Pavement Rehabilitation Using High-Polymer Asphalt Mix

RESEARCH SYNOPSIS

Problem Statement

Reflection cracking is common when distressed asphalt concrete (AC) pavements are rehabilitated with a mill-and-inlay approach, or shallow milling of the pavement followed by an overlay. Despite this problem, agencies often use this approach to avoid full-depth reconstruction costs and long delays for the traveling public. The result of this approach is often just a few years of adequate performance, at which time cracking reappears. To address this problem, fatigue cracking-resistant materials that can withstand high stresses and restore the structural integrity of the pavement are needed.

Objective

The objective of this research was to document a high-polymer content mixture (HPM) as an inlay material on a heavily cracked pavement at the National Center for Asphalt Technology (NCAT) Pavement Test Track. The results of this research are critical to its adoption as an overlay/inlay material on public roads.

Description of Study

Section N8 on the NCAT Test Track was originally constructed in 2006 as an under-designed perpetual pavement. Its performance history was divided into three main parts for the purposes of this study: original construction, conventional rehabilitation in 2009 and HPM rehabilitation in 2010.

The initial rehabilitation consisted of a 5-inch mill-and-inlay with 3 inches of dense Superpave mix under 2 inches of stone-matrix asphalt (SMA). The mixes used for this inlay were identical to the original mixes placed in the structure. At the request of the section sponsor, fabric interlayers were used in two different areas of the inlay to see if they would affect the onset of reflective distresses.

Although cracking did not occur as rapidly in the areas where the fabric interlayer was placed, the pavement condition in these particular areas deteriorated more quickly after cracking was observed. Figure 1 illustrates the most severely distressed area of the failed pavement surface, which was close to the installed paving fabric. This rehabilitated pavement failed completely after about 3.5 million equivalent single-axle loads (ESALs).

Figure 1 Severe pavement distress on Section N8 at the NCAT Pavement Test Track.

The HPM design used for the second rehabilitation consisted of three lifts of hot-mix asphalt (HMA) blended with binder modified with 7.5 percent low-viscosity styrene-butadiene-styrene (SBS) polymers. The surface and base lifts of the inlay were 3/8-inch nominal maximum aggregate size (NMAS) placed 1.25 inches thick. The intermediate lift was 3.25 inches thick with ¾ inch NMAS. The virgin asphalt combined with 7.5 percent polymer in this formulation resulted in a PG 88-22 binder. The distressed pavement was milled to 5.75 inches to accommodate the HPM inlay, and a crack map was developed on the milled surface. Fabric interlayers were not used in the HPM rehabilitation. After about 5.5 million ESALs on the new HPM surface (2 million more ESALs than the conventional rehabilitation), no changes in surface condition were noted. No cracking was observed, and measured rutting was less than 1/8 inch.

Beginning in the 2009 experiment, falling-weight deflectometer (FWD) tests were conducted every other Monday on Section N8. The deflection data were used to backcalculate asphalt concrete moduli, and relationships between temperature and modulus were established. These relationships were used to normalize the modulus to a reference temperature of 68˚F so that modulus versus time could be examined. Figure 2 shows these data split into before and after the HPM inlay. The plot shows that before the HPM rehabilitation, the AC moduli were much more variable and lower.

An important and unique component of this study was the embedded instrumentation to measure tensile strain at the bottom of the AC and vertical compressive stresses in the top of the base and subgrade layers, respectively. These measurements were used to determine pavement response before and after the HPM mill-and-inlay.

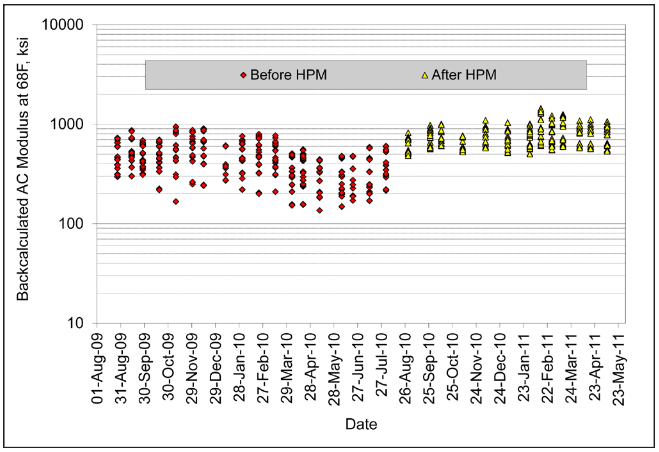

Figure 2 Backcalculated AC moduli before and after HPM mill-and-inlay.

