TECHNOLOGY DIGEST

Timely Technology Transfer

Test of GEOWEB® to Improve Track Stability Over Soft Subgrade

by Steven Chrismer

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Summary

A geosynthetic material known as GEOWEB® has been shown to significantly reduce traffic-induced stresses passed into track subgrade. Because track subgrade can be very sensitive to load increases — even for a limited number of large loads — the railroad industry is concerned about the effects of heavy axle loads (HAL), defined as 36-ton axle loads or greater. Much effort at the Facility for Accelerated Service Testing at the Federal Railroad Administration's (FRA) Transportation Technology Center near Pueblo, Colorado, has been focused on determining the effect of HAL traffic on a test section with a soft, deformable clayey subgrade and developing remedies to minimize the effects on marginal track substructure. This cooperative FRA/Association of American Railroads effort has shown that without the GEOWEB® the average tamping cycle was about 15 million gross tons (MGT). With the GEOWEB® the track has accumulated 85 MGT with only minimal loss of track geometry.

In recent years the effects of HAL upon subgrade performance have been studied extensively. Various remedies aimed at limiting the clayey subgrade settlement have been tested and their effectiveness judged. In particular, the geosynthetic material known as GEOWEB® was shown to provide increased track stability. The improved stiffness and load-bearing capacity of an additional composite subballast-GEOWEB® layer, placed over the soft clay subgrade, was found to reduce the traffic-induced stresses.

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Suggested Distribution:

- ❑ Research and Test
- ❑ Maintenance of Way
- ❑ Maintenance Planning
- ❑ Planning and Analysis

INTRODUCTION AND CONCLUSIONS

GEOWEB®, a geosynthetic material positioned as a layer in the subballast over soft clay subgrade, has been shown in tests to reduce the effects of heavy-axle-load (HAL) traffic on the subgrade. Under the cooperative Federal Railroad Administration/Association of American Railroads HAL program, extensive subgrade performance tests have been conducted over clayey subgrade. This particular test using GEOWEB® was performed to determine if this material provides a sufficiently stiff subballast layer to reduce stresses on the underlying soft subgrade.

The tests were conducted in the Low Track Modulus (LTM) test zone at the Facility for Accelerated Service Testing (FAST) at the Transportation Technology Center near Pueblo, Colorado. The LTM test zone provides a track modulus ranging from approximately 2,000 to 2,500 lb./in./in. and requires tamping on average every 15 million gross tons (MGT) of traffic loading to compensate for track settlement due to progressive shearing of the subgrade. (More information on the LTM test and results can be found in Reference 1.)

After GEOWEB® was placed in the subballast, as shown in exhibits 1 and 2, the measured vertical stresses on the subgrade surface from

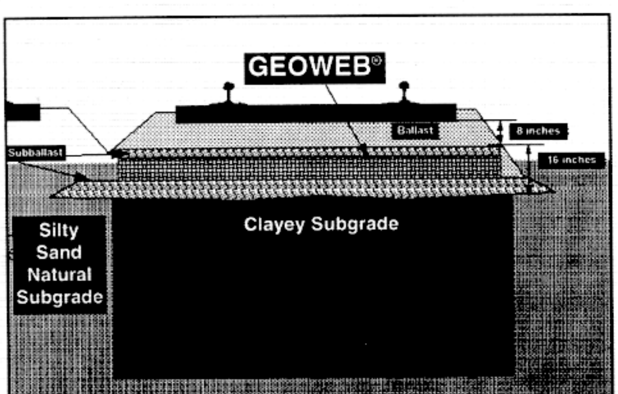

Exhibit 1. Track Construction with GEOWEB® in LTM Section of FAST

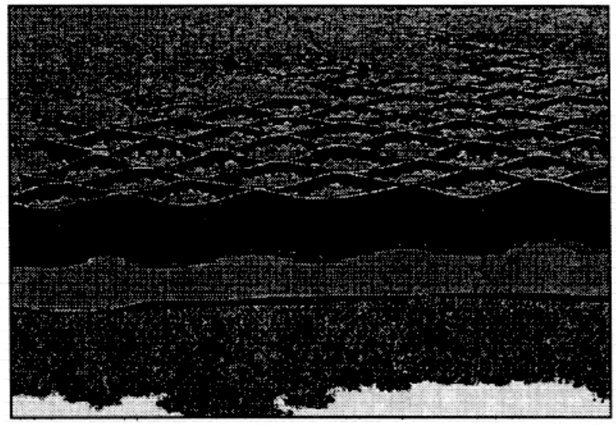

Photo courtesy Presto Product Company
Exhibit 2. GEOWEB® Cellular Confinement Systems

traffic loading were substantially reduced compared to the previous condition with no GEOWEB® but an equal granular layer thickness of ballast and subballast. With 85 MGT since the GEOWEB® was installed, track roughness is accumulating relatively slowly and is not expected to require surfacing in the near future.

SUBGRADE SENSITIVITY

The settlement of a soft, clayey soil can be very non-linear with load magnitude. The load sensitivity of a clayey subgrade is due to its fine-grained nature which does not allow rapid drainage of repeated load-generated excess water pressure in the pores of the soil. Because subgrade settlement can be non-linear with load magnitude, it becomes very important to accurately characterize the number of these largest loads which are expected to occur over the design period.

The measured vertical stresses on the clayey subgrade surface from HAL traffic loading varied from 10 to 25 psi depending on the amount of track roughness at the time of measurement. Because the unconfined compressive strength of the LTM clay is approximately 13 psi, it can be seen that the upper range of loading represents a significant over-stress.

