Stabilization of expansive soils using Geopolymers prepared from locally available resources

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Lead Institution:

Texas A&M University

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$ 130,000

Using geopolymers to stabilize expansive soils

The stabilization of soft and highly compressible soils is essential to construct transportation infrastructure using local geomaterials. Such geomaterials typically contain a high amount of clay, and therefore lack desired mechanical properties in their native state. Typically, traditional calcium-based compounds (i.e. Portland cement, lime), and organic polymers are used to improve the mechanical properties of those geomaterials. However, traditional calcium-based stabilizers have a high carbon footprint while organic polymers have durability issues. Geopolymers are a family of inorganic polymers that have recently received much attention as an alternative to ordinary Portland cement in various transportation infrastructure applications due to its good and comparable mechanical properties. In addition, geopolymer can be synthesized from various sources of waste materials (e.g., fly ash, steel slag) and natural materials (e.g., rice husk, volcanic ash, clay), which lowers its impact on the environment and carbon footprint. Although there are already many studies in the past decade or so on stabilized clayey soils with geopolymer, there are only a limited number of studies that utilize locally available resources. The objective of this research project is to synthesize an innovative, sustainable, and eco-friendly geopolymers suitable for stabilizing expansive soils for transportation infrastructure in Region 6, using calcined clays that are locally available in the region.

Problem Statement

At the present time, cementitious stabilizers such as ordinary Portland cement (OPC) and lime are commonly used as soil stabilizers, and their stabilizing mechanisms and properties have been well understood. One of the major issues is that conventional calcium-based soil stabilizers react with the clay and sulfate minerals (usually gypsum) in the soil causing the failures of pavement and other transportation infrastructure. Moreover, the production of cementitious materials is energy-intensive and emits massive greenhouse gases, e.g., CO2. For example, one ton of OPC produces approximately one ton of equivalent CO2. In recent years, polymers with different chemical additives have been also used as soil stabilizers to address problems including soil property enhancements, and provide durable solutions. However, their long-term durability effect on the environment still has enormous concern and subject of discussion. Therefore, the raw materials readily available for the production of cementitious and polymer-based soil stabilizers are being overconsumed. Over the last decade, geopolymers have been considered as an attractive alternative to OPC in various civil infrastructure applications not only because geopolymer has good mechanical properties, but also it can be processed from a selection of materials such as waste materials (fly ash, steel slag), and locally available resources (clays, rice husk, volcanic ash). Previous studies have shown that the use of geopolymer can reduce the carbon footprint by 44 to 64% approximatel. In addition, geopolymer has recently been applied to stabilize expansive soils since stabilization with OPC can often react with clay and sulfate minerals (i.e., gypsum) in the soil and cause significant swelling, which is a serious durability issue. However, there is still hesitation from the community to implement geopolymer as a soil stabilizer due to the high cost, lack of understanding in the mechanism of geopolymer stabilization, and the lack of consistency between published studies since every group has their own recipe to synthesize geopolymers.

Objectives

The objective of this research project is to synthesize an innovative, sustainable, and eco-friendly geopolymers suitable for stabilizing expansive soils for transportation infrastructure in Region 6, using calcined clays that are locally available in the region. The geopolymer stabilizer synthesized in this research is expected to be effective in enhancing the mechanical properties of problematic expansive soils in Region 6, and reduce the distresses on pavement infrastructure. More specific objectives of the proposed projects

include: 1) Select the appropriate locally available resources suitable for this study; 2) Select the geopolymer composition with optimum workability and mechanical properties; 3) Select appropriate expansive soil suitable for this study; 4) Investigate the effectiveness of geopolymers for stabilization of expansive soils; 5) Provide guidance for the optimum geopolymer composition for stabilizing expansive soils; 6)Implement research results and develop the workforce with the expertise in using novel soil stabilization technologies.

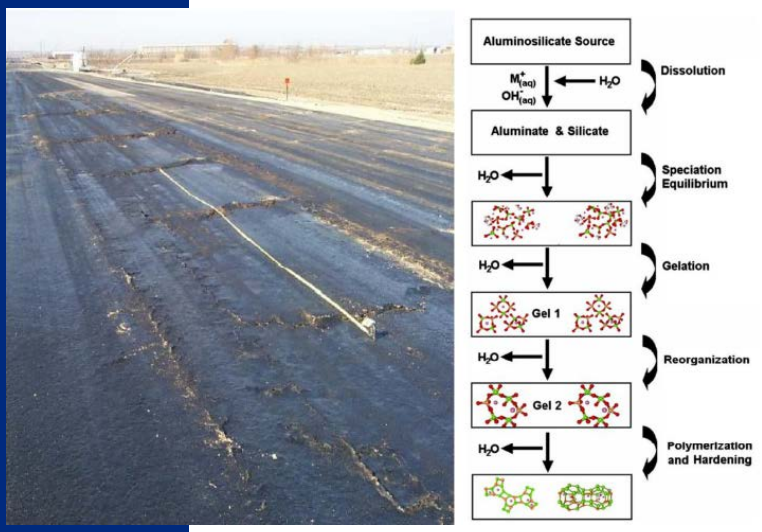

Figure 1. (left) Vertical heaves generated during the construction of U.S. 67 near Midlothian, TX, and (right) Conceptual model of geopolymerization.

Intended Implementation of Research

This project may lead to immediate implementation as Geopolymer are considered to be environment friendly, inexpensive, and resilient solution for transportation infrastructure. The outcome of this research will lead to a comprehensive report that will provide design methods and guidance for Geopolymer treatments of expansive soils. The information will also be disseminated in various venues including technical publications and conference presentations. The research team will also present these research findings at Transportation Research Board (TRB) annual meetings and the International Conference and Expo on Advanced Ceramics and Composites (ICACC). Moreover, the results of this project will be disseminated in peer-reviewed journals.

Anticipated Impacts/Benefits of Implementation

Manufacturing Geopolymer using locally available waste materials and using it for transportation infrastructure will result in a low carbon footprint. This will eventually lead to sustainable transportation infrastructure.

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.