

**Tuesday 3/14/2017**

**9:45–11:15 a.m.**

## **Application of Geofibers**

Chairs: Jie Huang, University of Texas at San Antonio; Ben Leshchinsky, Oregon State University

### **Use of Microgrid Inclusions to Reinforce Sand**

*Ben Leshchinsky, Oregon State University*

At the granular scale, use of fibers mixed within a soil is a demonstrated means of reinforcing both clays and sands, increasing strength, stiffness and ductility of the composite material. At a large scale, use of geosynthetic elements like geotextiles and geogrids provide an increase in composite strength and behavior by confining a reinforced soil mass with evenly placed tensile inclusions. Within this study, concepts of fiber-reinforced soil and geogrids are fused, focusing on randomly-oriented, small grid inclusions (“microgrids”), of various concentrations and aspect ratios mixed within dry sand. The addition of microgrids enabled improved strength and ductility of reinforced composites due to frictional interlock with small grid apertures and the tensile strength of the inclusions. Application of microgrid reinforcement increased soil strength soil by 5 to 10 degrees. Factors that affected behavior included aspect ratio, microgrid concentration by weight and confining pressure. The interlock behavior of microgrids and soil grains are based on frictional mechanisms similar to those of geogrids, demonstrating a dependence on grid transverse member thickness and aperture size in comparison to grain size. However, unlike large-scale reinforcements like geogrids, true soil composite behavior may be better exhibited upon homogenous admixing.

### **Study of Discrete Randomly Distributed Fiber on the Tensile Strength Improvement of Microbial-Induced Soil Stabilization**

*Lin Li, Changming Bu, Ubani Ogbonnaya, Kenjun Wen, and Farshad Amini, Jackson State University; Yingzi Xu, Guangxi University*

A laboratory study was conducted to investigate the addition of randomly distributed discrete fiber on shear strength of MICP-treated soil catalyzed by bacteria. Specimens were prepared at four different fiber ratios in full contact flexible molds. Unconfined compression tests and triaxial compression tests have been conducted on the fiber reinforced soils. The results showed that improvements in shear strength, ductility, and failure strain were achieved with fiber addition. The shear strength increased gradually with an increase in fiber content up to the optimum fiber content of 0.3%. The failure strain of MICP-treated sand at the 0.3% fiber is nearly 3 times higher than that without addition of fiber. Cohesion and angle of internal friction of fiber-reinforced sand increased by 29–45 kPa and 7.6–11o, respectively. The inclusion of fibers increases the residual strength and decreases the brittle behavior of the MICP-treated soil.

### **The Effect of Fiber Type and Size on Strength and Ductility of Fly Ash and Fiber Stabilized Fine-Grained Soil Subbase**

*Sazzad Bin-Shafique, Jie Huang, and Sepehr Rezaeimalek, University of Texas at San Antonio; Sanjoy D. Gupta, Consolidated Reinforcement LP.*

This study investigates the effects of the type and size of randomly oriented polymeric fibers on the strength and failure strain of fly ash stabilized high plasticity soil. Three different lengths of 13 mm, 25 mm, and 50 mm of two types of fibers, one with low (polypropylene) and the other with high

(polyethylene) tensile strength were mixed (1%) with high plasticity clay soil and Class C fly ash (10%). The mixtures were compacted to prepare specimens for unconfined compression test and split tensile test at the same dry unit weight. The fiber inclusions increased the compressive and tensile strength of fly ash stabilized soils significantly. The 25 mm fiber specimens with an aspect ratio of 0.45 that is the length of the fiber to the diameter of soil specimen, showed the maximum enhancement of strength for both compressive and tensile strength. Although all the specimens failed due to pullout of the fibers, the specimens with different fiber showed different strains at failure. The 13 mm fiber specimens (aspect ratio of 0.22) showed minimum increase in failure strain, whereas the specimens prepared with 25 mm and 50 mm fibers showed the maximum increase in failure strain, and failure did not occur even at 15% strain. The length of fiber has a relatively lower impact on gaining strength, but has pronounced effect on the ductility of the soil. The failure strain increased at least 132% when the 25 mm fiber was used. The polyethylene fiber stabilized soil showed slightly higher strengths because of its higher tensile strength and elastic modulus.

### **Optimizing Fiber Parameters Coupled with Chemical Treatment: Promethee Approach**

*Arif Ali Baig Moghal and Ateekh Ur Rehman, King Saud University; Bhaskar Chittooti, Boise State University*

In order to combat issues related to expansive soils, chemical stabilization augmented with use of synthetic fibers is gaining focus in recent times. However, in most of these applications, the practicing field engineers face difficulty in selecting the right mix of fiber size, fiber dosage and stabilizer content. The decision becomes more typical, as the target is to achieve or enhance multiple geotechnical properties which differ with fiber dosage and stabilizer content based on governing mechanisms. Addressing these issues, in this study an attempt is made to present an approach for selecting fibre dosage and lime mix for a typical expansive semi-arid soil. In this article, the effect of randomly oriented polypropylene fiber inclusion in enhancing various geotechnical properties of a typical expansive semi-arid soil is studied. The addition of lime is considered in order to ensure proper bonding between clay particles and discrete fiber elements. PROMETHEE is adopted in order to assist in multi-criteria decision-making process. The approach evaluates multiple geotechnical properties for possible alternatives viz., untreated soil; lime treated soil and other including combinations of fiber dosage and fiber size in the presence of lime. The response measures being the targeted geotechnical properties which include, linear shrinkage tests, unconfined compression strength test, California Bearing Ratio behavior, compressibility characteristics and hydraulic conductivity. The study revealed the best possible alternative considering all the selected response measures.

### **Reliability-Based Design Application for Fiber-Reinforced Clay**

*Assile Abou Diab, Shadi Najjar, and Salah Sadek, American University of Beirut*

The geotechnical community is shifting towards promoting sustainable technologies. One of the select applications in this domain consists of clays that are reinforced with natural or synthetic fibers. Extensive experimental work has been reported in the literature on the response/behavior of fiber-reinforced clays. This work led to, and/or was complemented by, several analytical and empirical strength prediction models. In this paper, an application involving the use of fiber-reinforced clays is selected for analysis from a reliability-based design perspective. The application involves a probabilistic assessment of the bearing capacity of shallow foundations on fiber-reinforced cohesive soils underlain by unreinforced clays of the same nature. Monte Carlo simulations were conducted to quantify the impact of model uncertainty and inherent variability in the input parameters on the probability of failure

of the foundation. Based on the results, recommendations are made regarding the required factors of safety and/or thickness of the “fiber-reinforced” replacement layer, which need to be adopted for the design of spread footings in order to achieve target reliability levels.