HMA Underlayments Solve Railroad Maintenance Issues

by Tom Deddens, Asphalt Institute Field Engineer

Although maintenance costs have increased dramatically for today's freight railroads, typical track roadbed construction and maintenance technologies have changed little over the past 100 years. Thousands of miles of roadbeds are in need of strengthening or rebuilding.

New technology is needed to provide stronger and longer-lasting structures to carry the higher speeds and heavier axle loading with a minimum of maintenance expense. Conventional ballast systems may no longer be feasible on some trackbeds with weak or unstable subgrades. For these conditions, hot mix asphalt (HMA) underlayment of trackbeds is a practical and effective answer.

HMA underlayments are generally used in difficult soil conditions where the use of conventional track bedding—usually stone ballast—does not provide satisfactory long-term support for heavy rail traffic.

Consequently, the best candidates for HMA underlayments are those carrying heavy rail traffic where one or more of the following conditions exist:

- ▲ Weak subgrade lacking the strength to support ballast and track
- ▲ Improper or insufficient drainage of the railbed structure
- ▲ Subgrades subject to a shallow groundwater table
- ▲ Subgrades sustaining high impact stresses at joints, special track works, bridge or tunnel approaches or open track where the track stiffness changes abruptly

A 30-Year Experiment

Railroad researchers and railroad maintenance engineers have been experimenting with HMA underlayments for more than 30 years. In 1969, an HMA underlayment was placed directly on the subgrade on a test section of the Santa Fe's track serving York Canyon Mine near Raton, New Mexico. The subgrade was composed of expansive clay that was subject to ponding.

This section of track is still in service after more than thirty years and very little maintenance has been performed on it during its service life. For those reasons, the test section's outstanding performance caught the attention of railroad maintenance engineers. They began using HMA underlayments beneath sections of track that required frequent maintenance and geometry corrections.

Increased Service Life

Placing HMA underlayment beneath these track structures often doubles their service life. An example of this is the double-diamond crossing at Sheffield Junction in eastern Kansas City. In 1985, Union Pacific (UP) placed HMA underlayment beneath the crossing. Before that, UP was replacing the structure every 1.5 years. Five years after placing the HMA underlayment, the structure was in good condition and performing well. The only maintenance required was some grinding of the rails. Not only were the costs of material and labor reduced, but there was also a substantial cost savings because traffic was not interrupted.

The Union Pacific has also used HMA underlayment to stabilize the subgrade beneath its mainline track through the Sand Hills region of Nebraska. Within this geographic area, the native sandy soils generally consist of between 20 and 25 percent material passing the #200 sieve. This fine material makes the soil subject to fluffing when it dries out and subject to pumping when it becomes excessively wet. To make the situation worse, quality limestone aggregates are scarce and require expensive, long hauls.

Supports High-Speed Mainline Track

Burlington Northern/Santa Fe (BN/SF) uses HMA underlayment for the support of heavy-duty, high-speed mainline track. Trains operating on this track typically consist of cars loaded with 120,000 pounds operating at speeds up to 80 miles per hour. These tracks cannot afford to have variation in the top rail elevation between adjacent tracks (called yawing) or longitudinally along the length of the track (called pitching).

The rapid yawing and pitching which result when the train is traveling at high speeds can result in the derailment of the train, loss of cargo,





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and a significant interruption of traffic. The BN/SF is currently in the process of double-tracking most of its high-speed, transcontinental track located in northern Oklahoma, the Texas panhandle, New Mexico and Arizona. HMA underlayment is included in the design section of a number of the new track sidings along this route.

HMA Underlayment in Tunnels

The Cincinnati Southern Express (CSX) has made significant use of asphalt underlayment for the support of expensive track structures, such as track switches, track crossings and roadway crossings.

CSX also pioneered the use of HMA underlayments on the floor of tunnels with approximately 12 inches of ballast supporting wooden or concrete ties. The HMA underlayment acts to reduce some of the vibration that develops between the massive locomotive and the hard rock tunnel floor.

Underlayment Mix Design

When HMA is used as trackbed underlayment, the composition is significantly different from that used in conventional roadway applications. The composition that provides the best performance for trackbed underlayments is a low modulus mix made by specifying the local dense-graded highway mix containing a maximum aggregate size between 1.0 and 1.5 inches. The asphalt binder content is increased approximately 0.5 percent above optimum highway applications. This creates the low modulus mix that can be easily compacted to a density of less than 5 percent in-place air voids and voids filled with asphalt greater than 78 percent. Used as a conventional roadway application, this mix would probably flush and rut. But this relatively soft, flexible material is just the right mix for railroad trackbeds. The increased percentage of asphalt binder in the mix increases its durability and prevents raveling and cracking.

Research Efforts

A substantial amount of private research has been done over the last twenty years by railroad researchers, the asphalt industry and university professors. Two of the experts, Dr. Jerry Rose, University of Kentucky, and Jay Hensley, retired Chief Engineer of the Asphalt Institute, have concluded that HMA underlayment provides specific benefits that maximize the operational efficiency of the railtrack system. Some of these benefits are:

▲ HMA underlayment separates the subgrade from sub-ballast and ballast layers.

▲ It prevents contamination or fouling of the ballast by the subgrade and significantly reduces stress distribution on the upper layers of ballast.

▲ It creates an impermeable layer that diverts water from infiltrating the ballast, which prevents fluctuation in subgrade moisture content and, consequently, variation in subgrade strength.

