# Tuesday 3/14/2017

## 1:15–2:45 p.m.

## Unconventional Materials 2

Chairs: Beena Ajmera, California State University, Fullerton; Binod Tiwari, California State University, Fullerton

**Influence of Bio-Cementation on Shearing Behavior of Sand using X-ray Computed Tomography**

*Jason DeJong, Michael Gomez, and Jack Waller, University of California, Davis; Gioacchino Viggiani, Laboratoire 3S–R (Sols, Solides, Structures–Risques)*

Microbially induced calcite precipitation is bio-mediated calcite precipitation process that can improve the geotechnical properties of granular soils. Bio-cementation offers an environmentally conscious alternative to more traditional ground improvement methods by utilizing natural microbial activity to induce calcite precipitation on soil particle surfaces and at particle contacts. Previous research studies have demonstrated the ability of bio-cementation to increase soil shear strength, initial shear stiffness, liquefaction resistance, and reduce hydraulic conductivity and porosity; however, few researchers have examined the shearing behavior of bio-cemented sands at the particle scale. In this study, four poorly-graded sand specimens were treated to different levels of bio-cementation and subjected to drained triaxial compression. During shearing, the internal structure of soil specimens was examined using X-ray computed tomography and various digital image correlation techniques. Results demonstrate that various levels of bio-cementation can increase peak shear strength by 47% to 1487%, reduce internal deformations required to mobilize peak strength, and change the onset of shear banding from a gradual and widespread development to a more abrupt and narrow feature after failure.

**Stabilizing Very High Moisture Content Fine Grained Soils: Early Age Strength and Later Age Property Correlations**

*Isaac L. Hoard and W. Griffin Sullivan, Mississippi State University*

Recently, chemical stabilization has gained attention for high moisture fine-grained soils, due at least partially to increased sustainability and beneficial use desires. As defined herein, Very High Moisture Soil (VHMS) is at a moisture content at or above the soil's liquid limit. Cases where VHMS is chemically stabilized with 5% or more cementitious material by total VHMS mass is referred to as cemented VHMS (C-VHMS). A primary objective of this paper is to compare portland cement to blended portland and slag cement for C-VHMS at early ages. Another objective is to determine strength, modulus, and ductility properties of C-VHMS over a period of several months to establish strength to modulus correlations. All other factors constant, slag cement's strength gain potential is greater at later ages than at early ages, and as such, sluggish early strength gain that can be problematic was evaluated a considerable amount in this paper.

**Time Dependent Properties of Very High Moisture Content Fine Grained Soils Stabilized with Portland and Slag Cement**

*Isaac L Howard and Brennan K. Anderson, Mississippi State University*

Recently, chemical stabilization applications seem to be expanding, in particular stabilizing fine-grained soils with elevated moisture. In this paper, Very High Moisture Soils (VHMS) chemically stabilized with 5% or more cementitious material by total mass are referred to as cemented VHMS, or C-VHMS. This

paper's primary objective is to evaluate strength gain of C-VHMS over time and use the measured properties to evaluate usefulness for various applications. A secondary objective is to compare properties of Portland cement to blended Portland and slag cement within C-VHMS. C-VHMS strength properties were reported from mixing through 180 days of curing on two soils. Results showed Portland and slag cement blends were able to produce on the order of 67% of compacted soil-cement (albeit with considerably different total dosage rates) in one of the soils. Overall, C-VHMS, when allowed sufficient curing time, was shown to be more robust than intuition might suggest.

**The Intersection of Modern Soil Mechanics with Ants and Roots**

*Alejandro Martinez, Georgia Tech; Seth D. Mallett, Georgia Tech; Mahdi M. Roozbahani, Georgia Tech; Jason DeJoong, University of California, Davis*

With no more than a couple of thousand years of experience, humankind has developed some innovative techniques to leverage the subsurface for a variety of beneficial functions. In contrast, nature has had the benefit of several billion years to initially design and subsequently evolve the manner in which flora and fauna practices soil mechanics. This paper uses two examples of biota to compare how nature has evolved its solutions in contrast to what humans have done and identifies enhancements that humans could exploit through a deliberate mimicking of what nature has done (i.e. bioinspiration). In particular, a comparison of selected aspects of ant-soil interaction and root-soil interaction are used to illustrate where significant potential exists in the emerging field of bio-geotechnics. The paper describes the salient characteristics of the framework by which nature designs its technology, and in turn, a methodology by which humans can augment our current design processes.

**Reliability Analysis of Embankment Dams**

*Suzanne M. Lacasse, Farrokh Nadim, Zhongqiang Liu, and Unni K. Eidsvig, NGI*

The reliability analyses of one rockfill embankment dam in Norway are presented. The event tree analysis and the Bayesian network approaches, the latter combined with Monte Carlo simula-tions, were used to obtain the annual probability of dam breach. The analyses were run partly in a workshop format, as a process to reach consensus among several experts on the parameters to consider in the calculation of probabilities. The analyses illustrate that the reliability analyses ena-bled the identification of an unexpected mode of failure and later quantified the effect of reha-bilitation measures on the estimated probability of dam breach.