TEXAS TRANSPORTATION INSTITUTE
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Project Summary Report 1742-S
Project 0-1742: Improved HMAC Plant Binder Aging Simulation

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PROJECT SUMMARY REPORT

A New Method for Simulating Hot-Mix Plant Asphalt Aging

The standard tests for simulation of asphalt hot-mix aging are the Rolling Thin-Film Oven Test (RTFOT,ASTM D 2872) and the Thin-Film Oven Test (TFOT, ASTM D 1754). The RTFOT and TFOT have a number of deficiencies when used for viscous or modified asphalts, such as uneven aging, film formation, and difficulty with cleaning laboratory equipment. The purpose of this project was to develop a new procedure for simulating asphalt short-term aging that occurs at a hot-mix asphalt cement plant. This procedure overcomes the shortcomings of the existing procedures, while duplicating the changes that occur during RTFOT aging at improved cost and with more efficient operation.

The resulting Stirred Air-Flow Test (SAFT) is designed based on fundamental studies of the process of air-blowing asphalt materials. Asphalt air-blowing is used commercially to produce roofing and paving asphalts by oxidizing the bottom crude oil

Figure 1. The stirred air-flow test apparatus

products with air, thereby altering the asphalt chemical composition and physical properties. The process conditions and binder composition have a direct impact on the properties of the resulting materials.

What We Did . . .

Development of a replacement apparatus and procedure for the RTFOT occurred in several stages. After a literature review on short-term aging methods, we conducted preliminary studies of the air-blowing technique. Next, we evaluated several designs of pilot test equipment and test operating parameters, such as air flow rate and rate of mixing, for their effectiveness at reproducing RTFOT aging. In the final development stage, we evaluated the apparatus by performing test trials.

Paralleling this development effort, we conducted fundamental studies of asphalt air blowing, as a basis for developing the SAFT aging procedure, but also to investigate the effect of air-blowing conditions and asphalt composition on Superpave performance grade properties and road-temperature aging properties. Several asphalt fractions were air blown at different temperatures. Their physical properties were analyzed with respect to Superpave performance grade, and their composition was determined by the Corbett method (ASTM D4124). Such aging properties as hardening susceptibility, hardening rate, and oxidation rate were determined for each air-blown asphalt.

What We Found . . .

Stirred Air-Flow Test (SAFT)

- The proposed test reproduces the RTFOT and TFOT procedures with respect to changes in chemical and physical properties of asphalt materials.

- The SAFT eliminates the shortcomings of standard methods, including:
  - inconsistent or unreliable test results due to skin formation at the surface of the asphalt;
  - difficulties with removing the asphalt for testing, with cleaning the apparatus, and with handling the hot equipment and asphalt; and
  - difficulties with processing polymer-modified materials.

- The SAFT procedure requires only 45 minutes to age an asphalt material, including 15 minutes required for pre-heating the sample in the apparatus. This total is about half the time required by the RTFOT.

- The proposed procedure achieves precise control of the oxidation time by using nitrogen or other inert gas during the warm-up stage, and by using the same inert gas to quench oxidation at the end of the aging process.

- The sample temperature in the SAFT is controlled directly and thus more precisely.

- The SAFT apparatus (Figure 1) allows for directly collecting and weighing the volatiles driven from the asphalt during the test. This is contrary to either the RTFOT or the TFOT which provide only a measure of mass change, which is a combination of mass loss by volatilization and mass gain by oxidation. The volatiles collected can be further analyzed for molecular size and composition.

- The SAFT apparatus costs significantly less and requires much less bench space than the RTFOT, and it can be manufactured from readily available materials and supplies.

Fundamental Studies of Air Blowing and Thin-Film Aging

- As defined by Superpave specifications, very good grade

asphalts can be produced by air blowing. The blowing temperature does not seriously affect the grade span, although there is some deterioration of the low-temperature grade when a material is air blown to increase the high-temperature grade. Also, the low-temperature stiffness, stress relaxation (represented by m-value), and the failure strain tend to deteriorate with increasing air-blowing temperature. The low-temperature performance grade for air-blown materials tends to be limited by the m-value rather than by the stiffness.

- Asphalt composition has a significant effect on a material's grade span. Materials with a higher concentration of asphaltenes and saturates have a higher performance grade span.

- Air blowing an asphalt material tends to increase its subsequent aging and hardening rates at 88 ˚C. This increase is expected to have an adverse impact on long-term pavement performance but Superpave grading is not affected by this phenomenon.

- The subsequent 88 ˚C hardening and oxidation rates are higher for materials blown at higher temperatures. Hardening susceptibility is a more complex function determined by kinetics of several competing reactions.

- Blowing fluxes with a high saturate content may result in a higher grade but can cause subsequent susceptibility to oxidative hardening. Optimization of both chemical composition of air blown material and process parameters is required in order to produce binders of superior physical and aging properties.

- The oxidation mechanism is the same for asphalt films of varying thickness. Decreasing film thickness to 0.5 mm helps increase rate of oxidation and reduce aging time to 50 minutes to obtain degree of aging equal to the RTFOT.

The Researchers Recommend . . .

- Conduct testing of the SAFT apparatus to establish inter-laboratory precision and consistency statistics.

- Replace the RTFOT and TFOT test methods with the SAFT method for short-term (hot-mix plant simulation) asphalt binder aging.

- Consider adopting the SAFT apparatus and procedure as a nationwide standard.

For More Details . . .

The research is documented in Report 1742-2, *Improved HMAC Plant Binder Aging Simulation*

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TxDOT Implementation Status October 2001

The Stirred Air-Flow Test (SAFT) equipment developed under this research project is being implemented with IPR 5-1742. This IPR covers pilot implementation of this equipment in five districts. This IPR also covers the training of technicians, as well as the development of the repeatability of the test procedure. If this pilot implementation is successful, TxDOT will implement this test in all the districts. The Construction Division is the OPR of this implementation project.

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