LOUISIANA TRANSPORTATION RESEARCH CENTER
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Evaluation of Crumb Rubber Modification of Louisiana Mixtures

INTRODUCTION

Crumb rubber materials have been used in HMA production in recent times due to the continuous expansion of scrap tire stockpiles in the U.S. Since the 1950s, there have been several global exploratory studies by highway engineers into the utilization of scrap tire rubber in the construction of asphalt pavements. During the 1960s, MacDonald conducted a study on crumb rubber-asphalt binder interaction characteristics and observed that after thoroughly mixing crumb rubber (CR) with asphalt binder, the CR particles absorbed asphalt binder and swelled in size at elevated temperatures. The expansion of the CR particles facilitated greater concentrations of liquid asphalt in CR-modified binders and mixtures. CR particles contain beneficial engineering properties that enhance the stiffness of CR-modified asphalt binder and mixtures, allowing for better performance at higher temperatures. Several state agencies have identified the effects of CR-modifiers on mixture design parameters as a major factor influencing the use of CR-modifiers in mixture production. Therefore, this study evaluated the changes in design and performance properties of previously designed conventional mixtures compared to a CRM mixture prepared with similar design parameters. The study focused on the effects of CR modification on various wearing course (WC) mixtures (OGFC, SMA, and dense-graded mixtures) in Louisiana and made necessary recommendations to address these effects.

OBJECTIVE

The objective of this research was to evaluate the effect of CR modification on the performance of asphalt mixtures used in Louisiana.

METHODOLOGY

Two types of crumb, cryogenic and ambient ground crumb rubber from five different suppliers, were used in the study. These crumb rubber particles were blended into three different types of asphalt mixtures typically used in Louisiana: dense-graded (DG), stone matrix asphalt (SMA), and open-graded friction course (OGFC) mixtures. The wet and dry processes of blending CR into asphalt mixtures were considered in the study following the suppliers' recommendation. For the dense-graded mixtures, seven CRM mixtures prepared with two types of CR particles (ambient or cryogenic) using different blending techniques (wet or dry process) and dosage rates were compared with an unmodified PG 67-22 and a modified PG 76-22 conventional HMA mixtures. For the SMA and OGFC mixtures, six CRM mixtures were prepared and compared with a polymer-modified PG-76-22 conventional HMA mixture.

The effects of CR modification on rutting and cracking performance were determined using HWTT and the SCB test, respectively. Further, solvent extraction and ignition tests were performed together with volumetric characterization to ascertain the effects of CR modification on asphalt binder content and other mix design parameters.

CONCLUSIONS

The following conclusions were made regarding the effects of CR modification on mixture volumetric properties as well as rutting and cracking performance.

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- CRM modification consistently resulted in a reduction in HWT rut depth values, except for two CR-modified and OGFC mixtures. CRM mixtures with increased asphalt binder content exhibited significantly similar or lower rut depth values. Nevertheless, the rutting performance of the CRM mixtures was within Louisiana DOTD allowable limits.
- CR modification reduced the cracking resistance of CRM mixtures. The reduction in cracking resistance was more noticeable in CRM binders with relatively higher high-temperature performance grades (PG).
- Increasing the asphalt binder content in the CRM mixtures above the optimum level resulted in increased cracking resistance. Mixtures prepared with hybrid CRM/SBS additives exhibited better cracking resistance than those prepared with regular CR additives. The aforementioned observations imply that the use of polymer additives and increased asphalt content should be considered to mitigate the impact of crumb rubber additives on the long-term cracking resistance of CRM mixtures.
- The HWT test showed that both the conventional dense-graded and the SMA mixtures exhibited higher HWT rut depth than their corresponding CRM mixtures.
- CR modification effectively reduced the rut depth for dense-graded and SMA mixtures. Nevertheless, the addition of CR particles to asphalt mixtures resulted in reduced fracture resistance. The aforementioned trend was generally observed for all the dense-graded mixtures considered in the study. However, some inconsistencies were observed in the SMA and OGFC mixtures. The aforementioned phenomenon is attributed to the fact that the rutting and cracking resistance of OGFC and SMA mixtures are dependent on the orientation of the aggregates in the mixture, and therefore, the performance characteristics of these mixtures are unpredictable.

RECOMMENDATIONS

The following recommendations have been made for consideration:

- Additional mix design procedures should be considered and adopted for CRM mixtures. Previously, procedures used for conventional mix designs were adopted for CRM mixtures. The findings of this study indicate that CRM modification requires the development of unique design approaches for each CRM mixture type.
- CR particles had a tendency to absorb the base asphalt binder that was used to produce CRM binders. The above phenomenon reduces the effective binder content and the ability of the remaining binder to effectively bind the aggregates in hot mix asphalt. Therefore, additional asphalt content should be considered in the proposed mix design approach for CRM mixtures.
- It is recommended that hybrids of CRM and SBS additives be used to improve the cracking resistance of CRM mixtures.
- The study showed that a 10% (by the weight of the total binder) CR modification without changes to the mix design will result in a significant decrease in the cracking resistance of the asphalt mixture. Consequently, lower percentages of crumb rubber modifications should be considered.

Figure 1
Scrap tire stockpile

Figure 2
Crumb rubber madifier in asphalt