National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Alternative Methods for Increasing the Durability of RAP Mixtures

RESEARCH SYNOPSIS 13-08

Problem Statement

Using reclaimed asphalt pavement (RAP) in asphalt mixtures can provide economic savings to contractors and highway agencies by reducing the demand of both the virgin binder and aggregates in asphalt mixtures. One reason agencies are reluctant to increase RAP contents is the general perception that RAP mixtures may be more susceptible to various modes of cracking. Before permitting high RAP percentages, agencies want assurance that high RAP content mixes will provide satisfactory field performance.

The goal of numerous research efforts is to increase the RAP percentage without sacrificing performance. One method of increasing the durability of high RAP mixtures is to adjust the grade of the virgin binder. Recent research has also suggested that the performance of RAP mixtures is also affected by the volume of the virgin binder in the mixture rather than just its performance grade.

Objective

This study examined three ways of possibly increasing the cracking resistance of asphalt mixes with RAP percentages from 10 to 50 percent. The three approaches evaluated in this lab study were - (1) increasing the virgin binder content, (2) using a softer virgin binder grade, and (3) using a warm-mix asphalt chemical additive and reducing the mixing and compaction temperatures.

Description of Study

For this study, 10, 25, and 50 percent RAP mixtures were designed in accordance with AASHTO R35, Superpave Volumetric Mix Design for Hot-Mix Asphalt. Each mix was designed as 12.5 mm nominal maximum aggregate size mixture. The mixes contained three aggregate stockpiles and a locally available RAP stockpile. As in standard practice, the RAP was characterized before being used in the asphalt mixtures. A PG 67-22 virgin binder was the base binder, and the softer binder was a PG 58-28 binder reduction in both the high and low temperature grades of the virgin binder. It should be noted that a lower virgin binder grade is not standard practice for 10 percent RAP mixtures; however, mixtures were prepared at each RAP content with the PG 67-22 binder and the PG 58-28 binder at the request of the research sponsor. When used, a chemical WMA additive was added to the asphalt binder during mixing at a rate of 0.53 percent by weight of the asphalt binder. Table 1 shows the RAP binder ratios for the experimental mixtures using the PG 67-22 virgin binder. The 10, 25, and 50 percent RAP mixes were replicated with the WMA additive at the corresponding optimum asphalt contents. Likewise, the 10, 25, and 50 percent RAP mixes were replicated with PG 58-28 virgin binder at the corresponding optimum asphalt contents.

Figure 1 Pavement Cracking

These binders were mixed in the laboratory with the previously determined blend of aggregates and RAP. Each mixture was tested to assess the fatigue properties of the blended RAP and virgin binders, evaluate top-down or surface cracking, and susceptibility to reflection cracking.

The linear amplitude sweep (LAS) was utilized to characterize the fatigue properties of the blended RAP and virgin binders. The LAS test is an accelerated binder fatigue test that accounts for damage resistance as well as traffic loading by using increasing cyclic load amplitudes to accelerate damage. The end result is a prediction of binder fatigue life as a function of strain magnitude.

Energy ratio testing was performed to evaluate each mixture's resistance to top-down or surface cracking. Three specimens were prepared and tested at 10°C for resilient modulus, creep compliance, and indirect tensile strength.

Overlay tests (OT) were conducted to assess the resistance to reflection cracking of the mixtures. Specimens were tested at 25°C in controlled displacement mode. Based on past research, a reduced displacement

Mix Design	Optimum AC Content			Opt. +0.25% AC			Opt. +0.50% AC		
	Virgin AC, %	RAP AC, %	RAP Binder Ratio	Virgin AC, %	RAP AC, %	RAP Binder Ratio	Virgin AC, %	RAP AC, %	RAP Binder Ratio
10% RAP	4.57	0.53	.103	4.82	0.53	.099	5.07	0.53	.094
25% RAP	3.72	1.33	.263	3.97	1.33	.251	4.22	1.33	.240
50% RAP	3.23	2.02	.385	3.48	2.02	.367	3.73	2.02	.351

Table 1 RAP Binder Ratios for the Experimental Mixes with the PG 67-22 Binder

of 0.013 inches was used to obtain reliable and usable data.

The rutting resistance of the asphalt mixtures was assessed using the Asphalt Pavement Analyzer (APA) to ensure that increasing mixture durability did not cause the asphalt mixture to become susceptible to rutting. Tests were conducted at 64°C with manual depth readings after 25 loading cycles and at the conclusion of testing to determine the sample rut depth. Past research from the NCAT Test Track has shown that mixtures with less than 5.5mm of rutting in the APA should be able to withstand 5 million equivalent single axle loads (ESALs) without rutting more than 9.5mm.

Conclusions

Based on this laboratory study, the following conclusions were made regarding modifications to RAP mixtures to improve cracking resistance:

1. Using a softer binder had the greatest impact on improving the fatigue life of all the RAP binder blends based on the LAS binder fatigue test.

2. Increasing the effective virgin binder content had little effect on the LAS test results.

3. Using 0.5 percent additional virgin asphalt and WMA technology improved the fracture energy of both the 10 and 50 percent RAP mixtures, although no statistical difference was found for the 25 percent RAP mixtures.

4. The Energy Ratio decreased for the 25 percent RAP mixtures that used a softer virgin asphalt or had increased asphalt content. Using a half percent additional asphalt or WMA showed the greatest Energy Ratio increase for the 10 and 50 percent RAP mixtures.

5. Overlay test results were not statistically affected by added asphalt, softer virgin binder, or WMA at any RAP content. The variability of this test is so large that statistical differences between mixes are often not evident.

6. For the 10 percent RAP mixture, using a softer binder increased the APA rutting results, but the results were less than 5 mm which would be acceptable for most roadways. The rutting resistance of higher RAP content mixtures were not detrimentally affected by using softer virgin asphalt, a higher asphalt content, or WMA.

Recommendations for Implementation

Based on this limited study, technical and cost-effective options for enhancing the durability of high RAP mixtures appear viable, although further work is needed to validate these solutions in the field. When using less than 25 percent RAP, using an additional 0.5 percent virgin asphalt or incorporating a WMA technology in the RAP mixture should provide additional durability. At 25 percent RAP, a softer binder or WMA technologies should be used to increase the mixture durability. At 50 percent RAP, an additional 0.5 percent most consistently had the greatest impact on mixture durability.

When using alternative technologies to increase mixture durability, one must ensure the mixture will not become susceptible to rutting. These options should be validated in the field and further analyzed on a regional basis. Using a different WMA technology may change the performance of the mixtures. Highway agencies and contractors should conduct cost analyses to determine if adding additional binder, a softer binder, or using a WMA technology would provide the most cost-effective solution when similar results are seen as options.

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