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Characterizing the cracking and fracture properties of geosynthetic interlayer reinforced HMA samples using the Overlay Tester (OT)

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HIGHLIGHTS

- Reflective cracking is one of distresses occurring in the hot-mix asphalt (HMA) overlays.
- Crack-impeding interlayer materials are used to improve the life of the HMA overlays.
- The Overlay Tester (OT) is used to evaluate cracking resistance of HMA samples in the laboratory.
- Different geosynthetic interlayer materials embedded in HMA samples are evaluated by the OT.
- Crack resistance of geosynthetic interlayer reinforced samples are substantially improved.

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ABSTRACT

Reflective cracking is one of the undesirable distresses occurring in hot-mix asphalt (HMA) overlays; costing highway agencies millions of tax payer dollars in maintenance and rehabilitation activities. To mitigate this distress, crack-impeding interlayer materials such as geosynthetic interlayers are specified to protect the HMA overlays as part of maintenance and rehabilitation strategies. Currently however, there is no universally standardized laboratory crack test method to aid in the selection of the most appropriate geosynthetic interlayer material for maximum crack resistance and performance. This study was undertaken to evaluate the laboratory cracking-resistance and fracture performance of different geosynthetic interlayer materials embedded in HMA samples. As a means to investigate its applicability for testing interlayer materials, the Overlay Tester (OT), in a monotonic tensile loading mode (3.375 mm/min) at 0 °C, was explored as the study test method. Eight different geosynthetic interlayer products with different properties were compared to a 'control specimen' using a dense-graded HMA mix. Although field validation is still warranted, the study results indicated a substantial improvement (over 20%) in the laboratory crack and fracture performance of the geosynthetic interlayer reinforced samples over the Control samples; suggesting that use of these interlayer materials may be beneficial in mitigating reflective cracking in HMA overlays. For the test conditions considered, the OT test in monotonic tensile-loading mode also exhibited promising potential as a rapid crack test method for testing geosynthetic interlayer materials. The sample crack failure mode, test repeatability, and statistical variability in the test data were generally within reasonable expectations.

1. Introduction

Reflective cracking is one of the undesirable structural distresses occurring in hot-mix asphalt (HMA) overlays over flexible and concrete pavements; costing highway agencies millions of tax payer dollars in maintenance and rehabilitation activities. To mitigate reflective cracking in existing pavements, various methods including application of crack-impeding geosynthetic interlayers such as paving grids, paving mats, or paving fabrics are often used in maintenance and/or rehabilitation projects as part of the HMA overlay construction; see Fig. 1 [1–3].

As illustrated in Fig. 1, the primary role of a geosynthetic interlayer is to arrest the upward propagation of cracks from an existing pavement to the surface. The geosynthetic interlayer is used to mitigate the cracks from reflecting through the HMA overlay to

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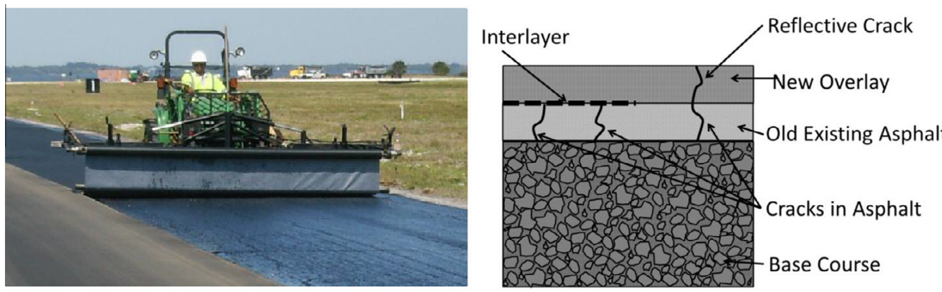

Fig. 1. Geosynthetic interlayer and HMA pavement construction.

the surface. Many types of geosynthetic interlayer materials are presently available in the commercial market and are widely used in HMA overlay projects during maintenance and rehabilitation projects [3].

