Mechanical Stabilization of Unsuitable Subgrade Soils During Interstate 95 Lane Widening

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ABSTRACT

During a Maryland Transportation Authority (MDTA) project to add toll lanes in place of the existing median on Interstate I-95 near MD 43 (White Marsh Blvd.) in Maryland, unsuitable soils that had been disposed in the median during past projects presented significant challenges related to constructability and project schedule. The conventional solution was to excavate and remove unsuitable soils. Instead, the contractor, the engineer, and Tensar worked together on a solution that used a mechanically stabilized aggregate layer to address the conditions more quickly and economically. This paper presents a description of the conditions encountered, describes the analysis that resulted in the geosynthetic solution, and reviews the construction of the project.

INTRODUCTION

The Maryland Transportation Authority (MDTA) and the Maryland Department of Transportation (MDOT) are implementing a multi-year, multi-phase project to add Express Toll Lanes (ETLs) to Interstate 95. The ETLs are expected to provide significant congestion relief in one of the most heavily-trafficked corridors in the United States. The major modification to I-95 consists of adding two ETLs in each direction. The eight General Purpose Lanes (GPLs) were maintained. The ETLs are located in the middle of the roadway and separated from the GPLs by a concrete barrier. The ETL lanes were designed for a 25-year life and 9.5-million ESALs and are located in the median between the north and southbound lanes just north of the I-95 bridge over White Marsh run.

During initial construction of the highway, and through subsequent expansions, maintenance, and reconstruction activities, it was standard procedure when unsuitable soils were encountered to excavate the material and dispose of it in the medians. While this practice had no negative impacts when the medians carried only periodic mowing equipment, it left large areas completely unsuitable for the construction of the new toll lanes. These conditions were not addressed in the original design and scope of work, so the general contractor on the project, Cherry Hill Construction, needed to determine an acceptable solution.
SITE CONDITIONS

The soils in the medians were weak, saturated clays and silts with very low shear strength. California Bearing Ratio (CBR) values were well below 1%, and the poor soils extended to depths of at least 1.8 m (6 ft) or greater. In many areas, Standard Penetration Testing (SPT) values were recorded as weight of hammer. Using a calibrated drop hammer penetrometer, the CBR values ranged from 0.1 to 0.5. These poor soil soils were first encountered in March 2014 but were thin enough that they were simply undercut. As the project advanced the poor soils got deeper, and test pits determined that the undercut would be significant. The roadway was to open in Fall 2014 and to undercut and replace would have delayed opening of the toll road.

The logistics of addressing the problem were equally challenging. Because the construction was occurring between the existing northbound (General Purpose Lanes) and northbound (ETL) exit ramps of a major interstate, any material that would be required to enter or leave the site would do so through limited access points. Depth of excavation was also an issue as the northbound exit ramps, to the west of the NB travel lanes ETLs, were supported on MSEs about 7.6 m (25 ft) high. There were active General Purpose Lanes immediately to the east of the NB ETL. Even though the active traffic lanes were separated from the work zone by a concrete barrier, if the depth of undercutting was too deep it could undermine the MSE and the active travel lanes requiring a Support of Excavation (SOE). Design and construction of this would have delayed the opening of the highway and increased the cost. Further, space to operate equipment was extremely limited, and any significant excavation would have to consider the impact on the existing roadway just a few meters away. The soft subgrade was encountered only a few months prior to the scheduled opening of the toll lanes and a delay would have been costly.

SOLUTION DEVELOPMENT

The contractor approached MDTA and MDOT to determine a solution. The initial proposed option was to remove and dispose of 1.8 to 2.5 meters (6 to 8 ft) of unsuitable material and replace it with suitable fill. While this approach would have resulted in an acceptable surface for construction, its impact on the project would have been extremely problematic due to the logistical and scheduling challenges noted above. After evaluating this option, the contractor and MDTA concluded that the impact on the project schedule would be so severe that a different approach was needed.

The contractor approached RK&K, the designer of record, and Tensar to see if a solution could be developed that would keep the project on track. Together, the team evaluated the site conditions and developed an option that used a mechanically stabilized aggregate layer (MSL) to create a stable surface above the unsuitable material while requiring greatly reduced soil excavation and disposal.

The design was developed based on the Giroud-Han design method for unpaved roads. This was suitable for the contractor’s haul road. It should be noted that while Giroud-Han served as a basis for the design, the final application was not an unpaved road subject to channelized traffic, for which the method is intended. However, Giroud-Han is the most rigorous and widely accepted method for designing gravel-surfaced roads over soft subgrades, so there is a large body of experience with conditions that are similar to those encountered in this case. Therefore, Giroud-Han can be effectively used to estimate thickness requirements as an initial step in the design.
Extensive field experience has shown that a Giroud-Han design based on a typical scenario (89 kN (20 kip) axle load, 689 kPa (100 psi) tire pressure, 1,200 passes, 38 mm (1½ in) max rut depth) consistently results in an improved subgrade surface with a CBR of 6% or greater. Based on this experience, a preliminary cross section can be developed. Since field conditions and constructability issues not considered in the Giroud-Han method can affect performance, field testing is often used for design verification, depending on how critical subgrade strength is for the final design.

