for 2 h. Record the total weight of the hard flour pellets. Sieve the pellets through standard soil sieves by shaking the stack for 2 min. Cull foreign matter and any double pellets from each sieve and record the total weight and pellet count for each size. **(1)**[5]

7.2.8 Repeat the raindrop size calibration procedure (7.2.7) three times for each desired intensity.

7.2.9 Determine raindrop fall height by measuring the average height of the raindrop trajectory using a surveyor's rod. Hold the rod vertically in the spray of a single riser and measure the wetted height. Repeat the height measurement for each desired intensity.

7.3 *Pre-Test Documentation*:

7.3.1 Maintain a test folder for each test cycle, including information on: site conditions; geotechnical and soil conditions; meteorological data; ECB product type, description and installation procedure, and; photo documentation.

7.3.2 Include the following subjective site information: general visual conditions of the plot to be tested; general meteorological information; plot 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.

[5] The boldface numbers given in parentheses refer to a list of references at the end of the text.

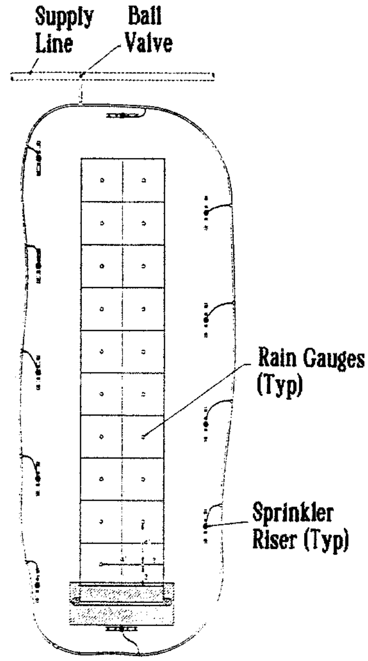


FIG. 5 Typical Sprinkler Riser Configuration

7.3.3 Include the following geotechnical and soils informatio : 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 Determine the optimum moisture content for the soil type on the given plot. Wet the plot using the rainfall simulation system until the soil reaches the optimum moisture content plus or minus 4 %. Take soil sample to determine the pretest soil moisture content within 1 h prior to the test.

7.4.2 Install the ECB on the plot after calibration has been completed and the test plot has been prepared. Permit no foot traffic on the plot, once the ECB has been installed. Document the installation methodology for the ECB including: orientation on the slope (longitudinal or lateral); placement (which side faces up); termination details; joint details, and; anchor type and installation pattern. Place the ECB so that no gaps are present along the perimeter barrier and be cut to fit, as necessary, to cover the plot.

7.4.3 Take photographs or videotapes, or both of the covered plot prior to testing.

7.5 *Test Operation and Data Collection*:

7.5.1 Include the following test data: operator name and title; operating pressure; sprinkler heads activated; time rainfall began; time runoff from the plot began; time rainfall stopped; time runoff stopped, and; volume readings taken at intervals ranging from 30 s to 3 min (the more frequent measurements shall be recorded at higher runoff rates).

7.5.2 Include one control plot (bare soil) and a minimum of three product test plots in each test series.

7.5.3 Perform testing at the desired intensity(ies) for 20 min or until catastrophic slope erosion is observed.

7.5.4 Collect samples to determine the total amount of sediment produced from the test plot and the time history of sediment concentrations in runoff during the course of the event. Determine total sediment from the plot tested by allowing settlement to occur in the runoff collection tank. Siphon off excess water and discard. Make sure that the sediment in the bottom of the tank is not disturbed. Depending on the amount of sediment produced during the test, collect either the entire amount of the settled sediment, or a representative sample, in a labeled one-gallon freezer bag. Weigh, record and then discard the unsampled portion, if any. Determine the water content of the sediment by assuming that the entire sediment produced during the test exhibited the same moisture content as the sample portion.

7.5.5 Take grab samples at intervals of 30 s to 3 min depending on the runoff rate to determine sediment concentration. Commence sampling when runoff starts and continue until runoff stops. Take samples from the plot apron in 200 mL laboratory sample bottles and analyze for suspended sediment. To keep rainfall from entering the bottle during filling, lift the cover on the apron and collection apparatus just enough to gain access for the sampling bottle. Label each bottle and place in a cooler until the laboratory analysis can be performed.

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 plot with as little disturbance of the soil as possible. Note general observations regarding the condition and erosion patterns (rills, etc.). Take photograph or videotape, or both to record the condition of the soil. Markers may be used to identify any rilling patterns for the pictorial documentation.

