

Problem Statement

Although most agencies allow reclaimed asphalt pavement (RAP) to be used in many asphalt mix types, it has not been common to use RAP in stone matrix asphalt (SMA) mixtures. SMA mixtures generally require polymer-modified asphalt, fiber stabilizers to improve durability and prevent asphalt drain-down, and more cubical, tougher aggregate to provide mix strength. These characteristics may not be present in most RAP sources. However, there could be a significant economic advantage to using RAP in SMA if it could be used without sacrificing the excellent performance of SMA mixtures.

Objective

The objective of this study, sponsored by the Georgia Department of Transportation, was to evaluate the effect of RAP on combined material properties and the overall performance of SMA mixtures in Georgia.

Description of Study

This study evaluated the effect of type and size of RAP, properties of RAP used in the blend, and aggregate source on laboratory performance test results. SMA mix designs were prepared using four aggregate sources, four RAP types, and RAP proportions of 0, 10, 20, and 30 percent. The four RAP types used were dense-graded RAP with high asphalt content, dense-graded RAP with low asphalt content, a coarse-fractionated (+4) RAP, and a fine-fractionated (-4) RAP. Both the RAP and virgin aggregate sources consisted of granite, typically used for SMA mixtures in Georgia. The 50-blow Marshall procedure was used for the mix designs and PG 76-22 was used for the binder. A one-fourth fractional factorial design was used to limit the size of the experiment and the number of tests required.

To determine if the RAP aggregates would meet SMA requirements, RAP from each source was extracted to recover the aggregates, then blended at the stated proportions with the virgin aggregates. The combined materials were then evaluated for physical properties of LA abrasion loss and percent flat and elongated (F&E) particles.

Asphalt binder testing was also conducted to evaluate the cracking potential and potential effect on mix stiffness. Binder from RAP materials was recovered through the rotary evaporator process (ASTM

D 5404), and its properties were evaluated by means of the dynamic shear rheometer and bending beam rheometer.

Finally, testing was performed to evaluate the binder effect on resistance to moisture susceptibility, rutting potential, thermal cracking potential and fatigue life of the RAP mixtures. The following tests were conducted to assess mix performance: diametral tensile strength, flexural beam fatigue, rutting using the Asphalt Pavement Analyzer (APA) and indirect tensile strength compliance.

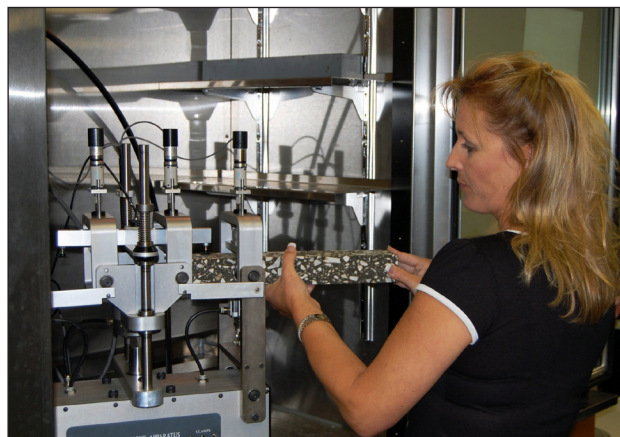


Figure 1 Assessing beam fatigue life with the bending beam fatigue tester.

Key Findings

The main findings of the study are summarized below. Results may vary if aggregate types other than granite are used.

- 1) Aggregate properties: The proportion of RAP in the combined blend had little effect on changes in LA abrasion and F & E particle shape, and in some cases actually improved those properties. The RAP aggregate may have been beneficial since some of the rough, irregular edges would have been broken off during previous handling, placement and milling of materials. It was found that LA abrasion loss and F & E properties were most influenced by the virgin aggregate source.
- 2) Binder properties: Adding up to 30 percent RAP had little effect on the low-temperature performance grade properties. The low-temperature grade of the combined binder blends was raised one grade in only one case, suggesting that the grade of virgin binder does not have to be adjusted to provide the desired low-temperature properties.

- 3) **Moisture susceptibility:** The tensile strength (conditioned and unconditioned) increased as the RAP percentage increased, which was not surprising since recycled SMA mixtures contain RAP binder that is expected to increase the stiffness of the samples. However, the tensile strength ratio (TSR) did not significantly increase with the addition of RAP. All mixtures were above the minimum requirement; therefore, moisture susceptibility was not an issue for the recycled SMA mixtures in this study.
- 4) **Rutting susceptibility:** The average rut depths for different RAP proportions ranged from 3.1 mm to 3.4 mm, indicating that RAP content did not have a significant impact on rutting performance.
- 5) **Thermal cracking:** In this study, mixture susceptibility to thermal cracking was poorly correlated with the aged-to-virgin binder ratio ($R^2 = 0.02$). This could be because even as the aged binder content increased, there was not a significant change in the combined binder blend properties that control thermal cracking (creep stiffness and creep rate).
- 6) **Fatigue life:** Increasing RAP content typically resulted in fewer cycles to failure, especially at high strain levels and high RAP proportions. Samples with 30 percent RAP had only about half the fatigue life of control samples without RAP.

Conclusions and Recommendations

- 1) Up to 20 percent RAP may generally be used without significantly reducing fatigue life. In this research, the only exception was for the -4 RAP blend in which RAP contributed a high proportion of the final binder content.
- 2) Using fine-graded RAP reduced virgin binder requirements because of its high asphalt content, which translates into economic benefits; however, these mixes are stiffer and more prone to fatigue cracking. Use of fine-graded RAP may require the use of binder blending charts or a reduction in PG binder grade. Fine-graded RAP also contained more material passing the No. 200 sieve, which must be accounted for during mix design.
- 3) Coarse-graded RAP had lower asphalt content, indicating that mixtures containing this material will have a reduced amount of old binder, and will result in less increase in stiffness and less potential for cold-weather cracking. Using coarse-graded RAP also alleviated the No. 7 stone requirement without affecting mix performance, which may be beneficial if quarries are faced with a critical shortage of No. 7 stone due to high demand.

Acknowledgements and Disclaimer

This study was sponsored by the Georgia Department of Transportation. This research synopsis provides a brief summary of the study's final publication. 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.