EB213 - FLEXIBLE LINING MATERIALS IN CHANNEL AND SLOPE APPLICATIONS

INTRODUCTION

This Engineering Bulletin is a summary of a more detailed paper prepared by U.S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory (EL) in Vicksburg, MS 1. The original paper, which contains a compilation of research and references related to flexible lining materials for channel and slope applications may be obtained from Propex Operating Company, LLC. As an alternative, the paper is available on the Ecosystem Management & Restoration Research Program (EMRRP) website at:

http://el.erdc.usace.army.mil/elpubs/pdf/eba13.pdf

The use of Rolled Erosion Control Products (RECPs) as a flexible lining material has become an accepted method for erosion control applications on slopes and in channels. RECPs are broken up into four different categories defined below.

- Erosion Control Blankets (ECB) – temporary, bio-degradable RECP designed to help establish vegetation with limited hydraulic performance improvement.
- Turf Reinforcement Mats (TRM) – permanent, 100% non-degradable RECP designed to help establish vegetation as well as improve hydraulic performance.
- High Performance Turf Reinforcement Mat (HPTRM) – permanent, 100% non-degradable RECP designed to help establish vegetation as well as improve hydraulic performance, having a minimum tensile strength of 3,000 x 3,000 lb/ ft.
- Anchor Reinforced Vegetation System (ARVS) – engineered solution utilizing the combination of an HPTRM and a Percussion Driven Earth Anchor (PDEA) for erosion control or slope stabilization.

The selection of an appropriate RECP is critical to the success of the slope or channel being lined, hinging on hydraulic, non- hydraulic, and environmental considerations.

HYDRAULIC CONSIDERATIONS

In erosion control applications, RECPs are utilized most effectively when the hydraulic stresses experienced in the field are greater than that of unreinforced vegetation or bare soil and less than that which would merit the use of hard armoring (Figure 1). When assessing the hydraulic considerations of an application one must perform a stability threshold analysis, comparing both the shear stress and the velocity experienced along the channel or slope with the permissible shear stress and velocity of the anticipated flexible lining material.

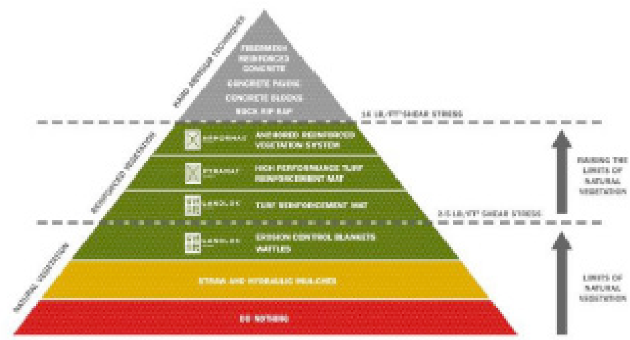

Figure 1 - Erosion Control Techniques

While expected flow durations in channels and across slopes can last for hours and even days the majority of reported values of permissible shear stress and velocity for RECPs are results from short duration testing. When comparing general permissible hydraulic values at varying flow durations, it was found that flexible lining materials can withstand between 1.5 and 3 times the hydraulic stresses at 1 hour flow duration as at 50 hour flow duration (Figure 2). From this a general Factor of Safety for erosion control applications with hydraulic stresses is found to be 1.3.

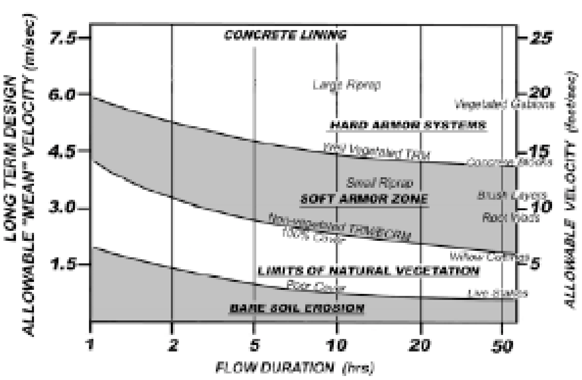

Figure 2 - Allowable velocities and flow duration for various erosion and bank protection measures

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The vegetation, or lack thereof, in an application utilizing RECPs is a very important hydraulic and long term design consid- eration for the performance of the project. In most situations, the use of a RECP will improve the hydraulic performance of a project in an unvegetated (0-30% vegetation establishment) state. However, in a partially (30-70% vegetation establishment) or fully (70-100% vegetation establishment) vegetated state the RECP is allowed to reinforce the vegetation and the overall per- formance of the project is greatly improved (Figure 3). When an unvegetated state is expected, the use of an ARVS for erosion control underlain with a nonwoven geotextile is suggested. The PDEAs will provide permanent anchorage of the HPTRM in lieu of vegetation while the nonwoven geotextile will mitigate the migration of fine soil through the HPTRM in lieu of vegetation.

