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The Hamburg rutting test – Effects of HMA sample sitting time and test temperature variation

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HIGHLIGHTS

- The Hamburg Wheel Tracking Test (HWTT) is a rutting test for asphalt (HMA) mixes.
- Summer field rutting failures with HMA mixes that passed the HWTT in the laboratory.
- The study evaluated the laboratory HMA sample sitting time and HWTT test temperature.
- The HWTT test results suggested five days as the optimal HMA sample sitting time.
- Higher (>50 °C) and/or multiple HWTT test temperatures should also be considered.

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ABSTRACT

The Hamburg Wheel Tracking Test (HWTT) is a widely used routine laboratory test with a proven history of successfully identifying and screening hot-mix asphalt (HMA) mixes that are prone to rutting and/or susceptible to moisture damage (stripping). Based on Texas specification Tex-242-F, the HWTT is typically conducted at a single test temperature of 50 °C (122 °F) with 12.5 mm rut depth as the standard HMA pass-fail screening criteria. However, with the record high summer temperatures of the recent years in Texas, several premature field rutting failures have occurred with some HMA mixes that had passed the HWTT screening criteria in the laboratory. This laboratory study was thus initiated to review and evaluate if the current Texas HWTT protocol and its associated Texas test specification (Tex-242-F) are simulative of the current summer field conditions for routine HMA mix-design and screening to optimize rutting resistance performance. Specifically, two key aspects were evaluated, namely the HMA sample sitting time and test temperature. The corresponding laboratory test results indicated that a maximum sample sitting time of five days should be consistently adapted, i.e., lab-molded samples should be tested within five days of fabrication, particularly for HMA mix-design screening purposes. For HMA mixes to be used in high temperature/stress environments, the study findings suggested that higher (>50 °C), and/or multiple HWTT test temperatures should be considered.

1. Introduction

Rutting is one of the major distresses occurring in hot-mix asphalt (HMA) pavements; typically manifesting itself as longitudinal depressions in the wheel paths [1,2]. HMA rutting is mainly caused through shear deformation in the upper HMA layers under traffic loading [3–6]. One of the routine laboratory tests commonly used for mix-design screening and assessing the HMA rutting susceptibility is the Hamburg Wheel Tracking Test (HWTT). Traditionally run at a single test temperature of 50 °C (122 °F) in the laboratory under Texas specification Tex-242-F, the HWTT has been proven as a reliable test method to identify and screen HMA mixes that are prone to rutting and/or susceptible to moisture damage (stripping) [7–10]. However, the current summer pavement temperatures can reach as high as 60 °C, which makes the HMA more susceptible to rutting failure under heavy traffic loading [11]. In particular, with the record high summer pavement temperatures (>50 °C) of the recent years in Texas, several rutting failures have occurred in the field with some HMA mixes that had passed the

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HWTT in the laboratory. These failures occurred mostly in high shear stress locations, in particular with slow moving (accelerating/decelerating) traffic at controlled highway sections (stop–go intersections), in areas of elevated temperatures, heavy/high traffic loading, and/or where lower performance grade (PG) asphalt-binders have been used for cost optimization purposes, etc. [11,12].

Since improper HMA mix selection due to poor laboratory screening can undesirably lead to costly premature pavement failures, tying laboratory testing to field performance is very critical to ensure optimal field performance and minimization of maintenance/rehabilitation costs. For rutting and as stated above, this is particularly critical in areas of elevated temperatures (in summer), heavy/high slow moving traffic with longer loading times, and/or where lower PG asphalt binders are used. In the recent years, where summer pavement temperatures have been excessively high (i.e., over 50 °C), several districts in Texas have experienced premature HMA rutting and shear failures for some surface mixes, particularly at highway intersections; yet, these mixes had satisfactorily passed the HWTT screening criteria in the laboratory. Fig. 1 shows some examples of summer surface rutting failures, mostly at highway intersections, where the mixes had passed the HWTT in the lab [12].

Based on the foregoing background, this laboratory study was conducted to review and evaluate if the current Texas HWTT protocol and its associated test specification are simulative of the current summer field conditions for HMA mix-design and screening to optimize rutting resistance performance. Specifically, two key aspects were evaluated and are discussed in this paper; namely the HMA sample sitting time and HWTT test temperature. In the subsequent sections, the Texas HWTT protocol and Tex-242-F specification are described, followed by the laboratory experimental plan. Laboratory test results are then presented and analyzed. The paper then concludes with a synthesis and summary of the key findings and recommendations.

