GEO-INSTITUTE
7th ANNUAL LIVE STREAMING WEB CONFERENCE

The Geo-Institute Earthquake Engineering and Soil Dynamics Technical Committee will live-stream the session “*Soil-Structure Interaction*” on Thursday, December 8, at 11 AM EST. The topics include:

“Unexpected Findings from a Decade of 3D Seismic Soil-Structure Interaction Analyses in the San Francisco Bay Area,” ***Kirk Ellison***, *Ph.D.,* P.E., GE. ENV SP, M. ASCE

3D dynamic finite element analysis has long been a valuable tool to assess seismic soil-structure interaction (SSI) and structure-soil-structure interaction (SSSI) phenomena. However, it has only recently become a commonplace design methodology in high seismic, urban areas due to factors such as: updates to national codes and local standards, increased computational speed and availability of cloud computing, widespread embrace of automation and digital tools throughout the industry, and increased demand from well-informed clients focused on long-term resilience. One of the benefits of performing advanced SSI and SSSI analysis is that it provides insights into the behavior of complex systems that cannot be obtained from simpler approaches. The findings are generally illuminating and sometimes challenge our intuitive understanding of the system. This presentation will highlight some surprising and unexpected findings from a variety of SSI and SSSI case studies for design projects in the San Francisco Bay Area over the past decade, ranging from tall buildings to deep tunnels/shafts, and buried water infrastructure.

“Experimental Evaluation of Helical Piles in Mitigating Liquefaction-Induced Foundation Settlements,” ***Ramin Motamed,*** Ph.D., PE, M.ASCE

Helical piles are one of the manufactured deep foundation types that are commonly used to underpin foundations suffering from excessive settlements or tilts. The application of helical piles is growing in urban areas given the facts that the installation process does not generate any vibration; causes minimum site disturbances; imposes low mobilization costs; can be installed in low-headroom areas with portable equipment; and no soil spoils are produced. Although some recent studies have demonstrated the satisfactory behavior of helical piles under seismic loading in dry soils, the response of helical piles in liquefiable grounds is not yet well understood. The main objective of this presentation is to evaluate the efficacy of helical piles in mitigating liquefaction-induced settlement of shallow rigid foundations and investigate their seismic performance in liquefiable grounds. Two large-scale shake table test series, one without any mitigation measure and one using helical piles, were conducted using the shake table facility at the University of California, San Diego. Each model comprised three soil layers measuring about 10 ft in height and included a shallow rigid foundation seated over an unsaturated crust layer underlain by saturated loose and dense layers. The model ground was based on similar subsurface ground conditions observed in recent earthquakes in New Zealand, Japan, and Turkey where shallow liquefiable soil layers imposed significant damage to the building foundations. The models were extensively instrumented using a wide range of sensors to capture the dynamic response of the soil-foundation-pile system. The experimental results overall illustrate the enhanced seismic behavior of the soil-foundation-pile system response such as reduced excess pore-water pressure around the helical piles which is attributed mainly to the densification around the piles during installation. In addition, the foundation supported on helical piles underwent almost no differential settlement and tilt. This study illustrates that helical piles are a reliable and highly efficient measure to mitigate liquefaction-induced foundation tilt and settlement.

"Performance-Based Assessment of Structures on Liquefiable Soils: from Triggering to Mitigation,"

Shideh Dashti, Ph.D., M.ASCE

Effective liquefaction mitigation requires an improved fundamental understanding of triggering in terms of excess pore pressures and shear strains in realistically stratified deposits that experience cross-layer interactions as well as performance-based consequence procedures that account for 3D soil-structure interaction (SSI), all mechanisms of deformation, total uncertainty, and the impact of mitigation. In this presentation, I first describe a series of centrifuge experiments to evaluate site response in layered liquefiable deposits, SSI, and the impact of ground densification as mitigation on SSI and performance. Second, experimental results are used to validate 1D and 3D, fully-coupled, nonlinear, dynamic finite element analyses of layered sites and soil-structure systems with and without mitigation. Third, numerical parametric studies (exceeding 167,000 1D and 63,000 3D simulations) help identify the functional forms for predicting liquefaction triggering in the free-field based on a newly proposed factor, the capacity cumulative absolute velocity (CAV_c) required to achieve a threshold excess pore pressure ratio (r_u), settlement of unmitigated structures on mat foundations, and the relative impact of ground densification on foundation's permanent settlement. And finally, a limited case history database is used to validate the models, accounting for field complexities not captured numerically or experimentally. This integrative approach yields a set of procedures that are the first to consider variations in soil layering and geometry, layer-to-layer cross interactions, foundation and structure properties (in 3D), contribution of all mechanisms of deformation below unmitigated structures, geometry and properties of densification, ground motion's cumulative characteristics, total inherent model uncertainties, and the explicit conditionality of structural settlement on free-field triggering—which are necessary to realize the benefits of performance-based engineering in liquefaction assessment.