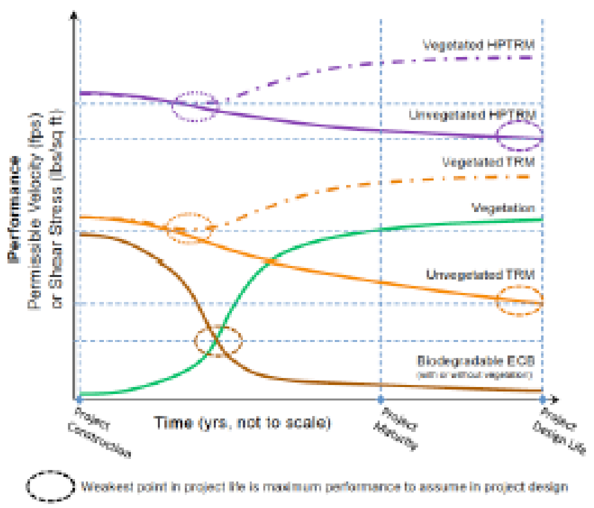

Figure 3 - Conceptual performance effectiveness curves for vegetation and TRM over time

NON-HYDRAULIC CONSIDERATIONS

While slope and channel hydraulics must be evaluated when utilizing RECPs, many non-hydraulic considerations must be made. Properties such as Material Composition, Flexibility, Ultraviolet (UV) Resistance, and Tensile Strength must be considered in selection of the most appropriate RECP for the slope or channel application.

MATERIAL COMPOSITION

Material Composition directly affects the long term performance of RECPs. RECPs that contain biodegradable components will contribute less performance benefits once the temporary components have degraded away. RECPs with components composed of polyester (PET) will be detrimentally affected by moisture and will be degraded over a wide range of pH levels. RECPs with components composed of nylon will also be detrimentally affected by the presence of moisture, causing rapid strength loss as moisture and temperature increase. However, RECPs with components composed of polypropylene (PP) are known to be very durable in aggressive environments. More details on the durability of PP can be found in Engineering Bulletin 405 – Durability of Polypropylene.

FLEXIBILITY

The Flexibility of a RECP, measured in inch-pounds, indicates its ability to maintain intimate contact with the soil. A stiff RECP will not easily follow the contours of the slope or channel, while a more flexible RECP will maintain direct contact with the soil even when undulations occur. The consequences of a lack of Flexibility, i.e. a lack of intimate contact with the soil, are erosion beneath the RECP and vegetation growing under the RECP (tenting) as opposed to growing in and through the RECP. A higher Flexibility value indicates a stiffer RECP and a lower Flexibility value indicates a more flexible RECP. While Flexibility and Tensile Strength are generally directly related, the RECP construction has a definite impact on this relationship. Generally, RECPs with multiple components, such as stitching, fused joints, or attached geogrids in attempt to artificially increase the RECPs Tensile Strength tend to be stiffer, more rigid materials.

UV RESISTANCE

UV Resistance is a crucial property for every RECP in every application, whether it is vegetated or unvegetated. UV Resistance is reported as a percent of tensile strength retained of a RECP after a certain period of accelerated UV exposure when compared to the original tensile strength of the RECP. The following relationships in Table 1 are generally seen when comparing UV Resistance to functional longevity:

UV Resistance (ASTM D-4355)	Functional Longevity
80% at 1,000 Hours	10 Years
90% at 3,000 Hours	25 Years
90% at 6,000 Hours	50 Years

Table 1 - UV Resistance vs. Functional Longevity

TENSILE STRENGTH

The Tensile Strength of a RECP is the primary property that determines the initial and long term performance of the RECP when non-hydraulic stresses are encountewred. Non-hydraulic, mechanical stresses encompass installation loading, mechanical loading, maintenance loading, debris loading, and animal loading. When the Tensile Strength of the RECP is not adequate to account for all of the non-hydraulic stresses incurred during the life of the project, non-hydraulic failure occurs, i.e. ripping or tearing of the RECP, lessening if not eliminating the improved hydraulic performance provided by the RECP.

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ENVIRONMENTAL CONSIDERATIONS

Every slope, channel, stream, levee, and shoreline restoration or stabilization must consider the environmental impacts of proposed treatment. The preferred remediation techniques use biodegradable or natural materials to minimize the environ- mental impacts. However, when project design factors, such as shear stress, velocity, loadings, etc… exceed that of natural vegetation, the use of permanent, non-degradable RECPs must be considered. The use of biodegradable or natural materials in these more severe applications can result in a material failure, causing a loss of vegetation, sediment pollution, and in turn less infiltration of water into the soil.

SUMMARY

As the use of RECPs continue to grow, the knowledge and use of consistent design considerations must grow as well. When utilizing RECPs the design engineer must consider the hydraulic, non-hydraulic, and environmental factors in order to select the appropriate solution for the problem at hand. For additional design support and installation consideration please contact Propex's Engineering Services at (423) 553-2450 or at InfrastructureSolutions@propexglobal.com

References

1. Miller, S. J., J. C. Fischenich, and C. I. Thornton. 2012. Stability thresholds and performance standards for flexible lining materials in channel and slope restoration applications. EBA Technical Notes Collection. ERDC TN-EMRRP-EBA-13. Vicksburg, MS: U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. http://cw-environment. usace.army.mil/eba/

2. Erosion Control Technology Council (ECTC). 2008. Installation guide for rolled erosion control products (RECPs) includ- ing mulch control nettings (MCNs), open weave textiles (OWTs), erosion control blankets (ECBs), and turf reinforcement mats (TRMs). St. Paul, MN.

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