Before significant distresses were noted in Section N8 during the 2009 research cycle, a strain-temperature relationship was developed to compare newly collected strain measurements with those taken during the 2006 cycle. Even with the mill-and-inlay at the beginning of the 2009 experiment, there was an increase in strain level, indicating that the original mill-and-inlay did not improve the structural cross-section with respect to strain response.

Three sets of measured pavement responses were obtained. Tensile strain at the bottom of the AC served as an indicator of cracking performance, and vertical pressures in the aggregate base and subgrade were considered in the context of rutting. As with the backcalculated AC modulus, comparisons were made before and after the HPM mill-and-inlay. Figure 3 summarizes the data from the pavement responses normalized to a 68˚F reference temperature. In each case, pavement responses were reduced, a sign of improved structural integrity, after the HPM rehabilitation.

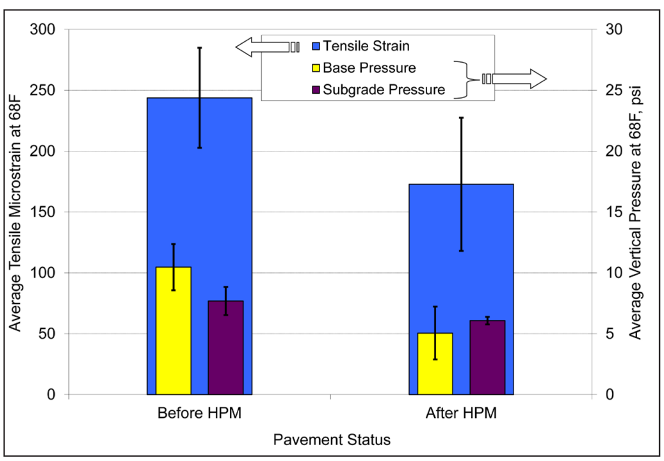

Figure 3 Pavement response at 68˚F.

Conclusions and Recommendations

This research investigated the use of HPM in a mill-and-inlay application on a severely distressed pavement at the NCAT Pavement Test Track. The following conclusions and recommendations are made based on the results of this study:

1) Traffic applied to the HPM rehabilitation has now surpassed the level needed to completely fail the original conventional rehabilitation, with no indication of another failure. Measured rut depths are less than 1/8 inch, roughness has not changed since the HPM was placed and no cracking has been observed.

2) The HPM had an immediate and statistically significant impact on the AC modulus of the pavement, with about a 55 percent modulus increase with reduced section-wide variability in the modulus. The coefficient of variation went from 47 percent before the HPM to 26 percent after the HPM was placed.

3) The original overlay at the beginning of the 2009 experiment was ineffective in terms of reducing pavement strain, as shown by a general increase in strain through May 2010.

4) The HPM had statistically significant impacts on measured AC strain, base pressure and subgrade pressure. Strains normalized to 68˚F were reduced by 29 percent, aggregate base pressure was reduced 51 percent and subgrade pressure was reduced 21 percent.

5) HPM mixes may be an effective rehabilitation option on roads that experience high strains and where increasing pavement thickness is not an option. They may also help prevent reflection of severe distresses and prevent rutting in heavy, slow traffic applications.

6) Further monitoring on this test section is recommended to fully validate these findings.

Acknowledgements and Disclaimer

This study was sponsored by the Oklahoma Department of Transportation. This research synopsis provides a brief summary of the complete study. This document is for general guidance and reference purposes only. NCAT, Auburn University, and the listed sponsoring agencies assume no liability for the contents or their use.