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Effects Of Trackless Tack Interface On Pavement Top-Down Cracking Performance

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Abstract

Tracking, the pick-up of bituminous materials by paving equipment tires, can occur when tack coat emulsion was not appropriately applied. This tracking can result in the existing pavement with little or no tack coat left in the wheel paths, leading to slippage and delamination. A special tack coat material, trackless tack, which does not track or pick up on paving equipment, has been developed. While researches have been conducted on the trackless tack shear strength evaluation, little work has been done on its cracking performance. Interface cracking performance of one type trackless tack at two application rates was evaluated using the composite specimen interface cracking (CSIC) test. The testing system involves repeated tensile loading and monitoring of the rate of damage development (reduction in stiffness) on composite specimens. Results indicated that trackless tack interface reduced the pavement top-down cracking performance as compared with conventional tack coat. However, it was reported in literature that trackless tack had superior shear strength than conventional tack. Therefore, it can be concluded that both shear strength along the interface and cracking resistance across the interface should be evaluated for any interface bond agents.

Keywords: Trackless Tack; Top-Down Cracking; Interface; Composite Specimen Interface Cracking Test.

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1. Introduction

Tack coat is usually applied on existing clean asphalt or concrete pavement surfaces to provide adhesive bond between existing pavement surface and newly constructed asphalt surface layer. A good bond between pavement layers can ensure the pavement layer system act as a uniform composite layer and more effectively transfer the

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external load into the subgrade. On the other hand, poor bonding or debonding can cause slippage and reduce shear strength between pavement layers, thus leading to pavement distress [1, 2, 3, 4].

However, tack coat is often picked up by the rubber tires of construction equipment and removed from the existing pavement surface when it is not thoroughly cleaned. The survey conducted by Mohammad et al. [5] indicated that 38% of the respondents required that tack coat material should be completely set before haul trucks are allowed on it to reduce the tracking problem. Only 13% of respondents allow haul trucks to drive on the tack coat before it breaks. Research by Hachiya and Sato [6] indicated that the strength of the wearing course increases as the time allowed for the tack to break increases.

Trackless tack coat, which breaks in 5 to 15 minutes and does not build up on haul truck tires, is used to address the tracking or pickup of tack coat on haul truck tires and reduce its setting time. As compared with conventional tack coat (CRS-1 and SS-1), superior shear strength has been reported for trackless tack coat [7, 8, 9]. Meanwhile, interface condition characteristics have been reported to strongly affect pavement performance [3, 10, 11, 12, 13, 14]. However, little or no research has been reported on the effect of trackless tack on pavement cracking performance.

Therefore in this study, the effect of trackless tack on pavement top-down cracking performance will be evaluated using a newly developed composite specimen interface cracking (CSIC) test. Top-down cracking is simulated by initiating cracks in Open-Graded Friction Course (OGFC) of composite specimen and propagating through interface and into dense-graded structural layer.

2. Objectives and Scope

The objectives of this study are as follows:

- To analyze the effect of trackless tack interface on top-down cracking performance;
- To compare trackless tack interface cracking resistance with interface shear resistance.

This paper primarily focused on evaluating the effects of trackless tack interfaces on pavement top-down cracking resistance. Dense-graded and open-graded mixtures were used for composite specimen layers with two types of interface bonding agents, i.e. conventional tack coat and trackless tack. Tests were conducted at one temperature (10ºC), which has been determined in prior fracture research on the same material at the University of Florida to correlate well with cracking performance of pavements in the field [15, 16]. The effects of trackless tack interface cracking resistance were compared with its interface shear resistance.

3. Materials

A dense-graded mixture commonly used by the Florida Department of Transportation (FDOT) as a structural layer, identified as Dense-GA-Granite, was used to produce composite specimen lower layer. Its aggregate was made up of four components: coarse aggregate, fine aggregate, screenings, and sand. Its gradation is shown in Table 1. The mixture was designed according to the Superpave^{TM} volumetric mix design method. The binder used for the mixture was PG 67-22 at the rate of 4.8%.

