Tuesday 3/14/2017

9:45–11:15 a.m.

Soil and Rock Testing and Modeling 3

Chairs: Maurice Morvant, Trautwein GeoTAC; Neil Schwanz, U.S. Army Corps of Engineers

Contact Testing and Simulation of Time-dependent Interaction Between Sand Particles

Zhijie Wang, Dowon Park, and Radoslaw Michalowski, University of Michigan

An apparatus was constructed for testing the response of contacts between silica sand grains subjected to sustained loads. Testing results clearly indicate the delayed convergence of grains, likely caused by fracturing of asperities at the contact. The resolution of measurements was about 150 nm, and the difficulties in testing will be discussed. With the development of a constitutive law for time-dependent behavior of an individual contact as a future goal, the Distinct Element Method (DEM) was adopted as a simulation tool. An individual grain was simulated as an assembly of bonded sub-particles. The true texture of a silica sand grain surface was scanned using atomic force microscopy, and the contact region was replicated in simulations by "carving" the surface from high-resolution assembly of sub-particles. Simulations indicate that the near-contact regions of grains are subjected to time-dependent micro-fracturing, leading to an increase in the number of interaction points within an individual inter-granular contact area. This, in turn, leads to an increase of contact stiffness. Increase in the small-strain stiffness of sand is then a consequence that has been observed in the field.

High-speed Trains and Ground Mach 1: Numerical Simulation

Somayeh Rezaei Tafti, Jean-Luis Briaud, and Gary Fry, Texas A&M University

High-speed trains (HST) bring about special problems compared to typical freight and passenger trains. These special problems include the train passing the Rayleigh wave barrier and associated large deformations, particularly when the HST travels on soft soils. Results from instrumented tests performed with an HST on soft soil at different sites and associated numerical analyses have indicated that a large dynamic amplification appears in the vertical dynamic movement of the high-speed railways (HSR) as the train speed approaches the Rayleigh wave speed; this is attributed to a resonance phenomenon. This Rayleigh wave speed is the equivalent Rayleigh wave speed of the rail/embankment/ground system. This threshold speed is called the Critical Speed and is known as Ground Mach 1 or GM1. The question is to quantify this dynamic amplification to be in a better position to decide if it can create some serious ride discomfort or even derailment. A 4-D finite element model, developed in LS-DYNA, was used to simulate this problem. The model included the full train length and the raised embankment. The results of this study show that the Critical Speed is controlled by the Rayleigh wave velocity of the subsoil and that the maximum deflection occurring at the Critical Speed is about three times larger than the static deflection.

Evaluation of Earthquake-induced Free-field Settlement under Partially Drained Conditions from Dynamic Centrifuge Tests

Joon Han Kim and Scott M. Olson, University of Illinois at Urbana–Champaign

Numerous empirical correlations are available to estimate shaking-induced settlement of saturated, coarse-grained soils. These correlations, widely used in practice, were developed using laboratory cyclic shear tests of small specimens tested under either drained or undrained conditions. In particular,

settlements of liquefiable soils are estimated using correlations derived from undrained laboratory element cyclic tests. However, simultaneous settlement and porewater pressure increase in dynamic centrifuge tests suggest that partial drainage may occur in the field. In this study, we compare shaking-induced settlements measured in dynamic centrifuge tests with settlements computed using three correlations for drained conditions and three correlations for undrained conditions. The comparisons illustrate that correlations based on drained conditions typically underestimate significantly the measured settlements, while correlations based on undrained conditions typically overestimate significantly the measured settlements.

Investigating the Creep Response of Marcellus Shale Formation

Arash Kamali-Asl and Ehsan Ghazanfari, University of Vermont

Shale formations have been widely characterized in recent years due to their importance in different petroleum and civil engineering applications, especially unconventional shale gas recovery. Hydraulic fracturing in these reservoirs requires having a complete understanding of the petrophysical, static-dynamic, ductile, and anisotropic properties of the shale. Creep deformation of these formations affects the state of regional stresses (impacts the success of hydraulic fracturing) and the transport properties of shale rocks (important in the long term).

This paper presents preliminary results from an experimental program that explores ductile behavior of specimens of the Marcellus Shale formation from Allenwood, Pennsylvania through a series of hydrostatic and triaxial experiments. Experiments were performed at 20 and 30 MPa following the same deviatoric stress (DS) path. The results show that the magnitude of creep is directly proportional to the deviatoric stress level and the confining stress does not significantly affect the creep response.

Influence of Weathering on Engineering Behavior of Rocks under Triaxial Confining Conditions

Endalu Tadele Chala and K. Seshagiri Rao, Indian Institute of Technology, Delhi

Weathering degrades the mechanical properties of rocks causing failure or large settlements in many rock-engineering structures. Rock weathering commonly expected to develop on a geological time scale. Tropical climates where there is a dynamic weathering environment (thermal, hydrological, mechanical and chemical (TMHC)) can have a rapid weathering rates. As weathering process continues, specific minerals leached out, altered and newly formed minerals are deposited in fractures. In advanced stages of weathering, large deformations can be produced even under very low loading conditions because of weaker bonding and development of voids.

In this study different degree of weathered basaltic volcanic rocks from Deccan Traps formations in India are studied under uniaxial and triaxial compression testing with confining pressure up to 10 MPa. The study introduces a weathering index i.e. Strength ratio (Rs) and rebound number value (RN) related to the GSI Chart (along with Jcond89 and RQD) for rock mass classification. The estimated GSI values for each stage of weathered rock mass are presented in this paper.