Montana Department of Transportation June 2014
RESEARCH PROGRAMS

Project Summary Report: 7712-251/TPF-5(251)

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Relative Operational Performance of Geosynthetics Used as Subgrade Stabilization

http://www.mdt.mt.gov/research/projects/geotech/subgrade.shtml

Introduction

State departments of transportation (DOTs) routinely use geogrids and geotextiles for subgrade stabilization applications. This construction practice involves placing a geosynthetic on top of a weak subgrade to help stabilize the ground in order to construct the remaining gravel platform. The geosynthetic generally provides stabilization of the subgrade by increasing the load-carrying capacity of the system and maintaining separation between the soft subgrade and subbase materials. Subgrade stabilization allows for a firm construction platform to be built with less aggregate and less construction time as compared to construction without the stabilization geosynthetic. Typical applications are temporary haul roads or unpaved low-volume roads. There is a general consensus concerning the effectiveness of geosynthetics in this application; however, there is a lack of understanding and agreement on the geosynthetic's material properties needed for performance. Those properties should be specified in order to ensure its beneficial use and to allow a broad range of products to be considered. The main objective of this project was to determine material properties of geosynthetics most related to the in-field performance of geosynthetics used for subgrade stabilization, so that DOT personnel can objectively and confidently specify appropriate geosynthetics based on material properties and cost for a specific situation, while also allowing competition from different manufacturers.

What We Did

The objectives of this research were accomplished through a comprehensive program that included constructing, monitoring and analyzing full-scale field test sections as well as extensive laboratory tests on geosynthetics. Seventeen test sections were constructed, trafficked and monitored during summer 2012 at the TRANSCEND test facility in Lewistown, Montana to evaluate geosynthetics when used as subgrade stabilization. Design of this experiment was based on previous work completed by the research team in 2009 (Cuelho and Perkins, 2009) and centered on providing a uniform platform to evaluate the performance of multiple geosynthetics and other unpaved road design characteristics.

Each test section was 50 ft. long. Subgrade soil was prepared and installed in a trench 16 ft. wide, 3 ft. deep and 860 ft. long (Figure 1). The average constructed strength of the subgrade was 1.79 CBR with the exception of two test sections reinforced with BX Type 2 geogrid, one of which purposely was constructed to 2.17 CBR and the other at 1.64 CBR. These test sections were constructed to determine the effect that subgrade strength had on the performance of the test sections. Reinforced test sections were constructed with an average base course thickness of 10.9 in. The base thickness was primarily based on results of a cyclic plate load test reinforced with BX Type 2 geogrid topped with 10 in. of base course. The Control 2 and Control 3 test sections were purposely constructed with thicker base course (16.3 in. and 24.9 in., respectively) to evaluate the effect of base thickness on test section performance. Information from the test sections that were purposely constructed with different subgrade strength and base course thickness were used to correct any variability in the remaining reinforced test sections. The final arrangement of the test sections is shown in Figure 2, which includes the target subgrade strength and base thickness properties for construction.

Figure 1: Filling lined trench with subgrade.

A fully-loaded, three-axle dump truck was driven at 5 mph to traffic the test sections. Measurements of longitudinal rut, transverse rut, geosynthetic displacement, geosynthetic strain, and subgrade pore-water pressure were taken during trafficking. Trafficking of the test sections was in one direction only and ran from mid-September to early November 2012 to permit 740 passes of the truck prior to winter. Trafficking continued until rut levels reached approximately 3 in. (defined as failure in this project), at which time the ruts were filled in. This allowed the remaining portions of the test sections to be trafficked until failure. Forensic investigations were conducted after trafficking to assess damage and evaluate tensile properties, and to facilitate strength, stiffness and moisture measurements of the base and subgrade. Damage to the geosynthetics was minimal. Products that failed earlier sustained the highest junction damage. Rib damage was greatest in the woven geogrid products, and these products also showed the greatest loss in tensile strength.

What We Found

Longitudinal rut measurements were periodically made at 40-inch intervals along the two rut paths formed by the truck. In addition, transverse rut measurements were made in two locations within each test section coincident with the instrumentation. Rut measurements were based on changes in elevation of the measurement points over time as compared to a baseline measurement made before trafficking. The accumulation of rut as a function of truck passes revealed that the woven geotextile (Mirafi RS580i) performed the best, followed by BX Type 2 geogrid, Secugrid 30-30 Q1 geogrid and the non-woven geotextile (Geotex 801). The poorest performance was observed in the Fornit 30, SF12 and TX160 geogrids. Individual rut measurements were adjusted (based on base thickness and subgrade strength) and averaged together within a particular test section to create the corrected rut responses presented in Figure 3 for each of the test sections.

