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Geosynthetic Performance in a Wet Track Environment

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Key Findings:

- After approximately 40 to 50 million gross tons accumulated over two years, test results indicated that each of the geosynthetics provided adequate filtering and separation effects.
- Results of in-track sampling and laboratory analysis of the shoulders of each test section and the control section showed that the geosynthetics reduced the infiltration of fines into the ballast by about 70 percent.
- This study indicates that geosynthetics are an appropriate separation and remediation measure for fine-filled ballast situations in which the fines are pumped upward from the underlying subgrade. If fines are introduced into the ballast from degradation or surface infiltiration, other remediation solutions would likely be needed.

** Norfolk Southern, retired*

In a multi-year study, Transportation Technology Center, Inc. (TTCI) worked with Norfolk Southern Railway (NS) at a revenue service site in Cleveland, Ohio, to evaluate the ability of three geosynthetic systems to prevent the upward pumping of fines in a wet track and subgrade environment.

NS operates a double track route through the area, and another Class I and a local transit agency occupy adjacent rights-of-way. Each NS track carries about 20 million gross tons (MGT) annually.

The double track is located in a 100-foot-wide cut with an elevation approximately 20 feet lower than the surrounding topography. The subgrade in this area consists of relatively impermeable silts and shales with little capability for drainage. Because of the depressed elevation profile and impermeable subgrade, water tends to pond in the adjacent ditches resulting in accumulation of water in the ballast zone. Dynamic pumping during train passage increases water pressure, which pushes fines upward into the ballast zone.

NS installed three geosynthetic material systems in 80-foot test sections (plus an 80-foot control section) in Track No. 2. After removing about 16 inches of ballast and subballast (measured below bottom of tie) down to the native soils, the track panels were replaced and realigned and the track restored to service.

In an effort to separate the track from the fine-grained subgrade and reduce fines pumping into the ballast, a 320-foot-long test section was designed with three different geosynthetic reinforcement materials each installed beneath 80-foot track panels. The test also included an 80-foot control section where clean ballast was installed directly over the shale subgrade.

Geosynthetics are a widely used separation and filter barrier used in vehicular roadway, building perimeter, and railway track applications. Their function is to prevent the deleterious effects of fine-grained soil in specific areas or zones during and after construction. These deleterious effects include high soil moisture retention, low permeability and shear strength, high liquefaction potential, and intergranular lubricating effects.

SITE DESCRIPTION

The NS track has an annual tonnage of approximately 20 MGT and is located within a cut region that is approximately 20 feet lower than the surrounding topography. The underlying subgrade consists of relatively impermeable silts and shales with little capacity for drainage.

Due to the depressed track, standing water often is observed in adjacent ditches and sometimes in the gage. Standing water often corresponds with mud pumping, which can increase the rate of track geometry degradation. Figure 1 shows the cut region with a thoroughly fine-filled ballast section before installation of the geosynthetics.

Figure 1. Fine-filled ballast from mud pumping

MUD PUMPING

Track pumping and the filling of the ballast section with fines can occur through multiple mechanisms, including ballast breakdown, surficial soil intrusion, and subgrade soil intrusion. The appropriate remedial method to reduce ballast fine-filling will depend on the mechanism.

In this case, the mechanism of ballast fine-filling consisted of hydraulic fracturing of the shallow, soft, native shale supporting the ballast section followed by upward migration of the resulting fines from pumping and flooding (Figure 2). This mechanism of subgrade breakdown and mobilization is well-documented in other railway subgrade studies.[1] In these situations, draining excess water or installing a barrier layer would address the underlying mechanisms producing the ballast fine-filling.

