TECHOLOGY DIGEST

Timely Technology Transfer — 01-015

Hot-Mix Asphalt Trackbed Performance Evaluation at Alps, New Mexico

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Summary

The Transportation Technology Center, Inc., in conjunction with the Burlington Northern and Santa Fe (BNSF) Railway and the University of Kentucky, evaluated the performance of hot-mix asphalt (HMA) trackbeds in the BNSF mainline near Alps, New Mexico. Approximately 2.2 miles of HMA trackbeds were installed between 1989 and 1994 as a remedy for soft subgrade problems. Interim tests indicate that HMA track has performed well in 40 million gross tons (MGT) per year track.

In the 1980's, BNSF made several track alignment changes near Alps, New Mexico, to reduce sharp curves. The relocated line, with conventional granular layer construction, was soon found to be inadequate to carry increased coal traffic, particularly in cuts where the relocated track was built on native weak subgrade. Some of these problem track locations required surfacing operations on a daily or up to monthly schedule to keep the track in service. Sources of the problems include weak clay soils, groundwater, and poor drainage, which attributed to excessive subgrade deformation, subgrade soil attrition and mud pumping.

Investigation results for the 2.2-mile HMA track indicate:

- Since installation, the HMA application has been effective at solving geometry deterioration and mud pumping problems and has lengthened surfacing cycles in the problem areas by 10 to 20 times. Currently, out-of-face surfacing is conducted once a year on HMA sections, with two isolated locations (in the earlier construction section) receiving spot tamping up to six times per year.
- Deterioration or cracking of HMA was observed at only two HMA coring locations. Analysis of the HMA samples from one of these two locations (from earlier installation) show large air voids in the HMA, obviously due to lack of compaction during the construction.
- No excess water developed under the HMA, which provided an impermeable layer, leading to decreased moisture content in the subgrade.
- Between the control granular layer section (with increased thickness) and the HMA sections, the latter showed less roughness, but more ballast fouling. Nevertheless, those differences are not significant.
- One failed HMA site involved 120 feet of track constructed on a very weak clay-shale cut where groundwater is present year around. The HMA was removed and the track was installed with a cross track drain.

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

Work performed by TTCI Transportation Technology Center, Inc.
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INTRODUCTION AND BACKGROUND

In the early 1980's, the Burlington Northern (BN) Railroad upgraded a secondary mainline from south of Pueblo, Colorado, through northeastern New Mexico, to northern Texas to carry increased coal traffic. The original alignment with sharp curves was undesirable for unit train traffic. Some alignment changes were constructed by company forces and the ballast was placed directly on the subgrade. Some larger line changes were constructed by grading contractors. The original engineering construction records are not available due to changes in headquarters and purging of old files. Typical railroad roadbed construction was done on the new alignment. At several locations, a filter fabric (geotextile), with 4-inch subballast and 8 to 12 inches of ballast was placed over the graded subgrade. The track superstructure was also upgraded to the BN mainline standard of 132RE continuous welded rail (CWR) and later with concrete ties.

The upgraded track proved to be acceptable for heavy coal train service in most instances. However, track surface problems were noted with the line relocations in the area near Alps, New Mexico. This area, near the crest of a hill, has many sharp curves and severe grades. The subgrade soils are weak and variable. With access of water to track and poor drainage, loss of track surface due to mud pumping and subgrade deformation became chronic maintenance problems from Mile Post 271 to Mile Post 274. Surfacing cycles were required monthly or weekly at different locations, and even daily on the worst spots. The track was frequently slow ordered and two track geometry-related derailments occurred.

To remedy the track instability problems, the railroad applied a roller-compacted 8-inch-thick hot mix asphalt (HMA) underlayment to the most troublesome section of track. This provided immediate relief to the railroad, allowing cessation of daily surfacing and slow orders. Following the first application in 1989, additional sections were installed in 1992 and 1994, comprising about 2.2 miles. The 1994 installations included a more rigorously documented "test" section that also included a 4-inch HMA section, and a control section of "all granular layer."[1] For all the sections, the combined thickness of ballast, HMA and subballast ranged from 19 to 21 inches. Exhibit 1 lists the locations of these sections, years installed, and the specified layer depths at construction. It needs to be pointed out that the 1994 "test section" was built near the original alignment. Although it had been a poor performing location, it was not in the sections with the worst track geometry performance. The worst sections were the first to be built with HMA in 1989 and 1992.

In the past, reported benefits of HMA trackbeds included attenuating loads over the weak subgrade soils, providing an impervious separation layer between the ballast and the subgrade which prevents surface water from entering and weakening the subgrade soil, and reduced subgrade mud pumping. Concerns raised about HMA usage included developing pore water pressure under the asphalt, crack development in the asphalt, durability of the HMA, and installation cost. The performance evaluation of this 2.2-mile HMA trackbeds was intended to verify and address some of these reported benefits and concerns.

