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TESTING AND SPECIFYING EROSION CONTROL PRODUCTS

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Biography

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Abstract

Sediment continues to be a major pollutant of public water resources even though erosion control best management practices, BMPs, are now commonly used. In order to help protect water quality as it relates to sediments, regulatory agencies and site designers are increasingly asking how well specific BMPs will perform quantitatively relative to alternatives. While a large amount of information on rolled erosion control products (RECPs) has become available in recent years, the information has not been synthesized and evaluated to identify property ranges for individual product types and product type hierarchies based on performance thresholds. Without specific product type information, it is difficult for users to create generic construction specifications or qualified product listings for different categories of products.

Standardized test procedures have been recognized as the means to develop generic product type data. Thus, a two decade effort by industry professionals has produced recognized tests for measuring relevant material "index" properties, as well as, relevant performance characterizations of RECPs.

This presentation will include the details of these commonly used standardized index, bench-scale, and large-scale tests for RECPs, along with a review of data from hundreds of independent tests performed on a range of rolled erosion control products (RECPs) under the auspices of the National Transportation Product Evaluation Program (NTPEP). Along with an assessment of the relevance and correlation of the various tests, recommendations will be made on the appropriate use of these test results in specifications for RECPs.

Keywords: RECP, erosion control, NTPEP, performance testing, specification

1 ROLLED EROSION CONTROL PRODUCTS AND ASSOCIATED TESTING

1.1 Rolled Erosion Control Product Types

While conventional erosion control materials ranging from loose straw to rock riprap continue to be used extensively, new developments in erosion control systems are also being used, including the following types of rolled erosion control products (RECPs):

- Temporary RECPs - For applications where natural vegetation alone will provide sufficient permanent erosion protection.
  - Open Weave Mesh (OWM). OWMs are a degradable product composed of processed natural or polymer yarns woven into a matrix. The most common of these are comprised of jute or coir.
  - Erosion Control Blanket (ECB). ECBs are composed of processed natural or polymer fibers mechanically, structurally or chemically bound together to form a continuous matrix.

- Permanent RECPs - For applications where natural vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection.
  - A turf reinforcement mat (TRM) is a permanent RECP composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness.

1.2 Quality Control, Quality Assurance and Performance Testing of RECPs

Basic index tests are typically needed to assure manufacturing quality control of RECPs. Not only are these tests useful for manufacturing quality control, but when used on the same materials deployed in bench-scale and large-scale performance tests, they serve to “bench-mark” the performance results to specific material properties. A variety of performance tests have been developed over the years to answer designers’ and specifiers’ questions regarding performance among different products and product categories.

Since 2003, the National Transportation Product Evaluation Program (NTPEP) has provided independent testing of RECPs. The program initially included both index tests and bench-scale “indexed performance” tests. Beginning in 2009, NTPEP began offering independently verified large-scale performance testing to complement the on-going index and bench-scale testing. The goal of the program is to minimize duplicative testing of erosion control products done by individual State Departments of Transportation (DOTs) by providing a process where manufacturers and suppliers submit their products to the NTPEP for independent index and bench-scale testing. The results of the testing are then shared with participating DOTs. The results of the testing may be used for assessing product conformance to material specifications. Further, the testing results provide quantitative material data necessary for placing specific products on, or removing specific products from a DOT’s qualified products list (QPL). The NTPEP program is intended to serve as a nationwide quality assurance (QA) program to supplement the DOTs’ own efforts. NTPEP (2011) describes the purpose and rationale for exclusive use of standardized test procedures in the programs.

