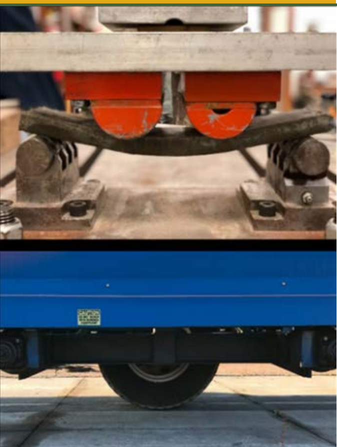
Transportation Consortium of South-Central States (Tran-SET)

Application of Engineered Cementitious Composites (ECC) for Jointless Ultrathin White-Topping Overlay



Evaluating the feasibility of Engineered Cementitious Composites (ECC) for jointless ultrathin whitetopping overlays

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Whitetoppings are concrete overlays on top of HMA pavement structures. Whitetoppings are used to rehabilitate distressed HMA pavements and are built with short joint spacing to reduce stresses induced due to loading and temperature and moisture gradients. This project evaluates the feasibility of Engineered Cementitious Composites (ECC) in Jointless Ultrathin Whitetopping (UTW) overlay application in order to mitigate joint related distresses typically observed in UTW and increase construction speed.

Background

Whitetoppings are concrete overlays on top of HMA pavement structures. Whitetoppings are divided in two categories, thin whitetoppings (TWT) and ultrathin whitetoppings (UTW), where the thickness of TWT and UTW ranges between 4 to 8 in and 2 to 4 in, respectively. UTW are used to rehabilitate distressed HMA pavement structures, which may have failed from rutting, local surface distresses, fatigue cracking, and low-temperature cracking. UTW are built with shorter joint spacing (usually 4 by 4 ft and 6 by 6 ft panels), with no tie bars and no joint sealing. Small joint spacings are utilized to reduce stresses due to loading as well as stresses induced due to temperature and moisture gradients occurring in the concrete slab. Commonly observed distresses in withetoppings include corner, reflective and load related cracking; yet, corner cracking appears to be the primary distress observed in UTW when joints coincide with the wheel path (usually when 4 by 4 ft panels are utilized).

While using smaller joint spacing allows for the utilization of UTW in whitetopping projects, it is usually more economical to utilize TWT with larger joint spacing, since the cost of concrete is relatively low compared to saw cutting and the performance of the overlay is not compromised due to the coincidence of joints with the wheel passing. Therefore, enhancements in the properties of concrete materials could allow for the utilization of ultra-thin overlays with large joint spacing that would mitigate joint related distresses, increase construction speed, and be more cost-effective. To this end, Engineered Cementitious Composites (ECC) are proposed as a novel alternative for UTW application since its outstanding mechanical properties, e.g. high tensile ductility (Figure 1) and superior flexural strength, have the potential to allow for jointless (or significantly large joint spacing) UTW systems at reduced thicknesses. For instance, the superior ductility of ECC provides with adequate deformation capacity to accommodate dimensional changes due to drying shrinkage and/or temperature variations, thus open the possibility for jointless concrete overlays.

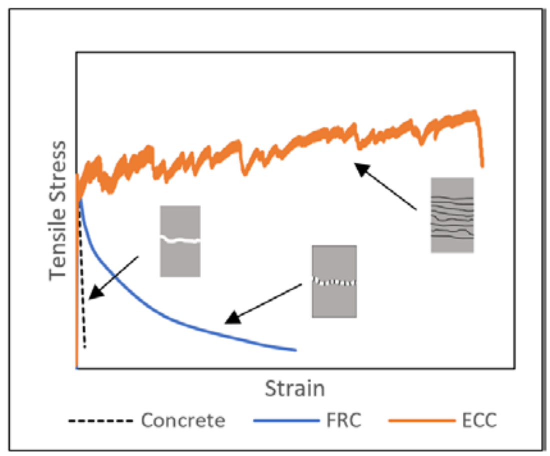

Figure 1. Stress versus strain behavior of cementitious materials in tension.

