National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Effect of Changing Virgin Binder Grade and Content on RAP Mixture Properties

RESEARCH SYNOPSIS 12-03

Problem Statement

Most highway agencies have experience using asphalt mixtures containing low to moderate amounts of reclaimed asphalt pavement (RAP) due to its economic and environmental benefits. However, agencies are often reluctant to allow RAP contents above 25 percent (by weight of aggregate) because of concern that such RAP mixtures would be more susceptible to cracking. RAP binder is stiffer and less strain-tolerant than virgin binder and, therefore, as the proportion of RAP increases, so does the potential for increased mixture stiffness and cracking. This could result in early performance problems and greater rehabilitation costs. Several research studies of mixtures with higher RAP contents have indicated that improving their cracking resistance and durability is needed. Suggested methods of improving durability include increasing the volume of effective virgin binder in the mixture or adjusting the virgin binder grade.

Objective

The objective of this study was to quantify how increasing the volume of virgin binder or decreasing its performance grade affects the durability of RAP mixtures.

Description of Study

For this study, 0, 25 and 50 percent RAP mixtures at optimum asphalt content were designed using a PG 67-22 virgin asphalt binder. Each mix was designed using a 9.5 mm nominal maximum aggregate size (NMAS), and the gradations consisted of four aggregate stockpiles and a locally available unfractionated RAP stockpile. As usual, the RAP was characterized before being used in the asphalt mixtures. Each mixture was evaluated using a variety of laboratory tests to assess its durability. Top-down (surface) cracking and reflection cracking susceptibility were evaluated using the energy ratio (ER) test and the overlay tester (OT), respectively. The linear amplitude sweep (LAS) test assessed the fatigue properties of the blended RAP and virgin binders. These tests were also conducted on the RAP mixtures with higher asphalt contents using a PG 58-28 virgin binder rather than the PG 67-22. Rutting resistance of the mixtures was also assessed with the asphalt pavement analyzer (APA) to ensure they were not susceptible to rutting due to increased durability.

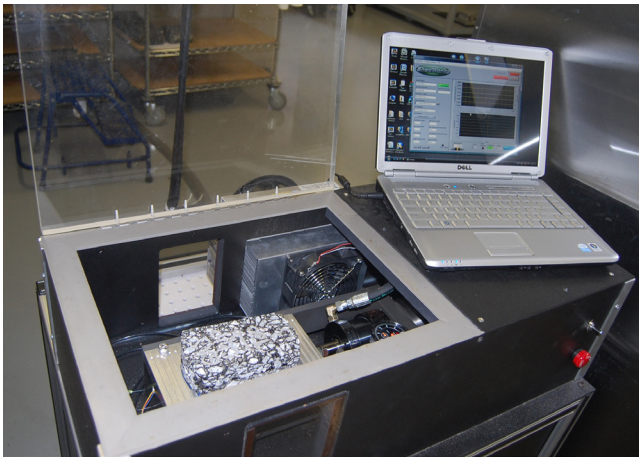

Figure 1 Overlay tester.

The LAS procedure is a binder fatigue test that can account for actual damage resistance as well as pavement structure and traffic loading, using cyclic loading with increasing load amplitude to accelerate damage. The end result is a prediction of binder fatigue life as a function of strain magnitude. For this study, a blend of extracted RAP and virgin binders were tested using the LAS methodology in order to assess the impact of the RAP binder on the fatigue properties of the blended binder.

The energy ratio test assessed the mixtures' resistance to top-down cracking using a combination of three tests: resilient modulus, creep compliance and indirect tensile strength. These tests were performed at 10˚C.

Overlay tests to determine reflection cracking susceptibility were performed in accordance with TxDOT 248-F with one modification. Past research has shown that using a maximum opening displacement of 0.025, as specified in TxDOT 248-F, can instantaneously fail RAP mixtures in the overlay tester. An experimental study was conducted to determine an appropriate maximum opening displacement for each mixture in the study. Based on preliminary testing, a maximum opening displacement of 0.013 inches was chosen for this particular study.

Rutting susceptibility of the asphalt mixtures was assessed with the APA following AASHTO TP 63-90. Past NCAT research suggests that mixtures with less than 5.5 mm of rutting in the APA can withstand 10 million equivalent single-axle loads (ESALs) in the field without rutting more than 12.5 mm.

An economic analysis was also performed to determine the financial implications of altering the standard RAP mixtures. Although using RAP saves virgin aggregate and binder costs, the total materials costs including added binder or a softer binder need to be evaluated.

Conclusions

Based on the laboratory test results, the following conclusions were made regarding increasing the durability of RAP mixtures:

1) Using a softer binder had the greatest impact on improving the fatigue life of both the 25 and 50 percent RAP binder blends based on the LAS binder fatigue test.
2) Increasing the effective virgin binder content increased the number of cycles to failure for 25 percent RAP binder blends in the LAS test; however, this was not the case for the 50 percent RAP blends.
3) Using a softer virgin binder grade was the only method that increased the fracture energy of the 25 percent RAP mixtures.
4) Using a softer virgin asphalt grade and increasing the effective virgin binder content increased the fracture energy of 50 percent RAP mixtures. This was the only benefit of increasing the effective virgin binder 0.5 percent beyond the optimum binder content.
5) The energy ratio decreased when using the softer virgin asphalt grade or increasing the effective virgin asphalt content of a mixture for both 25 and 50 percent RAP mixtures.
6) The 25 percent RAP mixture with a softer virgin binder grade had the best overlay tester results. Increasing the effective virgin binder content numerically increased the OT results, but there was not a statistical difference in the mixtures.
7) Neither using a softer virgin binder grade nor increasing the effective virgin binder content statistically increased the OT results for the 50 percent RAP mixtures. Using a softer virgin binder grade did numerically increase the cycles until failure by more than three times that of the standard binder mixture at the optimum asphalt content.
8) The 25 percent RAP mixture with the softer virgin binder grade was the only mixture that failed to meet the NCAT APA test criteria for heavy traffic pavements.
9) While using a softer grade of virgin binder or increasing the effective virgin binder content of a mixture can increase binder costs, the net effect of using these techniques in conjunction with 25 or 50 percent RAP can decrease the materials costs by 20 to 35 percent.

Table 1 Savings Using 25% and 50% RAP Mixtures

RAP Mixtures	Percent Savings: 25% RAP versus Virgin MIxure	Percent Savings: 50% RAP versus Virgin Mixture
PG 67-22 @ Opt.	19.96	34.99
PG 67-22 @ Opt. + .25%	17.16	32.18
PG 67-22 @ Opt. + .50%	14.35	29.38
PG 58-28 @ Opt.	14.85	31.08

Recommendations for Implementation

Based on this study, technical and cost-effective options for enhancing the durability of high RAP mixtures appear viable. Further work is needed to validate these solutions in the field. To improve cracking resistance, increase the amount of virgin asphalt by 0.1 percent for every 10 percent of RAP binder in the mixture for up to 30 percent RAP binder. When the RAP binder exceeds 30 percent, a softer grade of asphalt should be used to increase the mixture's resistance to cracking. All mixtures with increased virgin binder content or a softer grade of asphalt should be evaluated with a laboratory rutting test to ensure the mixture will be resistant to permanent deformation in the field.

Acknowledgements and Disclaimer

This study was sponsored by the Alabama 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.