Development of a Standard Test Method for Characterization of Asphalt Modifiers and Aging-Related Degradation Using an Extensional Rheometer

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Developing a test method to characterize modified asphalt binders and quantify the degradation of polymers due to aging

This study has been initiated to (a) characterize modified asphalt binders relating to their aging-related degradation; and (b) develop a new standard and specification to supplement the knowledge gap in the performance grade (PG) system for modified asphalt binders. In this study, an extensional rheometer fixture will be used in a DSR platform to perform a suite of tests. Elongation tests and fracture tests will be performed varying sample geometry, temperature and strain rate. To replace ductility test (AASHTO T51), the final strain in the elongation test will be analyzed along with other parameters. The second force peak of force ductility test (AASHTO T300) will be compared to second force peak in elongation test. A novel and direct low-temperature cracking susceptibility test will be developed by analyzing fracture strength and fracture energy parameters. The study will also investigate and quantify (a) the degradation of modifiers with aging; and (b) how polymers/ modifiers influence aging susceptibility. A standard test method and corresponding specifications will be developed for immediate implementation.

Problem Statement

With heavier trucks and increased volume, our roads are increasingly being constructed with modified asphalt binders. While polymers are the most commonly used modifiers, other modifiers such as polyphosphoric acid are also used. Superpave Performance Grading (PG) tests, however, are unable to characterize different polymers and other modifiers that were used. These tests also cannot quantify the degradation of polymers due to aging. Extensional rheometers such as the Sentmanat Extensional Rheometers (SER) are commonly used for polymer characterization. In the proposed project, a SER will be used for modifier characterization and for quantification of degradation of polymer in asphalt due to aging. A standard test method will be proposed, and specifications will be developed for DOTD pilot projects after the final report is submitted. An amount of 10% of the project cost will be used in that purpose.

Summary

Asphalt binder will be modified with different polymers and other modifiers of different percentages in the lab with a high shear mixer. These binders will also be aged with a Rolling Thin Film Oven and a Pressure Aging Vessel at different levels. A Sentmanat Extensional Rheometer (SER) will be used to determine different parameters such as Axial Force, Extensional Viscosity, etc. The behavior of different modifiers and polymer degradation due to aging will be investigated. A standard test method will be developed based on the findings and specifications will be developed based on the pilot projects performed.

Polymer modified asphalt binders (PMAB) and polymer modified asphalt emulsions (PMAE) were used in this study. The main objective of this study is to investigate the degradation of polymer in PMAB due to short term and long-term aging and the potential of the SER method for detecting the percent of polymer content in PMAE. In order to perform the tests on an aged binder, the sample geometry used in this study is 1 mm x 0.72 mm instead of 9 mm x 0.72 mm for PMAB. Similarly, for PMAE the geometry used is 3 mm x 0.72 mm.

Findings

First and Second Peak Elongation Forces: Polymer modified binder is a non-homogeneous material. In the elongation force vs. step time graph, the first peak, F_1 indicates the original asphalt binder property and the second peak, F_2 is related to the polymer characteristics and polymer content as no second is observed in non-modified binder.

PMAB Original and Aged Parameters: The ratio F_2/F_1 vs temperature is shown in Figure 1. F_2/F_1 is a very distinctive parameter of the original and aged PMAB, as the polymer is degraded with

aging, F_2/F_1 decreases. It is clearly observed that RTFO aging reduces F_2/F_1 and PAV aging further reduces F_2/F_1. Therefore, through this study it is recommended that this parameter can be used to determine aging susceptibility of polymer in an asphalt binder.

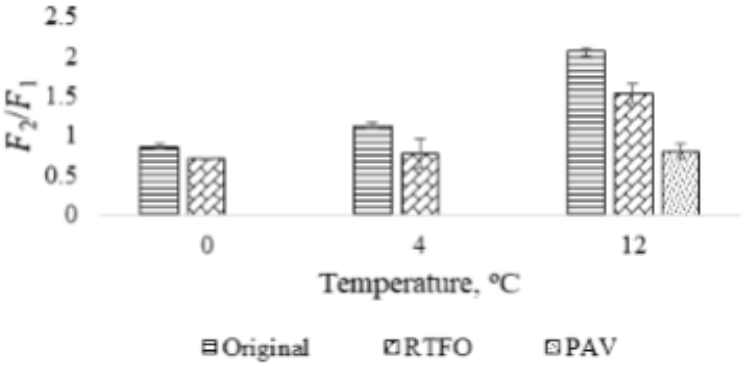

Figure 1. Ratio of average second peak elongation force over average first peak elongation force vs. temperature.

Polymer Percent Content Parameters: PMAEs with four different percentages of polymer were tested to establish a correlation between the polymer percent in the PMAE and the investigated parameter. The investigated parameter was F_2. As mentioned earlier, the four-different percents of polymer were 0%, 2.5%, 4%, and 5.5%. Figure 2 indicates the second peak elongation force, F_2 vs polymer content for four different polymer percentages. It can be observed that with the increment of the polymer percentage, F_2 increases, that is due to the improvement in the PMAE because of the polymer additives.

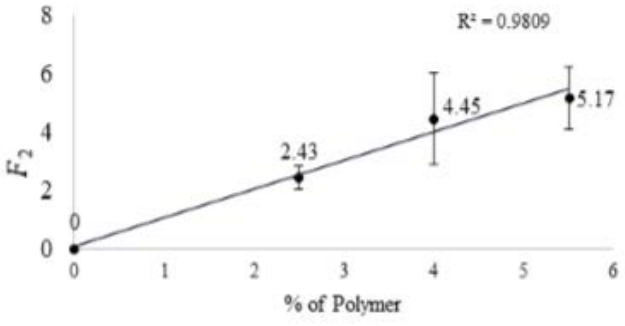

Figure 2. F2 versus polymer content (%).

For 0%, F_2 is equal to 0 N. For 2.5% F_2 is equal to 2.43 N and for 4% F_2 is equal to 3.25 N and for 5.5% F_2 is equal to 5.17 N.

The analysis indicates that F_2/F_1 decreases with aging, which clearly indicates the degradation of the polymer. F_2/F_1 is recommended as a polymer degradation parameter due to aging. All three testing temperatures used in this study exhibited reduction in F_2/F_1 due to RTFO aging and further reduction due to PAV aging. A detailed analysis indicates that F_2 has a strong linear correlation with the percent of the polymer in the PMAE.

Impacts

The purpose of this study is to use advanced technology for asphalt modifier characterization and aging-related degradation characterization and develop a new standard and specifications for immediate technology transfer, workforce development and outreach. This project will also help characterize our road building materials better and thereby, improve the durability and extending the life of the road infrastructure. This test method will fulfill a need in the currently used performance grading system of the asphalt binders.

Tran-SET

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