Development and Implementation of Low-Cost Engineered Cementitious Composites (ECCs) in Rural Roads in the State of Louisiana

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21CLSU13

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Principal Inverstigator(s):

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Lead Institution:

Louisiana State University

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Tran-SET

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Total Project Cost:

$217,822

Developing Low-Cost ECCs in the state of Louisiana

Over the recent years, the research team has successfully developed novel low-cost Engineered Cementitious Composite (ECC) mixtures for future implementation in pavement infrastructure in Louisiana. The mechanical properties of these mixtures have been successfully validated through laboratory testing. The main objective of this study is to facilitate the implementation of the best performing mixture in the field under real world conditions. To achieve this objective, the functional properties (i.e., frictional properties) of this mixture will be adjusted and validated through laboratory testing. Once validated, the final mixture will be applied as an overlay in a rural road in the state of Louisiana in partnership with the Louisiana Department of Transportation and Development (DOTD). Over the project duration, the field performance of the ECC overlay will be assessed through regular field surveys.

Problem Statement

Concrete is brittle and possess a low tensile strength, which makes it prone to cracking during restrained dimensional changes (i.e., shrinkage as well as temperature and moisture changes) or loading. In concrete pavements, cracks can significantly reduce the service life of the pavement structure, as water can effortlessly infiltrate into the substrate causing enhanced deterioration. Hence, the improvements of crack resistance in concrete materials is of particular interest of the transportation sector. The addition of fibers in concrete is a well-established practice to mitigate the brittle behavior of concrete by limiting crack growth and propagation. Yet, conventional fiber reinforced concrete (FRC) produces rather marginal improvements in ductility and tensile strength. Over the past three decades a new class of fiber-reinforced cementitious composites known as Engineered Cementitious Composites (ECCs) have been developed to mitigate the brittle nature of concrete. ECCs, which are also known as bendable concrete, exhibit high tensile strain capacity ranging from 1 to 8% (i.e., 100 to 800 times that of regular concrete), at relatively low fiber contents (i.e., typically 2% volume fraction). To attain this, ECCs are distinctively designed based on micromechanics and fracture mechanics concepts to transform the Griffith crack propagation mode of regular concrete and FRC to a steady-state flat crack propagation mode. Consequently, this enables a tensile pseudo strain-hardening (PSH) behavior in ECCs through the formation of multiple steady-state microcracks, which gives rise to the extraordinary tensile ductility of these composites. In addition to the exceptional deformation capacity, ECCs also exhibit high flexural strength (ranging between 2 to 3 times that of conventional concrete or FRC) and exceptional flexural fatigue resistance (several orders of magnitude greater than conventional concrete). Consequently, this make ECCs exceptionally attractive for pavement application where the flexural strength and flexural fatigue life of concrete plays a major role in the performance of the pavement structure. While ECCs' mechanical properties and durability potential are promising for transportation infrastructure, its broad implementation has been hindered by its high cost and low practicality. This study aims to facilitate the implementation of ECCs in the field under real world conditions by proposing alternative formulations and ingredients.

Objectives

The main objective of this research study is to facilitate the implementation of ECCs in the field under real world conditions. To achieve this objective, the functional properties (i.e., frictional properties) of the best performing mixture developed in the PI's previous studies will be adjusted and validated through laboratory testing. Once validated, this mixture will be applied as an overlay in a rural road in the state of Louisiana in partnership with the Louisiana Department of Transportation and Development (DOTD). Over the project duration, the field performance of the ECC overlay will be assessed through regular field surveys.

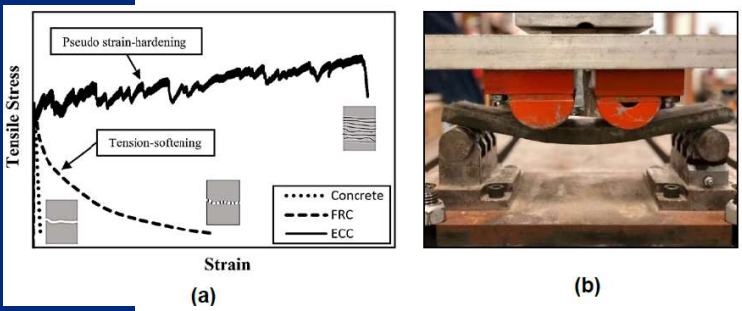

Figure 1: (a) Stress vs. Strain Behavior of Cementitious Materials in Tension (b) Bending Test of Ductile ECC Material Developed at LSU

Intended Implementation of Research

Workforce Development, Education, and Outreach: This research project will provide funding to one master student at Louisiana State University. This will help recruit and train future leaders in the Transportation Sector. The research team will also prepare educational materials on the mixture design and field performance of ECC mixtures. These educational materials will be shared and disseminated to government entities and the industry. Results of this work will be also presented at national conferences such as TRB and ASCE.

Anticipated Impacts/Benefits of Implementation

The development and implementation of low-cost novel ECC materials will deliver costeffective, efficient, and rapid solutions to today's crumbling transportation infrastructure. Furthermore, this project aims to advance the state of the art on ECC materials and share this knowledge with students, state DOTs and the transportation industry to speed up the adaption of this new technology.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

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 Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.