1.2.1 Index Testing

Index tests are standard tests that may be used for manufacturing quality control and to compare the relative material properties of different RECPs. Quality Control tests are index tests which are performed on a production basis to evaluate product integrity, quality and continuity, and to assess the impact of changes in production methodology on product properties. Quality control test results can be reported with statistical relevance when they are run with sufficient frequency. Recently, ASTM D4354, “Standard Practice for Sampling of Geosynthetics for Testing”, has been revised to include appropriate sampling frequencies to achieve a statistically relevant level for RECP quality control, quality assurance, and conformance testing. Following are the index test methods used for RECPs:

Mass per Unit Area**:** ASTM D 6475, "Standard Test Method for Measuring Mass per Unit Area of Erosion Control Blankets"**;** ASTM D 6566, "Standard Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats"**.** The mass per unit area, or "weight" per square yard of a sample, is an important quality control property. The TRM test uses ten 8"x8" specimens at ambient laboratory conditions. The ECB test uses five larger, typically 12"x14", specimens that have been dried at 50° overnight.

Thickness**:** ASTM D 6525, "Standard Test Method for Measuring Nominal Thickness of Permanent Rolled Erosion Control Products"**.** Thickness is another important quality control property which is measured after application of a 6-inch diameter presser foot under a 0.029 psi pressure.

Tensile Strength**:** ASTM D 6818, "Standard Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats"**.** The ASTM tensile test method for RECPs uses at least 5 inch-wide grips.

Light Penetration: ASTM D 6567, "Standard Test Method for Measuring the Light Penetration of a Turf Reinforcement Mat (TRM)". Within a light box, a calibrated meter measures the amount of light that is able to pass through the specimen from a 150 watt light source on the other side of the specimen. The inverse of the percent of light passing through the specimen is termed the "% cover".

Water Absorption: ASTM D 1117 Section 5.4 and ECTC-TASC 00197, "Standard Guide for Evaluating Nonwoven Fabrics – Absorptive Capacity Test (for Larger Test Specimens)". Water absorption is a measure of a material's capacity to absorb water and is generally applicable to organic RECPs.

Specific Gravity: ASTM D 792, Method A, "Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement". Specific gravity is the ratio of the unit weight of a material to that of water.

1.2.2 Bench-Scale Testing

Bench-scale "indexed" performance tests are a class of tests that have been developed to focus on testing the RECP/soil system under carefully controlled "standard" conditions. Bench-scale tests have been developed for slope erosion, channel erosion, and vegetation enhancement for RECPs. Variations in the mass per unit area, raw materials, manufacturing processes, and other product and production components are a constant challenge to manufacturers of RECPs. Since performance of RECPs relies on the complex interaction of the RECP structure with the soil and the water impact/flow, it is helpful and beneficial to a quality assurance program to be able to examine the effects of product variability without having to rerun large-scale tests. Bench-scale testing facilitates lower costs and quicker testing for evaluating product conformance. However, it is critical to emphasize that bench-scale testing is not appropriate for use in design models unless correlated to large-scale testing. Bench-scale tests do not reflect product installation techniques or site conditions to which these materials are typically subjected. Therefore the results of these tests may not be indicative of a RECPs actual field performance.

*Slope Erosion and Runoff Reduction**: ASTM D 7101, "Standard Index Test Method for Determination of Unvegetated Rolled Erosion Control Product (RECP) Ability to Protect Soil from Rain Splash and Associated Runoff under Bench-Scale Conditions".*** This test method evaluates the ability of RECPs to protect soil from rain splash and immediate runoff-induced erosion. The critical element of this protection is the ability of the RECP to absorb the impact force of raindrops, thereby reducing soil particle loosening through "splash" mechanisms. The test method utilizes containers of both bare and RECP-protected soil that are exposed to simulated rainfall and immediate runoff for 30 minutes in the test apparatus. It is a sloped table enclosed by a curtain. Rainfall is simulated using a laboratory drip-type simulator capable of creating uniform drops with a median diameter of 3.0 to 3.5 mm from a drop height of 2.0±0.1 m and producing rainfall intensities as high as 150 mm/hr. The amount of soil that splashes or is washed out of the containers is collected and weighed. From this data, an appropriate soil loss ratio (SLR) can be calculated by comparing the RECP-protected soil loss to the control. The inverse of the SLR is comparable to the C-factor which is more commonly used to relate to performance, but should not be

used as a true measure of performance without verification from large-scale testing.