Project Summary

The objective of this project is to evaluate ECC in UTW overlay application. To achieve this objective, a cost-effective ECC material will be designed for UTW application based on locally available ingredients. Fatigue evaluation of the UTW-ECC material will be performed to produce a σ-N relation (flexural stress vs. cycles to failure). Moreover, finite element analysis (FEA) and fatigue performance data of the UTW-ECC material (σ-N relation) will be integrated to produce an UTW-ECC overlay performance prediction model (overlay thickness vs. cycles to failure, H-N relation). To validate the developed model, a full-scale experiment of an UTW-ECC overlay system will be performed at the Louisiana Transportation Research Center (LTRC) Pavement Research Facility. Finally, a cost-analysis of the construction of jointless UTW-ECC compared to traditional jointed UTW overlays will be conducted.

Status Update

Nine different ECC mixture designs utilizing local ingredients where prepared. ECC materials were evaluated in compression, uniaxial tension and bending. After the evaluation of the materials, due to its mechanical properties and cost-effectiveness mix design, M3-1.5% was selected to be further evaluated in fatigue (Figure 2).

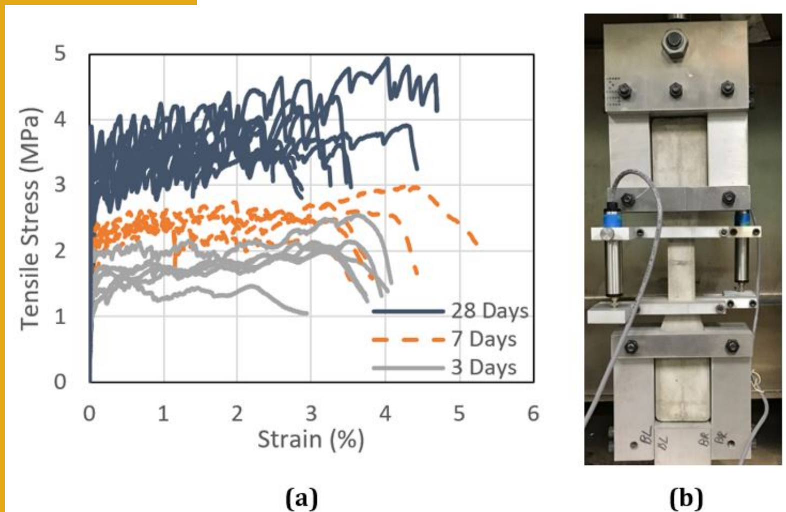

Figure 2. Mechanical properties of cost-effective ECC material: (a) tensile stress vs. strain curve showcasing robust pseudo strain-hardening behavior and high tensile ductility; and (b) uniaxial tensile test setup.

Currently, flexural fatigue testing of M3-1.5% is being conducted to determine the σ-N relation of the material. In addition, finite element analysis (FEA) is being conducted to predict critical stresses developed on an UTW-ECC overlay with varying ECC layer thicknesses (Figure 3).

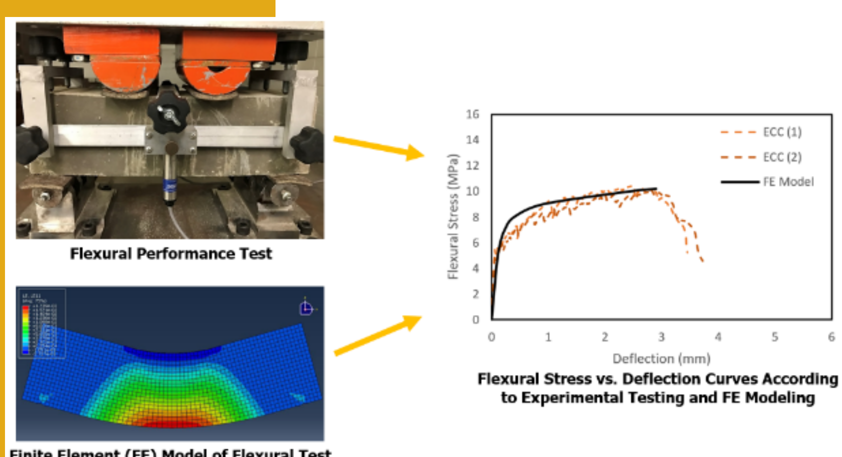

Figure 3. Finite element modeling of ECC under flexural loading.

Impact

The implementation of ECC for jointless UTW overlay systems is presented as an innovative solution to address durability problems of current and future transportation infrastructure in the region. This novel system has the potential to provide with a more durable and reliable repair alternative for pavement infrastructure compared to current practices.

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."

Learn More

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.