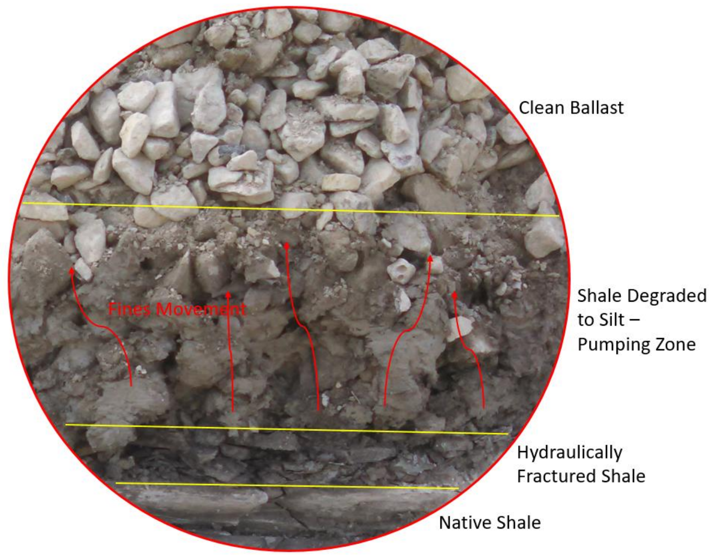

Figure 2. Breakdown of native shale and upward mud pumping

REMEDIAL SYSTEM INSTALLATION

Due to the difficulty of draining excess water from the track, different barrier methods were explored. Three different geosynthetics were selected for testing and, along with a control section, were installed to compare their effectiveness. The test materials included a a geocell product underlain by geofabric, a product specifically designed as an interlayer, and a geogrid bonded with fabric. These products are referenced as products “A,” “B,” and “C;” though not necessarily in that order. Each of these systems was tested in an 80-foot section against a fourth 80-foot control section that had no geosynthetic. The installation occurred in April 2016. Figure 3 provides design details and the test layout.

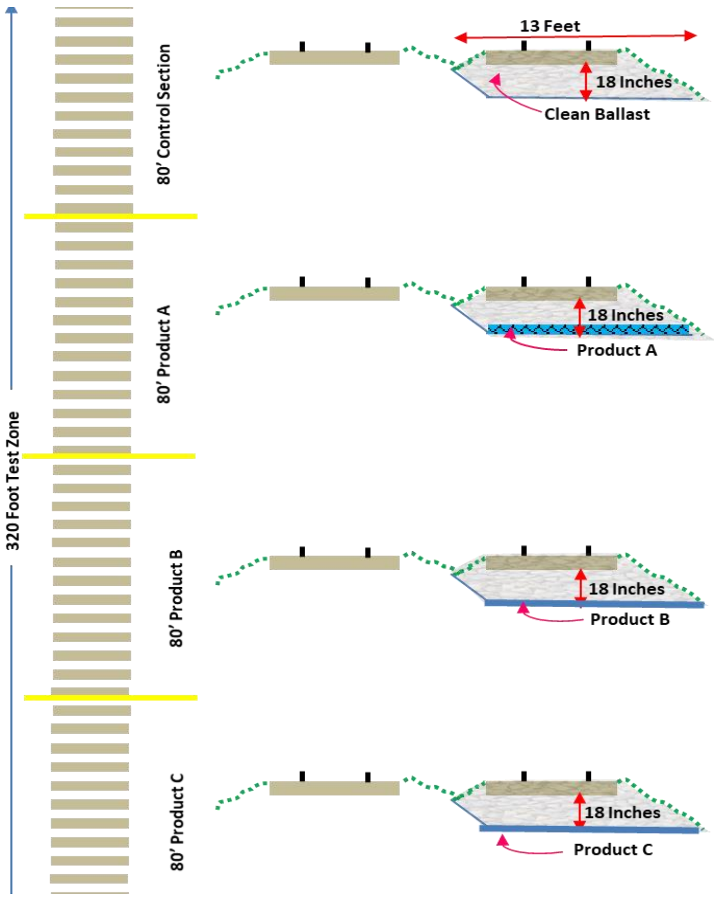

Figure 3. Test section layout

2018 SAMPLING RESULTS

To quantify the ability of the geosynethetics to reduce subgrade pumping and fine-particle intrusion, TTCI and NS worked jointly to take physical samples at ballast locations in each of the test and control sections. Shoulder area and under-rail sampling were performed; the gage cribs were not sampled.

TTCI and NS met at the Cleveland site in July 2018 to assess the ballast and geosynthetic condition after approximately 40 MGT. A backhoe was used to excavate samples from depths in each of the four test sections for a gradational assessment (Figure 4). NS noted that shoulder cleaning had been performed through the entire test zone in early 2018, so samples were collected from between the ties rather than from the shoulder.

