TECHSUMMARY June 2018

State Project No. 30000117 / LTRC Project No. 07-1B

Evaluation of Warm Mix Asphalt Technology in Flexible Pavements

INTRODUCTION

Warm mix asphalt (WMA) was first developed in Europe as an effort to reduce the greenhouse gas emission associated with asphalt pavement construction. In general, the WMA technologies can be divided into three categories: foaming techniques (water-based and water-bearing), organic or wax additives, and chemical additives. With the significantly lowered production temperature of WMA technologies, using them would bring benefits such as reduced fuel usage and emissions, easier compaction, possible use of higher percentage of RAP, extended paving season, longer haul times and distances, and improved job site conditions for workers. Nevertheless, the lower mixing temperatures have raised concerns that the aggregate may contain water and yield a mixture that is susceptible to moisture damage. Another concern is that the asphalt binder may not possess adequate stiffness characteristics at elevated pavement surface temperature, thereby resulting in rutting susceptibility. These considerations bring up the need to thoroughly evaluate the WMA mixtures to ensure an adequate pavement performance.

OBJECTIVE

The primary objective of this study was to evaluate the laboratory performance of plant-produced lab-compacted mixtures utilizing various WMA technologies, including some mixtures with higher percentages of RAP. The secondary objective of this study was to compare WMA energy consumption cost and emission data to conventional HMA mixtures in terms of fuel/energy savings at the plant and in terms of CO and CO_2 emissions.

METHODOLOGY

Six field projects in Louisiana utilizing four different WMA technologies were considered in this study, yielding 20 mixtures total. Each project included a companion HMA mixture section to allow for direct comparison. The WMA mixtures in this study were produced by either adding a chemical additive or by adding water to the liquid asphalt through a foaming process. In addition, the field experiments included two mixture compaction levels, two asphalt binder types, two nominal maximum aggregate sizes, and higher RAP contents.

Loose mixtures were obtained from trucks at the plant and compacted on-site in a mobile asphalt laboratory. Performance and durability in terms of permanent deformation, fatigue/fracture cracking, and moisture susceptibility of all asphalt mixtures were evaluated and compared through a suite of laboratory mechanical tests. These tests included dynamic modulus, flow number, semi-circular bend (SCB) at intermediate temperature, indirect tensile strength (ITS), loaded wheel tracking (LWT), dissipated creep strain energy (DCSE), and modified Lottman tests.

In order to assess the environmental benefits of WMA, CO and CO_2 emissions were monitored and quantified during the production and placement of two additional WMA field projects to the above-mentioned six projects. The environmental-economic analysis of WMA as compared to conventional HMA was realized through the life-cycle assessment. For this purpose, the Building for Environmental and Economic Sustainability (BEES) version 4.0 model was used.

CONCLUSIONS

Results indicated that WMA mixtures exhibited similar high and intermediate temperature performances in the laboratory as compared to HMA. On average, $1.61 of energy savings per ton of produced asphalt mixture was observed, along with a considerable reduction in air pollutants at the plant. However, the cost of additives and royalty fees would reduce the total cost savings from using WMA. These benefits were observed without reduction in the mechanistic performance of the mix. Specific conclusions in this study are listed as follows:

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- The dynamic modulus master curves revealed that most of the WMA mixtures had identical or better performance compared to that of the control HMA mixtures at all test temperatures and frequencies adopted, indicating comparable performance characteristics at high, intermediate, and low temperatures.
- The LWT test results did not indicate any significant differences in the rutting performances of the mixtures. In addition, stripping was not observed for any of the mixtures. All the WMA mixtures exhibited similar performance to that of the control HMA mixtures.
- The flow number test results showed similar permanent deformation performance in the mixtures. The statistical analyses showed that all the WMA mixtures performed at least similar to that of the control HMA mixtures, if not better. Foamed WMA mixture with higher RAP percentages outperformed the control HMA mixture.
- In general, the SCB test results were statistically similar for both HMA and WMA mixtures. Some of the mixtures (both HMA and WMA) did not meet the DOTD specification criteria.
- The DCSE results indicated comparable performance of WMA mixtures as compared to that of the control HMA mixtures.
- The ITS test results showed that the WMA mixtures exhibited similar or better performance compared to that of the control HMA mixtures for both aged and unaged specimens. Also, in most of the cases, WMA mixtures exhibited similar or better toughness index values than that of HMA mixtures.
- The moisture content, in general, of plant produced HMA and WMA asphalt mixtures were below the maximum specification limit of 0.3%. This indicates that the aggregates were drying adequately in the WMA mixtures.
- In general, WMA mixtures required less number of passes of the rollers to reach the desired level of compaction.
- WMA mixtures reduced the environmental impacts over conventional HMA mixtures with respect to global warming, criteria air pollutants, fossil fuel depletion, and smog formation.
- WMA with foaming technology significantly reduced CO emissions during production and placement. WMA with Sasobit also reduced CO emissions, but to a lower extent. With respect to CO_2 emissions, both foaming and chemical WMA technologies resulted in a reduction in air pollutants but at a lower level than what was observed with CO emissions

RECOMMENDATIONS

Based on the findings and the results of this project, specification recommendations were developed and communicated to the DOTD Asphalt Specification Committee. Several rehabilitation projects included those specifications as special provisions. DOTD has adopted permissive specifications to be included in the *2016 Standard Specifications for Roads and Bridges Manual*. An approved list of WMA additives and processes has also been developed to be maintained by the DOTD Materials section. In addition, a procedure for qualifying new manufacturers of WMA additives and processes for inclusion in the approved list was developed.

Figure 1
LWT test setup

Figure 2
SCB setup

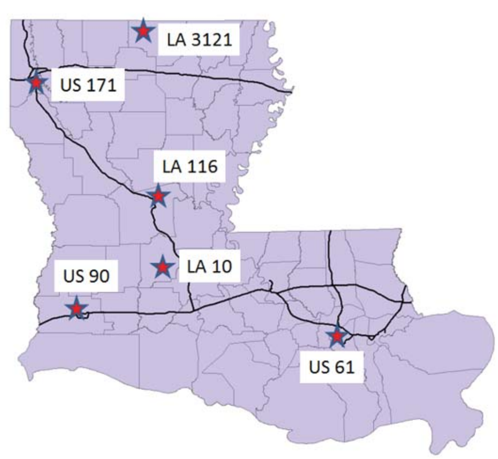

Figure 3
Locations of field projects