Project Summary Report: FHWA/MT-21-002/9564-602

Authors: Steve Perkins | Western Transportation Institute | Montana State University
Eli Cuelho | TRI Environmental | Manhattan, MT

Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications

https://www.mdt.mt.gov/research/projects/geotech/lab_testing.shtml

Introduction

The Montana Department of Transportation (MDT) routinely uses woven and non-woven geotextiles as a construction expedient in situations where roadway subgrades are or may become wet, weak and unable to support construction traffic. MDT also uses geotextiles as a physical separator between the base course aggregate and the underlying subgrade to maintain the integrity of the base layer. These geotextile functions are well-recognized by MDT pavement designers and roadway construction contractors as a means to reduce roadway maintenance costs by avoiding contamination of the base layer with subgrade fines and reducing construction costs through stabilization of weak subgrades.

MDT has previously supported research to investigate the use of geosynthetics (geogrids and geotextiles) for roadway reinforcement, where reinforcement provides structural value during the operational life of the roadway. Given the common use of geotextiles in the state for stabilization and separation, MDT was interested in studying whether geotextiles commonly used in the state for stabilization and separation also provide a reinforcement function for typical Montana rural low-volume highway conditions. Documentation of a reinforcement benefit would allow roadways to be constructed with less base course aggregate and/or to realize an increased life of the paved roadway. These options are attractive for areas of the state where good quality base course aggregates are not readily available.

Documentation of reinforcement benefit for geotextiles commonly used by MDT for typical low-volume highway conditions was not available in the literature. The majority of studies available focus on the use of geogrids for reinforcement. Many studies also use subgrades that are weaker than typical design values applicable to Montana roadways. MDT initiated this project to experimentally document reinforcement benefit for conditions commonly encountered in Montana roadways.

A spreadsheet design model for geosynthetic reinforcement was previously developed for MDT. MDT was interested in further validation of this model and updating this model to a current version of Excel.

What We Did

The reinforcement benefit of geotextiles commonly used by MDT for stabilization and separation was studied by the construction of a single test track in an indoor test facility. The test track contained two test sections with a reinforcement geotextile (woven and non-woven) while the third section was unreinforced. The materials used were TenCate Mirafi RS280i and Propex Geotex 801. The test sections constructed had a nominal section of 3.4 inch of hot mix asphalt and 13.3 inch of base course aggregate on a clay subgrade with a constructed

CBR of approximately 3.5. The test sections were trafficked by a full-scale accelerated pavement tester with approximately 1 million traffic passes applied. Figures 1 and 2 show photographs of the concrete lined trench used for the test track and the accelerated pavement tester located in Greenville, South Carolina and operated by TRI Environmental, Inc.

Figure 1: Accelerated test facility concrete lined trench.

Figure 2: Accelerated pavement test device.

Materials used in the construction of the test sections were selected to match those commonly encountered in the State of Montana. Base course aggregate was obtained from a pit located in Forsyth, MT and shipped to the test facility in SC. A low plasticity clay was obtained from a mine located close to the test facility. A HMA mixture having a PG grade of 64-22 was obtained from a local plant.

The test sections were originally constructed by preparing the base course to a moisture content ranging from 6.4 to 8.2 %. The optimum moisture content of the base by the Modified Proctor test was 7.7 %. HMA was placed on this first test section constructed and traffic loading occurred thereafter. The test sections were seen to rut more rapidly than expected. Trafficking was stopped and the HMA layer and the base course layer were removed and reconstructed. The base course layer in the second test section constructed was placed at a lower moisture content to correct the problem discovered in the first test section constructed.

The geosynthetic reinforcement spreadsheet model was updated to a .xlsm format. Predictions from the model were compared to recently published studies reporting results from constructed test sections. Results from this study were also compared to predictions from the model.

What We Found

The raw rutting results showed the unreinforced test section performed better than the two sections with a geotextile. Figure 3 shows the average rutting results for each test section along with measurement error bands corresponding to plus and minus one standard deviation of the measurement points taken along the longitudinal path of the wheel. A statistical analysis of the data was performed to examine the likelihood that variability in constructed material properties was responsible for the results obtained. This analysis showed that the use of average as-constructed material properties within the AASHTO 1993 pavement design equation resulted in a prediction of ESAL's corresponding to the order seen in Figure 3. The predicted ESAL's did not; however, show the degree of underperformance of the two sections containing a geotextile.

The analysis further showed that the variability in the as-constructed properties of the test sections led to a low probability (between 8.8 to 12.5 % chance) that the test sections containing a geotextile would equal or exceed the number of ESAL's carried by the control section. The low values of probability for the test sections containing a geotextile imply that the variation in as-constructed pavement layer properties do not account for the control section outperforming the reinforced test sections. This analysis also implies that the excellent consistency of the constructed pavement layers leads to a low level of uncertainty with the rutting results obtained.

This analysis led to the most likely explanation for the observation of the control section outperforming the reinforced sections as due to seating or shakedown of the pavement layers during initial trafficking.

