Tuesday 3/14/2017

1:15–2:45 p.m.

Numerical Modeling for Soil Liquefaction 1

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

Calibration of the PM4Sand Model for Sands with Substantial Amounts of Fines

Bret Lingwall, South Dakota School of Mines and Technology

In this paper, the PM4Sand plasticity model developed by Boulanger and Ziotopoulou is investigated for predicting soil behavior under cyclic loading for sands containing substantial amounts of low plasticity fines. In this study, the model is compared with test data for sands with higher fines contents of low plasticity in the literature. Results from experimental studies on silty and clayey sands at different relative densities and confining pressures are used in the comparison. Simulated and measured values of number of cycles to liquefaction triggering and pore pressure response are compared. The results show that PM4Sand can predict the number of cycles to liquefaction and pore pressure response with reasonable accuracy for a variety of cyclic stress ratios for fines rich sands at different relative densities consolidated to a range of confining pressures. Limitations to the use of a sand plasticity model for soils with substantial fines are also discussed.

Seismic Performance of a Layered Liquefiable Site: Validation of Numerical Simulations Using Centrifuge Modeling

Jenny Calderon, Mahir Badanagki, and Shideh Dashti, University of Colorado, Boulder; Majid Manzari, Mohamed El Ghoraiby and Morteza R. Abkenar, George Washington University; Andres Barrero and Mahdi Taiebat, University of British Columbia; Katerina Ziotopoulou, Virginia Tech

Effective mitigation of liquefaction requires a reliable evaluation of liquefaction triggering and its consequences in terms of excess pore pressures, accelerations, and displacements. However, reliable prediction of all these key response parameters remains challenging in the past. In this paper, the results of a centrifuge experiment modeling of a layered soil profile, including a liquefiable layer of Ottawa sand, are used to evaluate the predictive capabilities of two state-of-the-art constitutive models. The models were first calibrated using the same set of monotonic and cyclic triaxial tests and were then used to simulate the seismic performance of a layered soil deposit to a horizontal earthquake motion. This paper presents the systematic calibration process adopted for each constitutive model, followed by a comparison of the numerical results with centrifuge recordings. This effort aims to provide insight into the strengths and limitations of the adopted models.

Seismic Response of Liquefiable Sloping Ground: Validation of Class B Predictions against the LEAP Centrifuge Tests

Levi Ekstrom and Katerina Ziotopoulou, University of California, Davis

Numerical predictions of the Liquefaction Experiments and Analysis Project (LEAP) centrifuge tests were revisited in order to evaluate the consistency of the numerical approach and the degree of agreement between numerical predictions and recordings for each facility. The calibration of the numerical model is examined against three Ottawa Sand laboratory data sets, and the validity of the original calibration is confirmed. The recordings of the centrifuge experiments for each facility are compared to the corresponding numerical model analysis and results are presented in terms of excess pore pressure time histories and spectral accelerations. The comparison shows that the numerical model, within the range of uncertainties involved, can satisfactorily predict the results of the experiment for most facilities, but experimental challenges of the experiments for few facilities result to an inconsistent agreement. Additional research is required to identify the underlying causes for the discrepancies but the project is deemed an overall success in yielding high-quality testing results, providing insights for future tests, and demonstrating the predictive capabilities of the numerical approach followed.

Evaluation of a simplified soil constitutive model considering implied strength and porewater pressure generation for 1-D seismic site response

Xuan Mei, Scott M. Olson, and Youssef Hashash, University of Illinois at Urbana–Champaign

Porewater pressure (PWP) generation leads to soil softening and potential liquefaction of sandy soils during earthquakes, and can decrease ground motion amplitudes at high frequencies and increase the predominant period of shaking. This paper presents an evaluation of the generalized Quadratic/Hyperbolic constitutive model (Groholski et al. 2016) coupled with two PWP generation models, termed GQ/H+u, as implemented in DEEPSOIL V 6.1 (Hashash et al. 2016). The GQ/H+u model can represent large-strain shear strength and thus provides more realistic response at liquefiable sites where large strains are expected. First, sets of cyclic direct simple shear tests were used to evaluate the models. Comparisons of measured and computed stress-strain loops and excess PWP generation illustrate that the model reasonably captures measured cyclic stress-strain and PWP responses. The GQ/H+u model also can reasonably capture acceleration time histories and response spectra measured in centrifuge tests in loose and dense sands subjected to strong shaking.

Microscale Modeling of Soil Liquefaction under Multidirectional Shaking

Usama El Shamy, Southern Methodist University; Yasser Abdelhamid, Alpha Testing Inc.

Very limited number of computational studies has been presented for the analysis of the response of saturated granular soils to multidirectional shaking despite it being the realistic mode of loading that resembles an actual earthquake. Herein, we examine the capabilities of a recently developed coupled lattice Boltzmann method-discrete element method technique to model level and gently sloped soil deposits when subjected to bidirectional shaking. Results of conducted simulations show that bidirectional shaking may increase surface settlement of level deposits by about 30% compared to unilateral shaking. The depth along the deposit that experiences excess pore pressure ratio close to unity increases because of bidirectional shaking compared to unilateral shaking. In addition, bidirectional shaking increases the magnitude of lateral spreading and associated shear strains in sloping deposits.