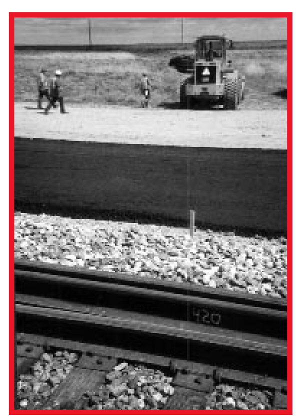
▲ It enhances load distribution and reduces the compressive live loads applied to the subgrade.

▲ It increases the modulus of the ballast and sub-ballast layers. Impregnation of the sharp ballast into the flexible surface of the HMA underlayment provides a high level of confinement for the ballast, which, in turn, develops high shear resistance and uniform distribution of applied live loads.

TTCI Research

During the last ten years, full-scale testing by the Transportation Technology Center, Inc. (TTCI) in Pueblo, Colorado, has substantiated much of the work done by railroad researchers. TTCI is a subsidiary of the Association of American Railroads, the Federal Railroad Administration, the railroad industry and various suppliers.

In 1991, TTCI set up an experiment on the High Tonnage Loop



(HTL) of the Facility for Accelerated Testing (FAST) track. A pit approximately 700 feet long, 12 feet wide and 5 feet deep was excavated in the subgrade beneath a section of existing track. The intent of the experiment was to model the effect of a low modulus subgrade on track modulus and geometry.

130 Million Gross Tons of Traffic

Between 1991 and 1996, this section of track was subjected to approximately 130 million gross tons of traffic (39-ton axle load rail cars). During the initial phase of testing the conventional cross section, correction of track geometry was required at intervals of 10 to 30 million gross tons. Near the conclusion of these phases, however, correction of the track geometry was required after 1 to 2 million gross tons until a general shear failure of the subgrade occurred.

Between 1996 and the summer of 1999, the track cross section was modified to consist of approximately 6 inches of sub-ballast, 16 inches of fabric-reinforced sub-ballast, and 8 inches of ballast supporting concrete ties and rails. After the application of more than 180 million gross tons of traffic, the reinforced sub-ballast was still well within deflection tolerances permitted for the composite material and did not require any reestablishment of track geometry.

HMA Underlayment Test

During the summer of 1999, the fabric-reinforced material was removed and the track cross section was modified to accommodate two different thicknesses of HMA underlayment. One 350-foot segment consisted of 6 inches of sub-ballast, 4 inches of compacted HMA underlayment, and 12 inches of ballast supporting concrete ties and rail. The second 350-foot segment consisted of 6 inches of sub-ballast, 8 inches of compacted HMA underlayment and 8 inches of ballast supporting the concrete ties and rails. The track was loaded with the 39-ton axle-load cars.

After 240 million gross tons of traffic of traffic, the two HMA sections showed less degradation than the all ballast sections. Moisture contents for the subballast under the HMA underlayment were also reduced.

Conclusion

Although not yet widely used in the railroad industry, the cost effectiveness and superior performance of HMA underlayments for trackbeds is getting the attention of railroad maintenance engineers and, as a result of the TTCI tests, the American Railroad Maintenance Association (AREMA) has recently begun the process of developing guidelines for the use of HMA underlayments. For more on HMA underlayments for trackbeds, read *Hot Mix Asphalt for Quality Railroad Transit Trackbeds, IS-137*, which is available from the Asphalt Institute.▲

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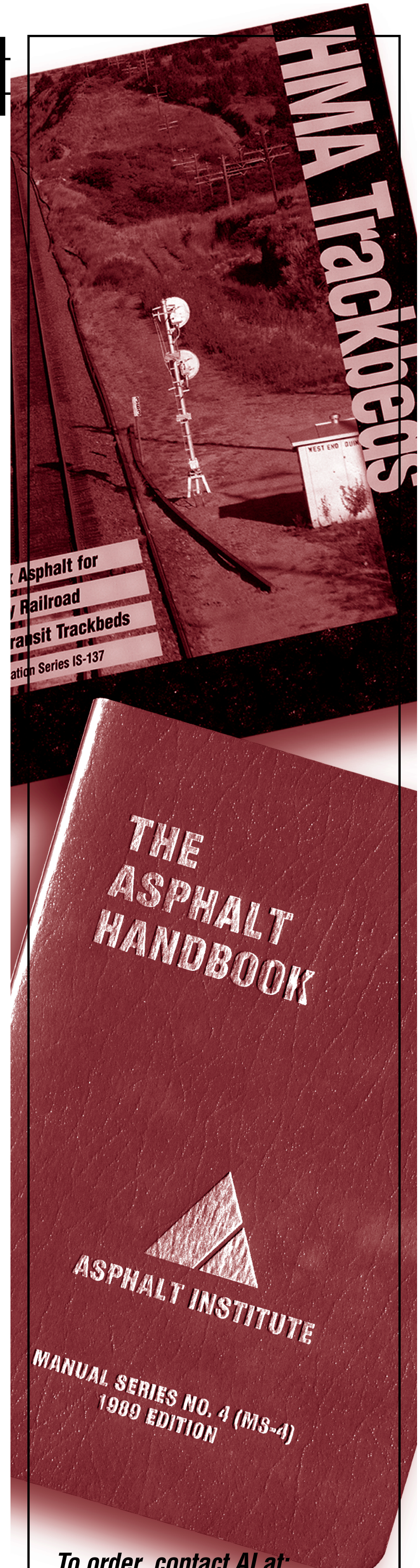

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