8. Calculation

8.1 *Calibration Data*:

8.1.1 Calculate the Christiansen uniformity coefficient (C_u) using a network of rain gages (20 min) each of which represents an equal area of the test plot. Calculate the C_u as follows:

$$C_u = 100\,[1.00 - \sum|d| \div n\,\bar{X}] \tag{1}$$

where:

C_u = Christiansen uniformity coefficient,
d = $X_i - \bar{X}$,
n = number of observations (20 in this case),
X = average depth caught, and
X_i = depth caught in each rain gage, i.

8.1.2 The average rainfall intensity over the entire test plot is the average depth of rainfall collected in the rain gages (see 7.2.5 and Fig. 5) divided by the elapsed time of the test. The formula to calculate intensity (in centimetres per hour) is:

$$i = 60[\sum_{j=1}^{J} P_j \div Jt] \tag{2}$$

where:

i = rainfall intensity (cm / h),
P_j = depth of rainfall (cm),
J = number of rain gauges (20 in this case), and
t = time of test (minutes).

8.1.3 Plot the raindrop size distribution for each intensity. Fig. 6 shows example raindrop size distribution curves.

8.1.4 Determine the kinetic energy imparted by the rainfall simulators at the soil surface by summing the kinetic energy of each drop size class multiplied by the relative percentage of that drop size, as determined by the distribution data. The kinetic energy represented by each size class is:

$$KE_{total} = \sum 0.5\, m\, v^2 \tag{3}$$

where:

KE = kinetic energy of drop size class,
m = mass of drop, and
v = velocity of drop at the soil surface.

Figs. 7 and 8 show velocity of fall of seven sizes of water drops after heights of fall from 0.5 to 20.0 m **(2)**, and terminal velocity of distilled water droplets in still air, respectively **(3)**.

8.1.5 As described in Refs **(4)** and **(5)**, calculate the Erosion Index (EI) for the rainfall simulators as:

$$EI = I \times 1099 \times [1 - 0.72\,\exp(-1.27 \times I)] \tag{4}$$

where:

EI = erosion index, and
I = rainfall intensity, in./h.

Calculate the EI value for the desired intensities and corrected for the kinetic energy of drops at less than terminal velocity.

NOTE 3—The USDA has not published a metric equivalent for Equation 4.

8.2 *Test Data*:

8.2.1 Plot runoff hydrographs showing discharge as a function of time.

8.2.2 Plot sediment concentration curves showing concentration as a function of time.

8.2.3 From the total runoff volume, compute the equivalent runoff Curve Number (CN), as used in Ref **(6)**.

8.2.4 From the peak runoff rates, compute the rational coefficient (C), as used for computation of peak discharge in the Rational Runoff Equation **(7)**.

8.2.5 From the total sediment yield, compute the equivalent Cover-factor (C-factor) used to compare soil loss to bare soil conditions in Refs **(4)** and **(5)**. The C factor is a ratio of the soil loss of protected soil verses bare unprotected soil.

