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Center for Transportation Research and Education

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RESEARCH PROJECT TITLE

Guidebook for Application of Polymer-Modified Asphalt Overlays: From Decision-Making to Implementation

SPONSORS

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Guidebook for Application of Polymer-Modified Asphalt Overlays: From Decision-Making to Implementation

tech transfer summary

A guidebook was developed that lays the groundwork for transportation agencies to integrate polymer-modified asphalt overlays into their overall pavement preservation strategies.

Problem Statement

Despite several transportation agencies' documented successes in adopting polymer-modified asphalt (PMA) overlays as a pavement preservation technique, there remains a limited amount of quantitative data to substantiate objective decision-making frameworks and provide structured processes for agencies to select PMA overlays as the appropriate treatment.

Goal and Objectives

The goal of the project was to lay the groundwork for the integration of PMA overlays into transportation agencies' overall pavement preservation strategies by developing a guidebook that offers insights into the implementation and efficacy of the technique.

The objectives were to survey the experiences of transportation agencies using PMA overlays and consolidate the existing knowledge of the pavement preservation technique.

Background

PMA cements have been extensively used as high-performance pavement materials. Polymer modification of asphalt binder allows altering the material's properties to suit specific climatic and service conditions.

Polymers typically include a wide variety of performance properties modifiers, with elastomers (rubber) and plastomers (plastic) being the most dominant categories. Elastomers mostly enhance strength at high temperatures and elasticity at low temperatures, while plastomers are only suitable for strength enhancement. Polymer types from which PMA overlays are produced include styrene-butadiene-styrene (SBS), ethylene-vinyl acetate, ethylene methacrylate, and reclaimed rubber, with all of them showing significant economic and performance promise.

Controlling the binder viscosity, improving temperature stability, improving mechanical strength, reducing rutting susceptibility, improving fatigue behavior, improving abrasion resistance and binder-aggregate bond, and increasing service life are among the main advantages of polymer modification of asphalt binder.

The exceptional attributes of PMA enable a reduction in pavement layer thickness, establishing it as a highly advantageous material for both conventional and thin asphalt overlays. Nevertheless, the effectiveness of PMA in overlays is considerably contingent on several factors including the inherent properties of the asphalt and polymers, the harmonious interaction of materials, the precision of mixing procedures, the execution of construction practices, and the underlying layer's properties. Conversely, akin to various pavement preservation techniques, the optimal efficacy of PMA overlays is realized when applied strategically, at the appropriate timing and in the suitable context.

Project Description

The project team first consolidated information from the literature to summarize PMA application history, concepts, materials, and methods and from case studies that documented PMA overlay implementation examples and discussed the methods and specifications used and the resulting benefits, challenges, successes, and lessons.

They next documented a prescribed decision-making process for transportation agencies to implement based on the literature and the research team's correspondence with state departments of transportation (DOTs).

Finally, they evaluated the effectiveness of PMA overlays as a pavement preservation technique based on data from the Iowa DOT and Florida DOT, two agencies that have extensive experience with the treatment and have documented its performance over the years.

Key Findings

- Enhancing asphalt binder properties through the addition of polymers has become a well-established practice for addressing major distresses. The introduction of polymers alters asphalt binder properties, resulting in benefits like improved resistance to rutting, crack resistance, increased durability, flexibility, and elasticity.

- Although initial construction costs are higher with PMA overlays, the reduced maintenance requirements and extended service life lead to significant life-cycle cost savings. PMA overlays provide superior performance, resilience, and durability, reducing disruptions to traffic and ensuring a robust pavement network.

- Previous research findings emphasize the significance of considering binder selection, asphalt composition, job mix formula, and volumetric properties in achieving resilient and sustainable asphalt mixtures.

- Specific considerations for PMA overlay mix design include using reclaimed asphalt pavement (RAP) to offset polymer costs. Incorporating minimal RAP with PMA binder avoids blending problems.

- The selection of aggregate gradation and characteristics is crucial to the performance of PMA overlays. While different agencies adopt varying aggregate sizes, the typical range is found to be within 0.375–0.492 in. nominal aggregate size.

- Research tends to recommend a practical range of 2%–10% polymer loading, with most manufacturers' specifications within the 3%–5% range. Conventional polymer modification typically employs up to 3% SBS, while highly polymer-modified solutions use approximately 6%–8% SBS content.

- The evaluation of high polymer-modified binders has relied on performance-based specifications and testing methods. Various tests measure stiffness, elastic response, and fracture resistance.

- To implement PMA overlays successfully, construction practices must be precise and efficient.

- Pre-construction planning and coordination are foundational to achieving desired outcomes.

- To enhance structural integrity and pavement longevity, proper mix production and placement techniques are essential. Noteworthy practices highlight the significance of temperature control and minimizing hand work.

- PMA overlays require quality control and assurance measures to ensure mix reliability and performance. Ensuring the quality of the mixture through well-structured quality control procedures is pivotal in ensuring the success of polymer-modified mixtures.

- During the construction process, various challenges and troubleshooting scenarios may arise, potentially affecting efficiency and quality. While no specific additional health, safety, or environmental challenges arise from PMA overlays, temperature sensitivity during production must be accounted for.

