Project Update Memo

Project Title: Relative Operational Performance of Geosynthetics Used as Subgrade Stabilization

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Construction

Fieldwork for this research project began in late June by excavating the old subgrade stabilization study from 2008 and widening and lengthening the trench to its final dimensions of 16 ft wide by 860 ft long. The trench was lined with 4-mil plastic liner to help maintain constructed moisture content of the subgrade throughout the duration of the project. The subgrade soil, obtained from the same source and having very similar properties as the first project, was screened to remove particles greater than 1 inch in diameter. For construction purposes, this material was characterized by evaluating vane shear strength and California Bearing Ratio (CBR) as the water content was varied. Field measurements of shear strength, using the hand-held vane-shear device, were used as the primary means to characterize the subgrade as it was placed in the open trench.

The subgrade was built in 6 lifts that were approximately 6 inches deep for a total depth of about 3 feet. The subgrade was delivered adjacent to the test pit and was processed to reach the target strength by adding water from a water truck and fire hose (Figure 1). Water was added until the portion of the pile being prepared reached a predetermined moisture content (e.g., 23 percent for test Sections 3 through C3). Processing was accomplished using a large excavator (Caterpillar 345B). The operator used the bucket to move and mix the material as water was being added (Figure 1). Sufficient material was processed to construct a single 6-inch deep layer over two test sections at a time (about 30 yd^3). The subgrade was then placed in the trench using the excavator and a track-mounted skid-steer tractor was used to level and initially consolidate the subgrade (Figure 2). A smooth, single-drum, vibratory roller (66-inch wide, 15,500 lb) was used to compact the subgrade by making two passes of the roller in three longitudinal paths of the freshly placed subgrade (Figure 3). The moisture in the top surface of the subgrade was maintained during construction by periodically wetting the surface and keeping it covered with plastic until the next layer of subgrade or the base course could be placed.

Figure 1: Watering and mixing subgrade with excavator.

Figure 2: Tracking freshly placed subgrade with track-mounted skid-steer.

Figure 3: Smooth-drum roller used to compact subgrade.

For quality control testing purposes, each 50-foot long test section was delineated into 14 subsections – seven in each wheel path, as outlined in the Task 1 report for this project. Four measurements of vane shear were made in each subsection for a total of 56 vane-shear measurements in each layer in each test section. A shear strength of 1,200 psf (58 kPa) was targeted, which corresponds to a CBR of 1.7. Shear strengths of 1,400 psf and 1,000 psf (67 kPa and 49 kPa, corresponding to CBRs of 2.0 and 1.4) were targeted for test sections 1 and 2, respectively. A plot of the composite shear strength of the subgrade for each of the constructed test sections, based on vane shear data, is shown in Figure 4. Measurements of dynamic modulus (using the light-weight deflectometer) were also made in six locations in each test section in each layer. Once construction of the subgrade was complete, dynamic cone penetrometer (DCP) readings were also made at these same six locations in each test section, in-field CBR was measured in one location in each test section, and density (using a nuclear densometer) was measured in two locations in each test section.

