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The use of index and bench-scale tests for the characterization of RECPs

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ABSTRACT: The rapidly growing erosion control industry has led to the development of a wide variety of RECPs. Despite their widespread use, engineers are often given little guidance on the selection of RECPs beyond maximum allowable slope, velocity, and shear stress. RECPs can vary significantly in basic index properties and overall field performance. Recently, the ECTC developed several index and bench-scale tests in an effort to compare and standardize RECPs. Although these tests represent a significant step forward, few studies have been conducted that relate basic index properties to laboratory or field performance. This paper considers the light penetration and water absorption tests developed by TRI and evaluates their usefulness in characterizing and comparing different RECPs. Further, an attempt has been made to relate these index properties to results obtained from the ECTC laboratory bench-scale vegetation enhancement test.

1 INTRODUCTION

The rapidly growing erosion control industry has led to the development of a wide variety of different rolled erosion control products (RECPs.) RECPs are made from natural fibers, such as jute, coir, and straw, synthetic fibers, such as polyester and polypropylene, and combinations of different natural and/or synthetic fibers. There are also different types of RECPs based on structure type and manufacturing process, such as erosion control nets, open-weave textiles, erosion control blankets, and turf reinforcement mats. A review of GFR (2004), which compiles product listings from participating manufacturers, indicates that 83 different degradable RECPs (25 wood, 28 straw, 12 straw/coir blends, 15 coir, and 3 jute) and 25 different non-degradable RECPs are available in the US.

Despite their widespread use, engineers are often given little guidance on the selection of RECPs beyond maximum allowable slope, velocity, and shear stress. RECPs can vary significantly in basic index properties and overall field performance. Recently, the Erosion Control Technology Council (ECTC), in conjunction with TRI/Environmental, Inc. (TRI), developed several index and bench-scale tests in an effort to standardize and compare different RECPs (Sprague et al. 2002.) The American Association of State Highway and Transportation Officials (AASHTO) currently uses the ECTC test methods and results obtained by TRI in their National Transportation Product Evaluation Program (NTPEP), which provides NTPEP member departments RECP test results to minimize the need for further RECP testing (AASHTO 2005.) Although these tests represent a significant step forward in standardizing and comparing RECPs, few studies have been conducted that relate basic index properties to laboratory (Ziegler and Sutherland 1998, Rickson 2002, and others) or field performance (Fifield 1992, Smith et al. 2005, and others.)

This paper considers the light penetration and water absorption index tests developed by TRI and evaluates their usefulness in characterizing and comparing different RECPs. Futher, an attempt has been made to relate these index properties to results obtained from the ECTC laboratory bench-scale vegetation enhancement test.

2 MATERIALS AND METHODS

2.1 *Materials*

Eight different RECPs were selected for the evaluation. Six of the RECPs are erosion control blankets (ECBs), temporary degradable RECPs composed of processed natural or polymer fibers mechanically, structurally, or chemically bound to form a continuous matrix (ECTC 2001.) Two of the RECPs are turf reinforcement mats (TRMs), long-term, non-degradable RECPs composed of UV-stabilized, non-degradable, synthetic fibers, nettings, and/or filaments processed into 3-D reinforcement matrices (ECTC 2001.) A description of the RECPs is included in Table 1.

Table 1. RECP descriptions.

RECP	Description
Wood Excelsior ECBs	
W1	ECB of curled Aspen excelsior fibers. The top is covered with a photodegradable plastic mesh
W2	Heavy weight ECB of curled Aspen excelsior fibers. The top and bottom are covered with a black, heavy-duty, extruded plastic mesh
Straw/Coconut Blend ECBs	
SC1	Double-netted ECB of 70% Kansas wheat straw and 30% coconut fibers
SC2	Machine-produced ECB of 70% agricultural straw and 30% coconut fiber matrix
Coconut ECBs	
C1	ECB of 100% coconut fibers. The top and bottom are covered with nettings
C2	Double net ECB of 100% coconut fiber
Synthetic TRMs	
T1	Triple-netted permanent TRM with 100% coconut fiber fill
T2	Triple-netted synthetic permanent TRM with polymer fiber fill

2.2 *Methods*

Light penetration and water absorption tests were performed to evaluate their usefulness in characterizing and comparing eight different RECPs. The results of the index tests are then related to the results obtained from the ECTC bench-scale vegetation enhancement tests conducted by TRI for NTPEP. The following sections briefly describe the testing procedures.

2.2.1 *Light penetration*

Light penetration testing was performed in accordance with ECTC (2001), which is based on ASTM D6567. In the test, light is projected through frosted glass to dissipate the light, then through a 20.3 cm × 25.4 cm RECP sample in a closed container. The amount of light that passes through the RECP is measured using a light meter. The percentage light penetration is calculated as the ratio of the amount of light that passes through a RECP sample to the amount of light that passes without a RECP sample.