Permissible Shear and Channel Erosion: ASTM D 7207, "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". This test method evaluates the ability of RECPs to protect soils from flow-induced erosion. The test method utilizes containers of RECP-protected soil that are immersed in water and subjected to shear stresses caused by the rotation of a three-blade impeller for 30 minutes in the test apparatus. The shear stress test apparatus includes a tank, test well, motor, plastic lid, and impeller. The three-blade impeller is mounted in the cylindrical tank so that the lower edge of the blades is slightly above the floor of the tank. The sample test well is a recession in the floor of the tank that holds the pots of soil prepared for testing. When the pots are placed in the well, the test surface is flush with the floor of the tank. Pots holding soil and test specimens are normally 200 mm diameter plastic pipe sections with height of 100 mm. The amount of soil that erodes is found by weighing the containers under water. The results of the testing include the amount of soil lost at various shear stresses. From this data, an appropriate permissible shear can be calculated by assuming a critical amount of soil loss, typically 13 mm (1/2-inch). The index limiting shear stress value obtained is comparable to the "permissible shear stress" commonly used to relate to performance, but should not be used as a true measure of performance without verification from large-scale testing.

Germination/Vegetation Growth: 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". This test method established procedures for evaluating the ability of RECPs to enhance the rate and quantity of seed germination and facilitate subsequent establishment of vegetation. Containers of soil are sown with a single indexed seed mix and then covered with an RECP. Additional containers are left uncovered as controls. Testing is conducted within a growth chamber where 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. 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-protected soil to the control.

1.2.3 Large-Scale Testing

Large-scale performance tests have been developed to simulate expected field conditions to report performance properties of "as installed" RECPs. Large-scale tests have been developed for slope erosion and channel erosion. The channel erosion test may be conducted un-vegetated or vegetated. Performance of RECPs relies not only on material properties but also on the installation techniques. Products are installed on the test slope or channel per manufacturer installation recommendations. The results of these tests are more indicative of actual field performance of RECPs and are acceptable for use in design calculations.

Slope Erosion: ASTM D 6459, "Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion". This large-scale test is conducted on one bare soil control and three replicate RECP-protected soil 3:1 slopes. Rainfall is simulated at target intensities of 2, 4, and 6 inches per hour which are applied in sequence for 20 minutes each. Runoff from each slope is collected and soil loss is measured. From this data, an appropriate soil loss ratio and associated C-factor can be calculated by comparing the RECP-protected soil loss to that of the control.

Channel Erosion: ASTM D 6460, "Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion". This large-scale test is conducted in a rectangular flume with at least four sequential increasing flows applied for 30 minutes each. Unvegetated RECP-protected soil is tested on a 10% slope flume. Vegetated RECP-protected soil is tested on a 20% slope flume. The limiting or permissible shear stress is defined as the shear stress necessary to cause an average of 0.5 inch of soil loss over the entire channel.

2. NTPEP TESTING TO-DATE.

As noted earlier, the NTPEP's nationwide quality assurance program for RECPs began in 2003 and uses the six index tests, three bench-scale tests, and – since 2009 – two large-scale performance tests discussed earlier to provide independent data on the RECPs entered into the program.

2.1 NTPEP Index and Bench-scale Testing To-Date

Table 1 shows the number and types of the most commonly tested RECPs and the average index and bench-scale test results for each type of RECP. All the products, except the 2NFF (double net polyfiber matting), 3D woven (woven mattings), and OWM (open weave meshes) are ECBs. The 2NFF and 3D woven are classes of TRMs.