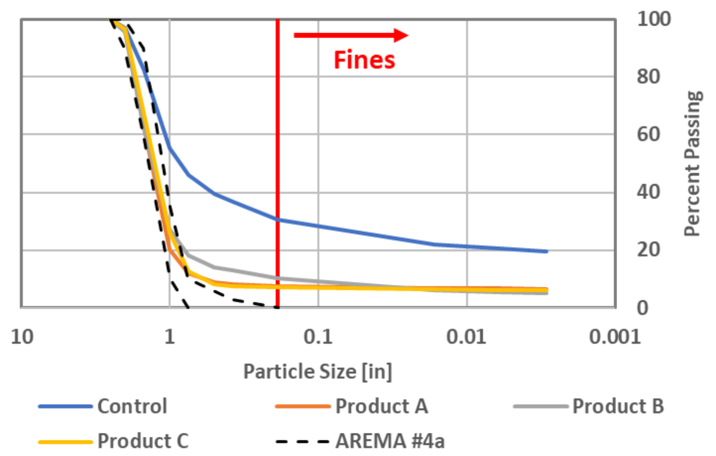

Figure 4. Sample gradation results

The percentage of fine material passing the No. 4 sieve and the associated ballast fouling index (FI) for each of the geosynthetics sections showed significant improvement compared to the control samples. The FI is defined as the summation of percentage by weight of ballast material passing the 4.75 mm (No. 4) and the 0.075 mm (No. 200) sieves.[1] (The FI provides a practical recognition of the deleterious effects of fines in the ballast; thus gives the fines percentage extra statistical weight.) For both metrics, the three test locations showed about a 70 percent reduction in fines compared to the control (Figure 5). The fines that did appear in the track section are believed to be from natural ballast degradation and possibly from the side if flooding did occur, but there is no evidence of any fines infiltrating the geosyntethics.

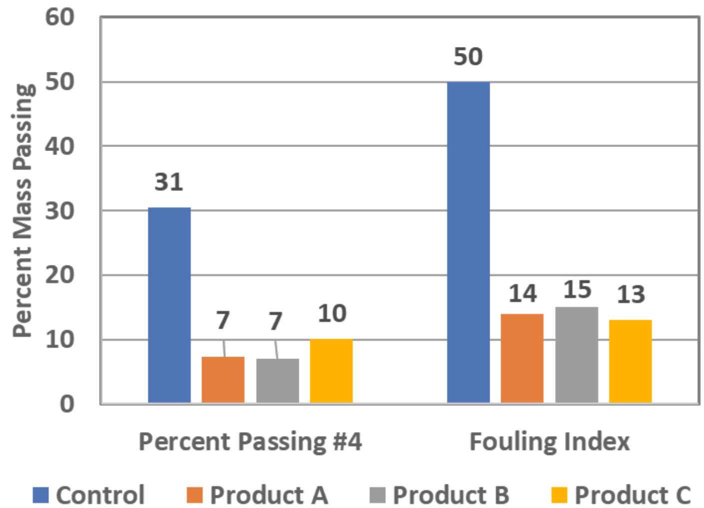

Figure 5. Sampling results

Since the lowest elevations in each test zone were flooded (or saturated) immediately above the geosynthetic during the site sampling activities, samples were not obtainable from these areas. However, fines tend to settle in quiescent flooded areas, so there was interest in documenting the cumulative volume of fine material that settled, washed in, and was produced by ballast wear. Figure 6 provides a visual measure of the fines that settled in the 6-inch tall geocells over the 2+ years of testing. Although the flood sediment-derived fines percentage appears significant in this lower area, the confining properties of the geocells still prevented track geometry degradation.

Figure 6: Geocell exposure showing fines infiltration

CONCLUSION

NS initiated the installation of three geosynthetic systems in 80-foot test sections, plus an 80-foot control section, in Track No. 2 by removing the ballast and subballast down to the native soil, or rock approximately 16 inches below bottom of tie. After placement of clean ballast on top of the geosynthetic systems, the track panels were re-installed and the track was surfaced and returned to service. The track carries approximately 20 MGT per year.

The results after approximately 40 MGT (over 2 years) indicate that each of the geosynthetics has provided adequate filtering and separation, reducing the fine percentage in the ballast by about 70 percent and maintaining a much cleaner ballast section. The project scope did not include a detailed comparasion of the products so that may be useful in future research projects.

References

1. Li, D., Hyslip, J., Sussman, T., and Chrismer, S., 2016. *Railway Geotechnics*, CRC Press, Cleveland, OH.

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