

Monday 3/13/2017

2–3:30 p.m.

Soil Liquefaction 1

Chairs: Katerina Ziotopoulou, Virginia Tech; Jack Montgomery, Auburn University

Influence of Soil and Structural Properties on the Response of Shallow-founded Structures on Layered Liquefiable Deposits

Zana Karimi, Shideh Dashti, and Zach Bullock, University of Colorado, Boulder

As the profession moves toward a performance-based approach for the evaluation and mitigation of liquefaction, increasingly the performance of the soil-foundation-structure system needs to be evaluated for a wide range of conditions. The influence of different soil and structural properties as well as Intensity Measures (IMs) need to be evaluated, before the system performance can be predicted in a probabilistic manner. Fully-coupled, 3D, nonlinear finite element analyses were performed to evaluate the integrated response of the soil-foundation-structure system on a layered liquefiable soil. After the numerical results were validated using centrifuge experiments, a parametric study followed to evaluate the influence of soil relative density, structure's height/width ratio, fixed-base fundamental period, and foundation pressure as well as IMs on building's permanent settlement and peak inter-story drift ratio. The results point to the importance of considering building's inertial properties and interaction with soil when evaluating its settlement, rocking, and deflection on liquefiable ground.

Verification of Random Field-Based Liquefaction Mapping Using a Synthetic Digital Soil Field

Qiushi Chen, Mengfen Shen, Chaofeng Wang, and Charng H. Juang, Clemson University

In this paper, a classical CPT-based liquefaction model is integrated with geostatistical tools and random field models to evaluate and map liquefaction potentials over an extended area. Verification of random field-based liquefaction prediction is challenging and rarely addressed in current literature due to limitation of soil data and liquefaction observations. To this end, a three-dimensional synthetic digital soil field is generated through novel numerical models, providing extreme detailed soil properties and corresponding liquefaction hazard information quantified in terms of the liquefaction potential index (LPI). Different virtual field testing plans are designed to investigate the effect of data inference on the model performance. Three ranking criteria are used to evaluate model performance. Knowledge gained through the model verification process can be used to guide the inference of model parameters and understanding the performance of random field-based liquefaction hazard mapping.

Monotonic, Cyclic and Post-cyclic Shear Response of a Gravelly Sand

Jonathan F. Hubler, Adda Athanasopoulos-Zekkos, and Dimitrios Zekkos, University of Michigan

Soil softening and soil liquefaction have long been a significant aspect of seismic risk, including at sites with gravelly soils. However, the performance of gravelly soils during and after earthquake events is still not well understood. A prototype large-size Cyclic Simple Shear (CSS) device is used in this research to perform monotonic and cyclic shear tests of a gravel, a sand and a gravelly sand mixture to evaluate the shear response of these materials. The importance of vertical strain control on constant volume behavior is also investigated for a uniform gravel material. Comparisons are made between monotonic, cyclic and post-cyclic shear response of a gravelly sand to show the relationship between these different

loading conditions. The results of these tests showed that the same ultimate state line (friction angle) is attained for this material from both monotonic and post-cyclic loading.

Evaluation of Liquefaction-induced Lateral Spreading Procedures for Interbedded Deposits: Çark Canal in the 1999 M7.5 Kocaeli Earthquake

Sean K. Munter, Ross W. Boulanger, Christopher Krage, and Jason DeJong, University of California, Davis

This paper presents results of one-dimensional (1-D) liquefaction vulnerability index (LVI) analyses and two-dimensional (2-D) nonlinear deformation analyses (NDAs) of a potential lateral spreading site adjacent to a channelized segment of the meandering Çark River in Adapazari, Turkey during the 1999 M7.5 Kocaeli earthquake. The site is underlain by fluvial deposits of clayey fine-grained sediments interlayered with potentially liquefiable sandy sediments. No lateral spreading damage was observed at the site after the Kocaeli earthquake despite an estimated peak ground acceleration (PGA) around 0.4 g. Current liquefaction triggering and lateral spreading analyses predict significant lateral displacements; results obtained with a multilinear regression model were presented by others and results obtained with LVI methods are presented herein. Additional LVI analyses were performed to consider the effects of transition and thin-layer corrections, different criteria for distinguishing between sand-like and clay-like soils, and site-specific fines content estimation. NDAs with stochastic realizations of interlayered sand and clay stratigraphy estimated from available CPT data were performed to assess the impact of accounting for 2-D site geometry, spatial variability in stratigraphy, and dynamic response. The realizations were produced using a transition probability geostatistical approach, and representative soil properties were selected by statistical examination of the properties estimated from the CPT data. Descriptions of the methods used for the LVIs and NDAs are included and the computed lateral displacements are compared to field observations. Lateral displacements from all LVI analyses are significant, while those from the NDAs are sufficiently small to be generally consistent with the absence of observable damage at the site. These comparisons illustrate that a realistic representation of the site and the dynamic loading conditions beyond what is accounted for by LVI methods can be important for evaluating potential lateral spreading in these types of interlayered sand and clay deposits.

Prediction of Lateral Spreading Displacement on Gently Sloping Liquefiable Ground

Omid Ghasemi Fare, University of Louisville; Ali Pak, Sharif University of Technology

A fully coupled numerical analysis using Biot's theory with u-p formulation considering variable permeability during liquefaction is used in this study to simulate liquefaction induced lateral spreading phenomenon. A centrifuge test performed on liquefiable soil at Rensselaer Polytechnic Institute is simulated using the developed model. The numerical results are in good agreement with experimental observations. A number of numerical simulations under different geometric, site-specific, and ground acceleration parameters have been carried out in the course of this study. Based on the statistical analysis conducted on the results of 31 different models, a new relation is proposed for predicting the liquefaction-induced maximum lateral displacement for gently sloping grounds. The proposed relation can predict the maximum ground lateral displacement obtained by the rigorous finite element analysis with less than 10% error. The predicted lateral displacements are in a good consistency with the ground movement observations in 16 different centrifuge tests as well as more than 250 field observations. The proposed relation in this study shows a better match compared to other well-known relations.