2.2 NTPEP Large-scale Testing To-Date

Large-scale performance testing information has now been added to the voluminous amount of index and bench-scale data found at www.ntpep.org to better characterize and differentiate between various RECP types. Table 1 also shows the results of independent large-scale slope and channel testing done under the NTPEP program and the index property results that "bench-mark" the large-scale results.

2.3 Review of Index, Bench-scale and Large-scale Testing

Table 1 presents the average test results for all products tested to-date in each product type category. The performance data, graphically presented in Figure 1, suggests that there is a hierarchy of performance among the most common RECPs. The data in Table 1 was further evaluated to attempt to identify any meaningful correlation(s) between index (QC) tests and associated bench-scale and large-scale performance tests. Based on "best fit" correlation coefficients, no consistently strong credible correlations exist directly between any of the index properties and product performance as measured by the bench-scale and large-scale tests used. Yet, suspecting that erosion protection should be related to some measurement of how well the soil surface is covered, the authors combined the results of two tests – dividing mass/area by thickness – to obtain the "density" of the products tested and examined correlations to this "derived" property. As shown in Table 2, there seems to be a much more consistent relationship between density and various measures of performance.

Used together, the index, bench-scale, and performance data facilitates the preparation of generic specifications that include performance criteria as well as minimum property "thresholds" to assure that only proven materials are used as will be shown in Section 3.

3. SPECIFICATIONS FOR RECPs

Many different specifications for RECPs are in circulation, including proprietary specifications promoted by product suppliers, broad product "categorizations" published by industry groups, and generic specifications used by public agencies. To insure free and fair competition, there are at least three critical elements to a material specification for use on public projects – the focus of this effort. The elements include:

1. The specification must be generic. That is, it must be completely comprised of requirements that are not exclusive to a single product.
2. The specification requirements must be relevant. That is, that each requirement must be shown to relate to how the product is expected to perform or must be critical to assuring product quality.
3. Specification conformance must be verifiable. That is, it must be possible to corroborate every requirement within the specification via independent sampling and verification (a.k.a. conformance) testing. For properties requiring long-term testing, a test report from an independent, accredited laboratory may be acceptable.

Table 1. Average Index, Bench-scale, and Large-scale Results for NTPEP Testing 2003-2014