An open-graded mixture commonly used by FDOT as friction course, identified as FC-5 Nova Scotia granite mixture, was used to produce composite specimen top layer. The mixture was designed according to the FDOT specification [17]. Asphalt rubber binder (ARB-12) at the rate of 6.0% was used, along with 1 percent lime pretreatment for the granite mixture. ARB-12 is a blend of PG 67-22 unmodified binder with 12% ground tire rubber.

Two types of tack coats, conventional unmodified asphalt emulsion and non-emulsified trackless tack, were evaluated in this study. The properties of conventional tack coat (an anionic slow setting asphalt emulsion, ASTM type SS-1) and trackless tack (a polymer-modified hard base asphalt cement) are presented in Table 2.

Table 1. Aggregate Gradation

Sieve Size (mm)		19.0	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
% Passing	Dense-Graded	100	99	86	65	47	32	23	14	7	4.2
	OGFC	100	96.2	75	21.6	10.7	7.2	5.7	5	4	3.1

Table 2. Physical Property of Conventional Tack Coat and Trackless Tack

Tests on Conventional Tack Coat Residue	AASHTO /ASTM	Specification
Penetration, 25ºC(77ºF), 100g, 5s	T 49 / D 5	100 - 200
Solubility in Trichloroethylene, %	T 44 / D 2042	97.5 Min
Ductility, 25ºC (77ºF), 5cm/min	T 59 / D 113	40 Min
Tests on Trackless Tack	AASHTO /ASTM	Specification
Penetration, 25ºC (77ºF), 100g, 5s	T49	5-15
Solubility, %	D2042	97.5 Min
Original DSR @82 ºC (G*/SIN d, 10 rad/sec)	T111	1 Min

4. Test Method And Sample Preparation

The composite specimen interface cracking test system included the environmental chamber cooling system, MTS loading system, measurement and data acquisition system. The testing composite specimen geometry and loading configuration are shown in Figure 1. The test was performed by applying a repeated haversine waveform load to the specimen for a period of 0.1 second followed by a rest period of 0.9 seconds (See Figure 1-B). The distinctive features of this test are specimen symmetry and application of load inside the stress concentrator. The hole at the center of the specimen serves both as a stress concentrator and a platform for load application. The composite specimen ready for testing is shown in Figure 2.

Composite specimen can be prepared by compacting loose open-graded mixture on top of the pre-compacted dense-graded structural layer using a Superpave^{TM} Gyratory Compactor (SGC). Two dense-graded specimens for the lower layer were obtained by slicing each of the Superpave^{TM} gyratory compacted specimens in half. Interface bonding agents, conventional tack coat and trackless tack, were applied on the cut surface of dense-graded specimen to reduce the density gradient effect near the ends of gyratory compacted specimens. Open-graded mixture was then compacted on the coated lower dense-graded layer after it was inserted back into the gyratory compaction mold. The open-graded mixture was compacted to the predetermined thickness to achieve design air voids. The resulting half of the final composite specimen with interface bonding agent is shown in Figure 3-D. Two half composite specimens were prepared and their OGFC surfaces were epoxied together to form a completely symmetrical composite specimen for testing. Additional slicing was required to obtain the final specimen configuration shown in Figure 2. A diamond-tip coring tool was used to introduce the 19.0 mm hole though which loading was applied. Finally, the end surfaces were reinforced with carbon fiber to mitigate the potential for shear failure through the OGFC itself. The composite specimen preparation process is shown in Figure 3.

