TechLink Research Summary #3323

Hydraulic Performance & Design for Channel Lining and Stream Bank Stabilization Using Low Impact Development Design Strategies

The Texas Transportation Institute (TTI) of Texas A&M University recently tested Filtrexx® Channel protection and Bank stabilization products for hydraulic performance as flexible channel liners under open channel flow conditions using ASTM Standard Test Method D-6460. The test is designed to determine the maximum hydraulic shear stress (lbs/ft2 or kg/m2) which flexible vegetated channel liners can withstand prior to an average ½ in (1.25 cm) of soil loss across the channel bed area. This soil loss threshold represents the point at which the planted seed bed within the channel has eroded and can no longer support vegetation establishment. Channel liner products are exposed to successional shear stress pressures of 2 lbs/ft2 (10 kg/m2), 4 lbs/ft2 (20 kg/m2), 6 lbs/ft2 (29 kg/m2), 8 lbs/ft2(39 kg/m2), 10 lbs/ft2 (49 kg/m2), and 12 lbs/ft2 (59 kg/m2) to determine product failure points on a 10% channel slope. Soil loss thresholds determined by TTI are 350 lbs/100 ft2 (17.1 kg/m2), 500 lbs/100 ft2 (24.4 kg/m2), 620 lbs/100 ft2 (30.2 kg/m2), 800 lbs/100 ft2 (39.0 kg/m2), 1180 lbs/100 ft2 (57.5 kg/m2), and 1200 lbs/100 ft2 (58.5 kg/m2) for each of the 6 shear stress test values, respectively. Of 60 flexible channel liner products tested and reported by TTI and the Texas Department of Transportation (TX DOT), only 7 other products have been rated for the maximum shear stress category reported by TTI of 12 lbs/ft2 (59 kg/m2).

Table 1. Testing Parameters and Results from Performance Testing by TTI.

Filtrexx Material	Vegetation type	Shear stress	Velocity	Flow rate	Water depth	Soil loss-limit	Soil loss-Filtrexx
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	2 lbs/ft2 (10 kg/m2)	3.1 ft/sec (0.9 m/sec)	93 cfm (2.6 m3/min)	4 in (10 cm)	350 lbs/100 ft2 (17.1 kg/m2)	97 lbs/100 ft2 (4.7 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	4 lbs/ft2 (20 kg/m2)	8.7 ft/sec (2.7 m/sec)	522 cfm (14.8 m3/ min)	8 in (20 cm)	500 lbs/100 ft2 (24.4 kg/m2)	183 lbs/100 ft2 (8.9 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	6 lbs/ft2 (29 kg/m2)	11.75 ft/sec (3.6 m/sec)	1013 cfm (28.7 m3/ min)	11.5 in (29 cm	620 lbs/100 ft2 (30.2 kg/m2)	259 lbs/100 ft2 (12.6 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	8 lbs/ft2 (39 kg/m2)	12.95 ft/sec (3.9 m/sec)	1506 cfm (42.6 m3/min)	15.5 in (39 cm)	800 lbs/100 ft2 (39.0 kg/m2)	476 lbs/100 ft2 (23.2 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	2 lbs/ft2 (10 kg/m2)	3.1 ft/sec (0.9 m/sec)	93 cfm (2.6 m3/ min)	4 in (10 cm)	350 lbs/100 ft2 (17.1 kg/m2)	1 lbs/100 ft2 (0.5 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	4 lbs/ft2 (20 kg/m2)	8.7 ft/sec (2.7 m/sec)	522 cfm (14.8 m3/min)	8 in (20 cm)	500 lbs/100 ft2 (24.4 kg/m2)	55 lbs/100 ft2 (2.7 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	6 lbs/ft2 (29 kg/m2)	11.75 ft/sec (3.6 m/sec)	1013 cfm (28.7 m3/ min)	11.5 in (29 cm)	620 lbs/100 ft2 (30.2 kg/m2)	127 lbs/100 ft2 (6.2 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	8 lbs/ft2 (39 kg/m2)	12.95 ft/sec (3.9 m/sec)	1506 cfm (42.6 m3/ min)	15.5 in (39 cm)	800 lbs/100 ft2 (39.0 kg/m2)	177 lbs/100 ft2 (8.6 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	10 lbs/ft2 (49 kg/m2)	13.85 ft/sec (4.2 m/sec)	1974 cfm (55.9 m3/ min)	19 in (48 cm)	1180 lbs/100 ft2 (57.5 kg/m2)	231 lbs/100 ft2 (11.2 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	12 lbs/ft2 (59 kg/m2)	14.45 ft/sec (4.4 m/sec)	2493 cfm (70.6 m3/ min)	23 in (58 cm)	1200 lbs/100 ft2 (58.5 kg/m2)	267 lbs/100 ft2 (12.9 kg/m2) **PASS**

