CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)
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Project Number
S0807

Project Title
The Development of an Eco-Friendly Calcium in situ Precipitation System for the Mitigation of Liquefaction Prone Soils

Abstract

Objectives/Goals
The purpose of this research is to develop a new approach of soil modification that takes advantage of intrinsic soil characteristics and the abundance of eco-friendly materials to transform the loose and porous soil mass into a denser and less permeable state capable of resisting liquefaction during earthquakes. Three processes: Microbially-Induced Calcium Precipitation (MICP), Calcium In-Situ Precipitation System (CIPS), and the proposed Eco-Friendly Calcium In-Situ Precipitation System (ECIPS), are experimented and compared.

Methods/Materials
While MICP and CIPS rely on controlled environment, specially selected bacteria (from bat guano) and/or particular commercial ingredients (such as liquid calcium fertilizer), the proposed ECIPS method causes calcium precipitation to occur within soil mass through permeation with a solution made of egg shells, vinegar, urea and baking soda. Soil samples were subjected to repeated tests consisting of gradation, direct shear, and unconfined compression.

Results
During the direct shear and compressibility tests, it was observed that all samples from all three processes showed an increase in hardness and soil strength. It should be noted that sandy soil is typically considered to possess zero or negligible unconfined compression strength due to lack of cohesion, or inter-particle bonding. However, after the permeation process, cementation within the soil mass enabled the treated sandy soil mass to stand alone in cylindrical form, and thus, is capable of being subjected to unconfined compressibility tests.

Conclusions/Discussion
The results indicate: 1) the delicate bacteria selection and the highly controlled environment of MICP process is too difficult to be duplicated, with the effect of bacteria undistinguishable; 2) the CIPS process could increase soil strength and reduce soil permeability substantially, but the materials used may not be eco-friendly; and 3) the proposed ECIPS process was able to improve the cohesion and the compressive strength of the tested soils substantially, thus rendering the treated soils liquefaction-proof. The ECIPS process also proves to be eco-friendly, organic-based, waste recycle-capable, minimally intrusive, cost effective and easily executable.

Summary Statement
My research develops a new and eco-friendly process of using wasted eggshells and organic vinegar to strengthen the soil against liquefaction.

Help Received
Used lab equipment at Associated Soils Engineering, Inc. under the supervision of my father, the Senior Project Engineer, and Mr. Don Zike, the lab manager. Science teachers, Ms. Shannon Bunch and Mr. David Knight, answered questions and edited my lab notebook.