An analysis of the longitudinal rut data was conducted to determine which geosynthetic material properties were most related to the performance of a particular test section. This analysis was conducted at various rut depths (1.0, 2.0 and 2.5 inches) to determine whether different material properties affected performance at various levels of rut. A linear regression analysis was performed using wide-width tensile

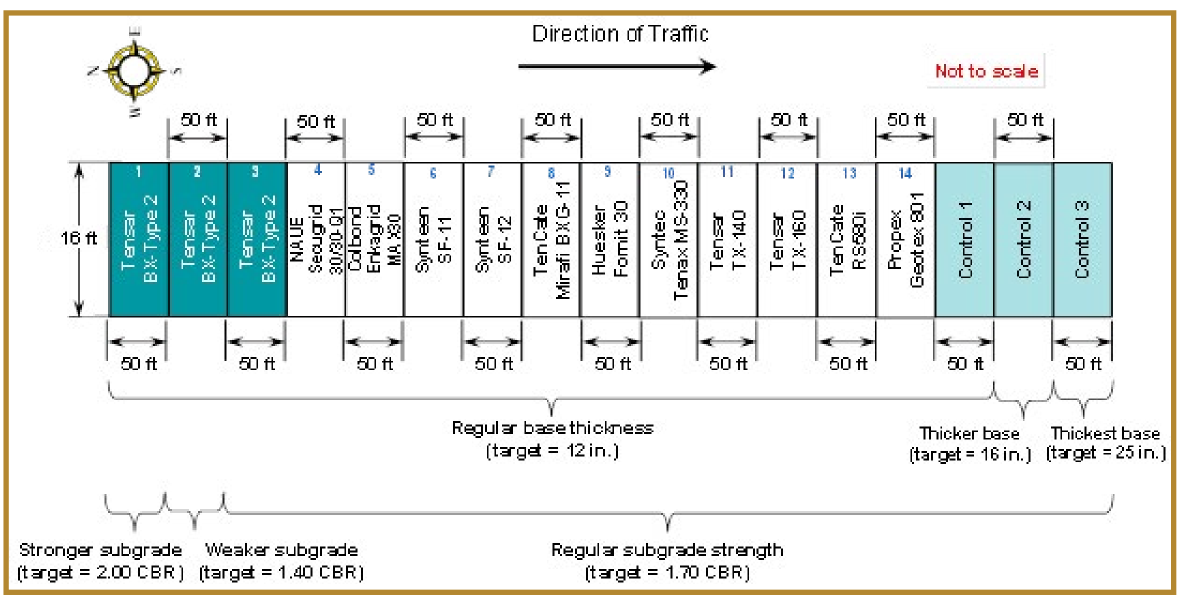

Figure 2: General layout of test sections with target construction parameters.