2. The HWTT protocol and Tex-242-F specification

Based on the Texas Tex-242-F specification, the current the HWTT protocol consists of the following test parameters: 0.7 kN (158 lb) vertical load at a wheel speed of 52 passes per minute up to 20,000 passes at 50 ± 1 °C (122 °F) in a water bath [9]. The HWTT protocol is routinely used to determine and quantify the HMA premature failure susceptibility due to weak aggregate structure, inadequate asphalt-binder stiffness, moisture damage (stripping), and other factors including inadequate adhesion between the asphalt-binder and aggregates. Fig. 2 shows a pictorial illustration of the HWTT equipment along with a sample loading configuration.

The HMA pass-fail screening criteria is based on a measured maximum rut depth of 12.5 mm (<12.5 mm) and the number of HWTT load passes to failure (or test termination), whichever comes first. The applicable number of HWTT load passes is a function of the PG asphalt binder as follows: PG 64-XX = 10,000 passes; PG 70-XX = 15,000 passes; and PG 76-XX = 20,000 passes [9,12,13]. Two aspects associated with the current HWTT protocol and the Texas Tex-242-F specification were investigated in this laboratory study and are discussed in this paper, namely: HMA sample sitting time and test temperature variation.

2.1. HMA sample sitting time and oxidative aging effects

As at the time of this study, the Texas Tex-242-F specification did not specify any time limits within which to test the lab-molded HMA samples after molding/fabrication. HMA samples are tested randomly without consideration of the sitting time from the time of molding to the actual time of testing, i.e., the sitting time can variably be 1 day, 3 days, 5 days, 1 week, 2 weeks, etc., before the samples are actually tested. This can particularly be an issue when comparatively evaluating HMA mixes. Also, if some samples are variably tested after a long sitting time period after molding/fabrication, there could be some possible short-term oxidative aging effects and stiffening up of the HMA that could impact the HWTT test results. To ensure consistency, it is better that lab-molded samples are consistently tested in a similar timely manner.

Specifically, for routine HMA mix-design screening, it is in fact desired that the HWTT samples be tested as soon as practically possible after molding/fabrication. Therefore, it was deemed necessary in this study to investigate and specify an acceptably reasonable sample sitting time so as to ensure consistency. Thus, the following sample sitting times at room temperature were comparatively studied and are discussed in this paper: 1 day, 3 days, 5 days, 7 days (1 week), and 14 days (2 weeks) [14].

As stated above, HWTT samples for routine HMA mix-design screening should desirably be tested within the shortest practically possible time period after molding/fabrication so as to minimize any short-term oxidative aging effects of the asphalt binder on the laboratory test results. However, circumstantial factors such

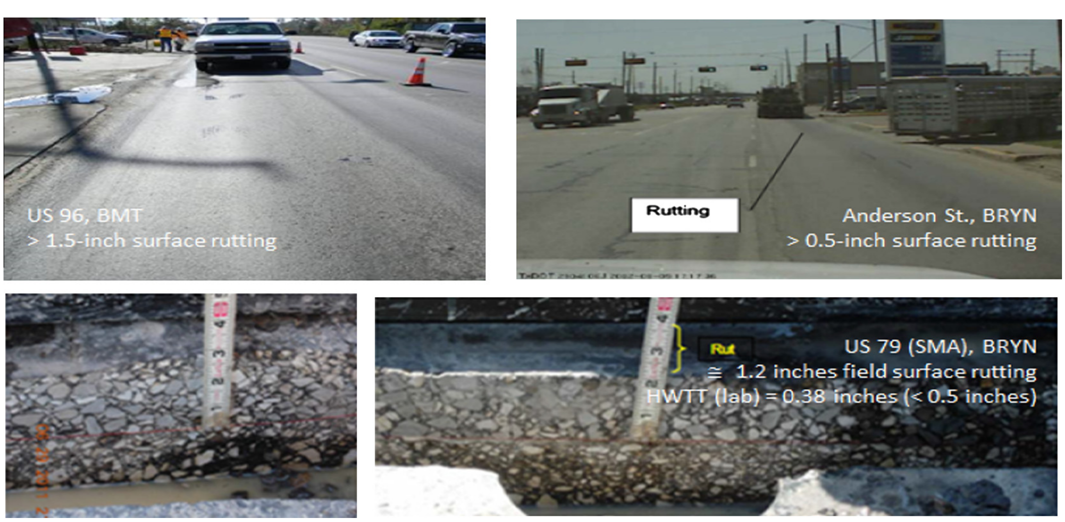

Fig. 1. Examples of premature and surface rutting on some Texas highways.