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Evaluation of performance characteristics of the heavy vehicle simulator in Florida

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Abstract

The Florida Department of Transportation (FDOT) Materials Office has recently acquired a heavy vehicle simulator (HVS) and constructed an accelerated pavement testing (APT) facility which uses this HVS. An investigation was conducted to evaluate the operational performance of the HVS, and to determine its most effective test configurations for use in evaluating the rutting performance of pavement materials and/or designs under typical Florida traffic and climate conditions. Five trial runs with the HVS used a super single tire with a load of 4082 kg, tire pressure of 793 kPa and a wheel traveling speed of 12.9 km/h. These five trial runs used different combinations of wheel traveling direction (uni-directional or bi-directional), total wheel wander and wander increments. The uni-directional loading was found to be a more efficient mode for evaluation of rutting performance using the HVS. As compared with the bi-directional loading mode, the uni-directional mode produced substantially higher rut depths for the same number of wheel passes and also for the same testing time duration. When the bi-directional loading with no wander was used, imprints of the tire treads were observed on the wheel track. It was found that using a loading mode with wander smoothened out the imprints of the tire treads considerably. The uni-directional loading mode with 10 cm wander using 2.5 cm increments was selected to be used for evaluation of rutting performance based on consideration of testing efficiency and realistic rutting results.

Keywords: Accelerated pavement testing; Superpave; Heavy vehicle simulator; Rutting

1. Introduction

1.1. Background

FDOT started the use of Superpave mixtures on its highway pavements in 1996. 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 has recently acquired a heavy vehicle simulator (HVS) and constructed an accelerated pavement testing (APT) facility which uses this HVS. The HVS can simulate 20 years of interstate traffic on a test pavement within a short period of time. Thus, a research study was started to evaluate the long-term performance of Superpave mixtures and modified Superpave mixtures using the APT facility. This research work is

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being carried out by a cooperative effort between the FDOT and the University of Florida. The main objectives of this study are as follows:

1. To evaluate the operational performance of the HVS, and to determine its most effective test configurations for use in evaluating the rutting performance of pavement materials and/or designs under typical Florida traffic and climate conditions.
2. 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.
3. To evaluate the relationship between mixture properties and the rutting performance.
4. 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.

1.2. Scope

This paper covers the evaluation of the operational performance of the HVS and determination of its most effective test configuration to evaluate the rutting performance of pavement materials under typical Florida traffic and climate conditions.

2. Materials

The two asphalt mixtures which were placed in the test pavements were (1) a Superpave mixture using a PG67-22 asphalt and (2) a Superpave mixture using a PG67-22 asphalt modified with a SBS polymer 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 blend used were similar to those of an actual Superpave mixture which had recently been placed down 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 properties of the aggregates used are shown in Table 1.

The designs for these two mixtures were done by the personnel of the Bituminous Section of the FDOT Materials Office. The optimum binder content was determined according to the Superpave mix design procedure and criteria using a design traffic level of $10–30 \times 10^6$ ESALs. The volumetric properties for these two mixtures are shown in Table 2.

3. Experimental design

3.1. Test track layout

The layout of the test track, which was constructed at the FDOT APT facility for this study, is shown in Fig. 1. The test track consists of seven test lanes. Lanes 1 and 2 have two 5 cm lifts of a SBS-modified Superpave mixture. Lane 3 has a 5 cm lift of the SBS-modified Superpave mix over a 5 cm lift of unmodified Superpave mix. Lanes 4–7 have two 5 cm lifts of the unmodified Superpave mix. Each lane is divided into three test sections, designated as A, B and C. The main testing program is to be run on Test Lanes 1–5, with a total of 15 test sections. Test Lane 6 is set aside for additional testing deemed necessary or desirable at the end of the main testing program. Test Lane 7 is to be used for trial runs to evaluate the performance characteristics of the HVS and to determine the most effective test configuration to be used in the testing program.

3.2. Testing configurations

All five trial runs with the HVS used a super single tire with a load of 4082 kg, tire pressure of 793 kPa and a wheel traveling speed of 12.9 km/h. These five trial runs used different combinations of wheel traveling direction (uni-directional or bi-directional), total wheel wander and wander increments as follows:

(1) bi-directional travel with no wander,
(2) uni-directional travel with no wander,
(3) uni-directional travel with 10 cm wander in 5 cm increments,
(4) bi-directional travel with 10 cm wander in 5 cm increments,
(5) uni-directional travel with 10 cm wander in 2.5 cm increments.

Trial Run 1 was run on Test Section 7C. Trial Runs 2 and 3 were run on the western and the eastern sides, respectively, of Test Section 7B, and were designated as 7B-W and 7B-E. The edges of wheel tracks from these two tests were separated by a distance of about 38 cm. Trial Runs 4 and 5 were run on the eastern and western sides, respectively, of Test Section 7C, and were designated as 7A-E and 7A-W. The edges of wheel tracks from these tests were separated by a distance of about 28 cm.

3.3. Temperature measurement

The temperature distribution in each test pavement was monitored by eight thermocouples. For each test section, three thermocouples (#1, 2 and 3) were placed on top of the base course, three (#4, 5 and 6) were placed between the two lifts of asphalt mixture, and two (#7 and 8) were placed on the surface. During each of the trial runs, the temperature readings for the test section were taken every 15 min and recorded by a PC data acquisition system. Table 3 displays (1) the average of the daily minimum temperatures, (2) the average of the daily maximum temperatures, (3) the overall minimum temperature, and (4) the overall maximum temperature as recorded by the three thermocouples between the two lifts of asphalt