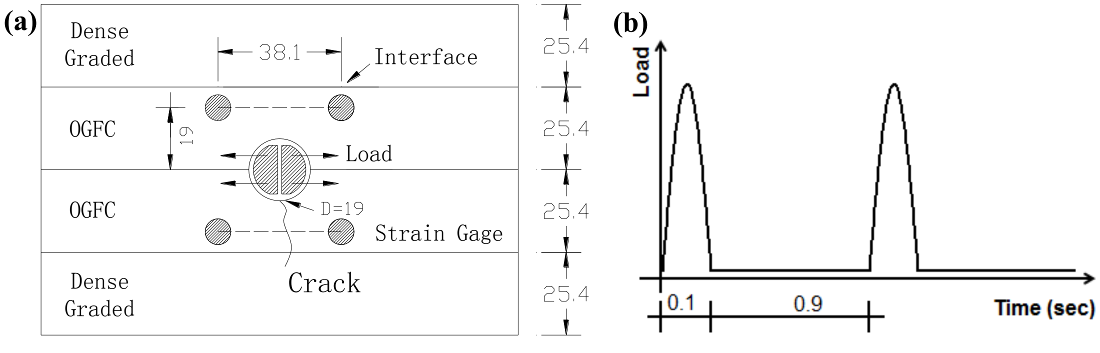

Fig. 1. (a) Composite specimen geometry (Unit: mm);.(b) loading mode

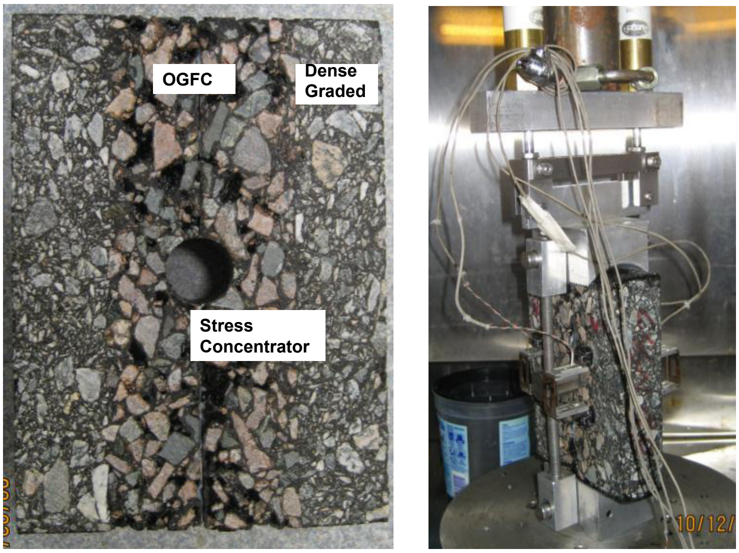

Fig. 2. Composite specimen and test setup [14].

5. Data Collection and Interpretation Method

As reported elsewhere in [18], extensometer data was acquired for calculation of the specimen's total recoverable deformation if a sudden deformation change occurred, or whenever desired. The number of loading cycles required to break the composite specimen and the damage rate were used to compare top-down cracking resistance for specimens with different interface conditions subjected to the same loading conditions. The damage rate was defined as the slope of the steady state response portion of total recoverable deformation progression curve as shown by the line in Figure 4.

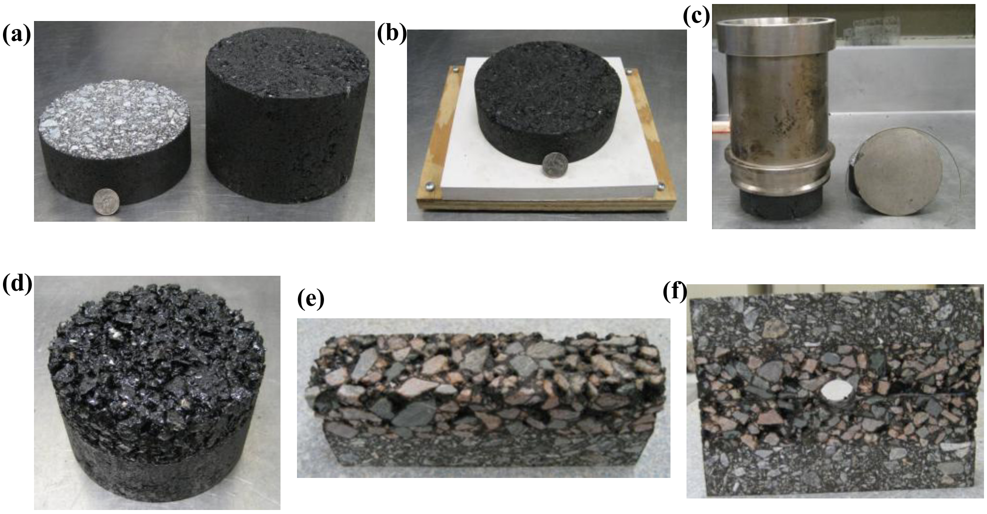

Fig. 3. Composite specimen preparation (a) Slicing; (b) Tack application; (c) Layered compaction; (d) Half-composite specimen; (e) Cutting; (f) Final epoxying, coring stress concentrator and carbon fiber reinforcement of the ends