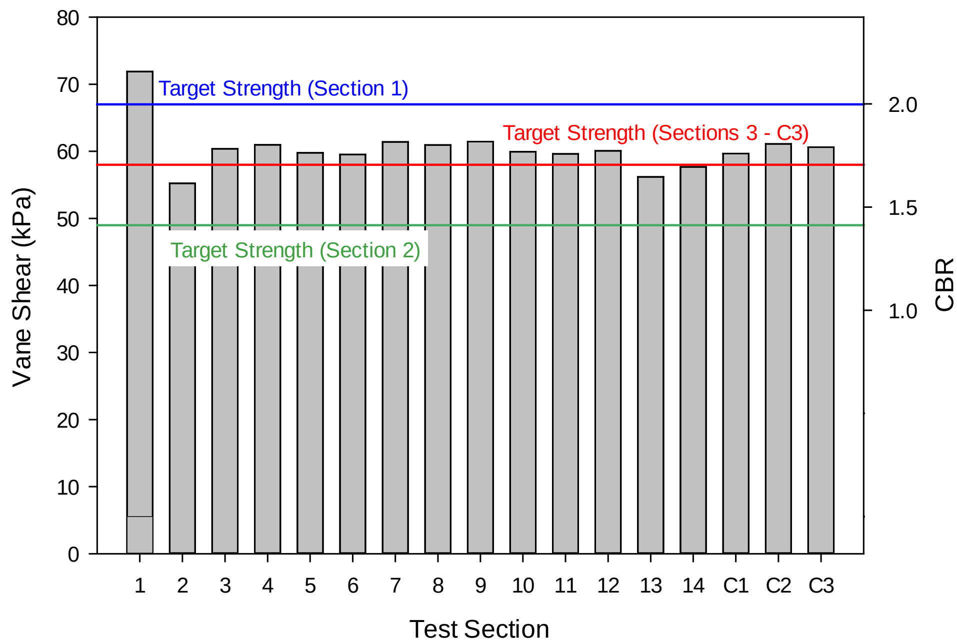

Figure 4: Composite vane shear strength of the constructed subgrade.

The base course was prepared by adding water and mixing with an end loader until it reached optimum water content. Prior to placement of the base course, the top surface of the subgrade was smoothed and screeded to the height of the adjacent pavement surface. This was accomplished by tilling the top of the subgrade and pushing a large metal edge along the surface to remove excess material. The top surface was then compacted using a smaller single-drum, vibratory roller from the side to minimize ruts in the subgrade surface. Pore-pressure gages were then installed and the geosynthetics were placed. The final arrangement of the geosynthetics in the test sections is shown in Figure 5. A large screed that rested on the paved surface on both sides of the subgrade trench was used to level the surface of the gravel layer (Figure 6). The target gravel thickness was 12 inches, which was determined using data from the cyclic plate load test conducted as part of this project, as well as past cyclic plate load test data from other research projects. The base course was placed in two layers. The final thickness of the first layer of base course was about 8 inches when compacted and the second about 3 inches deep for a total of about 11 inches of gravel. The final thickness of the base course in each test section is shown in Figure 7. Compaction was achieved using a smooth, single-drum, vibratory roller (54-inch wide, 12,000 lb). In total, eight passes of the roller were made per lift at three transverse positions. In addition to a topographic survey, the final gravel surface was measured using DCP, LWD, CBR, and nuclear densometer.

