Development of Ultra-High Performance Engineered Geopolymer Composites (UHP-EGCs)

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21CLSU18

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Principal Inverstigator(s):

Gabriel Arce

Louisiana State University

Miladin Radovic

Texas A&M University

Lead Institution:

Louisiana State University

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Tran-SET

Louisiana State University

Total Project Cost:

$ 285,000

Developing ultra-high performance engineered geopolymer composites

The emergence of ultra-high strength ultra-high ductility cementitious composites such as ultrahigh performance Engineered Cementitious Composites (UHP-ECCs) for construction application are promising for the future of civil infrastructure as these materials overcome important weaknesses of conventional concrete materials including their low tensile strength and brittle nature. However, these materials use large amounts of ordinary Portland cement (OPC), which limit their sustainability. The objective of this study is to develop novel Ultra-High Performance Engineered Geopolymer (GP) Composites (UHP-EGC) as materials for repair and new construction of transportation infrastructure in Region 6. The developed composites will be mainly made utilizing locally available resources (kaolin clays, natural sand, etc.) to enhance practicality and cost-effectiveness of these materials. To achieve this objective, a multidisciplinary team from Louisiana State University and Texas A&M University will develop several high-strength GP matrices reinforced with functionalized Ultra-High-Molecular-Weight Polyethylene (UHMWPE) microfibers. Material properties will be thoroughly evaluated to identify composition-microstructure-property relationships necessary for systematic design of the novel composites. Furthermore, UHP-EGCs' cracking characteristics, dimensional stability, and bonding properties with regular concrete will be assessed to determine the feasibility of the developed composites for repair applications.

Problem Statement

UHP-ECCs are promising for the future of civil infrastructure as these materials overcome important weaknesses of conventional concrete materials, such as low tensile strength, low ductility, and pervasive cracking. However, these composites use large amounts of energy- and emissions-intensive OPC, which limit their sustainability. Hence, there is a need to develop novel UHP-ECC materials with a low environmental footprint that can be manufactured using various local resources. Recently, GP binders have been proposed as an eco-friendly and sustainable alternative to OPC binders for the development of ECCs. However, these novel GP-based ECCs or EGCs remain greatly unexplored. In addition, ultra-high strength EGCs have not been yet achieved. Herein, we intend to develop novel UHP-EGCs as novel eco-friendly and sustainable high-performance concrete materials for the repair and new construction of transportation infrastructure.

Objectives

The objective of this study is to develop novel UHP-EGC materials for repair and new construction of transportation infrastructure in Region 6. The developed composites will be mainly fabricated using locally available resources to enhance practicality and costeffectiveness of these materials.

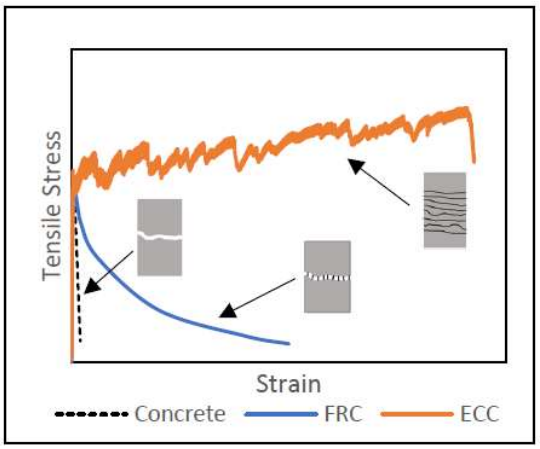

Figure 1. Stress vs. Strain Behavior of Cementitious Materials in Tension

Intended Implementation of Research

Workforce Development, Education, and Outreach: This research project will provide funding to one PhD student at Louisiana State University and one graduate student at Texas A&M University. This will help recruit and train future leaders in the Transportation Sector specializing in development of new materials for transportation infrastructure. The research team

will also prepare educational material on UHP-EGCs to be incorporated in courses at LSU and TAMU and share it with other universities. The educational material will also be summarized and disseminated to government entities and the industry. Results of this work will be also disseminated at national conferences such as TRB and ASCE.

This project will offer two internships for undergraduate students to train them for research in Transportation and Advanced Materials. Moreover, the developed educational material prepared in this project will be shared with our partner community colleges to be used to recruit students to Transportation. We anticipate using demonstration material in multiple K-12 outreach activates traditionally carried out by Women in Materials Science (WIMS) student organization at Texas A&M University. In addition, educational information explaining findings on of the project will be offered to research institutes and companies interested in emerging innovative technologies for the Transportation Sector in collaboration with the highway agencies in Region 6.

Anticipated Impacts/Benefits of Implementation

The development of UHP-EGC materials will deliver environmentally friendly high-performance materials for repair and new construction of transportation infrastructure in Region 6. The implementation of UHP-EGCs has the potential to significantly improve the durability, resiliency, and structural safety of the transportation infrastructure in the region.

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.