- Achieving optimal workability can be intricate due to polymer-induced viscosity changes, demanding a delicate balance between viscosity and workability. Attention to transition zones and construction joints is vital to ensure seamless connections and avert distress.

Recommendations

Technical Recommendations Based on Performance Evaluation

The technical recommendations are based on the analysis of equivalent uniform annual cost, life extension, index benefit, and benefit-cost ratio (BCR). Illustrated in the figures for composite and flexible pavement types, respectively, the gradation of blue shades underscores the preference hierarchy for PMA overlay application, with darker shades indicating the most favorable scenarios and white shades representing no implementation of the application scenario.

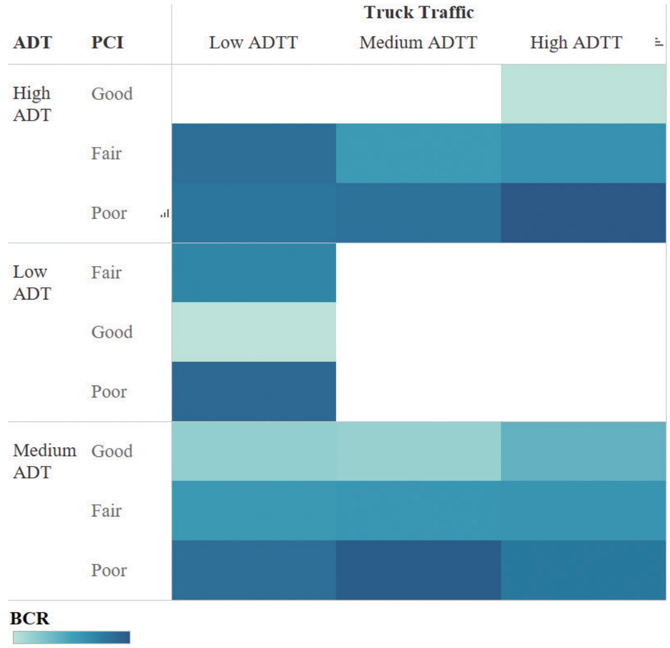
With the goal of this research centered around methodically structuring the decision-making process, the integration of PMA overlays as a preservation treatment gains significance. This approach enables the strategic application of PMA overlays, ensuring their deployment precisely when and where needed, as informed by the outcomes of the heatmap analysis.

Recommendations for Future Research

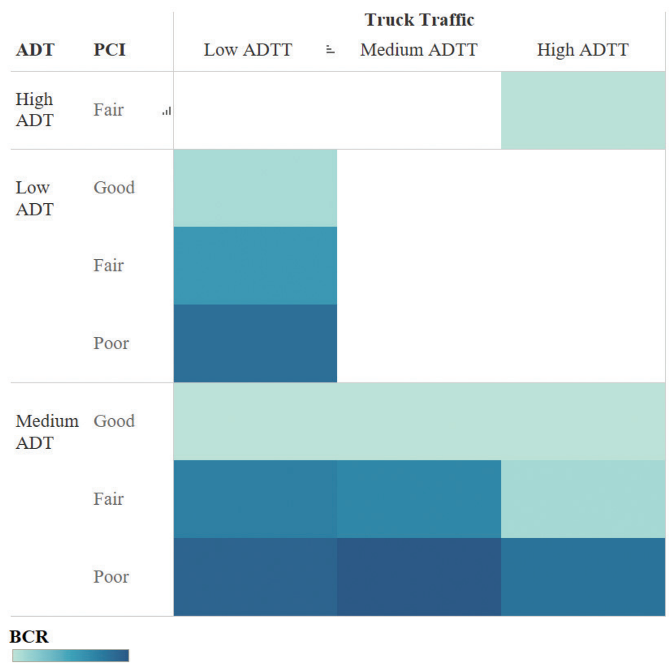
Recommendations for future research include the following evaluations and investigations into PMA overlays as a pavement preservation treatment:

- Long-term performance
- Effect of aging
- Polymer interaction
- Environmental impact
- Mix design optimization
- Binder testing protocols
- Effect on pavement structure
- Optimal polymer content
- Recycling of PMA
- Benefit-cost analysis
- Advanced testing techniques
- Climate resilience

By addressing these research areas, the asphalt industry can further optimize the use of PMA overlays, enhance pavement performance, and contribute to the development of more sustainable and durable transportation infrastructure.



BCR heatmap for composite pavements under different application scenarios



BCR heatmap for flexible pavements under different application scenarios

Implementation Readiness and Benefits

The implementation of PMA overlays offers transportation agencies numerous benefits that include the following:

- Address crucial considerations substantial to the selection and implementation of PMA overlays
- Unlock the potential of PMA overlays
- Promote informed decision-making at the edge levels of the agency
- Support a multifaceted approach to pavement preservation
- Advance sustainable infrastructure
- Chart a future path for structuring preservation techniques

After decades of PMA overlay implementations and insights from several transportation agencies, now is the time to encourage DOTs and industry stakeholders to recognize the benefits of adopting PMA overlays as a proactive strategy for enhancing pavement longevity and performance that can offer formidable benefits if utilized at the right time and with the right methods.

By developing a structured process for state DOTs for the selection and application of PMA overlays under diverse pavement and service conditions, the guidebook could be a significant step toward promoting the adoption of this technique and ensuring efficient use of its capabilities.