Project Capsule

26-2B

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Evaluation of RAP Fractionation and Its Impact on Mixture Performance

PROBLEM

As the world grapples with the need to reduce construction costs and promote recycling, the asphalt pavement industry has sought to incorporate more sustainable practices. One promising solution is the use of Reclaimed Asphalt Pavement (RAP). This approach offers numerous environmental and economic advantages, including reduced demand for virgin aggregates and binder, lower energy consumption, and decreased carbon emissions. Despite these benefits, the application of RAP is often limited by challenges with consistency. The primary issue is the quality of the aged binder and aggregates, which degrade over time, influencing pavement lifespan. To address this variability, the industry has introduced RAP fractionation. This technique involves sieving RAP stockpiles into distinct aggregate sizes, providing contractors with more consistent material. While fractionation primarily targets aggregate consistency, it also helps to manage asphalt binder variability. Because larger aggregate sizes generally retain less residual binder than those of smaller sizes, selecting specific fractions allows for better control over the final mix.

However, physical separation by size addresses only one aspect of RAP variability. The durability of RAP-modified mixtures is also fundamentally governed by the depth-dependent aging of the asphalt binder. Oxidative aging is not uniform throughout the pavement structure; rather, it exhibits a pronounced gradient relative to depth. The top 20mm of a pavement experience severe oxidative hardening due to environmental exposure, while materials deeper in the structure remain relatively soft. Consequently, RAP recovered from the surface layer carries a history of severe aging, possessing high stiffness and low fracture resistance, whereas RAP from deeper layers is subjected to minimal aging. The adoption of depth-dependent aging models, such as Pavement Aging Model (PAM) and Asphalt Mixture Aging-Cracking (AMAC), as well as conditioning protocols, such as AASHTO R 121, empowers the industry to better characterize RAP materials, ultimately leading to more durable and sustainable mixture designs.

Despite these technical advantages, the implementation of RAP fractionation and depth-specific milling raises valid concerns about economic feasibility and operational efficiency. Fractionation requires additional processing equipment, labor, and yard space to manage stockpiles. Similarly, recovering RAP at specific depths necessitates precise, multi-pass milling operations, which can extend construction timelines and complicate site logistics. These added processing costs threaten to diminish the economic savings typically associated with RAP usage. Therefore, widespread adoption of these techniques is unlikely unless the improved material consistency allows for significantly higher

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RAP dosages that financially offset the additional operational expenditures. Currently, Section 501.02.7 of the Louisiana Supplemental Standard Specifications require that RAP be kept separate from other materials to facilitate inspection and acceptance. Stockpiles must be kept uniform and free of contaminants, and the material must be screened or crushed to pass a 1-in. sieve prior to use, with allowable percentages defined in Table 502-6. Consequently, investigation is required to determine if integrating fractionation techniques and accounting for milling depth can justify the use of higher RAP percentages in Louisiana without compromising mixture performance.

OBJECTIVE

This research proposal has five primary objectives:

1. Quantify the impact of RAP aggregate quality on overall mixture performance.
2. Investigate the influence of milling depth on RAP quality and its subsequent effect on mixture durability.
3. Evaluate the effectiveness of RAP fractionation in reducing the performance variability commonly associated with high RAP content mixtures.
4. Identify three optimum fractionation scenarios (i.e., sieve sizes and fractions) required to support higher RAP percentages in Louisiana.
5. Compare the performance of mixtures containing classified RAP versus standard unclassified RAP to determine if the benefits of classification justify the implementation costs.

METHODOLOGY

There are eight tasks necessary to accomplish the goals of the proposed research:

1. **Conduct literature review and survey of practices:** This task involves a comprehensive review of existing literature on Reclaimed Asphalt Pavement (RAP) utilization, with a specific focus on RAP fractionation techniques, depth-dependent binder aging, and the performance of high-RAP mixtures.
2. **Identify and collect RAP materials:** The research team will coordinate with DOTD District Engineers and local contractors to identify and collect representative RAP materials from diverse geographical locations across Louisiana.
3. **Fractionate RAP materials:** In this task, the classified and unclassified RAP materials collected in Task 2 will be processed to evaluate the impact of particle size and quality.
4. **Assess RAP quality:** This task focuses on characterizing the quality of the fractionated RAP materials collected in Task 3 and the assessment of the properties of stratified RAP materials.
5. **Design and prepare fractionated RAP-modified mixtures:** This task focuses on the laboratory design and production of asphalt mixtures using RAP materials processed in Task 3.
6. **Conduct laboratory BMD performance testing:** In this task, the asphalt mixture samples produced in Task 5 will undergo comprehensive performance evaluation in accordance with Louisiana's Balanced Mix Design (BMD) framework.
7. **Perform data analysis:** The research team will conduct comprehensive statistical analyses to correlate RAP material properties with mixture performance.
8. **Prepare Final Report and Technical Summary:** The research team will prepare a comprehensive final report documenting the entire study.

IMPLEMENTATION POTENTIAL

The findings of this study will provide the Louisiana Department of Transportation and Development (DOTD) with the technical basis to update current asphalt specifications. Specifically, if the data confirms that multi-level fractionation and depth-specific recovery significantly reduce material variability, the research team will recommend revisions to the Louisiana Standard Specifications to permit higher RAP dosages for mixtures utilizing these techniques.

To facilitate industry adoption, the final report will also function as a guided document for contractors. It will delineate the optimal sieve configurations for fractionation and provide a cost-benefit framework, helping stakeholders determine when the operational investment in advanced processing is financially and technically advantageous.