Development of Soil-Biochar Mixtures as a Sustainable and Multi-Functional Roadway Fill Material

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Louisiana State University

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Tran-SET

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$ 60,000

Using Soil-Biochar mixtures as a sustainable roadway fill material

Many lightweight fill materials have limited applications due to their high costs and energy-intensive manufacturing processes. Biochar is an environmentally friendly and economical carbon-rich product formed by combusting waste biomass (e.g., forestry and agricultural residues) in an oxygen-limited environment through a process known as pyrolysis. Since biochar has a much lower density than typical soils, biochar is suitable for roadway applications as a lightweight fill material. Furthermore, biochar has a high surface area and porosity and excellent ability to adsorb a variety of contaminants, which has been amended in the soil to increase soil water retention, reduce potentials of soil cracking and erosion, adsorb contaminants, and enhance soil aggregation. Due to these favorable properties of biochar, soil-biochar mixtures have high potential to serve as a multi-functional lightweight fill material for roadway embankment applications to decrease the applied load to foundation soil, enhance the factor of safety against slope stability failure, reduce the soil erosion and cracking potential, and remediate the stormwater runoff. This research investigates the mechanical and hydraulic properties of sand-biochar mixtures as a sustainable and multi-functional fill material for roadway embankment applications. The goal of this research is to develop soil-biochar mixtures as a sustainable, economical, and multi-functional lightweight fill material for roadway embankment applications.

Problem Statement

Roadway embankments constructed on soft soil are susceptible to excessive settlement and slope stability failure. There are two main approaches to avoid those failures: (1) improvement of the mechanical properties (e.g., shear strength and compressibility) of foundation soils; and (2) reduction of the weight of the embankment. Recently, many DOTs and other transportation agencies used lightweight fill materials to decrease the weight of the embankment rather than ground improvement because of the uncertainty involved in using ground improvement techniques and cost-effectiveness in using lightweight fill. To date, the available lightweight fill materials in the U.S. include Expanded Polystyrene (EPS or "geofoam"), foamed concrete, and expanded shale, clay, and slate lightweight aggregate (LWA). However, the available lightweight fill materials are generally considered to be costly materials. A price range for delivered lightweight fill materials, including geofoam, foamed concrete, and LWA, is between approximately $65-130/cubic yard. At these prices, the lightweight fill materials have limited applications, mostly dealing with bridge approaching problems. Furthermore, the production of most lightweight fill materials is energy-intensive. Biochar is a promising solution to reduce greenhouse gas emissions due to its ability of carbon sequestration. Biochar has been increasingly used as an additive for building materials (e.g., panel, brick, plaster, and tile adhesives) due to its low thermal conductivity, high chemical stability, and low flammability. Thus, soil-biochar mixtures have high potential to serve as a multi-functional lightweight fill material in roadway applications with capabilities to decrease the driving force that causes settlement and slope stability failure, adsorb contaminants, reduce erosion and cracking potential, and reduce stormwater runoff, which will improve the sustainability and durability of the roadway embankment systems and significantly reduce the construction costs.

Objectives

The main objective of this research is to develop soil-biochar mixtures as a sustainable, economical, and multi-functional lightweight fill material for roadway embankment applications.

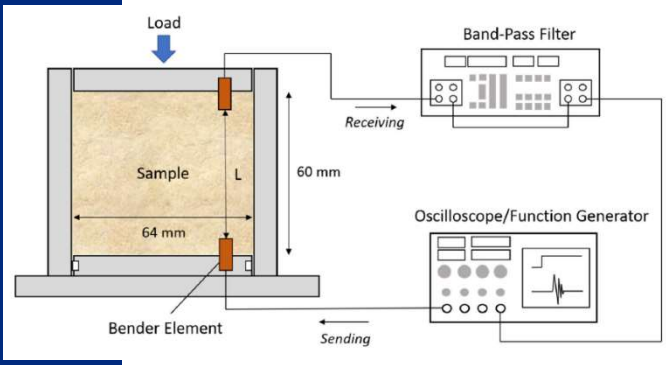

Figure 1. The experimental setup of the 1D consolidation test.

Intended Implementation of Research

Workforce Development, Education, and Outreach: The PI will develop a technical report incorporating the outcome of this research for the state DOTs, consultants, and contractors. One technical video that covers the overview, engineering properties, and production procedure of sand-biochar mixtures will be developed and disseminated to the professional engineers to understand the properties and application potential of sand-biochar mixtures. This video will also be incorporated into the online course, CE 7335 Soil Improvement and Stabilization taught by the PI, for the LSU online Master of Science program in Civil Engineering, which attracts many professional engineers. The results of this project will also be disseminated through journal papers, conference papers and presentations, webinars, and web-based science news.

Anticipated Impacts/Benefits of Implementation

Roadway embankments in Region 6 are susceptible to excessive settlement and slope stability failure due to extreme weather and soft soil conditions. Biochar is produced from waste biomass (e.g., switchgrass, wood, sugarcane, etc.) and is highly recalcitrant, which is potentially cost-effective, durable, and can sequester carbon and reduce greenhouse gas emission. The development of the new lightweight sand-biochar mixtures will potentially decrease the driving force that causes settlement and slope stability failure, reduce the costs for ground improvement, retain containments, and reduces stormwater runoff, which will ultimately improve the sustainability and durability of the roadway embankment systems and significantly reduce the construction costs.

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.