2.2.2 *Water absorption*

Water absorption testing was performed in accordance with ECTC (2001.) In the test, 20.3 cm × 20.3 cm RECP samples are placed on a screen and submerged in water for 24 hours. The RECP samples are then removed, allowed to drain for 10 minutes, and weighed. The water absorptive capacity is calculated as the ratio of the water held by a RECP sample to the original dry weight of the sample.

2.2.3 *Vegetation enhancement*

The vegetation enhancement results presented in this paper were performed by TRI for NTPEP (AASHTO 2005.) The tests were performed in accordance with ECTC (2001.) In the test, containers of soil are sown with seeds and watered. RECPs are then placed on the containers, with several containers remaining uncovered to serve as controls. The containers are then placed in an environmentally controlled chamber to control temperature, light, and humidity. The containers are periodically watered and monitored for vegetative growth. The percentage vegetation improvement is calculated as the ratio of the weight of vegetation in the RECP-covered containers to the non-RECP covered control containers, measured at 21 days germination.

3 RESULTS

3.1 *Light penetration*

Light penetration results are presented in Figure 1 for the wood excelsior (W1 and W2) and straw/coconut (SC1 and SC2) ECBs and Figure 2 for the coconut (C1 and C2) ECBs and the TRMs (T1 and T2.) The results are plotted in two different figures so that the trends can be more readily observed. As shown in the figures, there were overall decreasing trends in light penetration versus increasing mass per unit area for the RECPs tested.

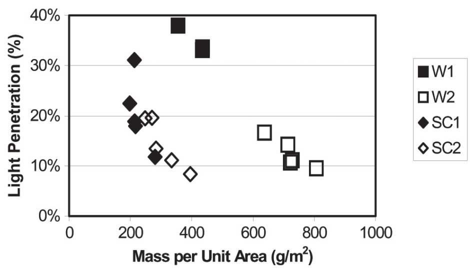

Figure 1. Light penetration results for the wood excelsior (W1 and W2) and straw/coconut (SC1 and SC2) ECBs.

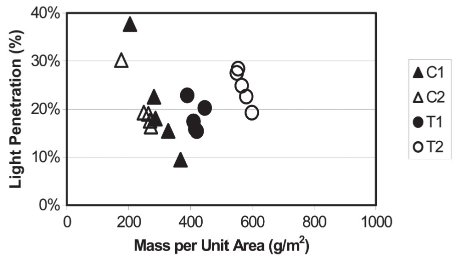

Figure 2. Light penetration results for the coconut ECBs (C1 and C2) and TRMs (T1 and T2.).

The decreasing trends in light penetration versus increasing mass per unit area were fairly sharp for the straw/coconut (SC1 and SC2) (see Figure 1) and coconut (C1 and C2) ECBs (see Figure 2). This indicates that slight changes in mass per unit area of the ECBs can greatly affect the light penetration results of straw/coconut and coconut ECBs. For example, light penetration results for coir RECP C1 (see Figure 2) varied approximately 30% over a 170 g/m^2 mass per unit area range. The large variations in mass per unit area and light penetration results are most likely due to the variability of the RECPs.

The light penetration results for the wood excelsior (W1 and W2) ECBs (see Figure 1) were fairly consistent and showed a linear trend between light penetration results and mass per unit area. The results for the TRMs (T1 and T2) (see Figure 2) also showed slightly decreasing trends in light penetration versus increasing mass per unit area.

3.2 *Water absorption*

Water absorption results are given in Figures 3 (wood excelsior and straw/coconut ECBs) and 4 (coconut ECBs and TRMs.) As shown in Figure 3, there was little change in water absorption capacity versus increasing mass per unit area for the wood excelsior ECBs (W1 and W2.) There was also no apparent trend in water absorption capacity versus mass per unit area for the straw/coconut ECBs (SC1 and SC2) (see Figure 3.) However, the coconut fiber ECBs (C1 and C2) showed a decreasing trend in water absorption capacity with increasing mass per unit area (see Figure 4.) TRM C1 showed a slight decreasing trend in water absorption capacity with increasing mass per unit area and TRM C2 exhibited relatively low water absorption capacity (see Figure 4.)

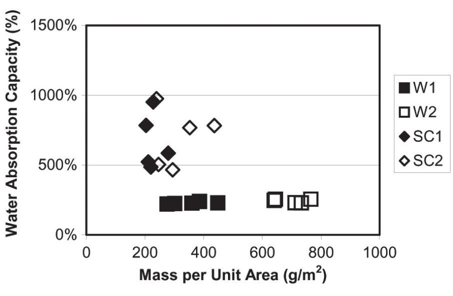

Figure 3. Water absorption results for the wood excelsior (W1 and W2) and straw/coconut (SC1 and SC2) ECBs.

