Transportation Consortium of South-Central States (Tran-SET)

Mitigating Reflective Cracking Through the Use of A Ductile Concrete Interlayer

Evaluating of ductile high-performance fiber reinforced concrete (HPFRC) as reflective crack control interlayer system for composite pavements

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Most common distress in composite pavement is the reflective cracking which is the direct result of horizontal and vertical movements of the Portland cement (PCC) slabs at the joints and cracks in the underlying PCC layer. Such movements are mainly due to temperature changes, shrinkage, and repeated traffic loads that induce tensile, shear, and bending stress concentrations in the HMA overlay. These stresses will lead to micro-crack initiation followed by the formation and propagation of macro-crack in the HMA layer. A ductile high-performance fiber reinforced concrete (HPFRC) interlayer is proposed to mitigate the reflective cracking problem in pavement overlays. It is hypothesized that by adding a thin layer of highly ductile HPFRC material between the existing pavement and overlay, reflective cracking can be arrested by the ductile interlayer. HPFRC mixtures will be selected for the proposed interlayer application and their mechanical properties will be characterized. HPFRC interlayer system will be designed and tested under static and fatigue loadings to evaluate its performance and effectiveness in suppressing reflective cracking. The outcome of this study will include design recommendations and guidelines for HPFRC interlayer systems.

Background

Overlays are constructed over existing pavement structures as a repair measure. When an overlay is placed on an existing pavement, under thermal, shrinkage or traffic induced loadings, cracking of the overlay often takes place at locations where there are joints or cracks in the underlying pavement due to stress concentration as shown in Figure 1. This phenomenon is referred to as reflective cracking. Reflective cracking in the overlay allows water to penetrate the pavement structure and contributes to many forms of pavement deterioration, including increased roughness, spalling and decreased fatigue life. Therefore, to achieve an effective and durable pavement repair using overlay system, reflective cracking needs to be suppressed.

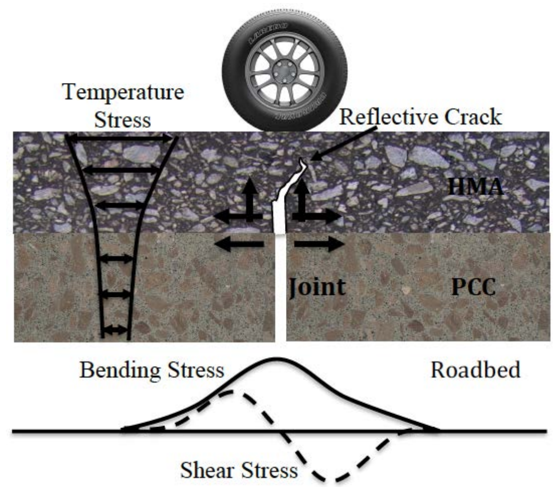

Figure 1. Mechanism of reflective crack initiation and propagation.

A ductile high performance fiber reinforced concrete (HPFRC) interlayer is proposed in this research to mitigate the reflective cracking problem in pavement overlays. HPFRC is a special kind of fiber reinforced concrete that exhibits strain hardening behavior and high ductility under tension. Unlike conventional brittle concrete, HPFRC forms multiple tight cracks under tension before final fracture, which leads to high deformation capacity and fracture resistance. Studies also showed that using HPFRC as overlays for repair of bridge deck and rigid pavement successfully suppressed reflective cracking and dramatically extended the fatigue life of the repair.

Project Summary

The overall objective of the project is to design and evaluate the behavior and fatigue performance of a novel interlayer system made of ductile HPFRC. Literature search will be conducted to identify current practices of interlayer systems and its design, available HPFRC mixtures and properties as well as testing methods and standards for pavement interlayers and overlays. Based on the literature review the experimental program will commence. This include the selection and acquisition of raw materials including but not limited to the Portland cement, aggregates, polymer fibers, asphalt binders, bonding agent, and molds, fixtures, and so forth.

