Monday 3/13/2017

12:15–1:45 p.m.

Seismic Parameters 2

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

Numerical Modelling of Dynamic Behavior of Unsaturated Soils including Hydraulic Hysteresis

Bo Zhang and Kanthasamy Muraleetharan, University of Oklahoma

Unsaturated soils are commonly encountered in natural soil deposit above the ground water table and in compacted soil structures. The use of compacted soils in earthquake prone areas is increasing. The accurate prediction of dynamic behavior of unsaturated soils is of practical importance to many geotechnical engineering problems, such as soil-structure interaction and liquefaction evaluation. The hydraulic hysteresis of soil water characteristic curves during wetting and drying cycles is not accounted for in most of the numerical analysis of dynamic behavior of unsaturated soils. To better understand the dynamic behavior of unsaturated soils, a fully coupled flow-deformation finite element code U_DYSAC2 with solid displacements, pore water pressure and pore air pressure as nodal variables is used to analyze an unsaturated embankment subjected to base shaking. A bounding surface elastoplastic model is utilized to describe the stress-strain behavior of unsaturated soils. The hydraulic hysteresis is also taken into account using a model developed based on the bounding surface plasticity theory. The U_DYSAC2 results show that the analysis with hydraulic hysteresis predicted smaller vertical displacements and larger suction change than the analysis without hysteresis.

Constant-Volume Cyclic Testing to Determine Input Parameters for the GMP Pore Pressure Generation Model

Carmine Polito, Valparaiso University

The GMP (Green, Mitchell and Polito) pore pressure generation model uses the energy dissipated in a soil during cyclic loading to predict the residual pore pressure rise in a saturated soil subjected to cyclic loading. In addition to the shear stresses and shear strains applied to the soil deposit being modeled, the GMP model requires a single calibration parameter referred to as the "pseudo energy capacity" or "PEC". The study reported in this paper examined the validity of using constant-volume cyclic simple shear tests to develop values of the PEC for input into the GMP model. The study performed consisted of using the PEC developed from a series of constant-volume cyclic simple shear tests performed on a loose sand to predict the residual pore pressures generated during a series of stress- and strain-controlled cyclic triaxial tests performed on the same sand prepared to the same density. It was found that once the pseudoenergy capacities from the constant-volume cyclic simple shear tests were scaled to account for the effects of specimen size, they did an excellent job of predicting the pore pressure generation that occurred during the cyclic triaxial tests.

Measurement of Damping in Soils by the Resonant Column Test

Vincent Drnevich, Purdue University; Jeramy Ashlock, Iowa State University

Soil behavior is inherently nonlinear, including the strain-dependent modulus and damping values measured in the resonant column apparatus. This paper describes the frequency response behavior in the resonant column test using a theory that is valid for all frequencies including those that differ from the resonant frequency, and for strain amplitudes ranging from near zero to those approaching failure.

The theory is based on the ASTM D4015-15 Standard for devices having a fixed specimen base, with torque and rotation measured at the top of the specimen. The theory accounts for damping in the apparatus. Results show that the frequency response at all shear strain amplitudes is significantly different from that predicted by linear viscoelastic theory, especially at small shear strains where both shear modulus and damping are most highly dependent on shear strain amplitude. Proof of this dependency at low strains is provided by plotting shear modulus and damping to natural scales rather than logarithmic scales as is traditionally done.

Estimation of Shear Wave Velocity in Centrifuge Models

Waleed El-Sekelly, Mansoura University; Tarek Abdoun, Rensselaer Polytechnic Institute; Vicente Mercado, Universidad del Norte

Shear wave velocity is an essential parameter to characterize the dynamic behavior of the soil in small-scale samples, centrifuge models as well as field deposits. In this paper, the bender elements system in the centrifuge lab at Rensselaer Polytechnic Institute is used to characterize the shear wave velocity and the small strain shear modulus of dry and saturated Ottawa sand. It was found that the shear wave velocity of saturated sand is smaller than that of dry sand having the same relative density. Also, the paper describes an analytical system identification (SI) method that can be used in the absence of bender elements to estimate shear wave velocity from acceleration recordings. The SI and bender elements were found to be in very good agreement with each other confirming the validity of both techniques, which are fully independent.

Modulus Reduction and Damping Curves for Landfill Covers

Neven Matasovic, Geo-Logic Associates; Dimitrios Zekkos, University of Michigan

Unlike dynamic properties of municipal solid waste (MSW), the dynamic properties of engineered fill landfill covers at MSW and other landfill sites have not been extensively investigated. The two main reasons for the dearth of research on this topic are: (i) design engineers realize that modern landfill covers are relatively thin (on the order of 1.5 m, or less), and hence, their influence on the overall landfill response is assumed to be small; and (ii) there are readily available sets of dynamic soil properties of cohesive soils that could be assigned to landfill covers soils based upon the results of index testing. However, not all landfill covers are “thin,” and the readily available sets of dynamic soil properties may not be applicable for low-plasticity compacted and overconsolidated soils such as landfill covers. At many old landfills and Superfund sites, landfill cover thickness readily exceeds 5 m, and covers can be as thick as 10 to 15 m. These thicker covers may have significant influence on the overall response of landfills, and hence, careful evaluation of cover material properties is warranted. In this paper, results of in-situ nonlinear testing of landfill cover soils was used to develop modulus reduction curves. Shear strains in the cover soils ranging from 10-4 % to 2×10-2 % were induced by Vibroseis shakers. The material damping curves were estimated from modulus reduction curves by means of a nonlinear constitutive model, Masing rules, and engineering judgement. The modulus reduction and damping curves presented herein may be used for seismic design of landfill covers and other engineered fills constructed of soils of similar plasticity and with similar stiffness (i.e., shear wave velocity) and compaction characteristics.

Post-cyclic Recompression of Clays Subjected to Undrained Cyclic Shear

Tran Thanh Nhan and Hiroshi Matsuda, Yamaguchi University

In this study, normally consolidated clays were subjected to undrained cyclic simple shear followed by drainage. Then the shear strain amplitudes (□) and number of cycl cts of Atterberg's limits on the pore water pressure accumulation and recompression were investigated. In conclusion, the pore water pressure accumulation and the settlement of saturated clays are significantly affected by the Atterberg's limits. For Kaolin with low plasticity index (Ip), the pore water pressure rapidly increases and becomes stable after relatively small number of cycles n. Meanwhile for Tokyo bay clay and Kitakyushu clay with higher Ip, the cyclic shear-induced pore water pressure is rather small leading to smaller post-cyclic settlement. The cyclic recompression index (Cdyn) of Kaolin is unchanged with n while those of Tokyo bay clay and Kitakyushu clay significantly decrease with n. By using these results, the post-cyclic settlement of clays was successfully predicted.