Product Type*	Test	# of Tests (487 total tests)	Mass/Area (osy)	Tensile Str. (lb/in)		Tensile Elongation (%)		Thickness (mils)	% Cover	Absorption OR Specific Gravity	Channel	Slope	Germination	Density **
				MD	XD	MD	XD				Perm. Shear	Avg C-Factor	% Impr.	
0NX	Index/Bench-scale	3	9.5	11.2	1.3	17.5	17.6	439	58.4	231	1.88	0.167	453	0.029
1NX	Index/Bench-scale	24	8.8	8.1	5.0	23.8	23.2	355	64.2	222	2.03	0.161	474	0.034
	Large-scale Slope	2	9.6	8.9	3.4	28.4	23.0	372	68.0	174		0.034		0.035
1NS	Index/Bench-scale	80	8.0	9.2	5.4	25.8	24.1	332	84.3	426	1.48	0.120	420	0.033
	Large-scale Channel	4	7.2	10.1	4.0	27.7	24.0	364	83.8	363	2.03			0.028
	Large-scale Slope	10	8.1	8.2	4.7	27.1	26.9	369	85.9	394		0.036		0.030
2NX	Index/Bench-scale	40	12.3	16.5	12.7	25.2	25.2	414	74.7	218	2.74	0.109	463	0.040
	Large-scale Channel	4	11.7	22.7	15.9	30.1	22.8	415	69.3	181	2.40			0.038
	Large-scale Slope	1	10.4	9.8	8.5	29.1	25.5	445	75.6	202		0.027		0.031
2NS	Index/Bench-scale	94	8.3	14.1	9.6	24.5	24.6	312	85.8	411	1.82	0.104	460	0.036
	Large-scale Channel	9	8.6	12.6	8.0	26.6	25.2	358	87.1	388	2.39			0.033
	Large-scale Slope	13	8.4	12.7	9.3	23.4	23.0	361	85.4	380		0.027		0.031
2NSC	Index/Bench-scale	45	8.8	17.2	11.9	21.0	22.9	283	88.1	375	2.25	0.074	502	0.043
	Large-scale Channel	3	8.1	15.7	11.6	24.3	22.5	282	88.2	319	2.20			0.039
	Large-scale Slope	6	8.5	13.6	10.7	25.3	23.9	333	89.0	392		0.018		0.035
2NC	Index/Bench-scale	54	8.8	23.7	16.4	21.9	26.6	242	83.7	258	2.68	0.063	478	0.050
	Large-scale Channel	4	9.0	23.9	16.8	22.2	26.0	267	82.7	309	2.70			0.045
	Large-scale Slope	4	9.4	22.2	13.7	19.5	24.0	261	82.8	247		0.007		0.048
2NFF	Index/Bench-scale	56	11.5	31.7	27.0	25.4	30.0	367	72.3	0.9	2.77	0.148	438	0.043
	Large-scale Channel	8	10.7	31.8	22.0	25.7	30.0	378	69.5	0.9	2.46			0.040
	Large-scale Slope	1	13.3	29.0	26.8	29.7	29.2	420	74.6	0.9		0.080		0.042
3D Woven	Index/Bench-scale	10	10.8	304.5	250.0	43.0	25.4	361	76.8	0.9	3.95	0.210	359	0.042
	Large-scale Channel	1	8.5	249.7	246.2	34.8	13.2	492	66.1	0.9	2.70			0.023
OWM	Index/Bench-scale	10	13.9	86.8	52.5	28.1	26.3	260	63.2	302	2.11	0.135	354	0.079
	Large-scale Slope	1	11.9	91.6	76.5	14.4	20.4	187	55.1	425		0.09		0.085

Bench-scale slope testing results in a soil loss ratio (SLR). An equivalent C-Factor is calculated as (1/(average of soil loss ratios at 50, 100, and 150 mm/hr));
**Density = (Mass per Area) / (Thickness)

*Product Type Key:

0NX = netless excelsior blanket;
1NX = single net excelsior blanket;
2NX = double net excelsior blanket;
1NS = single net straw blanket;
2NS = double net straw blanket;
2NSC = double net straw-coconut blanket;
2NC = double net coconut blanket;
2NFF = double net polyfiber matting;
3-D Woven = polymer yarn woven matting;
OWM = open weave mesh