TRACK GEOMETRY PERFORMANCE

Documenting track maintenance over such short sections of track and long periods of time was difficult. Interviews with local and regional track maintenance personnel were conducted to determine the extent of changes in surface maintenance at the HMA underlayments. Those interviewed reported a significant decrease in the surface maintenance required operating the railroad at 35 mph with unit coal trains. The HMA installations have been successful in solving track surface problems on the soft subgrades. In general, HMA application has lengthened surfacing cycles in the problem areas by 10 to 20 times. Currently, out-of-face surfacing on HMA track is conducted once a year, with only two isolated locations receiving spot surfacing up to six times per year.

Mile Post (old stationing)	Section	Design Depth: Ballast	Design Depth: HMA	Design Depth: Subballast	Actual Depth: Ballast	Actual Depth: HMA	Actual Depth: Subballast
272.0– 272.1	All granular (1994)	16"	----	5"	16.0-17.0"	---	5.0"
272.1 – 272.2	4" HMA (1994)	10"	4"	5"	4.5-8.0"	3.3-3.5"	2.0-4.5"
272.2 – 272.5	8" HMA (1994)	6"	8"	5"	2.5-7.0"	6.3-7.0"	3.0-6.0"
271.0 – 271.5 272.5 – 273.2 273.6 – 273.8	8" HMA (1992)	8"	8"	5"	20.0"	9.0"	1.5"
273.2 – 273.6	8" HMA (1989)	8"	8"	5"	9.0-13.0"	7.3-8.0"	5.0-6.8"

Exhibit 1. List of HMA Trackbed Sections

For the 1994 test section, no significant difference in geometry performance has been observed between the 4-inch HMA, the 8-inch HMA, and the control "all-granular layer" test sections, although the "all-granular layer" developed more roughness. After approximately 240 MGT of service, all sections have performed well. However, as mentioned earlier, the 1994 test section was near the original alignment that was not in the worst performance sections.

FIELD INVESTIGATION AND TEST RESULTS

In the summer of 2000, a field investigation was conducted to examine HMA trackbed conditions and to obtain samples of ballast, subballast, subgrade soils, and HMA cores for laboratory tests. Listed also in Exhibit 1 are the actual ranges of layer depths obtained at the nine sampling locations. As shown, ballast thickness for the HMA sections varied greatly with one spot having only 2.5 inches of ballast, below BNSF's minimum recommended depth of 12 inches. The earlier installed sections, however, have significantly more ballast. The actual HMA depths were generally thinner than the specified 4 or 8 inches.

All the collected samples were tested in a laboratory to determine material characteristics and their comparisons with the specifications or recommendations. Exhibit 2 shows the aggregate size distributions for the two HMA core samples and the range recommended by the Asphalt Institute.[2] As shown, the aggregate sizes are slightly finer than recommended.

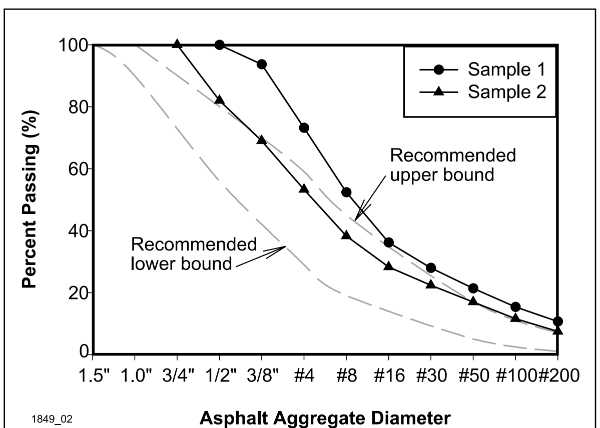

Exhibit 2. Asphalt Aggregate Size Distribution

The gradation results of the subballast samples and the range recommended by the American Railway Engineering and Maintenance of Way Association (AREMA) Manual are shown in Exhibit 3. As illustrated, the actual sizes of subballast materials are finer than those recommended.

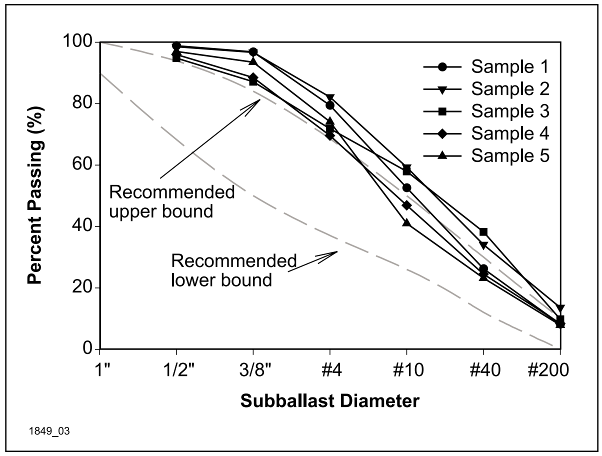

Exhibit 3. Subballast Grain Size Distribution

The ballast degradation results are compared among the 1994 control "all-granular" test section, the 4-inch HMA section, and the 8-inch HMA section in Exhibit 4 after approximately 240 MGT. As illustrated, the ballast degradation for the two HMA sections (classified as moderately clean to fouled) was only slightly higher than for the control "all-granular" section (classified as clean).