Following the ECTC standard and soaking the RECPs in water for a relatively short period of time, the coconut ECBs (C1 and C2) overall showed significant water absorption capacity (in the range of 700% to 1500%) in comparison to the other RECPs tested (see Figures 3 and 4.) The coconut ECBs were

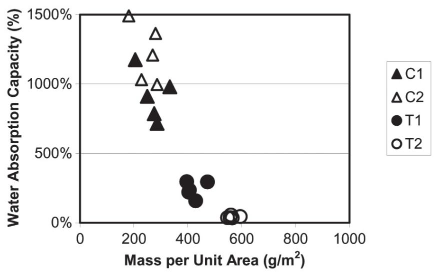

Figure 4. Water absorption results for the coconut ECBs (C1 and C2) and TRMs (T1 and T2.).

followed by the straw/coconut ECBs (500% to 1000%), wood excelsior ECBs (200% to 250%), TRM with coconut matrix (150% to 300%), and the TRM with synthetic matrix (30% to 50%) in water absorption capacity (see Figures 3 and 4.)

It is believed that fiber type plays an important role in the water absorption capacity of RECPs. Depending on the nature of the fiber, water could be absorbed on the surface of the fiber, within the fiber, or within the void space between the fibers. For example, the natural fibers tested (wood, straw, and coconut) are lignocellulosic materials that vary in cellulose, lignin, hemicellulose, and extractive content. The hemicelluloses, followed by cellulose and lignin content, play an important role in moisture sorption (Rowell 1998.) The type, number, and surface area of the fiber would then play an important role in how much water could be absorbed by a particular RECP. This could explain the differences in water absorption capacity for the RECPs with different fiber types and for the coconut ECBs (C1 and C2) (700% to 1500%) and the TRM with coconut matrix (T1) (150% to 300%), which contained a smaller amount of coconut fiber than the ECBs.

3.3 *Vegetation enhancement*

Based on the results of a field study that compared the performance of six different RECPs installed in a drainage channel in central New York, Smith et al. (2005) indicated that percentage area cover and water holding capacity play an important role in the long-term vegetation establishment of RECPs. To evaluate the importance of these RECP properties, light penetration (which relates to percentage area cover) and water absorption capacity (which relates to water holding capacity) results are compared to bench-scale vegetation enhancement test results obtained by TRI for NTPEP (AASHTO 2005.)

As shown in Figures 5 and 6, the straw/coconut (SC2) ECB exhibited the best performance of the RECPs compared, followed by the coconut (C1 and C2) ECBs and the TRMs (T1 and T2.) In comparing the index properties of the straw/coconut (SC2) ECB to the other RECPs, the straw/coconut (SC2) ECB

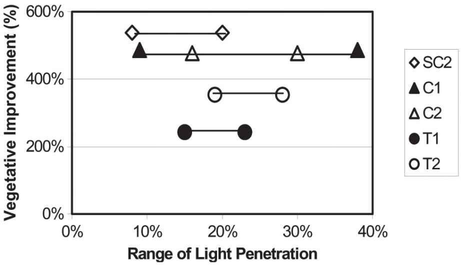

Figure 5. Light penetration versus vegetation improvement.

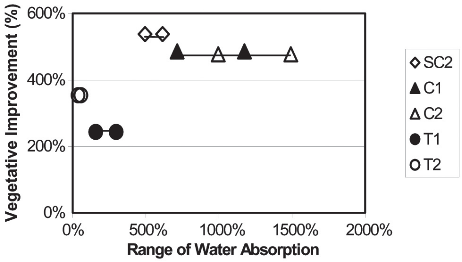

Figure 6. Water absorption versus vegetation improvement.

exhibited the lowest range of light penetration results (8% to 20%) and a relatively moderate range of water absorption capacities (500%) in comparison to the other RECPs. Since the range of results for the SC2 ECB light penetration data are on the low end of the RECPs tested, but on the moderate range in terms of water absorption capacities (with TRMs T1 and T2 exhibiting very low water absorption capacities and low vegetation improvement rates), it is believed that water absorption capacity plays a greater role in vegetation enhancement than light penetration. Although both light penetration and water absorption appear to be important properties for vegetative growth.

4 CONCLUSIONS

1. Light penetration results are more variable in straw/coconut and coconut ECBs than in wood excelsior ECBs and TRMs.
2. Fiber type plays an important role in the water absorption capacity of RECPs.
3. Water absorption plays a greater role in vegetation growth than light penetration.
4. Based on the results of this preliminary work, more research is needed on characterizing the water absorption properties of natural fibers and to define the thresholds of light penetration and water absorption for maximizing vegetation enhancement.

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