Low-Cost Sustainable Engineered Geopolymer Composites (EGCs) for Repair and New Construction of Transportation

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Tran-SET

Louisiana State University

Total Project Cost:

$ 300,000

Developing low-cost sustainable engineered geopolymer composites

The Engineered Geopolymer Composites (EGCs) are ductile strain-hardening geopolymer (GP) based materials that have been recently introduced as an eco-friendly and sustainable alternative to Engineered Cementitious Composites (ECCs). While EGCs exhibit mechanical properties exceedingly superior to those of conventional Portland cement concrete (PCC), mass adoption of these emerging composites is expected to be hindered by their cost, which is mainly driven by the use PVA reinforcing fibers, silica fume, and manufactured microsilica sand. To address this key shortcoming, the multidisciplinary team form Louisiana State University and Texas A&M university will develop and characterize novel low-cost EGC materials for repair and new construction of transportation infrastructure in Region 6 by evaluating the use of: (1) calcined clays and fly ash as replacements of commonly used silica fume for GP binders; (2) low-cost PP fiber, PVA fiber, and hybrid systems of PP and PVA fiber; and (3) natural sand instead of commonly used manufactured microsilica sand. To achieve this objective, several GP matrices, and fiber-reinforced GP composites will be developed and comprehensively studied to identify fundamental relationships between materials composition, properties, and microstructure. In turn, this will allow for rational material design and optimization.

Problem Statement

Geopolymer-based ECCs or EGCs were recently introduced to benefit from the eco-friendly and sustainable nature of GP binders and to enhance the mechanical properties (especially ductility) of otherwise brittle GPs. While ECCs have received significant interest in recent years, mass adoption of these exceptional materials has been hindered by its cost, which is mainly driven by the use PVA reinforcing fibers. The same issue with implementation of EGCs is thus also anticipated, and this calls for research on using less expensive reinforcement fibers in EGCs. Furthermore, GP binder cost is also expected to be an important factor limiting the implementation of these emerging composites as silica fume or sodium/potassium silicate solutions used to adjust SiO2/Al2O3 ratio in GP binders are expensive, as well as cost of microsilica used as an aggregate in the matrix. Therefore, the study of cost-effective GP binder alternatives for EGC application is of utmost importance to enable broad adoption of EGCs, and consequently help to enhance the durability of infrastructure while preserving the environment.

Objectives

The objective of this study is to develop novel low-cost EGC materials for repair and new construction of transportation infrastructure in Region 6 by evaluating the use of: (1) calcined clays and fly ash as replacements of commonly used silica fume for GP binders; (2) low-cost PP fiber, PVA fiber, and hybrid systems of PP and PVA fiber; and (3) natural sand instead of commonly used expensive manufactured microsilica sand. The developed composites will be mainly composed of locally available ingredients to enhance practicality and cost-effectiveness of these materials.

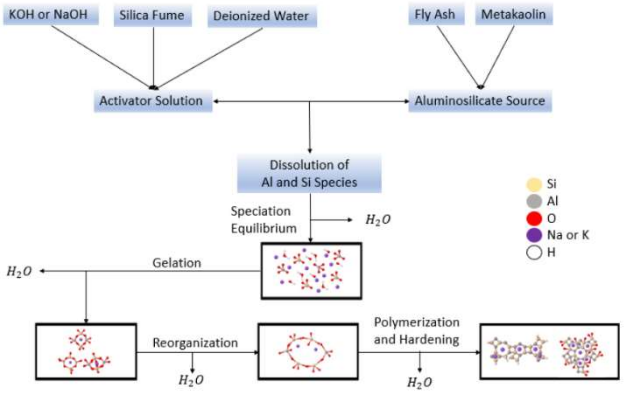

Figure 1. Geopolymerization Process

Intended Implementation of Research

Workforce Development, Education, and Outreach: This project will provide funding and train two graduate students (one at each participating institution), thus bringing forth future leaders in the transportation sector specializing in development of new materials for transportation infrastructure. In addition, the research team will prepare educational material on EGCs to be incorporated in courses at LSU and TAMU. The findings of this study will also be summarized and disseminated to government entities and the industry through national conferences such as TRB and ASCE.

This project will offer two internships for undergraduate students to introduce them to research in transportation infrastructure materials. Moreover, we anticipate participating in multiple K-12 outreach activates traditionally carried out at LSU and TAMU. In addition, educational information explaining findings of the project will be prepared and disseminated via Tran-SET webpage.

Anticipated Impacts/Benefits of Implementation

The development of low-cost EGC materials will deliver environmentally friendly materials for repair and new construction of transportation infrastructure in Region 6. The implementation of EGCs has the potential to significantly improve the durability, resiliency, and sustainability 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.