

ENGINEERING BULLETIN



EB212 - TEST METHODS FOR ROLLED EROSION CONTROL PRODUCTS

INTRODUCTION

One of the greatest challenges facing erosion control professionals is the appropriate characterization of the various available erosion control products in order to facilitate their orderly design, specification, and purchase. This is because test methods evolve over time and new test methods continue to be developed as new products are developed. Additionally, once developed, test methods must proceed through a standardization process before they can be confidently adopted by product manufacturers for quality control and performance characterization and by designers for material specifications. Fortunately, numerous rolled erosion control product (RECP) test methods have been developed and standardized over the last decade, while still others have been developed and are proceeding through the standardization process. The test methods include index tests that are useful for product quality control and product-to-product comparisons, as well as, performance-related tests that assist the designer in quantifying the effectiveness of RECPs in various applications.

The purpose of this ENGINEERING BULLETIN is to present the status and details of available RECP test methods – both index and performance – and provide guidance on the use of the various test methods in generic construction material specifications.

BACKGROUND

In 1994, the Erosion Control Technology Council (ECTC), an organization of rolled erosion control product (RECP) manufacturers, initiated a program to identify and establish a common terminology and develop standardized index and performance tests. In January 1997, the ECTC issued a manual of common terminology and recommended index testing standards (ECTC Technical Guidance Manual: TASC 00197). The ECTC then began a coordinated effort to work through the American Society for Testing and Materials (ASTM) to achieve consensus standardization of RECP test procedures. This work continues within ASTM Subcommittee D18.25, “Erosion and Sediment Control Technology” and Committee D35.05, “Geosynthetic Erosion Control.” Organized in 1898, ASTM is one of the largest voluntary standards development organizations in the world. It is a not-for-profit organization that provides a forum for the development and publication of voluntary consensus standards for materials, products, systems, and services.

More than 20,000 members representing producers, users, ultimate consumers, and representatives of government and academia develop documents that serve as a basis for manufacturing, procurement, and regulatory activities. Over the past several years, ASTM has released several new standard test methods for High Performance Turf Reinforcement Mats (HPTRMs), Turf Reinforcement Mats (TRMs) and Erosion Control Blankets (ECBs) that have been adopted by Propex and the RECP industry.

TESTING & EVALUATION OF RECPs

Index Property Tests of RECPs

Simple tests that measure a specific property of a material for the purpose of comparing products or monitoring production are called Index Property tests. Some Index Property tests are performed during manufacturing to evaluate product integrity, quality, and continuity and to assess the impact of changes in production methodology on product properties. While Index Property tests have historically been used solely for manufacturing quality control it has been found that they are a critical part of RECP specifications and include key predictors of long-term performance of the RECP. Typical RECP Index Property tests include Mass per Unit Area, Thickness, Light Penetration, Tensile Strength, Resiliency, Flexibility, and Ultraviolet (UV) Resistance. Most all Index Property test results can be reported with statistical relevance since they are run with great frequency. Commonly, minimum average roll values (MARVs) reflecting a 97.7% confidence level are reported and specified for quality control tests. However, some Index Properties, such as Flexibility and UV Resistance, are tested less frequently and therefore reported as average or Typical values. An overriding principle in RECP applications is that consistent performance is dependent upon consistent RECP properties. RECP Index Property values certified based on MARVs ensure delivery of a consistent quality RECP to any project. At Propex we believe that the manufacturer, the public agency, and the Engineer each have an obligation to ensure that the RECPs supplied are the same as those which have been tested and specified. More details on the MARV and Typical Values can be found in Engineering Bulletin 603 – Understanding Minimum Average Roll Values (MARV) and Typical Values.

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Mass per Unit Area

The Mass per Unit Area measures the mass (or weight) of an RECP relative to an equivalent unit of surface area to determine a density of the RECP. Because the sampling and cutting of RECPs can be quite challenging, two separate standards have been developed by ASTM:

- ASTM D-6566, “Standard Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats (TRMs),” which uses ten 8” x 8” specimens at ambient laboratory conditions
- ASTM D-6475, “Standard Test Method for Measuring Mass per Unit Area of Erosion Control Blankets (ECBs),” which uses five larger (typically 12” x 14”) specimens that have been dried at 50° overnight.

