# Monday 3/13/2017

## 2–3:30 p.m.

## Ground Improvement

Chairs: Aaron Goldberg, U.S. Wick Drain Inc.; Miriam Smith, Geopier SRT; Chris Woods, Densification Inc.

**Strengthening of Montmorillonitic and Kaolinitic Clays with Calcium Carbide Residue: A Sustainable Additive for Soil Stabilization**

*Nima Latifi and Christopher L. Meehan, University of Delaware*

Fine-grained soils are often problematic if they are used to construct certain types of earth structures or pavement foundation layers. If the use of poor site-specific fine-grained soils is desired for cost reasons, it can be useful to perform chemical stabilization to improve their engineering properties. Calcium Carbide Residue (CCR) is a by-product of the acetylene production process, which can be used as a cost effective and sustainable cementing agent for soils. This paper examines the effects of CCR content and curing times on the engineering characteristics of CCR stabilized fine-grained soils. In this study, a Green Bentonite (having a predominantly montmorillonite mineralogy) and White Kaolin (having a predominantly kaolinite mineralogy) were used as representative clay minerals that needed stabilization. Compaction, unconfined compression strength (UCS), and direct shear tests were performed to assess the engineering properties of the stabilized clay soils. From the test results, it was observed that in both clays the optimum water content tended to increase and the maximum dry density tended to decrease as the CCR content increased. The UCS test results showed that 9% and 12% CCR contents yielded optimal strength gain for the montmorillonitic and kaolinitic clays, respectively. The direct shear test results also showed significant gains in cohesion and friction angle for both soils at their optimum stabilization levels.

**Design and Construction of an Experimental Soil-Bentonite Cutoff Wall**

*Jeffrey Evans and Michael Malusis, Bucknell University; Daniel Ruffing, Geo-Solutions Inc.*

Soil-bentonite slurry trench cutoff walls are widely used for seepage control, levee repair, and pollutant containment. Their widespread use in these critical applications requires a better understanding of their as-built condition and long-term behavior. The in situ hydraulic conductivity of soil-bentonite cutoff walls is stress dependent. Changes in hydraulic conductivity of the wall over time can result from changes in stress due to consolidation and load transfer though shear to the formation along the sidewalls of the trench. This paper describes a soil-bentonite cutoff wall designed, constructed, and instrumented for the principal purpose of research. The cutoff wall instrumentation is designed to monitor the in situ conditions in the backfill in three dimensions (transverse, longitudinal and vertical), vertical and lateral deformations, and pore water pressures. All data is being collected as a function of time and location within the wall.

**Lessons from Case Histories of Electro Osmosis Consolidation**

*Milad Naghibi and Rolando P. Orense, University of Auckland; Hossam Abuel-Naga, Latrobe University*

Electro osmotic (EO) ground improvement technique has a promising performance history in improving the properties of fine-grained soils. A review of data from 11 case histories indicates that EO consolidation can strengthen various types of fine-grained soils, from slurries to clayey silt, with initial shear strengths from 1 to 28 kPa. The level of shear strength improvement depends on the ratio of applied electrical potential difference and electrode spacing (V/S). A maximum induced shear strength of up to about 4 times of initial value has been observed with 0.18 < V/S < 0.25 in about 4 days. A maximum improvement depth of 1.4 times the electrode length has been reported. In addition, utilizing electrodes made up of thin metal core, preferably steel covered by electrically conductive geosynthetics, can minimize gas production and potential loss at electrode-soil interfaces and consequently decrease the level of power consumption in EO systems.

**Rapid Load Testing of Stone Columns**

*John Touma, Salah Sadek, and Shadi Najjar, American University of Beirut*

Stone columns are an economic solution for improving the bearing capacity of shallow foundations on soft soils. A novel impulse load test was developed and used to quantify the load-displacement response of shallow foundations on stone columns at a clay site. The testing methodology used is the Rapid Plate Load Tester. Static and dynamic tests were conducted on a 2 m x 2 m footing supported on slightly overconsolidated clay reinforced with stone columns and the results are presented. The stone columns were 6 m deep and constructed using the dry method at different area replacement ratios by varying the spacing and diameter of the stone columns. Static and dynamic field tests were performed to target loads of 2000 kN and equivalent bearing pressures of 500 kPa. Displacement time histories were acquired by both photocells and accelerometers. The Unloading Point Method was used to derive an equivalent static load settlement curve for the footing on clay soil both prior as well as post improvement. The derived static curves show good correlation with measured load settlement curves in the static mode.

**Mineralogy of Calcium Carbonate in MICP-treated Soil Using Soaking and Injection Treatment Methods**

*Hamed Khodadadi Tirkolaei and Edward Kavazanjian, Arizona State University; Huriye Bilsel, Eastern Mediterranean University*

Treatment method can have a significant influence on the mineralogy of the precipitated calcium carbonate ($CaCO_3$) in soil treated by microbially-induced carbonate precipitation (MICP). Rhombohedral calcite crystals are the most desirable form of $CaCO_3$ for geotechnical applications due to their thermodynamically stable nature. However, not all treatment methods produce this form of $CaCO_3$. Soaking and injection are two methods for MICP treatment of soil commonly used in the laboratory. The injection method was found to be more efficient for obtaining rhombohedral calcite crystals. It appears that rhombohedral calcite crystal growth is hindered in the soaking treatment method due to high concentration of organic matter in the treatment solution. These results indicate that mineralogical considerations should be included when determining an appropriate method for MICP-treatment of soil in the laboratory such that the resulting specimen is representative of the in situ mechanical behavior of MICP-treated soil.