The highway pavement design used the SpectraPave4-PRO software. This application uses the empirically based 1993 AASHTO Guide for Design of Pavement Structures and enhanced layer coefficients to account for the benefits of the geogrid, and complies with AASHTO R-50, Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures. The coefficients used in this application are based on laboratory and field testing these specific geogrids and should not be used with other geogrids. (ARA & Ryan R. Berg Assoc, 2013)

Once a preliminary design for the haul road was developed, two test strips were built: one using two 305 mm (12 in) layers Graded Aggregate Base (GAB) with two layers of multi-axial geogrid and the other using one 610 mm (24 in) layer of No. 2 stones and one layer of multi-axial geogrid. The No. 2 stone was choked with GAB to improve the rideability. The test strips were trafficked with a fully loaded tandem dump truck (GVW 23,000 kg to 27,000 kg, 50,000 to 60,000 lb) to observe rutting behavior.

The ruts observed in the first test strip were approximately 89 mm (3.5 in) deep after fewer than 10 passes. The second test strip developed very shallow ruts (15 mm (1/2 in) or less). This experience with the haul road was then incorporated into the final pavement design as described below.

Once the initial estimate of required thickness for the final pavement was established, the team considered other site conditions that might affect the success of the design and adjusted accordingly. Two primary concerns were addressed: variability in the strength of subgrade soils across the project, and the potential effects of ground water and drainage. Constructability of the pavement drainage system and how the drains tied into the already construction storm drain system were also considered.

To address the variability in soil conditions, the primary concern was to ensure that the MSL would maintain maximum stiffness so that the surface would remain stable. Stiffness in the layer is established by the confinement and interlock of the particles of granular fill. Prior research has demonstrated that the compacted granular fill above a geogrid has both fully-confined and partially-confined zones, so as thicker granular layers are used, confinement can be enhanced using additional layers of geogrid. In general, layers of multi-axial geogrid that are spaced at approximately 300 mm (12 in) within the MSL are adequate to maintain full confinement. The test strips indicated that only one layer of geogrid with the No. 2 stone provided adequate support; therefore, in this case, it was decided that the design would use one layer of geogrid in the 610 mm (24 in) thick MSL. As this might not be adequate to provide support for the highway design ESALs, a second layer was located at the top of the MSL/haul road and the pavement section. The multi-axial geogrid selected had high flexural stiffness, to provide the most stable surface possible for placing the initial layer of fill over the extremely soft soils below.

To address the potential detrimental effects of ground water and drainage, it was decided to construct the first (lower) 300 mm lift using an open graded aggregate, in order to provide a
capillary break and prevent water that might enter the fill from either above or below from becoming trapped and potentially causing frost heave or weakening of the MSL. The second (upper) lift was constructed using dense graded aggregate base, to provide a smoother and more stable surface that was suitable for construction. A non-woven geotextile was placed above the first lift and below the second layer of multi-axial geogrid, in order to maintain separation of the aggregate layers above from any fine-grained soil that might migrate into the capillary break layer. To direct groundwater to the drainage system the MDTA standard pavement drain was modified to accommodate the new pavement section and lateral finger drains were added under the pavement. In areas where a third lift was used, the multi-axial geogrid was placed above the second lift, and the layer was completed with dense graded aggregate base. Figure 1 shows a cross section of the design.

![Figure 1. Final Design Cross Section (305 mm HMA, 305 mm GAB, 152 mm GAB choke layer, 610mm #2 stone).](image)

The geotextiles specified were 203 g/m\(^2\) (6 oz/yd\(^2\)) non-woven (Class SD) and 271 g/m\(^2\) (8 oz/yd\(^2\)) non-woven (Class SE). The specified geogrids were integrally-formed multiaxial geogrids with nominal aperture dimensions of either 41 mm (1.6 in) or 57 mm (2.24 in), that have been calibrated to the Giroud-Han design method based on full scale traffic testing.

Once performance of the design was verified using test strips, the contractor worked with MDTA and MDOT to put an appropriate change order in place, and the solution was implemented. Figures 2, 3, and 4 present photos of the construction at the site.
Figure 2. Construction photo showing lower layer of grid on subgrade.

Figure 3. Construction photo showing first lift of aggregate.
RESULTS

The original design included 12-inches of asphalt, 12-inches of GAB and in soft areas, 12-inches of sand with a separation geotextile between the sand and the subgrade. The proposed treatment replaced the sand and separation fabric with two layers of geogrid and 24-inches of No. 2 stone. This required only an additional 12 inches of excavation. The MSL solution successfully addressed the issues related to unsuitable soils on the project and allowed construction to proceed on the toll lanes. The contractor was able to maintain the project schedule while addressing the site conditions, and the cost was significantly lower than would have been the case with the conventional solution of excavation, disposal, and replacement.

Based on the success of the solution, the next phase of the project included this approach as part of the specifications and scope of work, to deal with similar conditions.

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REFERENCES


