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Laboratory Evaluation of the Performance of HMA Mixtures Containing Thiopave Additives

INTRODUCTION

In the past few years, many highway agencies have experienced a significant increase in construction bid prices. One major reason for this sharp increase is the rise in energy costs and the price of liquid asphalt cement, a petroleum product. While the price of asphalt has recently eased, economists widely agree that a sharp rebound in the price of petroleum products will take place as the United States' economy recovers from the current recession.

It is imperative that innovative technologies that can improve the energy and resource efficiency of pavement construction operations be introduced to ensure continuous growth of the economy. Since the 1970s, attempts have been made to use sulfur as a binder extender in order to reduce the amount of asphalt binder required in the mixture and to improve the mix mechanistic characteristics. However, the concept of using sulfur in hot-mix asphalt (HMA) materials was abandoned in the 1980s after environmental and safety problems were encountered during installation and doubts about the cost viability of the modification were expressed.

The idea reappeared in the late 1990s with the development of a new class of solid dust-free sulfur product known as Shell Thiopave®. Many of the safety problems encountered earlier appeared to have been solved, as long as the mixture is produced at a target mixing temperature of 140 ± 5°C. Since warm-mix asphalt (WMA) is designed to reduce the mixing temperature during production by 16 to 55°C lower than with typical HMA, the use of sulfur in the production of WMA may offer the potential to reduce energy and asphalt consumption in the preparation of asphalt mixtures.

OBJECTIVE

The objective of this study was to characterize the laboratory performance of conventional HMA mixtures and mixtures containing Thiopave additives through their fundamental engineering properties. Specific objectives included comparing the laboratory performance of conventional HMA wearing course mixtures to similar WMA mixtures that contain Thiopave additives.

SCOPE

A limited experimental factorial to determine the optimum proportions of Thiopave additives was conducted. The loaded wheel tracking (LWT) and semi-circular bend test (SCB) were conducted as part of the screening factorial for high temperature and intermediate temperature performance, respectively. The optimum percentage of Thiopave additives was determined to be 40 percent.

Three HMA mixtures meeting Louisiana Department of Transportation and Development specifications were designed and examined. The first mixture (WC70CO) was a conventional wearing course mixture using PG70-22 polymer modified asphalt cement; the second mixture (WC64CO) was a conventional wearing course using unmodified PG64-22; and the third mixture (WC64SU) was a wearing course mixture containing a binder consisting of 60 percent PG64-22 unmodified asphalt cement and 40 percent Thiopave additives. The

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mixture performance tests conducted were the Modified Lottman Test, dissipated creep strain energy (DCSE), SCB, dynamic modulus (E*), flow number, LWT, flexural bending fatigue, thermal stress restrained specimen test (TSRST), and repeated shear at constant height (RSCH). Triplicate samples were tested in all cases, excluding the LWT test where duplicate samples were tested.

CONCLUSIONS

Results of the experimental program showed that the rutting performance of sulfur-modified WMA was comparable or superior to conventional mixes prepared with polymer-modified and unmodified asphalt binders. Results of the modified Lottman test showed that the moisture resistance of the sulfur-modified mixture was comparable to conventional mixes. Additionally, fracture and fatigue properties, as measured by the SCB and beam fatigue tests, show that the sulfur-modified WMA mixture possessed stiffer properties than that of a conventional polymer-modified mixture. TSRST results showed that the sulfur-modified WMA had a greater fracture stress than the polymer-modified mixture. However, there was no statistical significance between the average fracture temperatures for the mixes tested.

RECOMMENDATIONS

Based on the results of this laboratory study, construction of field test sections of asphalt mixtures containing sulfur-modified additives alongside conventional asphalt mixtures are recommended to evaluate constructability, long-term performance and environmental impacts. The Louisiana Accelerated Loading Facility is a possible location for the field test sections.

Figure 1
Illustration of the laboratory preparation of sulfur-modified asphalt mixture materials

Figure 2
The Hamburg-type loaded wheel tester

Figure 3
The semi-circular bending test

Figure 4
The thermal stress restrained specimen test