Thickness

The nominal thickness of an RECP when a pressure of 0.029 psi (0.2 kPa) is evenly applied to the specimen per ASTM D-6525, “Standard Test Method for Measuring Nominal Thickness of Permanent Rolled Erosion Control Products (RECPs)” is known as the RECPs Thickness. While the Thickness value of an RECP may have been historically viewed as relevant only to manufacturing quality control assurances, it has significant impact to erosion control performance of lofter, three-dimensional RECPs. The Thickness of an RECP, when evaluated alongside the Light Penetration, correlates to the volume of soil effectively contained within a tightly configured RECP.

Light Penetration

As research efforts continue on RECP technology, we are learning that Light Penetration may have more significant bearing on overall RECP performance than any other Index or Performance Property. Light Penetration is a function of the percent open area of an RECP and lower values indicate a denser configuration, therefore a better ability to trap and contain finer particles of soil from escaping through the RECP. This is especially critical when vegetation is absent, or in the early stages of establishment, where root mass provides little or no contribution to the containment of underlying soils.

A light box has commonly been used to quantify the openness of textile materials. It illuminates a light source inside a box on one side of the specimen. On the other side, a calibrated meter measures the amount of light that is able to pass through the specimen. This amount – stated as a percentage of the amount associated with no specimen in place – is the Light Penetration, as tested per ASTM D-6567, “Standard Test Method for Measuring the Light Penetration of a Turf Reinforcement Mat (TRM)”. The inverse of Light Penetration is the ground cover. The values stated as a percentage are to be regarded as Typical values.

Figure 1 below shows the soil loss encountered after subjecting two RECPs (10% and 30% Light Penetration, respectively) to rigorous wave overtopping simulation testing at Colorado State University in 2013. With all other parameters (soil type, vegetation establishment, pinning, hydraulic forces) being equal in these two test sections, significantly higher soil loss can be seen from beneath the RECP with the higher Light Penetration.

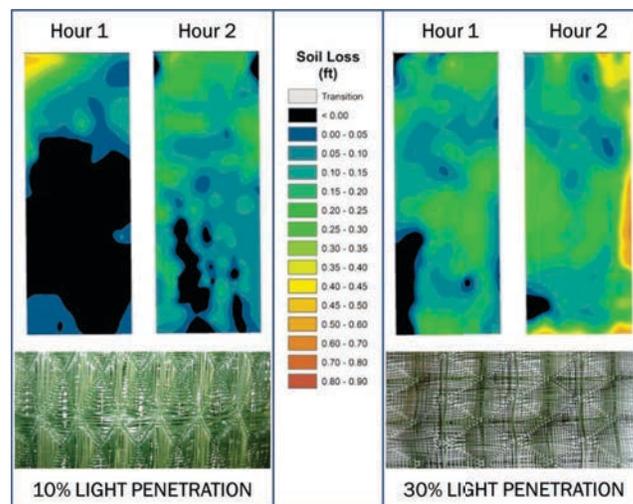


Figure 1 - Light Penetration Comparison

Tensile Strength

The Tensile Strength of an RECP is an important Index Property and is shown as the resistance of a RECP to breaking under tension. A higher Tensile Strength indicates an RECP with generally more resistance to emergency and recreational vehicular traffic and maintenance such as mowing, known as non-hydraulic stresses. The Tensile Strength of an RECP is tested per ASTM D-6818, “Standard Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats (TRMs).”

Resiliency

It is often useful to measure the impact of cyclic loading on the thickness of RECPs. The Resiliency of an RECP is measured by its ability to resist short-term, repeated compressive loading stated as a percentage comparing the resulting RECP thickness to the original RECP thickness per ASTM D-6524, “Standard Test Method for Measuring the Short-Term Compression Behavior of Turf Reinforcement Mats (TRMs)”. A higher Resiliency shows the RECPs durability and ability to protect newly developing seed from damage during loading.