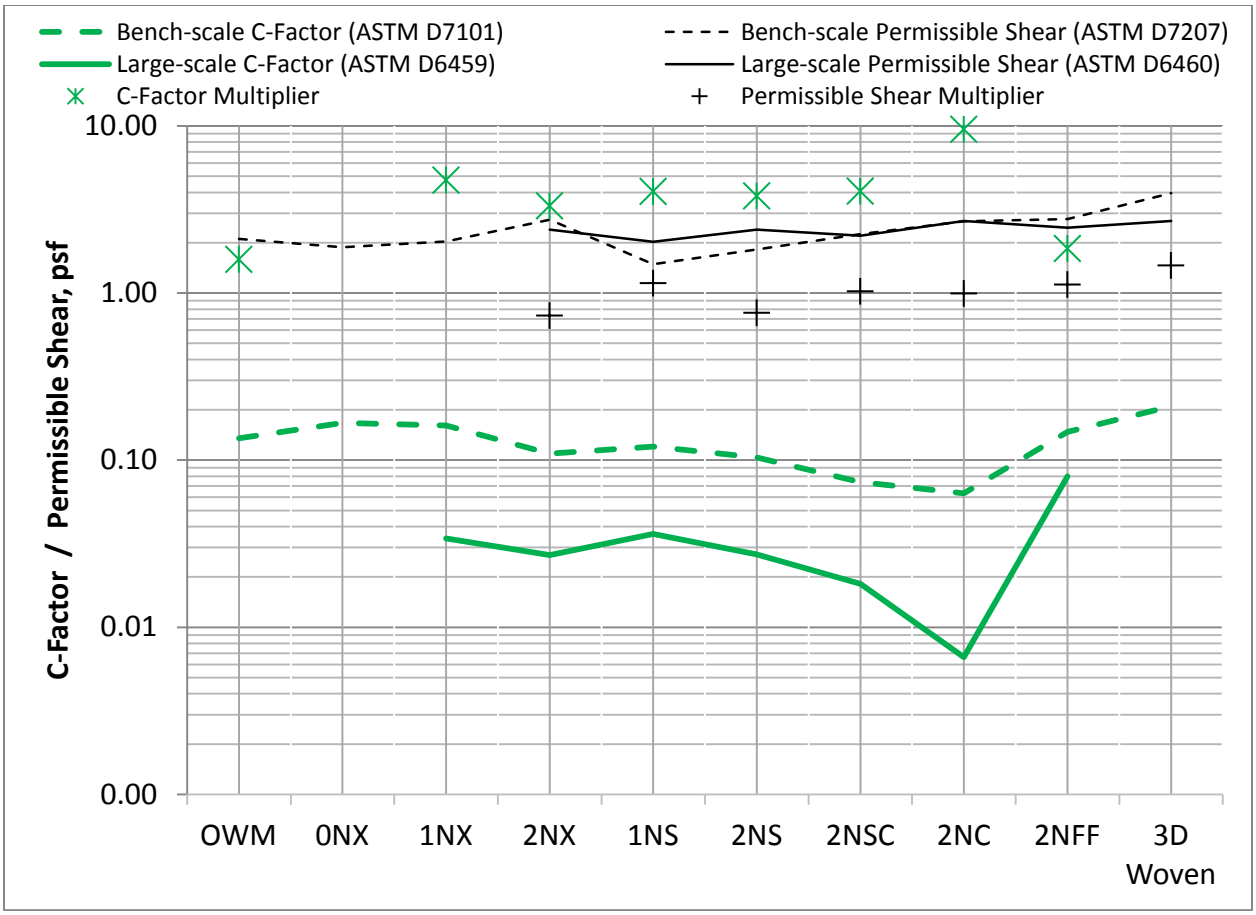

Figure 1. Comparison of Average Bench-scale vs. Large-scale Performance Results

Table 2. Possible Index, Bench-, and Large-scale Correlations

Index Test	R^2				
	Bench-scale Test			Large-scale Test	
	D7101 Rainfall	D7207 Shear	D7322 Germination	D6459 Slope	D6460 Channel
Mass/Area, D6475	0.01	0.43	0.01	0.02	0.23
Thickness, D6525	0.63	0.02	0.14	0.53	0.11
Percent Cover, D6567	0.76	0.01	0.02	0.12	0.04
Tensile (MD), D6818	0.72	0.60	0.28	0.56	0.01
Absorption, D1117/ECTC	0.14	0.35	0.07	0.01	0.07
Density, calculated	0.80	0.59	0.34	0.72	0.67
Regression Equation using the calculated density	C-Factor = -5.2264x + 0.3124	Allow. Shear = 52.436x + 0.1397	Germination = 2168.5x + 382.18	C-Factor = -1.4083x + 0.0742	Allow. Shear = 30.821x + 1.2205

3.1 Existing Specs

The most widely circulated "generic" specifications for RECPs are the categorizations presented by the ECTC (2006) and the Federal Highway Administration's FP-14 (2014). These specifications include both temporary and permanent RECPs, and reflect different performance levels based on functional longevity, C-Factor, and Permissible Shear from large-scale testing. The FP-14 specifications, which closely parallel the ECTC (2006) specs, are summarized in Tables 3 and 4. ECTC expects to issue revised specifications in 2015.

