Characterization of Regular Concrete and Low-Cost Engineered Cementitious Composites with Incorporation of Cellulose Nanoparticles and Cost- Effective Ingredients

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Louisiana State University

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Tran-SET

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$ 58,868

Characterizing regular concrete and ECCs with cellulose nanoparticles

Cellulose nanocrystals (CNC) are a special class of nanomaterials derived from cellulose, which is the most abundant natural polymer. These nanomaterials have gained growing interest due to their mechanical, chemical, optical, and rheological properties. This study aims to investigate the effect of CNC on the physical and mechanical properties of ECC and concrete materials. To accomplish the goal of this study, three levels of CNC dosage will be assessed for both ECC and conventional concrete. In the case of concrete, a structural class A1 concrete mixture will be prepared according to the Louisiana specifications. In addition, three different mixtures exhibiting different strength and ductility levels will be assessed for ECC. A comprehensive experimental program will be conducted to evaluate the mechanical properties of the prepared mixes (compressive strength, tensile strength, and surface resistivity as an indicator of concrete permeability). Furthermore, the microstructure and crack behavior of the prepared mixes will be evaluated using scanning electron microscopy (SEM) coupled with energy dispersive X-ray spectroscopy (EDS). Results will provide insights into the effects of CNC on the fundamental properties of ECC and PCC composites. It is also expected that incorporating CNC into ECCs can further help the implementation of the readily available low-cost ingredients for optimum performance and cost.

Problem Statement

The PIs have conducted extensive research on the assessment of alternative formulations and ingredients in the production of ECCs to enhance their practicality and cost-effectiveness. These strategies included a) the implementation of non-oil-coated PVA fiber as a replacement of oil-coated PVA fiber, b) the use of fine river sand to replace microsilica sand, c) the utilization of recycled crumb rubber and bagasse ash as a partial fine aggregate replacement, and d) the use of class F fly ash as a partial cement replacement. While practical and cost-effective ECCs have been developed using readily cheap resources (i.e., fly ash, crumb rubber), reduced tensile and compressive strengths of ECC materials are a major concern. In this study, we propose a modification of microstructural properties of low-cost ECCs and regular concrete using cellulose nanocrystals. It is expected that incorporating CNC in ECCs can further help the implementation of the readily available low-cost ingredients for optimum performance and cost.

Objectives

The main objective of this study is to investigate the effect of cellulose nanocrystals (CNC) on the physical and mechanical properties of ECC and concrete materials along with the evaluation of cost-effective and readily available ingredients.

Intended Implementation of Research

Workforce Development, Education, and Outreach: This research project will provide funding to a graduate student at Louisiana State University (LSU). This will help recruit and train future leaders in the Transportation Sector specializing in materials for transportation infrastructure. The research team will also prepare educational material on cellulose nanocrystals (CNC) to be incorporated in related courses on ECC and concrete materials at LSU and to share it with other universities. The educational materials will also be summarized and disseminated to government entities and to the industry. The results of this work will also be published and presented at national conferences such as TRB and ASCE. This project will offer internships for undergraduate students to introduce them to research in advanced materials for the transportation infrastructure. Moreover, the developed educational material prepared in this project will be shared with our partner community colleges to be used to recruit students to the Transportation field.

Anticipated Impacts/Benefits of Implementation

The main outcome of this research project will be a new mix design for ECC that incorporates CNC and local ingredients and that will be readily available for implementation in local infrastructure as well as for further evaluation in future research projects. The outcomes of this study will help extend the life of the existing transportation infrastructure and will promote sustainability and resiliency of the transportation infrastructure renewal and upgrade.

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.