TECHOLOGY DIGEST

Timely Technology Transfer — 01-022

Comparison of Three Methods for Strengthening Bridge Approaches in Revenue Service

by David D. Davis, Ruben D. Peña B. and Brian Doe

Summary

Transportation Technology Center, Inc. and the Union Pacific Railroad conducted a revenue service test of bridge approach strengthening methods. The subgrade strengthening methods were evaluated by monitoring track elevations and surfacing work performed on newly constructed track and bridges. Four bridges and their approaches were monitored in the test: one with standard track construction (as the control section) and three with subgrade strengthening methods intended to reduce track settlement. The three strengthening methods consisted on special subbase layers: Hot Mix Asphalt (HMA), soil cement, and a geocellular confinement system called GEOWEB®.

Conclusions drawn from the study include:

- Track on the bridge approaches has more settlement than track on the bridges or open track. The bridge approaches are often the driver of surfacing maintenance.
- None of the three strengthening methods is performing better than the granular sub-base control section.
  - The relative performance of each bridge approach appears to be affected more by local conditions than by the subgrade strengthening method used.
  - Cumulative bridge approach settlement is correlated to open track settlement at each site, with the difference in settlement between the bridge approach and the surrounding open track being similar at all sites.
- The lowest spot on the approaches occurred at 20 to 25 feet from the end of the bridge during the first 100 MGT. This is about one half the length of the truck center distance of typical coal cars. During a period of 35 mph speed restrictions, the lowest spots moved to within 15 feet of the bridge.
- The "downstream" approach (in terms of loaded traffic direction) has developed larger surface dips.
- The surrounding track, also newly constructed, is settling at a higher rate than is typical for heavy tonnage mainline.
- Settlement of the track on the ballasted deck bridges has been about 1/3 of that on the approaches. This is all occurring in the ballast layer, presumably accelerated by the frequent tamping initially required.

A comparison of bridge approach performance was made on a Union Pacific line using bridge approaches from newly constructed, ballasted deck bridges. The approaches of four bridges were each monitored for surface performance and required maintenance from installation in 1999 to September 2001. The two-track line has a significant amount of tonnage at 150-180 MGT per year.

Suggested Distribution:
- ❑ Maintenance of Way
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

INTRODUCTION AND CONCLUSIONS

Changes in track structure, such as those that occur at bridges, often cause maintenance problems. The sudden change in track structure or support conditions associated with bridges and bridge approaches can result in track running surface discontinuities, changes in dynamic properties, and impact loads to the structure. Many bridge approaches are seen with a dip a few ties from each end of the bridge.

Work with subgrade strengthening methods has been successful in mitigating support problems with open track and special track work in soft subgrade locations.[1,2] Both HMA and geocellular confinement layers have been successful in reducing surface maintenance in soft subgrade test sections under HAL operations. Success of these methods is attributed to their ability to effectively spread load over the subgrade and reduce peak stresses. Additionally, HMA can provide a moisture-proof barrier that protects the subgrade from surface moisture.

During the construction of a second track on portions of a heavy tonnage coal route, Union Pacific installed a test section of bridge approach strengthening methods. Each of the methods was used to strengthen the approaches on a pre-cast concrete ballasted deck bridge. Exhibit 1 lists the subgrade strengthening methods used in constructing the test sections.

Exhibit 1. Subgrade Strengthening Methods used in the Bridge Approach Test Section

Subgrade Strengthening Method	Layer Thickness (in.)	Approach Length (ft)	Comments
Control Granular Subballast	8	100	UP standard construction
HMA	8	100	Rolled & Compacted
Soil Cement	80 to 8	23.5	Thickness decreases with distance from bridge after 10 ft
Cellular Confinement GEOWEB™	8	100	Back filled with subballast & rolled

The bridges were 30 to 180 feet long with 28-foot spans typical. The track structure consisted of 133-RE rail, concrete ties, elastic fasteners, and 12 inches of ballast below the bottom of the tie. The bridge approach embankments were built of selective fill materials. The embankment was constructed in 6-inch lifts to 95 percent modified Proctor compaction.