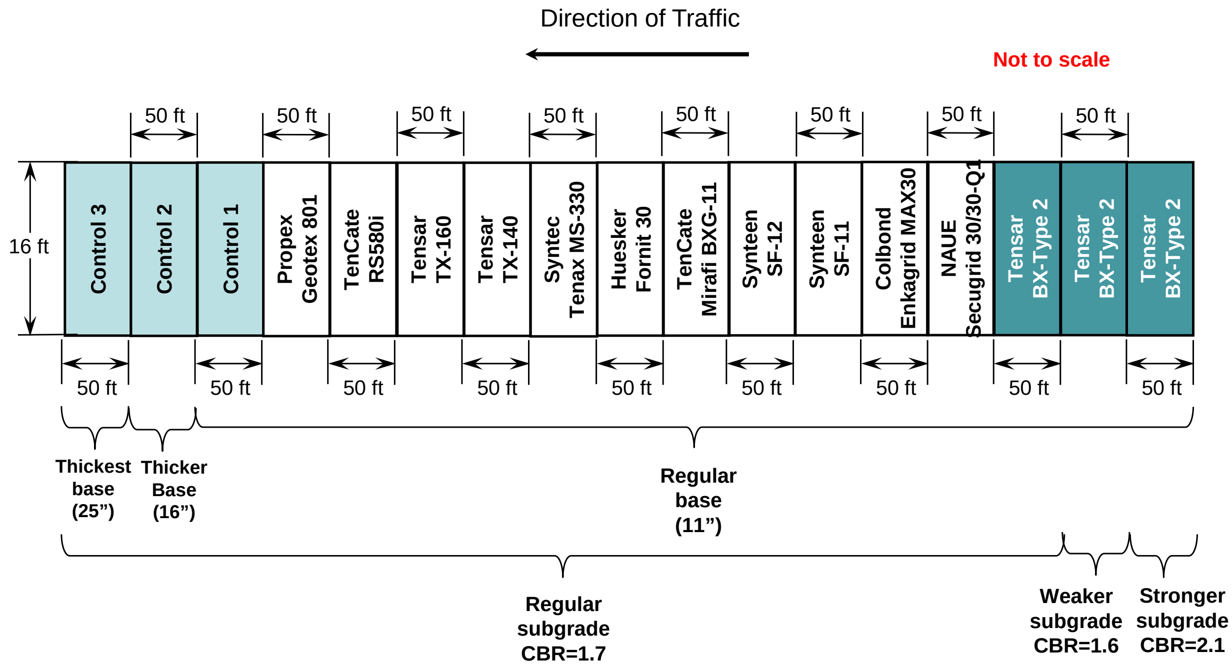

Figure 5: General layout of test sections.

Figure 6: Screeding gravel surface.

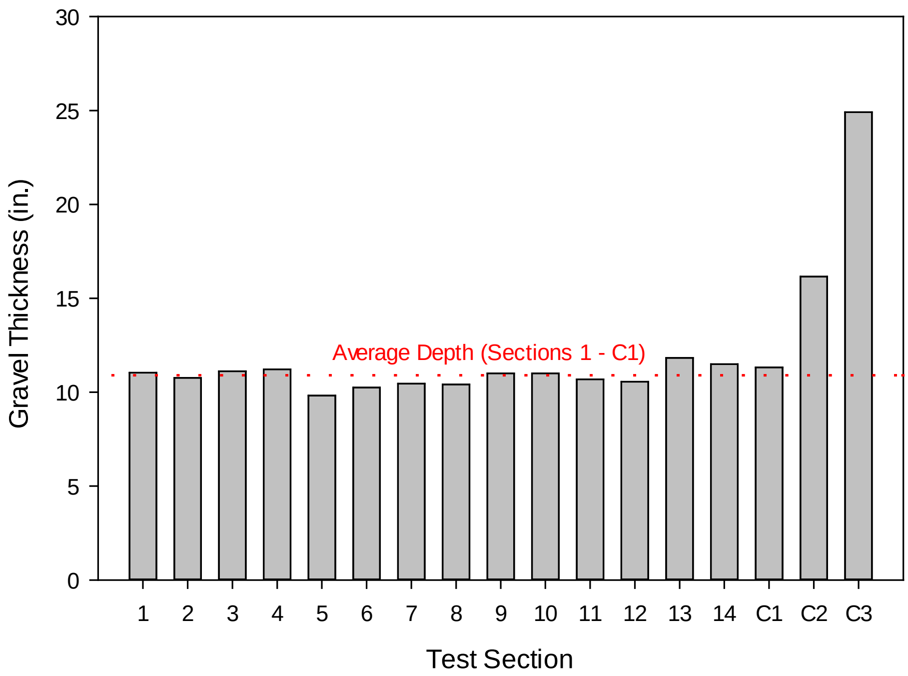

Figure 7: Gravel thickness.

The schedule of the construction activities is summarized in Table 1. Construction took approximately three weeks longer than expected which caused trafficking to be delayed until mid-September (originally scheduled to begin mid-August). This shift in the construction schedule is mostly due to the additional time it took to construct the subgrade and a delay in the delivery of the base course material. Despite these delays, however, most test sections were trafficked to significant levels of rut to facilitate comparative analysis of performance. To reduce further delays to trafficking, Task Report 2 (summary of construction activities prior to trafficking) and Task Report 3 (summary of trafficking and monitoring activities) were combined and postponed until after trafficking was complete.