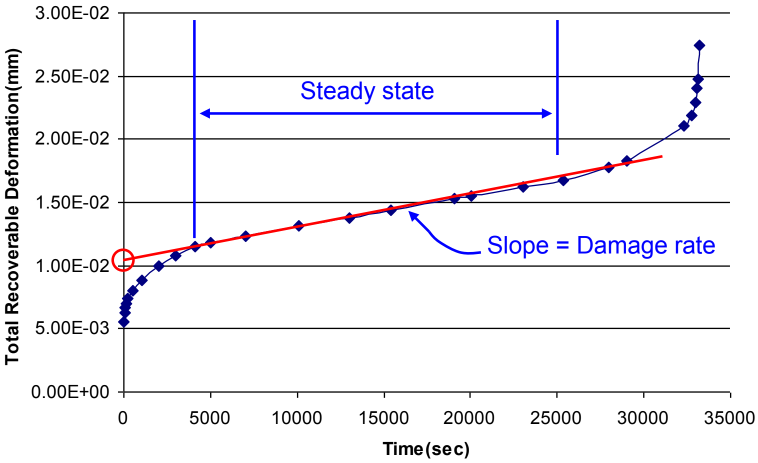

Fig. 4. Typical total recoverable deformation and damage rate

6. Test Results

Three replicate specimens for each of the three types of interfaces, 0.113 L/m^2 conventional tack coat residue and 0.585 and 0.9 L/m^2 trackless tack residue, were prepared. Based on previous research experience [14, 18] with these materials, it was determined that a peak load of 2535N was appropriate. Typical composite specimen failure mode is shown in Figure 5; this appears to correspond nicely with the crack propagation phenomenon in the field. Test results were presented in Figure 6 and 7 for number of loading cycles to failure and damage rate, respectively. These results indicate that trackless tack applied at the interface reduced the top-down cracking performance as compared with composite specimens with conventional tack interface.