Currently however, there is no universally standardized laboratory crack performance test method to aid in the selection of geosynthetic interlayer materials. Engineers therefore have to rely on the index properties of the geosynthetic interlayer products alone, as there is minimal or no crack performance data on geosynthetic interlayers when embedded in HMA. Consequently, a fundamental challenge exists to provide a laboratory crack performance test method that can evaluate geosynthetic interlayer materials that would best improve the crack performance of any asphalt layer. Therefore, for a given overlay, on a pavement (PVMNT) with a cracked existing surface, how does one select the best geosynthetic interlayer material to effectively mitigate the reflective cracking? Which of the laboratory crack test methods could one use to fundamentally characterize the fracture properties and accurately evaluate the crack performance potential of the geosynthetic interlayer materials when embedded in HMA? With this background, this laboratory study was initiated to address the following primary objectives:

(1) To investigate if the Overlay Tester (OT), when run in monotonic tensile-loading mode, could satisfactorily serve as a laboratory crack test method for characterizing the fracture properties and evaluating the interactive cracking resistance potential of geosynthetic interlayers when embedded in HMA samples.
(2) To comparatively evaluate the fracture properties of various geosynthetic interlayer materials using the OT test method and rank them in their order of superior cracking resistance performance; in comparison to Control samples with no interlayer.

To achieve these objectives, eight different commercial geosynthetic interlayer materials with different properties were evaluated alongside Control samples in the OT test using a dense-graded HMA mix. As presented in this paper, the study also addressed the following key aspects: (a) the fracture performance improvement of each geosynthetic interlayer type/material over Control samples; (b) a comparison of the fracture performance of different geosynthetic interlayer types; (c) the potential of the OT test and the measured fracture parameters to screen and effectively differentiate between geosynthetic interlayer types; and (d) the OT test's repeatability and statistical variability in the lab test data when run in monotonic tensile-loading mode.

In terms of the paper organization, the experimental test matrix including the geosynthetic interlayers is discussed in the first section, which is followed by the monotonic OT test setup and loading configuration. Thereafter, the data analysis models are discussed; followed by the test results and synthesis of the findings. The paper then concludes with a summary of key findings and recommendations.

2. Experimental plan and materials

Eight different geosynthetic interlayer products, referenced as GIM1 thru to GIM8, were evaluated using a single dense-graded HMA mix with 12.5 mm nominal maximum aggregate size (granite/quartzite) and PG 64-22 asphalt-binder (≅5.0% by weight of the aggregates). HMA samples, reinforced with each of the geosynthetic interlayers, were tested using the OT to get the fracture properties and crack resistance potential versus the Control HMA samples. All geosynthetic interlayer types were installed using a PG 64-22 hot asphalt tack coat. A minimum of three replicate specimens were tested for each geosynthetic interlayer type.

HMA samples (150-mm diameter by 100-mm in height) constructed with the geosynthetic interlayer material were molded using the Superpave Gyratory Compactor (SGC) in two layers, namely the "bottom 50-mm thick HMA" plus tack-coat (PG 64-22) plus interlayer material plus the "top 50-mm thick HMA". Then the geosynthetic interlayer reinforced HMA samples were fabricated/cut to the final test specimen dimensions as shown in Fig. 2.

The HMA samples were basically molded in two steps (bottom 50-mm thick layer first and top 50-mm thick layer second) following the SGC volumetric procedures for fabrication of 150-mm diameter HMA samples using a gyratory compactor. One hundred and fifty-millimeter diameter samples of geosynthetic interlayers were then cut and placed into the measured (by weight) amounts of hot tack coat that had been placed on the base 50-mm thick HMA layer. The tack coat rates were reflective of the individual interlayer requirements by their manufacturer. The interlayer orientation was marked on the sides of the base and then on the top of the final 50-mm thick HMA layer thickness. As indicated in Table 1, only one interlayer, GIM5 (a biaxial product), was measured off angle at 45° from the machine or cross-machine direction and the product provided equivalent resistance regardless of the orientation.

As shown in Fig. 2, all the HMA samples were cut to a total thickness of 62.5 mm and then notched to 18.75-mm depth (3.125-mm wide) from the bottom in the direction of the SGC compaction to simulate a reflective crack on an existing cracked pavement (PVMNT) surface. While the geosynthetic interlayer was located at 25-mm from the bottom in the direction of the SGC compaction, the notch depth was only 18.75-mm (instead of 25-mm) so as to avoid cutting the interlayer material during the notching process. With the notching, the effective thickness of the test specimens was 43.75-mm over the notch; see Fig. 2. At an asphalt mix specific gravity (Rice) value of 2.656 (G_{mm}), the average density of the composite HMA samples (with the interlayer material) prior to notching was measured to be fairly consistent at 87.45% with a