After 150-180 MGT of HAL traffic, the following conclusions were drawn:

- Track on the bridge approaches has more settle ment than track on the bridges or open track. The bridge approaches are often the driver of surfacing maintenance.
- None of the three strengthening methods is performing better than the granular sub-base control section.
  - The relative performance of each bridge approach appears to be affected more by local conditions than by the subgrade strengthening method used.
  - Cumulative bridge approach settlement is correlated to open track settlement at each site, with the difference in settlement between the bridge approach and the sur rounding open track being similar at all sites.
- The lowest spot on the approaches occurred at 20 to 25 feet from the end of the bridge during the first 100 MGT. This is about one half the length of the wheelbase of typical coal cars. During a period of 35 mph speed restrictions, the lowest spots moved to within 15 feet of the bridge.
- The "downstream" approach (in terms of loaded traffic direction) has larger surface dips.
- The surrounding track, also newly constructed, is settling at a higher rate than is typical for heavy tonnage mainline.
- Settlement of the track on the ballasted deck bridges has been about 1/3 of that on the approaches. This is all occurring in the ballast layer, presumably accelerated by the frequent tamping initially required.

Test Section Performance

Being newly constructed track, all sections are settling at a higher rate than is typical under HAL traffic. This is seen in open track 150 feet from the bridge, in the bridge approaches, and on the bridges themselves. Exhibit 2 shows a plot of average track settlement rate (top of rail elevation loss) versus tonnage. While track settlement occurred on all track tested, the bridge approaches have the most surface roughness. The track on the bridges is relatively stable, with lower support values beyond the bridge abutments. It was observed that initial settlement on the bridges has been about one third of the initial settlement on the approaches. This suggests that the majority of settlement is occurring in the subgrade layers. The Control and the HMA sections are performing somewhat better than the other two sections in terms of settlement.

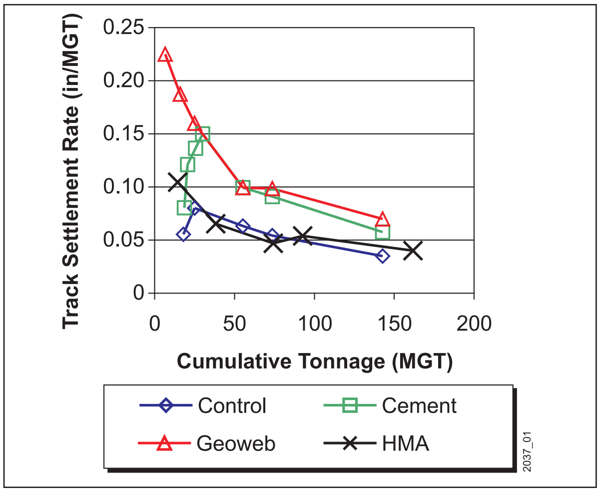

Exhibit 2. Track Settlement vs. Tonnage for each Test Section

Performance of the track surface on the approaches with strengthened subgrade layers has been similar to the control approaches. All approaches exhibit the characteristic low spot at 20 to 25 feet from the bridge abutment. This length is about one half the length of the truck spacing of a typical freight car. Exhibit 3 shows the track surface at one bridge just before surfacing.

Exhibit 4 shows the relationship between settlement in open track (150 ft from the bridges) on the bridge approaches and on the bridges for the latest maintenance interval. The approaches have settled the most, followed by open track and the bridges. The approaches are all on newly constructed embankments; whereas, the tracks on the bridges do not have subgrade under the ballast. There also appears to be a relationship between the amount of settlement on the approaches and the amount of settlement in open track without strengthening. Thus, local conditions may be responsible for the relative performance of the four test sections.

Exhibit 5 is a plot of settlement versus location for the bridge approaches. The plot shows where settlement was occurring on the approaches prior to the surfacing done in April 2001. The most deformation (i.e., track low spot) was at 14 feet on each of the test approaches and 11 feet on the control section. The low spot location has moved towards the bridges in most sections compared to previous surfacing cycles. This may be due to the slow order imposed during the winter of 2000-2001. Train speeds were reduced from 50 mph to 35 mph on this line.

