GEO-INSTITUTE 7th ANNUAL LIVE STREAMING WEB CONFERENCE

The Geo-Institute Engineering Geology and Site Characterization Technical Committee will live-stream the session "*Bioinspired Geotechnics*" on Friday, December 9, at 11 AM EST. The topics include:

"Bio-inspired active underground sensing network enabled by burrowing robots and vibrational communication," ***Julian Tao***, Ph.D., M.ASCE

An alternative underground sensing network is proposed to realize active, dynamic, wireless, and coordinated site characterization. In such a network, the sensor nodes are integrated into a bio-inspired burrowing robot, that deploys itself autonomously with minimal disturbance to the soil and minimal human intervention; due to its motility, each robotic sensor node can reposition easily to form a dynamic, reconfigurable network; sensor nodes communicate with each other using coded mechanical waves, inspired by mole rats; probing activities can be achieved during or after burrowing, and can be coordinated based on obtained data. In this presentation, efforts in understanding the fundamental mechanisms of burrowing, from a soil mechanics perspective, will be first introduced; specifically, lessons from burrowing razor clams and self-burial seed awns will be discussed; it will be followed by a demonstration of several burrowing robot prototypes; finally, a wireless underground communication system based on mechanical vibrations will be presented, with a close look to its design, components, algorithms and performance.

"Snakeskin-inspired piles and soil nails: from bio-inspiration to systems integration," ***Alejandro Martinez***, Ph.D., PE, M.ASCE

Many aspects of the construction and performance of infrastructure rely on load transfer between soils and structures. Examples include deep foundations, soil nails, and geosynthetics. This presentation will highlight the application of bioinspiration towards the transfer of load at soil-structure interfaces, with an emphasis on piled foundations and soil nails. A dilemma in design exists: while large skin friction promotes a large capacity, it can also lead to difficulties during installation (i.e. refusal). To address this, surfaces with textures inspired by the belly scales of snakes were designed to assess the potential for mobilizing direction-dependent friction and centrifuge pile load tests were performed to assess their effect the shaft capacity of piles. The laboratory and centrifuge results reveal that greater skin friction is mobilized when the surfaces and piles are displaced in the cranial direction (i.e. soil moving against asperities) than when they are displaced in the caudal direction (i.e. soil moving along asperities). This direction-dependence is shown to be due to the greater soil deformation induced when the surfaces are displaced in the cranial direction. Cyclic interface shear tests and centrifuge load tests inform the degradation of skin friction mobilized by the bioinspired surfaces and piles. This presentation will also provide a description of the field deployment of snakeskin-inspired soil nails in sandy and silty sites.

"Development of bioinspired laterally expansive piles" ***Paola Bandini***, Ph.D., P.E., M.ASCE

This talk describes the development of a bioinspired deep foundation system designed to provide greater capacity than conventional cylindrical piles with the same dimensions. A multifaceted bioinspiration approach was used to identify biological strategies for increasing the shaft resistance and anchorage of the new piles. Selected biological strategies called for a longitudinally split steel pipe pile with an expansion mechanism housed inside the pile. Prior to applying the structural load, a portion of the pile is expanded radially against the surrounding soil, and the expansion is locked. The increase in pile diameter causes the soil confining stress and the frictional resistance to increase over the expanded length of the pile. A patent protects the design concepts of the expansive piles and soil anchors. The gain in pile capacity with this approach has been evaluated numerically and experimentally in sand. Two series of mid-scale instrumented pile prototypes were designed, fabricated, and tested in dry, medium dense sand in a 12 ft-deep test pit, and the load test results demonstrate the remarkable advantage of the expansive piles. The capacity improvement of the expansive piles measured in pile load tests was in the range of 120%-170% compared to the control piles, and these results are consistent with the advantages shown through numerical modeling of the field-scale expansive piles. Different expansion mechanisms are being designed for future testing in compression and pullout.

"The hole story of rock drilling angelwing clam," ***Sheng Dai***, *Ph.D., P.E., M.ASCE*

With the need of drilling to greater depths for resources and energy, modern drilling technologies are challenged by the wear of drill bits, low penetration rates, and low levels of autonomy that increase costs with decreased safety. This presentation will share our preliminary investigations of the mechanisms by which angelwing clams (cyrtopleura costata) bore into rocks. Angelwing clams have thin and brittle shells, yet can burrow into rocks through unique body morphology and surface denticle patterns to effectively break the rock and remove the cuttings. This research combines tomographic characterization, surface indentation, and numerical shear-mode cutting simulation to unravel the morphological advantages of rock drilling clams in boring. This research aims to develop bio-inspired technologies for efficient drilling at greater depths, in harder media, and under extreme environments.

"Bio-inspired geotechnics in landed extraterrestrial subsurface exploration," ***Douglas D. Cortes***, Ph.D., M.ASCE

The direct measurement of in-situ regolith properties and the assessment of resources stored within the subsurface are recognized as critical steps in the development of Lunar ISRU technologies. On Earth, subsurface exploration equipment has developed over time to take advantage of the planet's gravitational acceleration and abundant fossil fuel energy availability. Today heavy surface equipment provides the reaction forces needed to overcome the ground penetration resistance. Energy is so readily available that the depth limiting parameter is often the surface anchor weight. Penetration in Lunar regolith poses two primary challenges: a low gravity environment, and limited power supply.

Earthworms have had over three hundred million years to develop and fine tune sophisticated light-weight subsurface penetration strategies that work more with the ground than against it. These organisms not only use the granular media for support but are also capable of adjusting their deformable bodies to gain mechanical advantages and maneuver around obstacles, reducing the energy needed for excavation. We created a simple earthworm-inspired soil penetration device by combining a miniature steel cone penetrometer with a soft membrane and deployed it in a bed of Lunar mare regolith simulant (LMS-1). The results of these bio-inspired tests are presented along with the implications for terrestrial and extraterrestrial subsurface exploration.