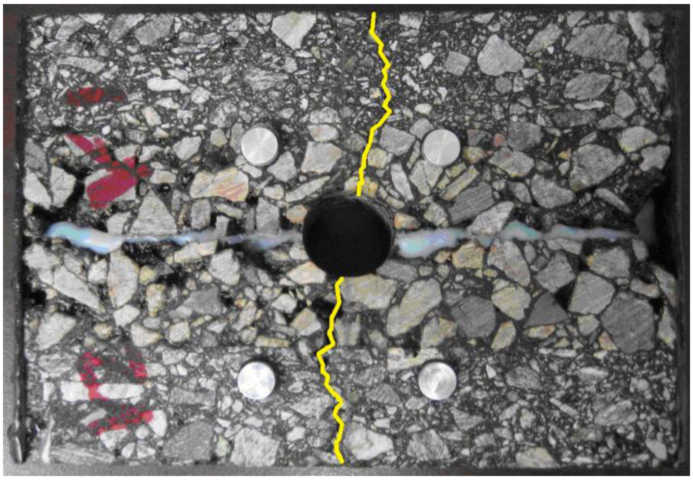

Fig. 5. Typical failure mode of composite specimen

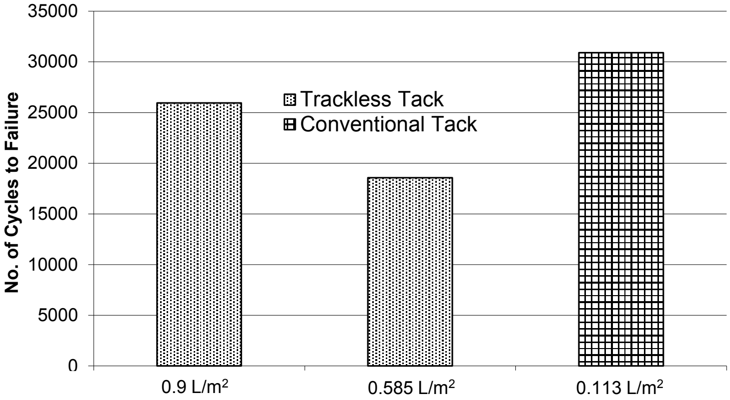

Fig. 6. Number of cycles to failure for trackless and conventional tack

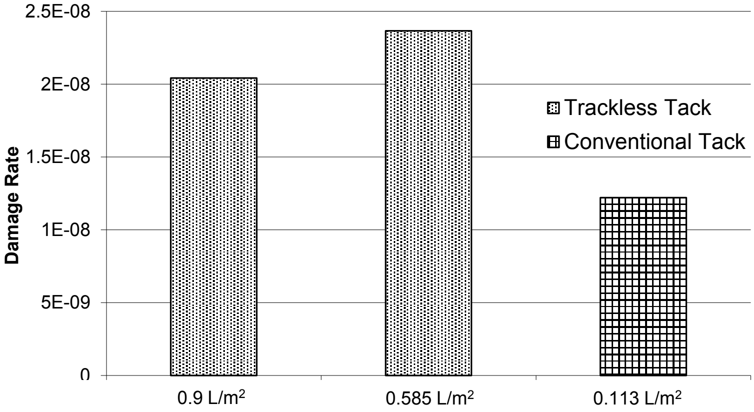

Fig. 7. Damage rate for trackless and conventional tack

7. Discussion

As stated earlier, trackless tack was reported to have superior interface shear strength than conventional tack coat [7]. The interface shear strength was measured using Louisiana Interlayer Shear Strength Tester at the loading rate of 2.54 mm/s. The interface shear strength results for trackless tack and conventional tack (CRS-1) at 3 application rates under 10ºC are presented in Figure 8.

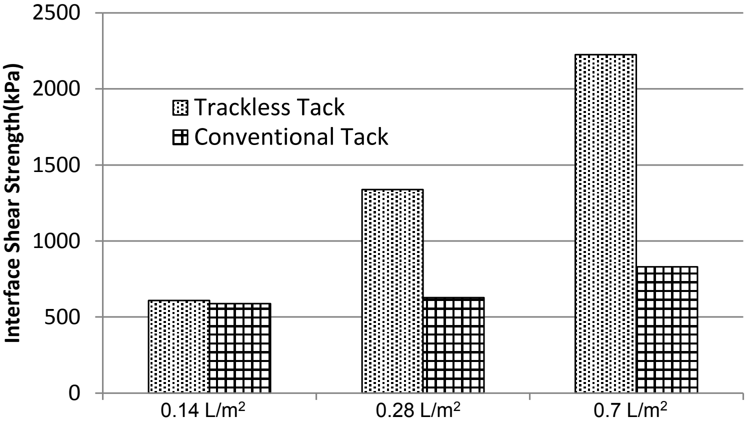

Fig. 8. Interface shear strength for trackless tack and conventional tack

Trackless tack clearly has higher interface shear strength than conventional tack (Figure 8), whereas trackless tack has lower top-down cracking resistance than conventional tack (Figures 6 and 7). This contradiction might be explained by the fact that trackless tack residue is hard and brittle as compared with conventional tack residue (See penetration value presented in Table 2).This high brittleness of trackless tack led to high interface shear strength as the shear strength test was performed under monotonic loading but low fracture resistance as the CSIC test was performed under repeated loading. This comparison indicates that both interface shear strength and interface cracking resistance should be considered when it comes to the selection of appropriate tack type and application rate.

8. Conclusion

In this research work two different approaches were followed, each one with a specific experimental technique. The results clearly show that a bonding agent with high interface shear strength can lead to low cracking resistance across the interface because of its high brittleness. In particular, results from study indicate that the high brittleness of trackless tack attributed to its high interface shear strength but low top-down cracking resistance as compared with conventional tack coat. Pavement layer interface conditions affect both interface shear resistance along the interface and cracking resistance through the interface. Both interface shear strength and cracking resistance should be taken into account when it comes to the selection of appropriate tack coat type and application rate.

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