Tuesday 3/14/2017

3–4:30 p.m.

Numerical Modeling for Soil Liquefaction 2

Chairs: Mourad Zeghal, Rensselear Polytechnic Institute; Majid Manzari, George Washington University

Liquefaction Analyses of the Port of Long Beach Using the UBC3D–PLM Constitutive Soil Model

Luis G. Arboleda-Monsalve and Andrew Sover, California State University, Long Beach; Jaime Mercado and David G. Zapata-Medina, Universidad Nacional de Colombia

The expansion of the Port of Long Beach- Pier S, a major U.S. port facility, has been completed through the past decades by placing loose man-made hydraulic fills. These fills and their subjacent natural estuarine and marine deposits, have shown to be susceptible to liquefaction. This case of study is located within a few miles of the Newport-Inglewood and the Palos Verdes faults, which represent a high seismic hazard to the port. In this paper, numerical analyses are performed using the UBC3D-PLM constitutive soil model to determine the onset of liquefaction and estimate free-field ground-induced settlements based on post-liquefaction excess pore water pressure dissipation. It is concluded that this model, even with certain limitations, is able to predict the onset of liquefaction capturing numerous features of dynamic soil behavior, and can be used as a first estimate of liquefaction-induced settlements arising from dissipation of excess pore water pressures.

Nonlinear 3-D Modeling of Dense Sand and Simulation of Soil-Structure System under Multi-directional Loading

Ozgun A. Numanoglu, Youssef M.A. Hashash, Alfonso Cerna-Diaz, Scott M. Olson, Lopamudra Bhaumik, and Cassandra J. Rutherford, University of Illinois at Urbana–Champaign; Thomas Weaver, Nuclear Regulatory Commission

The seismic performance of nuclear power plants (NPPs) constructed on compacted, dense sands depends on their cyclic response. NPPs founded on a thick deposit may experience nontrivial settlements due to small, but accumulated volumetric strains during an earthquake. Nonlinear, three-dimensional (3-D) numerical simulations can be utilized to assess the deformations of the soil-structure system. This work examines the performance of a class of distributed element constitutive models which has a parallel-series Iwan type distribution of elastic - perfectly plastic nested components. The performance evaluation is limited to deviatoric space since the volumetric component is yet not implemented. Soil-structure 3-D interaction and single element numerical simulations are compared to dynamic centrifuge and cyclic direct simple shear (cDSS) tests respectively. The simulations reasonably capture the measured shear behavior in small to medium shear strain ranges achieved in the centrifuge. However, the constitutive model deviates from measured response at the large shear strain levels achieved in cDSS.

Comparison of Liquefaction Constitutive Models for a Hypothetical Sand

Trevor J. Carey and Bruce L. Kutter, University of California, Davis

This paper presents numerical liquefaction simulations of a hypothetical sand in cyclic direct simple shear tests for four different constitutive models. The four models are PM4Sand in FLAC, UBCSand in FLAC, Pressure Dependent Multi Yield 02 (PDMY02) in OpenSees, and the Manzari-Dafalias04 model in OpenSees. Parameters published by others for various sands were used for this work to avoid possible

introduction of our bias into the calibration process. The material properties were determined by others for different uniformly graded sands, all with a relative density of approximately 50%. The simulations do not pertain to one sand or one set of laboratory data, so therefore, there is no right or wrong answer. Instead, the goal of this paper is compare a consistent set of results that show the implementations of each model behave as expected, and to illustrate basic differences in behavior of the different models. Cyclic strength curves (cyclic stress as a function of number of cycles) illustrate the behavior of the models over a range of cyclic stresses. Each model displays pore pressure build up, softening, and cyclic contraction-dilation cycles associated with cyclic mobility. Two of the models soften to a point, but then stabilize in a repeated hysteresis loop with no additional growth in the cyclic strain amplitude after some number of cycles.

Energy Dissipation in Soil Structure During Uniform Cyclic Loading

Guney Olgun and Soheil Kamalzare, Virginia Tech

Characterization of soil response under cyclic loading is one of the major challenges in evaluating liquefaction triggering. In this paper, we have performed numerical simulations to study dissipated energy and accumulated damage in soil structure at onset of liquefaction. For this purpose, at first, we validated Plasticity Model for Sands (PM4Sand) in capturing soil cyclic response with findings in experiments. Thereafter, the model was utilized to simulate soil behavior during uniform cyclic loading under controlled boundary conditions and stress paths. Simulations were performed on soils with different relative densities and under different confining pressures. The results of this study indicate that energy dissipation is directly related to PWP generation, and is independent of the amplitude, form and frequency of loading. Dissipated energy can be utilized as a versatile metric to characterize soil strength degradation and liquefaction triggering during cyclic loading.