Table 3. Temporary Rolled Erosion Control Product (RECP) Specifications (per FP-14, Table 713-3)

Property	1.A[(1)]	1.B	1.C	1.D	2.A[(1)]	2.B	2.C	2.D	3.A[(1)]	3.B	4	Test Method
Typical functional longevity[(2)] (months)	3	3	3	3	12	12	12	12	24	24	36	N/A
Minimum tensile strength (kN/m)	0.73	0.73	0.73	0.73	0.73	0.73	0.73	1.09	0.36	1.45	1.82	ASTM D6818
Maximum "C" factor[(3)]	0.10 at 1V:5H	0.10 at 1V:4H	0.15 at 1V:3H	0.20 at 1V:2H	0.10 at 1V:5H	0.10 at 1V:4H	0.15 at 1V:3H	0.20 at 1V:2H	0.10 at 1V:5H	0.25 at 1V:1½H	0.25 at 1V:1H	ASTM D6459[(6)]
Minimum permissible shear stress[(4)(5)](Pa)	12	24	72	84	12	24	72	84	12	96	108	ASTM D7207[(6)]

(1) Obtain max "C" factor and allowable shear stress for mulch control nettings with the netting used in conjunction with pre-applied mulch material.
(2) Functional longevities are for guidance only. Actual functional longevities may vary based on site and climatic conditions.
(3) "C" factor calculated as ratio of soil loss from rolled erosion control product protected slope (tested at specified or greater gradient, v:h) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ASTM D7101.
(4) Minimum shear stress the rolled erosion control product (unvegetated) can sustain without physical damage or excess erosion (> 1/2-inch soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ASTM D7207.
(5) The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 to 0.05.
(6) Or other qualified independent large scale test method determined acceptable by the CO.
Categories of Temporary RECPs : 1.A, 2.A, 3.A = mulch control nets; 1.B, 2.B = netless ECBs; 1.C, 2.C = single net ECBs and Open Weave Textiles; 1.D, 2.D = double net ECBs; 3.B, 4 = ECBs & Open Weave Textiles

Table 4. Turf Reinforcement Mat (TRM) Specifications (per FP-14, Table 713-4)

Properties[(1)]	Rolled Erosion Control Product Type			Test Method
	5.A	5.B	5.C	
Minimum tensile strength[(2)(3)] (kN/m)	1.82	2.19	2.55	ASTM D4595
UV stability (minimum % tensile retention)	80	80	80	ASTM D 4355 (500-hr exposure)
Minimum thickness[(2)](mm)	6.35	6.35	6.35	ASTM D6525
Maximum gradient for slope applications	2V:1H	2V:1H	2V:1H	-
Minimum permissible shear stress[(4)](Pa)	288	384	480	ASTM D6460[(5)]

(1) For TRMs containing degradable components, obtain all property values on the non-degradable portion of the matting alone.
(2) Minimum average roll values, machine direction only.
(3) Field conditions with high loading and high survivability requirements may warrant the use of turf reinforcement mats with tensile strengths of 44 kN/m (3,000 lb/ft) or greater.
(4) Minimum shear stress the turf reinforcement mat (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (1/2-inch) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ASTM D7207.
(5) Or other qualified independent large scale test method determined acceptable by the CO.

3.2 Proposed Generic Specs

Table 5 is a proposed specification that includes all of the critical specification elements listed above, reflects as much as possible the generally accepted specification requirements of Tables 3 and 4, and incorporates new knowledge gained (and discussed above) from the NTPEP program. This includes setting minimum or maximum "thresholds", or lower/upper limits, to protect against deficiently manufactured or underperforming product being furnished to the project. The values in Table 1 are used to guide the choice of the specification values recommended in Table 5. These "threshold" values are generally set approximately 20% below (or above in the case of C-Factor) the average value to account for product and test variability.