Table 1: Anticipated and Actual Construction Schedule

Construction Steps	July 2-6	July 9-13	July 16-20	July 23-27	Jul. 30 - Aug. 3	Aug 6-10	Aug 13-17	Aug 20-24
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Excavate, Widen, Line Trench (anticipated)								
Excavate, Widen, Line Trench (actual)								
Construct Subgrade (anticipated)								
Construct Subgrade (actual)								
Install Sensors and Geos (anticipated)								
Install Sensors and Geos (actual)								
Construct Base (anticipated)								
Construct Base (actual)								

Trafficking and Data Collection

Trafficking began on September 13th and continued until November 7th, using a three-axle dump truck that weighed 45,420 lbs. Trafficking was always in one direction, and the speed was approximately 5 mph to ensure that dynamic loads were not induced in the test sections from any unevenness in the gravel surface. Occasional rainstorms having accumulations greater than one-tenth of an inch over a 24 hour period interrupted trafficking. Traffic resumed once the surface of the gravel had dried significantly. Trafficking continued until rut levels reached 3 inches – defined as failure in this project. Once 3 inches of rut was attained, repairs were made by placing additional gravel in the rutted areas using a skid-steer loader. Repairs within test sections were made incrementally, so that even un-failed portions of test sections could continue to be trafficked.

Rut measurements were made at 1-meter (40 inch) intervals along two longitudinal lines that corresponded to the outside rear wheels of the test vehicle. Twenty-eight rut measurements were made in each test section at various trafficking levels. The longitudinal rutting results have not been fully analyzed yet and are, therefore, not ready to be presented. A summary of the measurements timetable is shown in Table 2. Transverse rut measurements were also made at these same times in two locations in each test section (geographically coincident with the instrumentation locations). Long-term measurements of strain, pore-pressure and displacement were made at 30 minute intervals. Dynamic measurements of strain, pore-pressure and displacement were also taken at various times during trafficking.

Table 2: Summary of Rut Measurements

Date Measured	Truck Passes	Notes
9/13/2012	0	
9/14/2012	3	
9/19/2012	10	
9/20/2012	20	
9/20/2012	40	
9/21/2012	70	C1 only
9/23/2012	80	
9/23/2012	102	C1 only
9/24/2012	125	2, 7 and 9
9/25/2012	175	
10/2/2012	250	
10/9/2012	300	
10/15/2012	325	
10/18/2012	351	
10/19/2012	395	
10/29/2012	440	
11/1/2012	540	
11/6/2012	640	
11/19/2012	740	

Preliminary Forensics

Preliminary forensics work was conducted on site after trafficking was complete to investigate potential reasons for significant differences in rut within a particular test section. Base course was removed to expose the subgrade at up to two places in most test sections using a mini-excavator. Measurements of the subgrade were made using DCP, vane shear and LWD, as well as moisture contents. This information will be compared to one another in the coming months to help determine possible reasons for any discrepancies.

Next steps

Forensic work is scheduled to resume in the spring when the ground has thawed and higher levels of moisture have subsided (May/June timeframe). As outlined in the proposal, this work will entail full excavation of the test pit, testing of the subgrade and base course, and removal of geosynthetic samples for further testing and damage evaluation. The task report to summarize post-trafficking forensic investigations is currently postponed and will be submitted after this work has been completed. The following other activities are also planned for the coming months.

- Submit task report to thoroughly document construction, trafficking and monitoring activities. Task Report 2 (summary of construction activities prior to trafficking) and Task Report 3 (summary of trafficking and monitoring activities) were postponed to allow researchers to complete fieldwork on this project before winter. In consultation with MDT, these documents will be combined into a single report to be submitted by February 15, 2013.
- Analysis of sensor data (displacement, pore-pressure and strain).
- Analytical and statistical study of the rut data.
- Geosynthetic material characterization (wide-width, cyclic tension stiffness, resilient interface shear stiffness, aperture stability modulus, and junction strength).