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Using Logistic Regression to Estimate the Probability of Asphalt Binder Failure at Low Temperatures

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Abstract

Although rheological properties of asphalt binders have been widely used to characterize asphalt mixtures performance in the last 50 years, the cost and availability of the laboratory equipment hampered the spreads of using viscoelasticity to qualify asphalts. During 1987-1992 through the SHRP project a new bitumen grading protocol based on new testing techniques were introduced, which tries to relate rheological properties of binders to pavement performance in the high, intermediate and low service temperature ranges. Each of these ranges has their own failure mechanism and criteria.
The goal of the paper is introducing the concept of mathematical modeling of the probability of asphalt failure. The logistic regression approach is used to model the probability of asphalt failure at low service temperatures. The sample set used in the model calibration is selected from a recent laboratory study report, where for each sample the low temperature stiffness and m-values are measured by Bending Beam Rheometer. Some related applications of the resulting model are also discussed.

Keywords: Rheological Properties, Failure Criteria, Low Service Temperature, Logistic Regression

1. Introduction

Rheological properties of asphalt binders have been widely used to characterize their performance in the last 50 years. But, the cost and availability of the laboratory equipment hampered the spreads of using viscoelasticity to qualify asphalts [1]. During 1987-1992 through the SHRP project [2] a bitumen grading protocol based on new testing techniques were introduced to relate rheological properties of binders to the performance of them in high, intermediate and low service temperature ranges. Each of these ranges has their own failure mechanism and criteria.

One of significant forms of asphalt pavement deterioration that can occur in cold climates is thermal cracking. During thermal cooling, asphalt stiffness increases continuously and thus results in higher stresses for a given shrinkage strain. Simultaneously, thermal stress relaxes due to viscoelastic flow of the asphalt binder. To reliably predict asphalt mix contribution to cracking, both the stiffness of the binder and its rate of relaxation need to be evaluated. A lower stiffness and higher rate of relaxation are favorable for resistance to thermal cracking [3].

Conventional asphalt binders have such a range of rheological and durability properties that sometimes are not sufficient to resist on distresses caused by vehicular traffic. Then, modification of asphalt binders by specialized refining practices, chemical reaction, or different additives is used to improve their performance in roadways. Asphalt modification can usually improve one or more of the main performance related properties of asphalts. There are several test results in literature quantifying the effectiveness of different additives (modifiers) on asphalt properties [1].

The goal of the paper is introducing the concept of mathematical modeling for identifying the probability of asphalt failure. The logistic regression approach is used to estimate the effect of statistically significant factors on asphalt failure at low service temperatures. The sample set used in the model calibration is selected from a recent laboratory study report, where for each sample the low temperature stiffness and m-values are measured by Bending Beam Rheometer according to ASTM D6648 [4].