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Summary Report

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MIX DESIGN PROCEDURES AND CONSIDERATIONS FOR POLYMER-MODIFIED ASPHALT COMPATIBILITY AND STABILITY

PROBLEM STATEMENT

To perform reliably, an asphalt pavement must be capable of resisting moisture damage, temperature-induced cracking, the effects of aging, and distresses caused by traffic loads. Yet these and other desirable characteristics are, as engineers have discovered, difficult to achieve. An approach to improved pavement performance that shows particular promise, however, is one in which asphalt modifiers — specifically polymers — are added to the pavement binder.

Asphalt modification is certainly not a new concept. Engineers have been looking at this procedure ever since the 1973 Arab oil embargo halted the flow of single-source crude oil into U.S. refineries—an action that forced these refineries to process oil obtained from multiple sources. The variation in asphalt performance resulting from this process, along with escalating pavement performance demands, has made it increasingly difficult for highway designers and engineers to meet specifications for paving-grade asphalt cement. Asphalt modification was thus accepted as a way of overcoming the problems inherent in multisource crude oil and, more importantly, enhancing asphalt concrete performance.

But because particular properties of current asphalt modifiers are dependent on the type of asphalt cement used, there is still a need to determine asphalt-additive compatibility, binder characteristics, and mixture design procedures that are sensitive to modified binders. This research project looked specifically at these questions.

OBJECTIVES

The Center for Transportation Research (CTR) of The University of Texas at Austin, in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA), undertook this research project to determine whether asphalt pavement performance can be improved through polymer modification of the asphalt binder. The overall goal was to improve the mechanical properties of binders to reduce the occurrence of particular pavement distresses (e.g., thermal and fatigue cracking, moisture damage, and permanent deformation). The specific objectives were to: (1) define the properties desirable in a polymer-modified binder; (2) select test methods that best measure or best quantify these properties in materials used for hot-mixed asphaltic concrete (HMAC); (3) evaluate proper design procedures for HMAC; and, finally, (4) establish specifications for modified binders for each application.

FINDINGS

Guided by the above objectives, the project team undertook a five-year program of laboratory and field studies to investigate the behavior of binders and asphalt mixtures containing polymer modifiers. In their field work, the researchers attempted to determine to what extent the use of polymer-modified binders mandated changes in the construction process. Additionally, they were interested in monitoring the long-term performance of polymer-modified pavements. Thus, twenty-eight test sections containing different aggregates, asphalt cements, and polymers were constructed in six TxDOT districts (San Antonio, Lufkin, Childress, Tyler, Bryan, and Odessa). Of these six projects, four were constructed of HMAC and two were seal coats.

In both the field and laboratory tests, seven different polymers were used, including Goodyear UP-70 (SBR), Polysar NS 175 (SBR), Styrelf (SBS), Polybilt 103 (EVA), Dow (SBR/Polyolefin), Kraton D1101 (SBS), and Crafco rubber C107 (recycled tires). The laboratory testing involved binder and mixture tests conducted in accordance with applicable Texas test methods or ASTM standards. Several additional tests were also evaluated to determine their effectiveness in accurately characterizing polymer-modified asphalt.

The technical findings of this report are summarized under four headings: test methods, binder properties, mixture properties, and plant-mixed versus laboratory-mixed properties. The following represent selected study findings.

Test Methods:

Regarding the test methods, the empirical and fundamental test methods that were evaluated in this study may be useful in identifying polymer-modified binder properties. Viscosity tests, however, do not adequately characterize polymer-modified binders, unless the shear rate is measured. Moreover, most polymer-modified binders exhibited low viscosity at the high shear rates that exist in plant production processes. Finally, a comparison was made between various test methods that predict thermal cracking, permanent deformation, and temperature susceptibility. This comparison yielded results that may be useful in identifying tests that accurately predict field performance.

Binder Properties:

With respect to binder properties, the researchers found that temperature susceptibility—as measured by either penetration index or penetration viscosity number—is significantly decreased for modified binders. They also determined that the addition of polymers decreased stiffness temperature susceptibility (especially for the SBS and Genstar C107). The addition of polymers significantly increased tensile strength and the area under stress-strain curves of the binder, indicating perhaps the binders' higher resistance to cracking.

Mixture Properties:

In examining mixture properties, the CTR project team found that the polymers used in this study, especially SBS, improved a mixture's resistance to moisture damage. Furthermore, indirect tensile creep testing showed that adding polymer to mixtures improves permanent deformation resistance, with SBR-modified binders showing better performance than SBS-modified binders.

Plant-mixed vs Lab-mixed Properties:

In their study of plant-mixed versus laboratory-mixed properties, the researchers performed a stepwise regression analysis that yielded regression equations that may be used to predict the properties of plant-mixed HMAC mixtures.

CONCLUSIONS

The test pavements constructed for this study have not aged sufficiently to provide performance indications; that is, more time is needed before the project team can undertake an assessment of field performance. Study 1306 has been initiated to accomplish this task. It is recommended that the Texas Department of Transportation use its current mix design procedures and test methods until Study 1306 is complete. Once long-term performance evaluations of the test pavements have been carried out, the researchers are confident that the study results will lead to the development of a comprehensive mixture design and analysis method for polymer-modified hot-mixed asphaltic concrete.

In the meantime, the regression equations developed in this project can be used to predict the engineering properties of plant-prepared mixtures. In addition, the information obtained regarding polymer-modified binder and HMAC properties can be stored in a database for use by anyone interested in the properties of currently available commercial polymers.

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