Investigations of subgrade failure indicated significant subgrade squeezing (progressive shear failure) in the test zone. Subgrade surface soil from under the rail to the tie end was pushed outward and upward to the ballast shoulder. As a result of significant subgrade deformations, track surface, cross-level, and twist geometry deviations were unacceptable for FRA Class 4 operations. Also, the rate of track geometry deterioration was found to be directly related to track modulus as the track roughness would increase rapidly at locations in the LTM where the track modulus was equal to or less than 2,000 lb./in./in.

GEOWEB® TEST IN LTM

One of the most effective methods to reduce the stresses transmitted to a soft subgrade layer is to increase the stiffness of the overlying layer. This was the aim of placing a GEOWEB® material in the subballast layer in the LTM section. When GEOWEBs® are expanded from their collapsed state prior to placement in the track, the interconnected cells attain an approximate honeycomb structure with open tops and bottoms which are filled with granular material (in this case subballast). The sides of the cell walls provide lateral confinement to the subballast resulting in a reinforced soil layer. The GEOWEB® and subballast act as a composite material resulting in increased stiffness and more load-bearing capacity than with the subballast alone.

As shown in Exhibit 1, subballast extends a few inches above and below the GEOWEB® providing a nominal subballast layer thickness of 16 inches. After placement of the subballast, a steel drum vibratory roller was used for compaction. Then an 8-inch layer of ballast was placed, followed by the track superstructure. Measurements of track geometry, track modulus, and subgrade pressures were obtained as traffic tonnage accumulated.

As stated, the average tamping cycle duration before GEOWEB® placement was about 15 MGT, although it ranged from a high of about 30 MGT to as low as 1 MGT. The GEOWEB® was placed while the track was experiencing the 1 MGT tamp cycle conditions. After 75 MGT since GEOWEB® installation, the track geometry error is still well within the limits for FRA Class 4 track. Judging by the current rate of increase in the cross level and profile error, geometry-correcting maintenance should not be required in the near future.

The reason for the increased stability appears to be due to a reduction in subgrade vertical stresses as shown by Exhibit 3. The subgrade stresses under 40-mph traffic were obtained for both pressure transducers under the rail-tie seat (usually the location with the maximum pressures) for each of three consecutive ties.

Figure 3 shows the averaged data for these six measurement locations. This "percent exceeding" type of graph allows good visualization of the relative occurrence of the maximum stresses to which track settlement is so sensitive for LTM-type subgrade. Note that the vertical subgrade stress data for the case with HAL and GEOWEB® seems to indicate a significant stress reduction below the case of HAL with unreinforced subballast. It is also interesting to note that the pressure data for 39-kip wheel loads without GEOWEB® is nearly a uniform 20 percent increase over the 33-kip data which is consistent with the load increase.

It appears that the reinforced subballast layer had the desired effect of reducing the pressures passed on to the subgrade by pro-

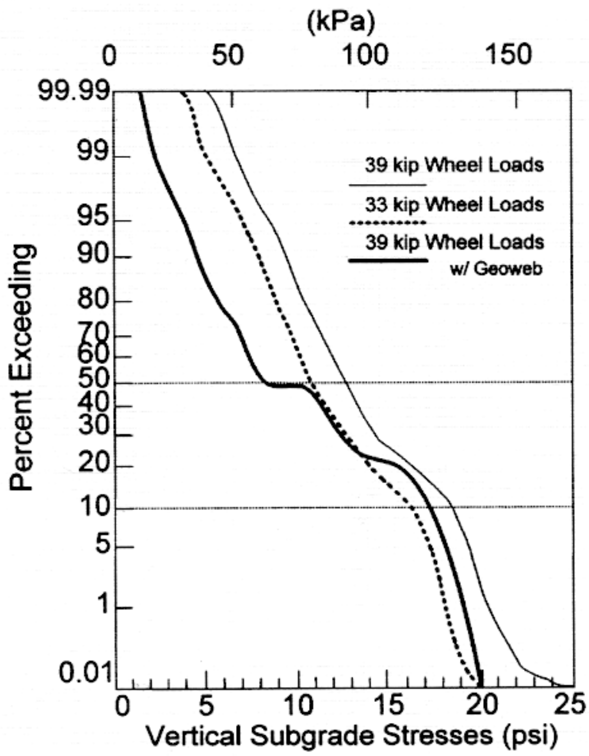

Exhibit 3. Subgrade Vertical Stress Distribution under Various Wheel Loads and Track Conditions

viding a stiffer upper layer. Although it could not be confirmed, it may be possible that the GEOWEB® gave an additional benefit by reducing the variability (as well as the overall magnitude) of deviator stresses imposed on the subgrade along the long axis of the tie. If such an effect did occur, this would provide improved stability by reducing the progressive shear failure occurring near the tie ends by producing a more uniform distribution in the deviator stress.

The testing and track geometry measurements are expected to continue at least until the track requires surfacing so that the actual improvement in tamping cycle can be determined and economic analysis of the benefits can be conducted.

FUTURE TESTING IN LTM

After the GEOWEB® test is completed, a test of asphalt underlayment is proposed to be installed in the FAST/LTM track section in 1998. The LTM provides a suitable test site to evaluate the performance of hot-mix asphalt (HMA) underlayment and the amount of benefit gained in stabilizing the track and reducing the maintenance requirement compared to previous attempts at remediation. The test may also provide valuable information to the efforts now underway by Committee 1 of the American Railway Engineering Association to establish design guidelines for the use of HMA in track. The test will also be used to establish the HMA failure modes (if failure occurs within the test period) which will be used to help establish design criteria.

REFERENCES

1. Li, Read, and Chrismer, TD 97-020.

Note: Contact Steve Chrismer at (719) 584-0590 with questions or comments regarding this document.
E-mail: steven _chrismer@aar.com