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Comparison of rutting resistance of unmodified and SBS-modified Superpave mixtures by accelerated pavement testing

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Abstract

Superpave asphalt mixtures have been used in highway pavements in the US since the late 1990s. Modified binders have also been used in some of the Superpave mixtures in an effort to increase the cracking and rutting resistance of these mixtures. Due to the short history of these mixtures, it is still too early to assess the long-term performance of these Superpave mixtures and the benefits from the use of the modified binders. This paper presents the results of a full-scale pavement-testing program to evaluate the rutting resistance of Superpave mixtures with and without polymer modification using a Heavy Vehicle Simulator.

Results from the HVS tests showed that the pavement sections with two 5-cm lifts of SBS-modified mixture clearly outperformed those with two 5-cm lifts of unmodified mixture, which had two to two and a half times the rut rate. The pavement sections with a lift of SBS-modified mixture over a lift of unmodified mixture practically had about the same performance as the sections with two lifts of SBS-modified mixture when tested at ambient temperature, and had only about 20% higher rutting than those with two lifts of modified mixture when tested at 50 °C. The test section with two lifts of SBS-modified mixture and tested at 65 °C still outperformed the test sections with two lifts of unmodified mixture and tested at 50 °C. Rutting of the unmodified mixture was observed to be due to a combination of densification and shoving, while that of the SBS-modified mixture was due primarily to densification.

Keywords: Rutting; SBS; Heavy Vehicle Simulator; Superpave

1. Introduction

Florida Department of Transportation (FDOT) started the use of Superpave mixtures on its highway pavements in 1995. Modified binders have also been used in some of the Superpave mixtures in an effort to increase the cracking and rutting resistance of these mixtures. Due to the short history of these mixtures, it is still too early to assess the long-term performance of these Superpave mixtures and the benefits from the use of the modified binders. There is a need to evaluate the long-term performance of these mixtures and the benefits obtained from the use of modified binders, so that the Superpave technology and the selection of modified binders to be used could be effectively applied.

The FDOT Materials Office recently acquired a Heavy Vehicle Simulator (HVS) [1,2] and constructed an Accelerated Pavement Testing (APT) facility (Fig. 1), which uses this Heavy Vehicle Simulator. The HVS can simulate 20

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Fig. 1. Photo of the test track (APT facility).

years of interstate traffic on a test pavement within a short period of time [3]. This study was to use the accelerated pavement testing facility to evaluate the long-term performance of Superpave mixtures and SBS-modified Superpave mixtures with particular emphasis on the rutting resistance of these mixtures. This research work was a cooperative effort between the FDOT and the University of Florida.

The main objectives of this study are as follows:

- To evaluate the rutting performance of a typical Superpave mixture used in Florida and that of the same Superpave mixture modified with a SBS polymer.
- To evaluate the relationship between mixture properties and the rutting performance.
- To evaluate the difference in rutting performance of a pavement using two lifts of modified mixture versus a pavement using one lift of modified mixture on top of one lift of unmodified mixture and two lifts of modified mixture versus a pavement using two lifts of unmodified mixture.

2. Experimental design

2.1. Materials

The two asphalt mixtures, which were placed in the test pavements, were (1) a Superpave mixture using PG67-22 asphalt and (2) a Superpave mixture using PG67-22 asphalt modified with a SBS polymer (3% by weight of the total binder), which had an equivalent grading of PG76-22. Both mixtures were made with the same aggregate blend having the same gradation, and had the same effective asphalt content. The types and gradation of the aggregate (Florida limestone) blend used were similar to those of an actual Superpave mixture, which had recently been placed in Florida. These mixtures can be classified as 12.5 mm fine Superpave mixes, with a nominal maximum aggregate size of 12.5 mm and the gradation plotted above the restricted zone. The gradation of the aggregate used in the asphalt mixtures is given in Fig. 2. Design of the Superpave mixture was done according to the Superpave mix design procedure and criteria using a design traffic level of 10–30×10^6 80-kN (18-kip) Equivalent Single Axle Loads (ESALs) [4]. The binder contents and volumetric properties for these two mixtures are shown in Table 1.

2.2. Testing parameters and sequence

The main testing program was to be run on Test Lanes 1–5, which had a total of 15 test sections. The testing parameters and sequence to be used for the main testing program are shown in Fig. 3. The testing program was divided into two phases. Phase I was conducted at ambient condition on five test sections, 1C–5C. Phase II was conducted with temperature control on the other ten test sections. In Phase II, Lanes 1 and 2, which have two 5-cm lifts of SBS-modified Superpave mixture were tested at controlled pavement temperatures of 50 and 65 °C. The rest of the test sections in Phase II were tested at only one temperature, namely 50 °C. The testing sequence was arranged such that the effects of time on each lane could be averaged out. It was also arranged such that the HVS vehicle would not have to drive over a test section, which has not been tested in order to minimize damage to the test sections.

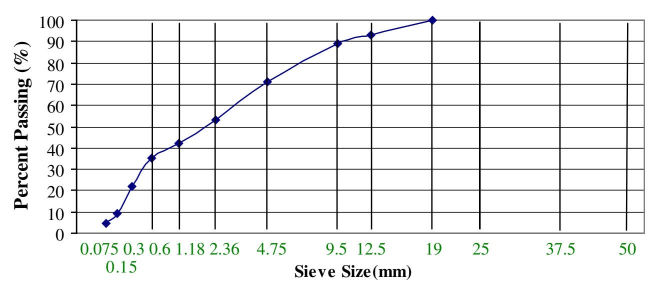

Fig. 2. Gradation of aggregate used in the asphalt mixture.

Table 1
Volumetric properties of the asphalt mixtures

Mix properties	Mix type	
	Superpave mix (compacted at 149 °C)	Modified Superpave mix (compacted at 163 °C)
Asphalt binder	PG67-22	PG76-22
% Binder	8.2	7.9
$V_a@N_{design}$ (Air voids) (%)	4.0	3.8
VMA (Voids in the mineral aggregate) (%)	14.5	14.2
VFA (Voids filled with Asphalt) (%)	72	73
P_{be} (Effective asphalt content) (%)	4.97	4.90
G_{mm} (Maximum specific gravity of the mix)	2.276	2.273