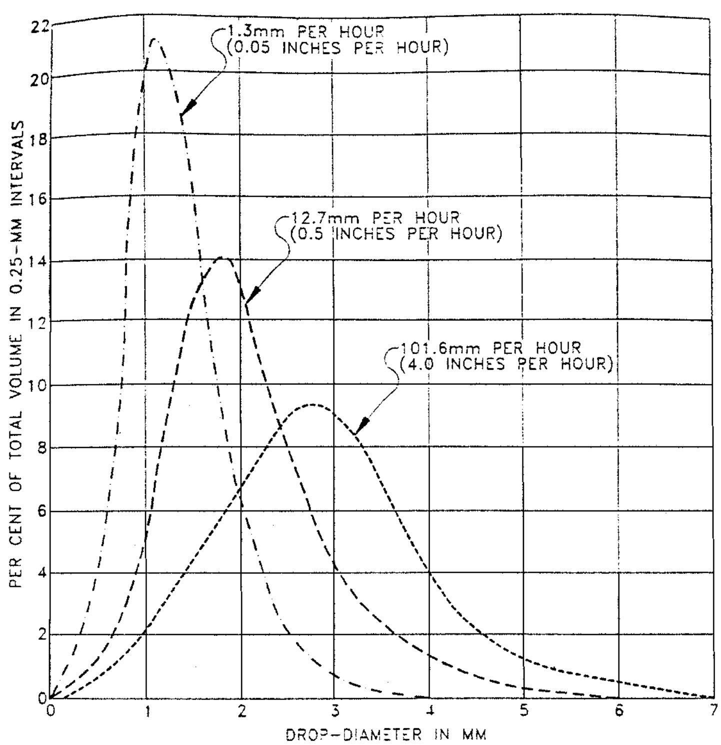


FIG. 6 Example Raindrop Size Distribution

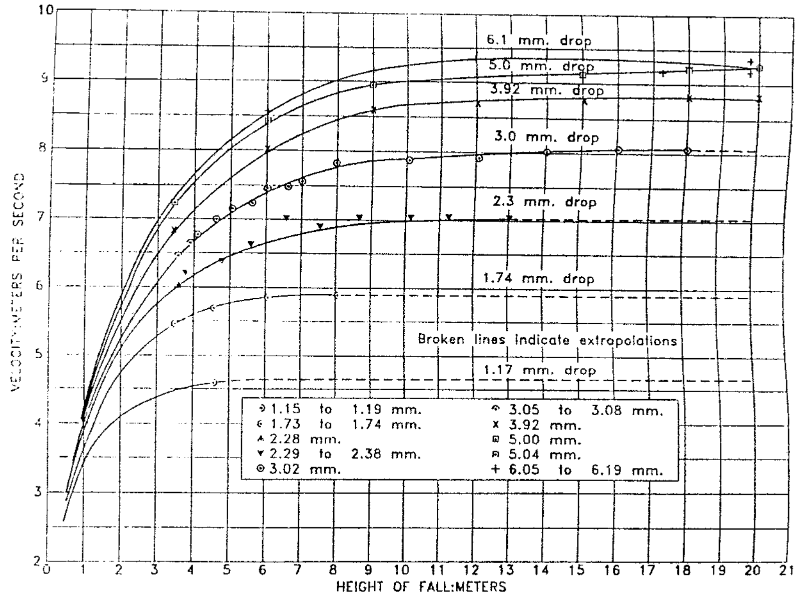


FIG. 7 Velocity of Fall of Seven Sizes of Water Drops After Heights of Fall from 0.5 to 20.0 m.

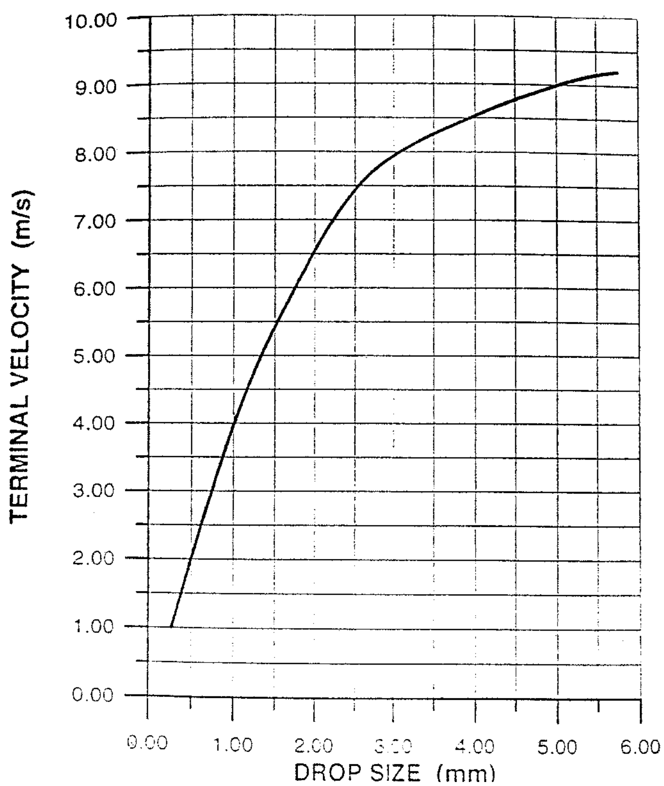


FIG. 8 Terminal Velocity of Distilled Water Droplets in Still Air.

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 plot 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 graphs and key indices).

9.2 *Reporting of Significant Digits*:

9.2.1 Values from computation shall be rounded off to the number of decimal places justified by the data. All calculations and reporting of experimental results shall adhere to the procedures described in Ref **(8)**.

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 not inherent bias.

11. Keywords

11.1 cover and mulch; ECB; erosion control; erosion control blanket; rainfall simulation; rolled erosion product; runoff; sediment; soil loss

APPENDIX

(Nonmandatory Information)

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