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Flexibility

The Flexibility of an RECP is a measure of how much it will deflect under its own weight. Products with lower Flexibility are more flexible and can easily conform to the subgrade. Establishing and maintaining intimate contact with the subgrade is paramount to a successful installation. A lower value for flexibility denotes an RECP that is more flexible and can easily conform to the subgrade, allowing for greater overall performance. Flexibility is measured per ASTM D-6575, “Standard Test Method for Determining Stiffness of Geosynthetics Used as Turf Reinforcement Mats (TRMs).”

Ultraviolet Resistance

Ultraviolet (UV) light degradation is a process in which the strength of a synthetic, permanent RECP is reduced by exposure to sunlight. The Tensile Strength (both in the machine and cross directions) of a permanent RECP is the single-most important predictor of its long-term performance, as it dictates the ability of the material to resist damage to non-hydraulic stresses (e.g., construction and maintenance loadings, debris accumulation, wildlife disturbance). Since UV degradation reduces the RECP’s Tensile Strength over time, it is important to understand the relationship of UV Resistance to long-term performance of manufactured polypropylene RECPs.

The most common standard accelerated UV lab test is ASTM D-4355, “Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus” which exposes specimens to UV produced by a Xenon Arc light source. Specimens are exposed to continuous 120-minute cycles of 90 minutes of light only, followed by 30 minutes of water spray and light. Specimens are typically removed after 150, 300, and 500 hours of exposure and tested for residual tensile strength in accordance with ASTM D-6818. The retained strength is reported as the measure of a material’s UV Resistance.

Although installed RECPs are often covered with a combination of soil and vegetation, one must assume that full exposure to constant sunlight is the critical design condition. In arid locations (such as the Southwestern United States), RECPs are often installed with no soil fill or vegetation and subject to intense thermal radiation for a vast majority of the year. Because of this, Propex RECPs are stabilized for the UV radiation generated in critical locations using a patented blend of stabilizers added to the resins prior to manufacture. These stabilizers work to minimize the damage caused during photooxidation reactions in the polypropylene triggered by prolonged solar radiation exposure. While acceptable industry standards (Erosion Control Technology Council, Federal Highway Administration) call for 500 hours of simulated exposure, Propex RECPs are tested after 1,000, 3,000, 6,000, and 10,000 hours of prescriptive exposure in the Xenon Arc Weatherometer.

Trilobal Fiber

The combination of root length and volume of vegetation established through an RECP has a substantial effect on hydraulic performance – more so than the vegetated surface coverage. Research has shown that RECPs with woven Trilobal Fiber cross sections are able to facilitate deeper and denser root masses by capturing more moisture and retaining more sediment than equivalent diameter round fibers (Figure 2), leading to more robust long-term root establishment and greater performance. Propex TRMs and HPTRMs feature Trilobal Fibers utilizing our patented X3® fiber technology, enhancing the rate of vegetative growth.

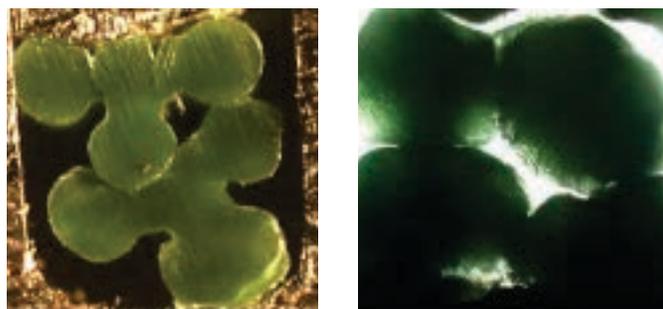


Figure 2 - Trilobal Fiber (Left) vs. Round Fiber (Right)

