LOUISIANA TRANSPORTATION RESEARCH CENTER
LTRC

TECHSUMMARY March 2013

State Project No. 736-99-1574 / LTRC Project No. 09-1B

Characterization of HMA Mixtures Containing High Reclaimed Asphalt Pavement Content with Crumb Rubber Additives

INTRODUCTION

With the increase in hot mix asphalt (HMA) mixtures' prices continuously climbing, highway agencies and owners are continually searching for methods to decrease material costs and maximize their benefits with no compromise in performance. One such method is to develop innovative technology to incorporate waste and recycled materials, such as crumb rubber from waste tires and reclaimed asphalt pavement (RAP), in HMA mixtures. As HMA pavements age over time, the asphalt binders become hardened and oxidized causing premature cracking in pavements. Thus, the current limiting factor in increasing the percentages of RAP is the excessive stiffness of the resulting HMA mixture. Rejuvenating additives are often used to soften the asphalt cement binder of RAP materials and may enable the use of higher percentages of RAP in the finished product. Furthermore, absorption properties of crumb rubber may be used to carry those additives to revitalize the properties of the aged binders.

OBJECTIVE

The main objective was to fundamentally characterize the laboratory performance of conventional HMA mixtures and mixtures containing high RAP content and waste tire crumb rubber/additives through their fundamental engineering properties. The second objective was to characterize the laboratory performance of an HMA mixture containing 100 percent RAP and waste tire crumb rubber/additives.

SCOPE

A Superpave 19-mm nominal maximum aggregate size (NMAS) Level 2 HMA mixture meeting Louisiana Department of Transportation and Development (LADOTD) specifications was designed and examined. Siliceous limestone aggregates and coarse natural sand that are commonly used in Louisiana were included in this study. A total of four mixtures were examined in this study to fulfill the main objective. The first mixture was a conventional one, as a control mixture, that contained a styrene-butadiene (SB) polymer modified asphalt cement meeting Louisiana specifications for PG 76-22M. The second mixture contained no RAP, 30 mesh crumb rubber (CR) plus additives blended (wet process) with a PG 64-22 asphalt cement binder, which yielded a PG76-22. The third mixture contained 15 percent RAP and PG 76-22M asphalt cement binder. The fourth mixture contained 40 percent RAP, 30 mesh crumb rubber, and additives blended (dry process) with a PG 64-22 asphalt cement binder. In addition, to fulfill the second objective of this study, an asphalt treated base mixture utilizing 100 percent RAP and 30 mesh CR plus additives was characterized to determine its fundamental engineering properties.

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METHODOLOGY

A limited comparative laboratory mechanistic performance evaluation of conventional HMA mixtures and mixtures that contain waste tire crumb rubber, additives, and RAP were conducted. To evaluate performance, physical and rheological tests were evaluated on asphalt binders and HMA mixtures. The rolling thin film oven (RTFO) test, pressure aging vessel (PAV) test, rotational viscometer (RV) test, dynamic shear rheometer (DSR) test, and bending beam rheometer (BBR) test were performed on the asphalt cement binders to characterize their physical and rheological properties. In addition to asphalt cement rheology characterization, HMA mixture performance and characterization tests, namely, the semi-circular bend (SCB) test, dissipated creep strain energy (DCSE) test, simple performance tests (dynamic modulus, E*, and flow number, F_N), loaded wheel tracker (LWT), and modified Lottman test, were conducted to define permanent deformation (stability) and the fatigue life (durability) of HMA mixtures considered in this study.

CONCLUSIONS

This study characterized the laboratory performance of conventional HMA mixtures and mixtures containing high RAP content and waste tire crumb rubber/additives through their fundamental engineering properties. Based on the objectives of this study, the following conclusions were drawn:

- The addition of the crumb rubber additives softened the blended AC for the high RAP HMA mixture as determined by rheology testing of the asphalt cement extracted from the mixture.
- It was determined that the use of the absorptive properties of crumb rubber to carry rejuvenating products into a HMA mixture is viable.
- The HMA mixtures considered in this study were subjected to the modified Lottman test that quantifies the HMA mixture's sensitivity to moisture damage. The mixtures containing 100 percent RAP and unmodified virgin asphalt cement binder failed this test as expected. The high RAP HMA mixture that contained PG 64-22 with crumb rubber and additives passed the modified Lottman test. This indicates the CR additives had a positive influence in the asphalt cement binder's ability to increase adhesion to the aggregate structure.
- Generally, HMA mixtures containing high RAP content showed a propensity to fracture resistance than mixtures containing SBS modified asphalt binders.
- Generally, the high RAP content and 100 percent RAP HMA mixtures had the greatest propensity to resist permanent deformation for the mixtures evaluated.

RECOMMENDATIONS

The results of this study illustrated the benefits of utilizing the absorptive properties of crumb rubber to carry engineered additives into asphalt mixtures containing high levels of RAP content. Optimization of crumb rubber and engineered additives for the various types of RAP sources should be performed. Further, it is recommended that the use of crumb rubber and engineered additives in a dry process be investigated to ascertain its utilization in applications such as warm mix additives and anti-strip additives. In addition, life cycle cost analysis should be performed to indicate the economic benefits in utilizing high RAP and recycled products such as crumb rubber in flexible pavement construction and rehabilitation.