PROJECT SUMMARY

Texas Department of Transportation

0-6591: Developing a Fundamental Understanding of the Chemistry of Warm Mix Additives

Background

Several technologies have been introduced during the last decade to produce asphalt mixtures at temperatures that are 30° to 50°C lower (54° to 90°F lower) than conventional mixing and compaction temperatures. These mixtures are referred to as warm mix asphalt or WMA mixtures. There are several different technologies that may be used to produce WMA mixtures. These include additives such as chemicals, organic compounds, water-bearing zeolite particles or introduction of water during mixing to cause foaming. There are several benefits of using WMA including but not limited to reduced energy consumption during mixture production and placement, reduced emissions, reduced oxidative aging in the asphalt binder and an extended construction season. The long-term success of using WMA rests on being able to demonstrate that the roads constructed using this technology are similar to or better than the conventional hot mix in terms of durability and performance. Several independent research studies have made broad comparisons between the engineering properties and performance of WMA mixtures to conventional HMA mixtures. However, there has been very little work that investigates the effect of WMA additives on the performance-related properties of the asphalt binder or on the long-term impact of using such additives in asphalt binders and mixtures. In addition, there is a need for work to be performed to evaluate the effectiveness of using recycled materials in conjunction with the WMA technology. The overall goal of this study was to bridge the aforementioned knowledge gaps.

What the Researchers Did

A set of asphalt binders and nine different WMA additives were selected for this study. The asphalt binders were carefully selected to demonstrate diversity in terms of their chemical makeup. The performance of these materials was evaluated at three different length scales: asphalt binders, sand-asphalt mortars and full asphalt mixtures. Several different types of tests were conducted at each length scale to evaluate the effect of the additives on the performance of the asphalt binders and mixtures. The evaluation also included asphalt binders and sand-asphalt mortars after long-term aging as well as the impact of using reclaimed asphalt pavement (RAP) binder.

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What They Found

The mechanical properties of different materials that were measured in this study included stiffness, rutting resistance, fatigue and fracture resistance and resistance to moisture-induced damage. The specific binder-additive pairs dictated performance of the WMA asphalt. While there were certain binder-additive pairs that had performance characteristics at par with a similar hot mix asphalt, there were also binder-additive pairs that did not perform well. The results at different length scales (binder, mortar and mixture) related to these performance characteristics were found to be consistent.

What This Means

WMA technology offers certain advantages, such as improved workability at reduced temperature. In fact the advantages to workability are more significant if the hot mix asphalt is to be stored in heated silos or hauled over long distances.

WMA additives and production temperatures result in reduced rutting resistance of asphalt mixtures. Strategies such as the use of RAP to offset the decrease in rutting resistance can further add to the sustainability aspect of using WMA. However, such strategies must be employed with due consideration to the type of WMA additive being used. For example, certain WMAs with wax-based additives do not demonstrate reduced rutting resistance with many (but not all) binders. In such cases, the use of RAP may adversely affect the long-term durability of the mix.

The binder-additive pair dictates the fatigue cracking resistance of different WMA additives. To the extent possible, the fatigue cracking resistance of a proposed WMA must be evaluated with the additive. In other words, a job mix formula (JMF) must be developed and evaluated with the WMA mix with the additive, instead of using a JMF for the hot mix and adding a WMA additive to it.

The stiffness and relaxation properties of WMA after long-term aging are similar to the stiffness and relaxation properties of HMA. In other words, the benefits of reduced aging due to the reduced mixing temperatures appear to diminish after a certain period of time. For the purposes of evaluating performance characteristics that are critical after long-term aging (e.g., low temperature cracking), the WMA must be treated similar to the HMA.

For More Information

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