PUTTING RESEARCH TO WORK BRIEF

Assessing the Cost-Effectiveness of Stone Matrix Asphalt Overlays

Use of stone matrix asphalt, the durable asphalt mix design imported from Europe, is growing in the United States. SMA mixes contain a high concentration of coarse aggregate that maximizes stone-to-stone contact, providing an efficient network for load distribution that holds up well to heavy traffic. While the use of SMA entails higher initial costs, studies have shown that SMA mixtures used in pavement rehabilitation or as the surface layer for new construction can outperform conventional hot-mix asphalt mixtures.

What's the Problem?

Wisconsin DOT was the first agency in the United States to use SMA, and to date WisDOT has constructed approximately 25 SMA projects, primarily for resurfacing existing pavements. However, an evaluation of the overall cost-effectiveness of SMA overlays compared to conventional HMA overlays in Wisconsin has not been performed. With the adoption of SMA in 2000 as a WisDOT standard product, and with budgets for highway construction and rehabilitation shrinking, a detailed, economic-based analysis of SMA overlays was warranted. WisDOT also wanted to identify conditions under which SMA resurfacing is most and least cost-effective.

Research Objectives

The primary objective of this research was to provide a comparative life-cycle cost analysis of SMA overlays compared to WisDOT's conventional HMA overlays (the Marshall-based "V" mixes used prior to 2001 and the Superpave-based "E" mixes used since then), based on parallel life cycles (including required maintenance) and performance. Based on the results of the LCCA, the researchers then sought to develop recommendations for future use of SMA and conventional HMA overlays.

Methodology

Researchers' tasks included:

- Selecting 12 completed WisDOT SMA projects and 12 conventional HMA overlay projects with similar profiles that could serve as companions for evaluating the cost-effectiveness of SMA.
- Estimating the unit costs of all major pay items and activities associated with SMA- and HMA-overlaid pavements over a life cycle.
- Analyzing pavement performance of the selected projects. Researchers divided the pavements into three groups based on Equivalent Single Axle Loads, representing predicted traffic over a 20-year service life:
  - **Group 1:** low-volume (less than 300,000 ESALs) asphalt pavements on U.S./state routes
  - **Group 2:** high-volume (over 3 million ESALs) jointed reinforced concrete pavements on Interstate/U.S. routes
  - **Group 3:** moderate-volume (300,000 to 3 million ESALs) JRC pavements on U.S./state routes

  Researchers used Pavement Distress Index and International Roughness Index threshold-based life projections combined with survival analysis techniques to estimate the pavements' service life of SMA and HMA overlays.
- Developing pavement life-cycle cost models for SMA and HMA overlays for each group.

Using the life-cycle models, best estimates of pay item unit costs, a 45-year analysis period, and a discount rate of 5%, the researchers conducted deterministic and probabilistic LCCAs to compare the cost-effectiveness of SMA and HMA overlays. They used RealCost 2.1, FHWA's LCCA spreadsheet program, in their analysis.

Investigator

"SMA overlays can offer performance benefits, and this research helps identify when SMA is also the more cost-effective choice."

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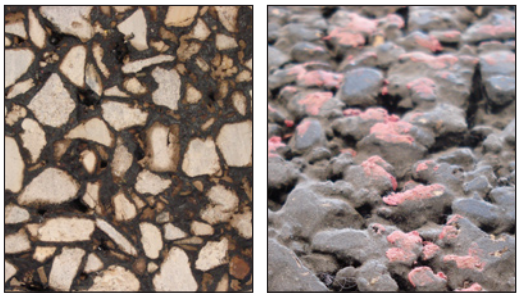
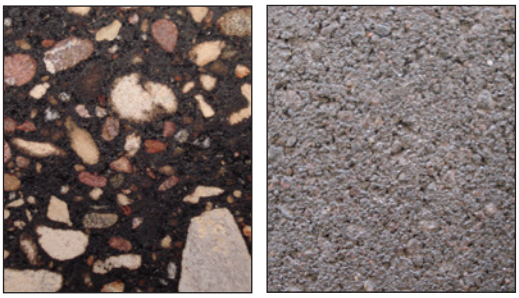
Stone matrix asphalt

Profile Surface



Hot-mix asphalt

Profile Surface



Stone matrix asphalt, left, tends to have a high concentration of coarse aggregate that maximizes stone-to-stone contact, in contrast to conventional hot-mix asphalt, right. Photos represent typical Wisconsin materials.

Results

Group 1 pavement analysis showed that SMA overlays were more cost-effective than conventional HMA overlays on these low-volume asphalt pavements. Because the cost difference was not substantial, the researchers recommend that decisions about which type of overlay to apply on flexible pavements be made on a case-by-case basis, evaluating items including initial costs, maintenance and rehabilitation frequency, and sources of roadway construction and maintenance funding.

For Group 2 and Group 3 pavements (moderate- to high-volume jointed reinforced concrete), conventional HMA overlays were more cost-effective than SMA. However, researchers believe that the SMA overlays that were evaluated in this study were likely placed on pavements that were rougher and more deteriorated than the pavements overlaid with HMA. This would cause the SMA overlays to have shorter service lives and higher life-cycle costs. Because this issue probably contributed to the higher life-cycle costs for SMA in Groups 2 and 3, researchers recommend that designers select overlay materials for these pavements on a case-by-case basis as well, particularly when the existing pavement is in relatively good condition.

Implementation and Benefits

WisDOT pavement designers can use this study to help optimize their choice of overlays for performance and cost-effectiveness. The Bureau of Technical Services will use the study results to further identify the most cost-effective applications for SMA overlays in the state, and to develop guidance on the use of SMA resurfacing to add to the WisDOT Facilities Development Manual or Construction and Materials Manual. The guidance will include economic and performance scenarios, and will prove especially helpful to regional pavement designers who are not yet acquainted with SMA resurfacing.

Further Research

The LCCA performed in this study was based on a limited sample of pavement performance data, and the pavements analyzed are relatively young with few distresses. Therefore, the researchers recommend that WisDOT consider expanding the database of performance and cost information. An updated study should be initiated in approximately three years to reevaluate the service lives of SMA overlays on asphalt and rigid pavements. Future analyses should include at least a preliminary assessment of user costs, such as time delay and vehicle operating costs.

This brief summarizes Project 0092-04-06, "Life-Cycle Cost Analysis of SMA Pavements and SMA Application Guidelines," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

James McDonnell, WisDOT Research and Communication Services

Project Manager

"This research provides WisDOT with hard numbers to base initial application decisions on, and identifies appropriate data collection areas to maximize the future benefits of SMA use."

–Judie Ryan
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