Monday 3/13/2017

9:45–11:15 a.m.

Seismic Parameters 1

Chairs: Adrian Rodriguez-Marek, Virginia Tech; Ashly Cabas-Mijares, Virginia Tech

What Can We Learn from Kappa (κ) to Achieve a Better Characterization of Damping in Geotechnical Site Response Models?

Ashly M. Cabas, North Carolina State University; Adrian Rodriguez-Marek, Virginia Tech

Site response analyses (SRA) provide a means to assess the seismic wave propagation phenomenon in shallow deposits and capture its influence on ground motions. One of the key model assumptions in SRA involves the characterization of the attenuation at the site. Typical damping models are developed by testing small-scale soil samples in the laboratory. These procedures can only characterize material damping and fail to capture other sources of attenuation as they occur in the field (e.g. scattering). The spectral decay parameter, kappa, is used in this study to define alternative damping models. These combined models of geotechnical and seismological attenuation descriptors provide larger estimates of damping than laboratory-based models. The most important practical application of this study is the definition of the portion of attenuation that is ignored when solely relying in dynamic laboratory testing. Insights on similarities between kappa and damping values used in geotechnical models are also provided.

Damping and Shear Moduli of Laboratory Prepared Mineral Mixtures

Beena Ajmera and Binod Tiwari, California State University, Fullerton

Seventeen soil specimens were prepared in the laboratory as mixtures of commercially available montmorillonite or kaolinite with quartz and used to conduct cyclic simple shear tests. The soils were subjected to different amplitudes of strain-controlled sinusoidal loading at a frequency of 0.5 Hz. The results obtained were used to determine the relationship of the strain-dependent dynamic properties. Modulus reduction curves were developed and found to be dependent on both the plasticity index and the mineralogical composition of the soil specimens. Specifically, for two soils with the same plasticity index, but different mineralogical compositions, a lower reduction in the shear modulus with shear strain was observed in the soils containing montmorillonite as the clay mineral in comparison to the soils containing kaolinite as the clay mineral. Furthermore, at a given shear strain, the damping ratio in the soils with montmorillonite as the clay mineral was lower than the damping ratio for the soils with kaolinite as the clay mineral.

Use of Pore Pressure Response to Determine Shear Strength Degradation from Cyclic Loading

Beena Ajmera, Binod Tiwari, and Pavitra Pandey, California State University, Fullerton

Case histories have demonstrated the disastrous consequences of cyclic mobility in the underlying fine-grained cohesive soils. Cyclic mobility is the reduction in shear strength resulting from an increase in the pore pressure in soils from dynamic loads. This increase in pore pressure will cause a reduction in the effective stresses in the soil mass. In this study, over twenty soil samples were subjected to sinusoidal cyclic loading in the cyclic simple shear apparatus at a frequency of 0.5 Hz. Immediately following the cyclic loading phase, the shear strength of the soils was determined. The pore pressure response of the fine-grained soils was back-calculated from changes in the normal stress in order to maintain constant volume in both phases of the testing. The results were used to determine the stress paths followed by the soils during the cyclic and post-cyclic loading phases. The behavior observed demonstrated that the post-cyclic shear strength of the soils could be calculated by estimating the pore pressure as a result of a cyclic loading. This pore pressure could be used to determine the effective stresses on the soil just following the cyclic loading and thus, compute the overconsolidation ratio for the soil. The SHANSEP principles could, then, be applied to determine the relationship between the undrained strength ratio and the overconsolidation ratio. Relationships between the multiplier and exponent of a power function representation of the variation between the undrained strength ratio and the overconsolidation ratio with the liquid limit and the plasticity index are proposed.

Parametric Study on Effectiveness of Deep-Soil Mixed Soil-Reinforcement Panels on the Seismic De-amplification at Soft Clay Sites

Prakash Khanal, Binod Tiwari, Beena Ajmera, Michael Mann, and Murtdha Al Quraishi, California State University, Fullerton

Soft clay deposits around the world pose several issues including low bearing support, high compressibility and an amplification of earthquake motions. As a result, ground improvement techniques have been implemented in order to improve the engineering properties of these soft soils. Furthermore, if these ground improvement techniques can help to reduce the amplification of seismic waves as they travel through soft soil deposits, the demands placed on infrastructure can also be reduced. In this study, the effectiveness of deep soil mixed panels on reducing the seismic amplification through a soft clay profile is examined with the use of an unidirectional shake table. The influence of replacement ratio of these panels is evaluated by preparing three models representing replacement of 0%, 10% and 20% of the plan area of the unimproved soil. Similar models were also prepared with compacted soil-cement panels and used for comparison. The amplification of the seismic waves was found to reduce as the replacement ratio of the deep soil mixed panels increased. Relationships between the replacement ratio and reduction in seismic amplification are presented in this paper.

Centrifuge modeling and analysis of soil structure interaction under biaxial dynamic excitations

Omar El Shafee, Tarek Abdoun, and Mourad Zeghal, Rensselaer Polytechnic Institute

The paper presents a centrifuge test of a level site consisting of granular soil deposits and an embedded structure subjected to various bi-axial base excitations. The test was conducted at RPI NEES centrifuge facility to assess the dynamic response characteristics of soil-structure interaction (SSI) under multidimensional conditions. Synthetic sinusoidal waves were used as base excitations to test dense model under biaxial shaking. A dense array of accelerometers was used to monitor the deposit response (beneath and outside of the structure, along with pore water pressure transducers. The observed acceleration and pore pressure are used along with non-parametric identification procedures to estimate the corresponding dynamic shear stress-strain histories. The measured results along with the obtained histories are used for two purposes. First, to shed light on the mechanisms of soil-structure interaction under biaxial shaking. Secondly, to show the difference in soil behavior at different locations beneath the footing when subjected to biaxial shaking. The later objective is evident when comparing soil stress-strain loops and dilation behavior at locations beneath the structure, and those measured in the free field.

A Relationship between Modulus and Damping Provides for Simple, Unified Modeling of Both

Vincent Drnevich and Vincent Drnevich, Purdue University
The shear stress – shear strain behavior of soil is characterized by a hysteresis loop. The geometry of the loop over one cycle of loading can be used to establish a simple equation that relates secant shear modulus to shear damping. The equation applies to values of modulus and damping obtained at all values of shear strain. No other information is needed. Two simple hyperbolic expressions, with only two coefficients, accurately describe both the shear modulus degradation and damping increase with shear strain. The equations include reference strain to allow the results to be relatively independent of confining stress. They are obtained with an optimization program in a spreadsheet. Results from resonant column tests on sand, silt and clay soils demonstrate their efficacy for determining minimum and maximum values of damping.