This explanation is illustrated in Figure 3 by the difference in rutting response during the early portion of loading, followed by a similar slope of the rutting curves for the three test sections. Small differences in construction may lead to significant differences in the initial seating or shakedown of the pavement layers under trafficking. The absence of construction traffic on the test sections failed to provide seating of the materials as would have occurred in a field application. The inability to incorporate construction traffic and material seating in the test sections may provide justification for comparison of the rutting response once seating due to initial trafficking is completed. Since the average slope of the rutting curves for the three test sections are approximately equal, this argument leads to the conclusion that the three test sections performed similarly and the conclusion that no reinforcement benefit was observed for these conditions and for the two geotextiles used.

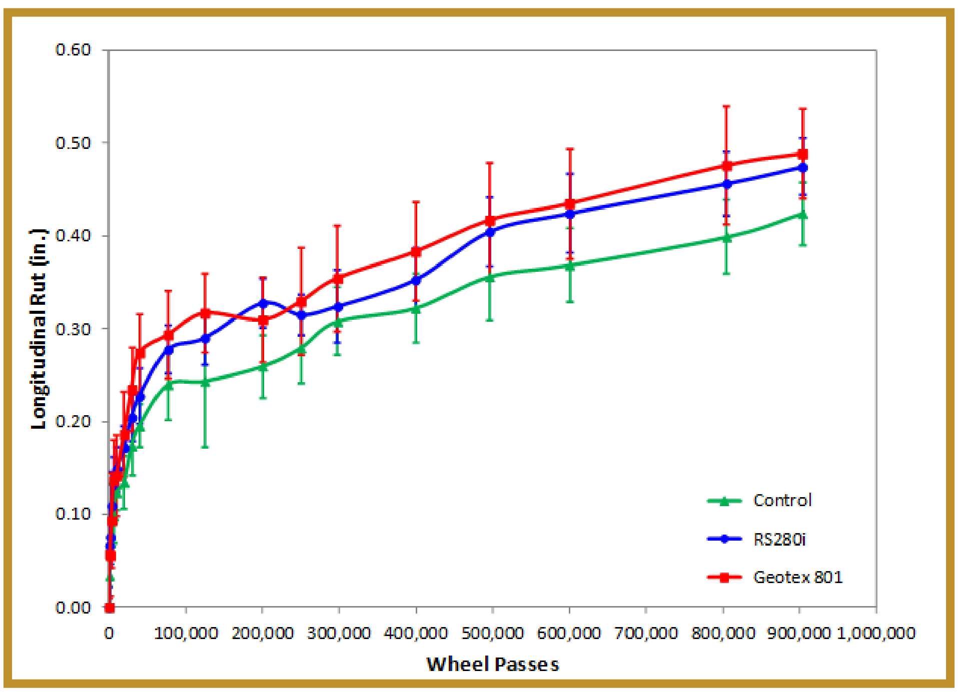

Figure 3: Longitudinal rut responses showing data scatter.

Experience from the first construction when the base course layer was placed at a moisture content greater than that used in the second construction showed the sensitivity of the stiffness of the base course material to moisture content. Stiffness of the base course layer during the second construction was markedly greater when the moisture content was modestly less than that of the first construction. The poor rutting performance of the test sections after the first construction illustrates the need to control moisture both during construction and during the service life of the pavement.

The geosynthetic reinforcement spreadsheet model on the average compared well to previously published results from studies where test sections were constructed. This model predicted little reinforcement benefit for the conditions present in this study. This model; however, showed moderate reinforcement benefit for weaker subgrade conditions (i.e. subgrade CBR of 2.5) that might be present in typical Montana roadways during seasonally wetter periods. This study did not quantify the separation benefit of the geotextiles, which are a recognized benefit applicable to most roadways in the state.

What the Researchers Recommend

This study resulted in the following recommendations:

- Woven and non-woven geotextiles should continue to be used in Montana roadways for the well-recognized benefits of stabilization and separation.
- For roadway designs involving a design subgrade CBR of 3.5 and greater, typical roadway designs for the State of Montana should not consider reducing the base course layer thickness in design for roads where a stabilization and/or separation geotextile has been used.
- Current test section work subsequent to the completion of this project, where rutting of the base during construction occurred, should be considered to possibly revise the recommendations given in this report.
- Base course materials for highway construction should be placed dry of optimum moisture content and should not be allowed to become wet during construction. Excessively wet base course layers during construction may lead to premature pavement failure.
- The geosynthetic reinforcement spreadsheet model previously developed for MDT should be used for future roadway construction projects in Montana to examine the potential for reinforcement benefit of currently used geotextiles and for the possible use of geogrids.
- The spreadsheet design model should be updated by replacing geosynthetic material property check boxes with value-input boxes and provide guidance for how values for three geosynthetic material properties are selected.

For More Details . . .

The research is documented in Report FHWA/MT-21-002/9564-602, https://www.mdt.mt.gov/research/projects/geotech/lab_testing.shtml.

MDT Project Manager:
Vaneza Callejas, vcallejas@mt.gov, 406.444.6338

Researcher's Organization Project Manager:
Steve Perkins, stevep@ce.montana.edu, 406-994-6119

To obtain copies of this report, contact MDT Research Programs, 2701 Prospect Avenue, PO Box 201001, Helena MT 59620-1001, mdtresearch@mt.gov, 406.444.6338.

MDT Implementation Status: June 2021

Implementation will be documented in the Implementation Planning and documentation form for this project as per the implementation report, which can be found at the above URL.