ABSTRACT

Behnood, Ali, Ph.D., Purdue University, August 2016. Rheological Properties of Modified Asphalt Binders: An Analysis of the Multiple Stress Creep Recovery Test. Major Professor: Jan Olek.

The Superpave specifications and equipment, introduced in 1993, represented a major advancement with respect to offering a better understanding of the behavior and characteristics of asphalt binders based on their rheological properties. However, the Superpave high-temperature test protocol has been shown to be inadequate for characterizing the high-temperature behavior (rutting resistance) of asphalt binders, particularly polymer modified ones. Recently, a specification based on the Multiple Stress Creep Recovery (MSCR) test has been proposed to address the shortcomings of the Superpave high-temperature binder specifications. This study aims to investigate the merits of implementing the MSCR test and specification as a replacement for the conventional high-temperature testing in the Performance Graded (PG) system. A statistical analysis was conducted on a dataset of more than 2500 binders graded based on both PG system and MSCR protocol obtained from Indiana Department of Transportation (INDOT) to see how MSCR and PG procedures differ in grading different binders used in the state. In addition, an experimental program was conducted on several modified binders that were prepared from the same neat binder. Using various percentages of styrene-butadiene-styrene (SBS), ground tire rubber (GTR) and polyphosphoric acid (PPA) additives, the objective of this research was to investigate the effects these additives on the rheological properties of the binders. The results of the binders grading obtained from this experimental program were also used to compare the performance of the PG system and the MSCR protocol. In addition, another experimental study was conducted using seventeen different modified and unmodified binders. In the former experimental program, the binders were modified in the laboratory, which allows to control the amount of the added modifier. However, in the later experimental program, commercially available asphalt binders were used. In addition to binder tests, seven of the commercially available binders were selected to

conduct asphalt mixture tests such as dynamic modulus and flow number. The results confirm that the MSCR test is a suitable replacement for the current PG high temperature test since it provides a better tool to rank modified asphalt binders as well as unmodified ones. That is, creep compliance from the MSCR test more fundamentally represents binder behavior at high temperatures compared to the PG rutting parameter. In addition, the very simplified approach, known as grade-bumping, used in the current PG system to account for high traffic levels and low speed limits can be eliminated when using the MSCR test. The MSCR test also provides a better coefficient of correlation (at both stress levels) with flow number test results than the PG rutting parameter, again indicating that it more accurately reflects binder performance at high temperatures.