Table 5. Proposed Generic Specification for RECPs (Minimum Values)

RECP Classification		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Typical RECP Type (for guidance only)		0NX, 1NX, 1NS, OWM	2NX, 2NS	2NSC	2NC	2NFF, 3D	2NFF, 3D	2NFF, 3D
Durability (for guidance only)		Ultra Short-Term	Short-term	Extended Term	Long-Term	TRM	TRM	TRM
		3 - 6 mo.	6 - 12 mo.	12 - 24 mo.	> 24 mos.			
C-Factor - ASTM D 6459		C ≤ 0.08	C ≤ 0.06	C ≤ 0.04	C ≤ 0.02	C ≤ 0.08	C ≤ 0.06	C ≤ 0.04
Max. Slope Gradient	Max. Slope Length (ft)	Permitted Use on Slopes (X)						
< 5:1	100	X	X	X	X	X	X	X
5:1 ≤ ___ < 4:1	80	X	X	X	X	X	X	X
4:1 ≤ ___ < 3:1	60		X	X	X	X	X	X
3:1 ≤ ___ < 2:1	40			X	X	X	X	X
2:1 ≤ ___ < 1:1	20				X	X	X	X
Permissible Shear, Unvegetated - ASTM D 6460		1.5	1.75	2.0	2.25	2.0	2.5	3.0
Permissible Shear, Fully Vegetated - ASTM D 6460		Not req'd	Not req'd	Not req'd	Not req'd	6.0	8.0	10.0
Tensile Strength (MD),lb/in	ASTM D6818	4.0	8.0	12.0	16.0	16.0	20.0	24.0
Tensile Elongation (MD),%	ASTM D6818	10	10	10	10	10	10	10
Tensile Strength (XD),lb/in	ASTM D6818	2.0	4.0	6.0	8.0	8.0	10.0	12.0
Tensile Elongation (XD),%	ASTM D6818	10	10	10	10	10	10	10
Mass / Unit Area, osy	ASTM D6475	7.0	7.0	7.0	7.0	8.0	10.0	12.0
Thickness, mils	ASTM D6525	200	200	200	200	200	200	200
Ground Cover, %	ASTM D6567	50	60	70	70	60	60	60
Water Absorption, % (ECBs); Sp. Gravity (TRMs)	ASTM D1117	200	200	200	200	0.9	0.9	0.9
Bench-scale Slope, Avg Soil Loss Ratio	ASTM D7101	5.0	8.0	11.0	14.0	5.0	5.0	5.0
Bench-scale Shear Permissible Shear, psf	ASTM D7207	1.25	1.5	1.75	2.0	2.0	2.5	3.0
Bench-scale Germination, % Improvement	ASTM D7322	200	200	200	200	200	200	200
UV Stability, % Retained at 500 hrs	ASTM D4355	n/a	n/a	n/a	n/a	80%	80%	80%
QC Data from daily testing must be provided with certification.		Product must be listed at www.ntpep.org.			Reports for large-scale testing must be provided from accredited independent laboratory.			

*Product Type Key: OWM = open weave mesh; 0NX = netless excelsior blanket; 1NX = single net excelsior blanket; 2NX = double net excelsior blanket; 1NS = single net straw blanket; 2NS = double net straw blanket; 2NSC = double net straw-coconut blanket; 2NC = double net coconut blanket; 2NFF = double net polyfiber matting; 3-D Woven = polymer yarn woven matting;

4. CONCLUSIONS

Commonly used index, bench-scale, and large-scale standardized tests have been discussed along with a review of results from independent testing performed on a range of rolled erosion control products (RECPs) under the auspices of the National Transportation Product Evaluation Program (NTPEP).

Using results to-date as a guide to establishing property thresholds, and considering potential correlations between commonly measured index and performance properties, a generic specification has been presented for consideration.

5. REFERENCES

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