Exhibit 3. Track Surface on HMA Approach Bridge Prior to Surfacing

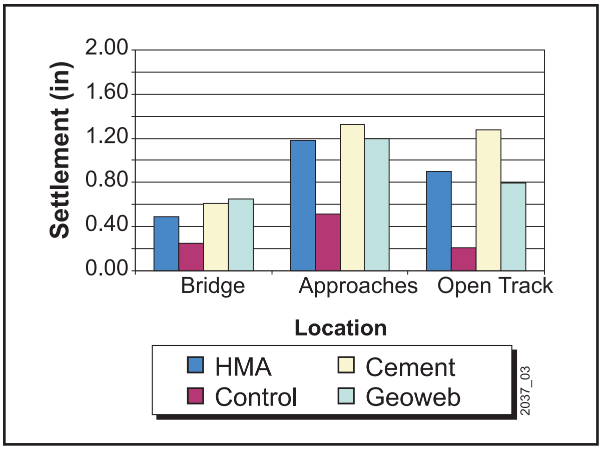

Exhibit 4. Settlement by Location Bridge Approach Test

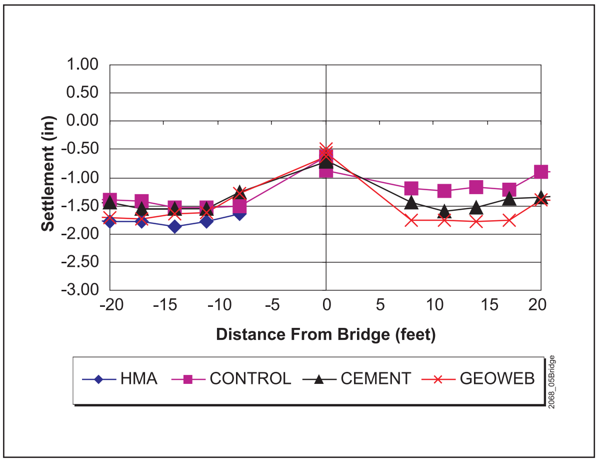

Exhibit 5. Track Settlement vs. Distance from Bridge Recent Measurement

Performance Measurements

The performance of the track is being measured in several ways. Track surface is measured with surveys of the unloaded top of rail profile. Pre- and post-maintenance profiles are measured when possible to determine recent settlement. Track maintenance records are collected to determine what maintenance is being done.

Some of the pitfalls of revenue service testing, where many variables are uncontrolled, have been seen in this test. Rail strain gages and accelerometers were installed at locations on the approaches. These gages were placed where the maximum loads were expected to occur. Analysis of the data, however, shows that the gages are further from the bridges than the locations of maximum settlement. Dynamic loads are lower than expected static loads, indicating most cars are bouncing prior to the load cells and partially unloading at the load cells. Plates installed in the track to determine the settlement of the test layers vs. the total track settlement were destroyed during the track laying operation.

FUTURE WORK

TTCI will continue monitoring the performance of these bridge approaches in 2002. Additionally, TTCI will investigate track transition issues at bridge approaches under a program sponsored by the Federal Railroad Administration.

Acknowledgement

The assistance of the following Union Pacific personnel was essential to this study: Bill Gemeiner, Manager Research & Methods and Bill Stapp, Bridge Engineer.

REFERENCES

1. Li, Dingqing, Jerry G. Rose, Henry M. Lees, Jr., and David D. Davis. July 2001, "Hot Mix Asphalt Trackbed Performance Evaluations at Alps, NM," *Technology Digest* TD01-015, Transportation Technology Center, Inc., Pueblo, CO.

2. Rose, Jerry. Use of Hot Mix Asphalt for Road Crossings and Turnouts, AREA Annual Technical Conference, 1994.

Note: Please contact Dave Davis at (719) 584-0754 with questions or comments about this document.

E-mail: dave_davis@ttci.aar.com
Web site: www.ttci.aar.com