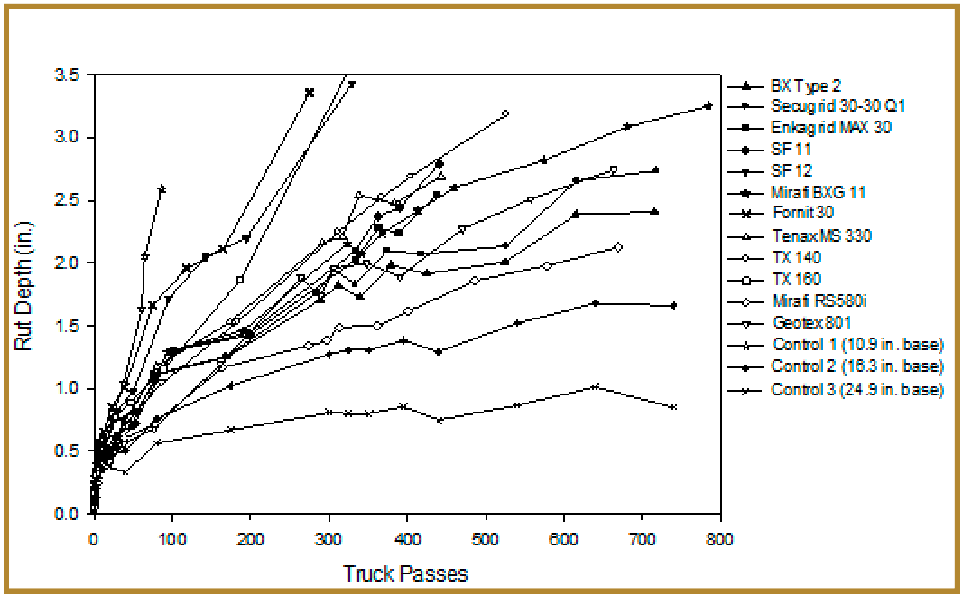

Figure 3: Corrected rut response for all test sections.

strengths, cyclic tensile stiffness, resilient interface shear stiffness, junction strength and stiffness, and aperture stability modulus. Overall, this analysis revealed that wide-width tensile strength, junction strength and junction stiffness in the cross-machine direction were chiefly related to the performance of the reinforced test sections.

The results of a base course reduction (BCR) analysis indicated that the greatest reduction in base thickness was approximately 26.9 percent (TenCate Mirafi RS580i) corresponding to a difference of 4.0 in. of gravel; the least was 10.2 percent (Huesker Fornit 30) corresponding to 1.2 in. of gravel. These comparisons are valid for situations where additional gravel would be sufficient to allow heavy construction equipment to operate on the weak subgrade without excessive rutting or other damage. The results of the traffic benefit ratio (TBR) analysis indicated that the greatest benefit was achieved by using the TenCate Mirafi RS580i geotextile, resulting in an improvement of almost 11 times the traffic level when compared to the unreinforced test section (Control 1). The smallest TBR was in the Huesker Fornit 30 test section (TBR = 2.3).

What the Researchers Recommend

The results of this study indicate that strength and stiffness of the junctions and tensile members mainly contribute to the performance of geosynthetics when used as subgrade stabilization, and the relative contribution of these material properties depends on the thickness of the base course aggregate layer and the anticipated rut depth. Practitioners who wish to use geosynthetics as subgrade stabilization should consider specifying minimum values for material properties that correlated with good performance of the test sections. These minimum values can be categorized by the severity of the site conditions, ranging from moderate to severe, as demonstrated in the two phases of this project. Further work is necessary to more confidently specify minimum values for geosynthetic material properties associated with good rut performance. The specified properties are mutually important, and products having only one of the specified properties may not perform well. Further research is necessary to determine the combined effect of these properties as they relate to subgrade stabilization of a greater variety of base thicknesses and subgrade strengths. Information from that research could be used to augment or determine specific design parameters for a wider range of subgrade stabilization applications. Despite the fact that the woven and non-woven geotextiles performed well in the field study, it is unknown which material properties are directly responsible for their performance. Intuitively, surface friction properties and tensile strength of the materials plays an important role however, additional work is needed to evaluate the effect individual geotextile properties have on their performance in subgrade stabilization applications.

References

Cuelho, E. and Perkins, S. (2009) "Field Investigation of Geosynthetics Used for Subgrade Stabilization" Final report to the Montana Department of Transportation, FHWA/MT-09-003/8193, 140 pp.

For More Details . . .

The research is documented in Report FHWA/MT-14-002/7712-251, Relative Operational Performance of Geosynthetics Used as Subgrade Stabilization.

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MDT Implementation Status: June 2014

The results of the research have been evaluated in conjunction with guidance and publications from FHWA, research into other state specifications, and other geogrid performance research to revise the MDT geogrid subgrade stabilization material specifications (as necessary on a per project basis) for specific site conditions and overall project intent. These revisions for geogrid properties will enable sufficient manufacturers to provide their products on MDT projects to ensure adequate competition without jeopardizing quality. The research results have provided insight into what geogrid properties appear to be the most relevant for subgrade stabilization applications under certain conditions, however additional research is required to definitively determine which geosynthetic material properties most directly relate to stabilization of weak subgrade soils in a broader sense. Based upon the very good performance of the geotextiles in this study, MDT is considering additional research consisting of large scale laboratory testing. Overall, MDT geosynthetic specifications will be continually evaluated as additional research and published information becomes available.