Seeding Emergence

The Seeding Emergence test method establishes procedures for evaluating the ability of RECPs to encourage seed germination. The results of the test can be used to compare RECPs and other erosion control methods to determine which are the most effective at encouraging the growth of vegetation in different climates. However, it should be noted that Seeding Emergence must be balanced with a low Light Penetration to ensure adequate protection of the subgrade soil and establishing vegetation. Testing is done within a growth chamber as containers of soil are sown with seeds and then covered with an RECP. Additional containers are left uncovered as controls. The light, water, and temperature are regulated and documented. The rate of germination is measured periodically throughout the test, and the weight of vegetation is calculated at the conclusion of the test. Test sets are designed to evaluate an RECP’s ability to enhance the rate and quantity of germination. The testing results include the rate and total weight of germination after 21 days. From this data, a percent enhancement can be calculated by comparing results from the RECP covered soil to the control per ASTM D-7322, “Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Ability to Encourage Seed Germination and Plant Growth Under Bench-Scale Conditions”.

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Performance Property Tests of RECPs

Only a few tests are typically used to assure manufacturing quality control of RECPs and, thus, are done with sufficient frequency to support product certifications. Thickness, Light Penetration, Tensile Strength, and Resiliency are typically run by manufacturers to monitor quality. These properties, therefore, should be certified by the manufacturer with statistical certainty. While these Index Properties can indicate the overall performance of the RECP, performance tests are needed.

Performance tests are used to evaluate the Performance Properties of RECPs and to correlate the Index Properties of RECPs to performance where appropriate. These tests typically are performed using boundary conditions that simulate field conditions. Because they are run infrequently, these tests can only report results and provide certifications as nominal test values. Erosion control designers typically use general Performance Properties rather than project-specific Performance Properties for design properties such as C-Factor, permissible shear, and functional longevity. This is because it is too costly and time consuming to run regular project-specific tests.

Because of the high cost and extended time periods required for Performance Properties testing at large-scale research-oriented facilities, currently available Performance Properties are generally derived from infrequent, single-specimen, non-standard tests. The Performance Properties obtained through these testing programs feature specific soil types, vegetation classes, flow conditions, and failure criteria, which may not be relevant to every project. Therefore, the results must be used cautiously.

Slope Erosion & Runoff Reduction

A slope is generally eroded by rainfall impact and sheet runoff forces. Test procedures have been developed for the measurement of the amount of soil loss caused by rainfall generated by a rainfall simulator. At the same time, the increased infiltration or runoff reduction can also be measured. Soil type, slope, and rainfall rate and duration can be controlled. In one such procedure, plots measuring 8 ft x 40 ft (2.4 m x 12.2 m) on a 3H:1V slope are used to compare the effects of rain on a RECP protected slope versus a control, or unprotected, slope (Figure 3). The slopes can be bare, seeded, or allowed to establish vegetation prior to testing, and wind can also be applied to the slope. Simulated rainfall is applied to the plots until significant rilling has occurred. Runoff is collected, weighed, dried, and then weighed again. The effectiveness of the RECP is based on the dried runoff as tested per ASTM D-6459, "Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion".