The experimental program also includes the characterization of HPFRC mixtures under compressive and bending load conditions. The compressive strength will be evaluated using a small cube specimens while the third-point bending test on a thin will facilitate the determination of flexural strength and deflection behavior. HPFRC interlayer specimens similar to that shown in Figure 2 will be prepared and tested under third-point static flexural and fatigue.

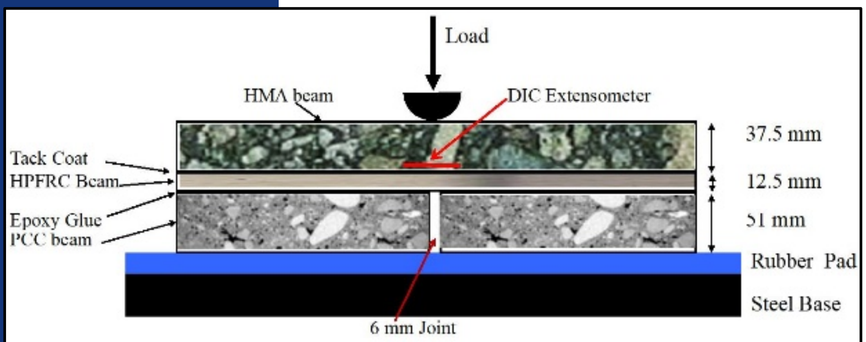

Figure 2. Schematic of the HPFRC interlayer specimen test.

Digital image correlation (DIC) techniques will be applied to determine the load-deflection relationship and failure mode of the specimen in order to evaluate the effectiveness of the interlayer in arresting reflective cracking. The fatigue testing will be conducted using the continuous haversine wave form loading. Vertical deflection and horizontal strains will be monitored throughout the testing at the center of overlay layer using DIC technique. The fatigue behavior and fatigue life for specimens with HPFRC interlayer and the control specimens will be compared.

Status Update

The static third-point bending test with and without HPFRC interlayer system showed that the HPFRC interlayer specimens exhibited higher flexural stress level at failure of about 14 MPa as oppose to the control ones which failed at stress level of 8.6 MPa. DIC images displayed that without any HPFRC interlayer, one single reflective crack propagated from bottom to top, whereas with the presence of HPFRC interlayer, multiple cracks propagated from the bottom of HMA and they joined together at failure. Furthermore, DIC did not detect any crack in HPFRC interlayer at failure.

The results of fatigue testing exhibited that the accumulation of plastic strain at the bottom HMA layer due to repeated loading was significantly lower for HPFRC interlayer system as compared to the control specimens with no interlayer. This resulted in higher fatigue life of the HPFRC interlayer specimens relative to the control ones as shown in Figure 3.

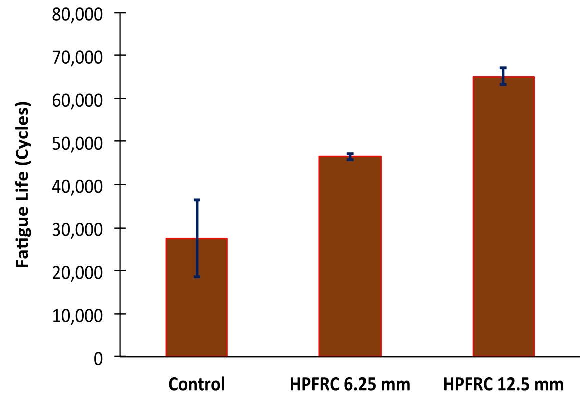

Figure 3. Comparison of fatigue life of HMA overlay specimens with and without HPFRC interlayer.

Impacts

The results of the study will develop the understanding of the mechanism of preventing/retarding the crack growth in the HMA overlay of composite pavement due to HPFRC interlayer. The anticipated impact of this research includes the development of a new interlayer system that can effectively prevent pavement reflective cracking, extend the service life of the pavement, and reduce the maintain cost of the pavement. The Louisiana DOTD and other State DOTs could implement this new interlayer system for pavement repair.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.

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