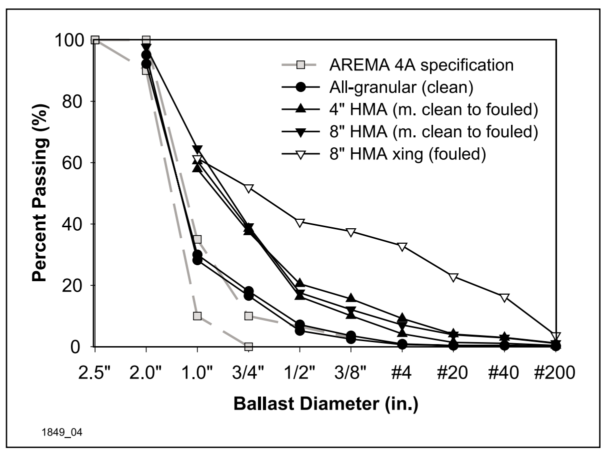

Exhibit 4. Ballast Grain Size Distribution

The moisture contents of the subgrade and subballast samples collected in the summer of 2000 are shown in Exhibit 5. For comparison, the moisture contents obtained for the subgrade samples collected prior to HMA installation are also shown in Exhibit 5. As illustrated, subballast moisture contents are low, typically 5 to 7 percent, indicating that the HMA has provided an impervious layer and no excess water has developed under it. The comparison of the results before and after the HMA construction shows that subgrade moisture content has been reduced.

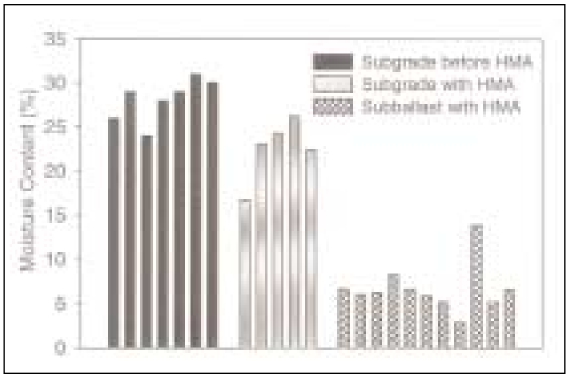

Exhibit 5. Subgrade and Subballast Moisture Content

IDENTIFIED PROBLEM SPOTS

Only three isolated problem areas are evident in the 2.2 miles of HMA track. At one site, mud-pumping occurred when a temporary construction road crossing made of subballast was not entirely removed. The gradation result for the fouled ballast is also included in Exhibit 4.

The second failed HMA location involved 120 feet of track in a curved cut section. At this location, groundwater is present almost year round and there was inadequate provision for drainage. Due to poor soil, ground water conditions, and inadequate subgrade construction, a subgrade shear failure occurred within one year following the HMA construction. To remedy this problem, a section of HMA was removed and cross-track drainage (ballast French drain) was installed.

The third HMA failure location involved 30 feet of the HMA squeezed out from under the track primarily due to a subgrade shear failure. Subsequent analysis of the HMA in this section showed that it was not compacted. It had an air void content of 15-16 percent (as compared to 4 to 6 percent for the rest of the HMA core samples collected, and the recommended range of 1 to 3 percent to ensure compaction). Thus, the HMA was not impervious, but allowed water to pass through and saturate the subgrade fill section. In addition, a less compacted HMA could deform and break more easily.

FUTURE WORK

HMA is one of several remediation techniques available to railroads to solve track surface problems over weak soils. TTCI has evaluated the performance of two other methods and is in the process of evaluating HMA underlayments under 39-kip wheel load traffic at the Facility for Accelerated Service Testing (FAST). After the long-term performance of HMA is established, further work will determine the economics of each method. Guidelines on the most economical solution for various operating scenarios will be developed.

ACKNOWLEDGMENTS

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REFERENCES

1 Chrismer, S.M., Terrill, V. and Read, D.M., "Hot Mix Asphalt Underlayment test on the Burlington Northern Railroad," R-892, Association of American Railroads, July 1996.

2 "HMA Trackbeds – Hot Mix Asphalt for Quality Railroad and Transit Trackbeds," *Information Series IS-137*, Asphalt Institute, 1998.

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