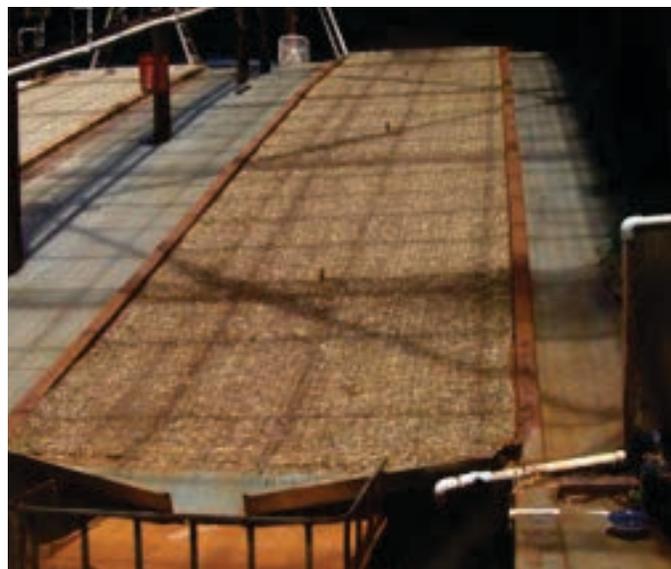


Figure 3 - ASTM D-6459 Test Plot

Permissible Shear and Channel Erosion

Permissible shear, as used with channel flow, refers to the shear force caused by flowing water that can be resisted by the surface of the soil or RECP without excessive erosion. The higher the permissible shear, the more stable the soil or RECP will be under more severe flow conditions. Not only does a RECP material need to retain its integrity under the expected flow conditions, but it also needs to prevent the erosion of underlying soils. Large scale flume testing and field trials have been used to measure this performance property. Nonstandard test procedures provide for the measurement of the amount of soil loss caused by flowing water and visual inspection of the specimen in a relatively flat laboratory flume. In one such procedure, the mat is fastened to an 18-inch (46 cm) bed of compacted soil in a 4-foot (1.2 m) wide flume (Figure 4). Water is then released into the flume at velocities that increase incrementally to approximately 20 ft/s (6 m/s) or higher. Average cross sectional velocities and flow depths are measured at stations along the flume. Shear stress can be calculated from these measurements and related to soil loss. While testing can be conducted in either a vegetated or unvegetated state, vegetation density will have an impact on erosion results. The effectiveness of the RECP is determined by the material's permissible shear stress as tested per ASTM D-6460, "Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion".

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Figure 4 - ASTM D-6460 Test Plot



Figure 4 - ASTM D-6460 Test Plot

Waver Overtopping

A Wave Overtopping test simulates the hydraulic forces seen when a levee or berm is overtopped by waves or storm surge. Unlike the steady state full scale flume tests described above per ASTM D-6460, a Wave Overtopping test consists of intermittent overflow of water that is characterized as highly turbulent, super-critical, and unsteady in both time and down-slope distance. Peak flow velocities of a Wave Overtopping test can be several times greater than velocities of steady overflow having the same average discharge. Full-scale levees are simulated by “planter boxes” or trays, being specially prepared to mimic the geometry and vegetated surfaces of typical levees. The tested levee geometry is constructed using two steel trays. The upper portion of the levee slope is represented by a straight tray having a length of 20 ft. The tray for the lower portion of the levee has a bend with 8 ft of the length oriented on a 3H:1V slope and 12 ft oriented on a 25H:1V slope. Both planter trays making up a “set” have width of 6 ft and depth of 12 inches (Figure 5). The test consists of discharging water from the reservoir at a rate of 2.0 ft³/s per ft (cfs/ft) for the first hour, 3.0 cfs/ft for the second hour, and 4.0 cfs/ft for the third hour. During the successive tests, the stability of the trays is monitored and their soil loss is measured. The effectiveness of the RECP is determined by the material’s ability to retain the underlying soil throughout the testing simulation.

SUMMARY

As the use of RECPs continues to grow, the knowledge and use of consistent design considerations must grow as well. When utilizing RECPs the design engineer must consider both the Index Properties and Performance Properties in order to select the appropriate solution for the problem at hand. Table 1 presents suggested relationships between common RECP Index Properties and Performance Criteria. For additional design support and installation consideration please contact Propex’s Engineering Services at (423) 553-2450 or at: InfrastructureSolutions@propexglobal.com.

Performance Criteria	Index Property
Soil Protection - Retention	Light Penetration Thickness
Vegetation Reinforcement	Light Penetration Thickness
Vegetation Growth	X3 Fiber Technology Thickness Flexibility
Survivability & Durability	Tensile Strength Resiliency Ultraviolet Resistance

Table 1 - Rolled Erosion Control Product Index Property to Performance Criteria Comparison

References

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2. ASTM, 2006, "ASTM D-6475-06: Standard Test Method for Measuring Mass Per Unit Area of Erosion Control Blankets," American Society for Testing and Materials, West Conshohocken, PA.
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