JOINT TRANSPORTATION RESEARCH PROGRAM

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Stone Matrix Asphalt (SMA) Overlay Performance Evaluation

Introduction

Stone matrix asphalt (SMA) is a specialized asphalt mixture designed to improve pavement performance by combining a coarse aggregate skeleton with a high-binder content mortar. This innovative design, adopted by the Indiana Department of Transportation (INDOT) in the late 1990s, offers distinct advantages over conventional hot mix asphalt (HMA). One of the most notable benefits of SMA is its extended service life beyond that of a conventional HMA mixture. Compared to HMA, SMA is well-known for its improved resistance to deformation and cracking—critical factors in maintaining pavement integrity under heavy traffic loads. In Indiana, SMA is more expensive than conventional HMA mixtures due to the necessity for high-quality, durable aggregates, increased asphalt binder content, and often-modified asphalt binders and fibers. SMA production involves a more meticulous process than HMA, which also contributes to the higher cost.

Currently, INDOT SMA-surfaced pavements are undergoing a second round of rehabilitation, presenting a valuable opportunity to assess their performance and return on investment (ROI). By quantitatively examining SMA-surfaced pavement performance, the aim of this study was to determine if SMA mixtures have extended years of service and reduced pavement maintenance needs when compared to pavements with conventional asphalt mixture surfaces.

In addition to performance assessment, questions have been raised about SMA coarse aggregate requirements. SMA coarse aggregate must be sufficiently durable to support traffic loads through its stone-on-stone aggregate skeleton. In Indiana, steel slag is used as the primary SMA coarse aggregate because of its toughness and durability. However, it may be possible to use other, locally available coarse aggregates in SMA without a loss of mixture performance.

Given the opportunity to assess SMA performance, and the need to investigate the possibility of using additional coarse aggregate types in SMA mixture, the objectives of this study were to (1) evaluate the SMA mixture performance compared to conventional HMA mixtures, and (2) to conduct a comprehensive life cycle cost analysis (LCCA) of pavement preventive maintenance treatments. Specifically, the study evaluated the cost-effectiveness of two overlay materials, SMA and HMA, under varying conditions, as well as identified alternative aggregates for use in SMA that reduce reliance on steel slag in Indiana.

Findings

Field performance evaluations of SMA and HMA mixtures used on two road classifications, U.S. highways and interstates, highlight the superior performance of SMA on U.S. highways. The significant percentage differences in roughness (as measured by the International Roughness Index (IRI)) and cracking demonstrate SMA's enhanced durability and ability to resist deformation and cracking. Performance differences were less pronounced on interstates, but in many cases, SMA still outperformed conventional HMA, especially regarding rutting resistance. However, for road classifications, there were instances where HMA demonstrated performance comparable to SMA, underscoring the importance of selecting the appropriate asphalt mixture type based on road classification, traffic conditions, and performance expectations.

U.S. highways were presented as an example of LCCA, and the results demonstrate that, despite higher initial construction costs, SMA overlays exhibited superior long-term cost performance relative to conventional HMA. The net present value (NPV) for SMA was calculated as $112,448 per lane mile, compared to $190,373 per lane mile for HMA, which reflects a 40.9% reduction in lifecycle costs. Additionally, the ROI analysis revealed that SMA overlays yielded a 14.6% ROI over the 29-year analysis period.

Exploring steel slag alternative aggregates for Indiana provided important insights into coarse aggregate selection for Indiana SMA mixtures. With strict coarse aggregate requirements, steel slag and dolomite have been the main choices for Indiana SMA mixtures. However, the study results indicated that crushed gravel could perform similarly to steel slag in laboratory testing, possibly expanding options for aggregate selection. Although increasing dolomite content to replace steel slag is possible, it would require careful consideration of the aggregate toughness requirements.

Recommendations

Although SMA is more expensive than conventional HMA, field performance evaluations demonstrated its superior overall performance. ROI analysis confirmed that SMA is worth the initial cost investment. This economic advantage is primarily attributed to the extended service life of SMA mixtures, which delays the need for costly rehabilitation activities, thereby reducing total maintenance expenditures.

This study also found that crushed gravel can effectively replace steel slag to meet aggregate requirements and maintain SMA mixture performance. While dolomite showed no significant difference from steel slag in overall mixture performance, higher dolomite content indicated a potential reduction in friction. Further research is needed to better understand the impact of dolomite content on friction characteristics.

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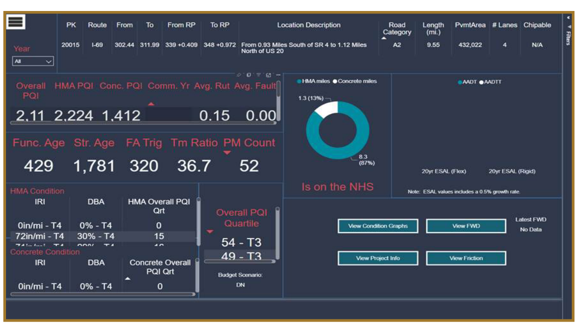

INDOT pavement condition and inventory information.