**Based on 10% Slope, and Unit Weight of Water = 62.4 lbs (28.3 kg)*

What is hydraulic shear stress?
Shear stress is the tractive or frictional force exerted by moving water across a plane or channel bed, or in this case a channel liner. In design considerations for channels and streams banks shear stress is recommended over flow velocity principally because it accounts for depth of flow, slope angle, and water weight variables that contribute to the pressure exerted on the channel bed, bank, or liner. In a straight channel, the channel bed experiences more shear stress than the banks, therefore, in this standard test method the channel liner is only installed on the channel bed with the understanding that if it can withstand the tractive force along the bed it can withstand the force along the walls. It is important to note that this test method is not designed to determine failure of the channel liner from dislodgement, rupture, or destruction (although these occurrences would certainly result in a product failure under this particular test method), but to determine the point at which vegetation can no longer be established due to excessive erosion of the seed bed underneath or within the channel liner. Unlike some flexible channel liners, the Filtrexx system encapsulates the growing media and the root structure of the vegetation, thereby preventing erosion of the seed bed and root zone, which ensures stability and sustainability of the vegetation. Designers can use the maximum shear stress value to determine if a particular product is designed to withstand potential shear forces that may be exerted in a given channel, ditch, conveyance system, or stream bank. As an alternative, some designers may use the maximum hydraulic velocity value to rate the performance capacity of a given channel liner or bank stabilization management practice, although this is not recommended. Table 1 describes the testing parameters and results from performance testing conducted and reported by the Texas Transportation Institute at Texas A&M University and the Texas Department of Transportation.

What is Manning's equation and Manning's n roughness coefficient?
Manning's equation is commonly used to analyze and simulate water flows in open channel systems and culverts. Manning's roughness coefficient (n) is the value given to a material surface used to convey water, or where water is transported via sheet flow or concentrated flow. Typically the lower the Manning's n coefficient the smoother the material surface. For example, PVC pipe has a Manning's n of 0.01 and clay tile has a Manning's n of 0.014, while a densely wooded floodplain has a Manning's n of 0.15 (LMNO, 2000). Additionally, the rougher the surface, typically the greater the propensity to slow water flow, increase infiltration, and reduce erosion. Rougher surfaces are part of Low Impact Development (LID) design strategies and also tend to Mimic Nature™. Contained in Table 2 are Manning's n roughness coefficients for non-vegetated and vegetated Filtrexx® Channel protection and Bank stabilization products. Note that the roughness coefficient value is more a function of the vegetation type, establishment phase, and density rather than the Filtrexx® Channel protection or Bank stabilization product alone.

Table 2. Manning's n Roughness Coefficients for Filtrexx® Channel Protection and Bank Stabilization

Vegetated Characteristic of Soxx™	Manning's n (roughness coefficient)
No Vegetation	0.022
Grass Only	0.035
Grass + Live Stakes (young or sparse)	0.05
Grass + Live Stakes (mature or dense)	0.075

References
LMNO, 2000. LMNO Engineering, Research, and Software, LTD. Athens, OH. http://www.lmnoeng.com/manningn.htm. Accessed 6-5-2007.

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