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SIMULATION OF LATERAL SPREADING OF GENTLY SLOPING LIQUEFIED GROUND

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This paper is focused on the simulation of the lateral spreading phenomenon and the anticipated maximum surface displacements of sloping ground. An innovative numerical methodology is proposed employing a generalized plasticity model implemented in a finite element code, which has been thoroughly validated against VELACS centrifuge liquefaction experiments.

Lateral spreading is the term used to refer to the development of large horizontal ground displacements due to earthquake induced liquefaction, in the case of even small free ground surface inclination or small topographic irregularities. Recent earthquakes have emphasized the fact that this phenomenon has significant practical importance for civil engineering structures (coastal structures, bridge piers, lifelines, etc.), since it imposes considerable lateral loads and may lead to widespread failures. Fortunately, there exist methods today which can be used for the design of such structures against lateral spreading (e.g. P-y analysis). However, their accuracy depends greatly on the ability to estimate the anticipated lateral ground displacements and their variation with depth.

In this research, a fully coupled two-dimensional dynamic analysis based on effective stress formulation using saturated porous media considering fluid movement has been used to simulate the lateral spreading and evaluate the amount of deformations occurred in liquefiable soils. The governing equations are developed for saturated porous media based on the extension of Biot formulation. The cyclic elastoplastic behavior of soil under earthquake loading is modeled using the generalized plasticity theory composing of a yield surface together with non-associated flow rule proposed by Pastor and Zienkiewicz. A fully explicit dynamic finite element method and a fully coupled (u-w) formulation are employed in a computer code to analyze soil displacements and pore water pressures (Taslimian et al., 2014).

In order to ensure the accuracy of numerical analysis results, a centrifuge experiment results has been utilized. The results of numerical analysis compared with experimental measurements indicate that the proposed numerical model has the capability to simulate the lateral spreading phenomenon. The same finite element mesh was used for all numerical simulations, as shown in Figure 1.

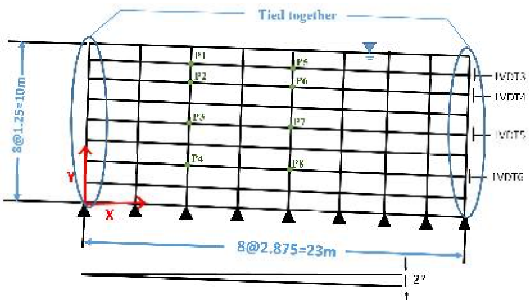

Figure 1. Finite element mesh used for the numerical simulation of centrifuge tests and associated instrumentation for test M2-1

Figures 2 and 3 illustrate a typical comparison between predicted measured excess pore water pressure and displacement. These comparisons indicate a good agreement.

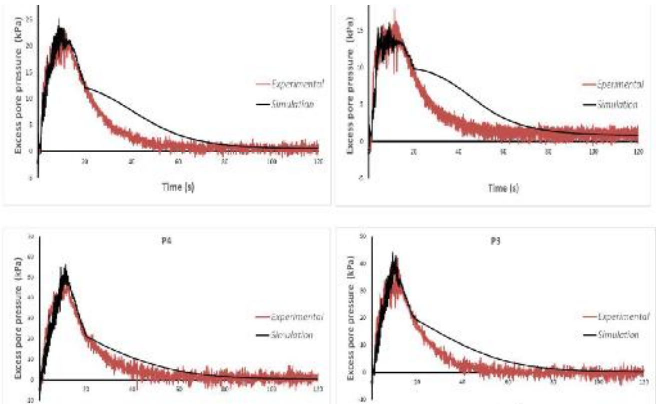

Figure 2. Comparison of numerical predictions of excess pore pressure to their respective centrifuge test measurements

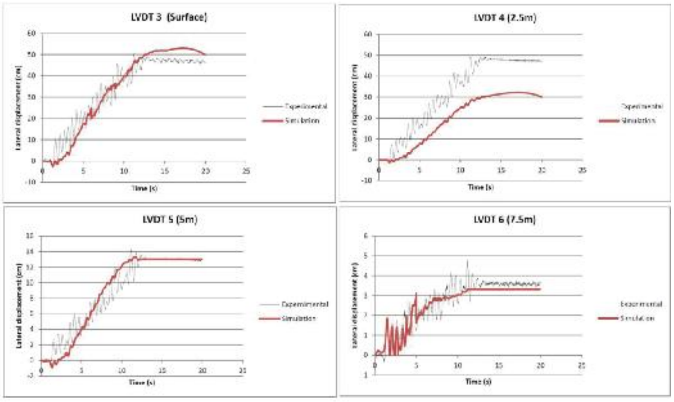

Figure 3. Comparison of numerical predictions of maximum lateral ground displacements to their respective centrifuge test measurements

The model has been used to find out the effect of frequency of input motion on the magnitude of soil displacement. The results demonstrate that the amount of maximum displacement is significantly decreased by increasing the magnitude of frequency.

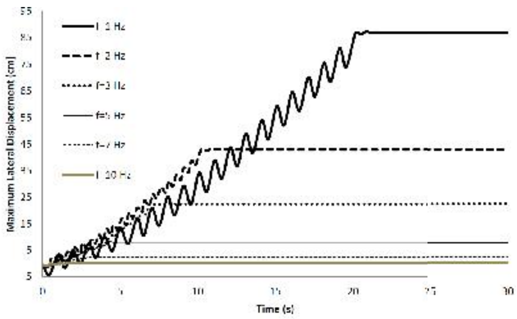

Figure 4. Variation of maximum lateral displacement for various frequencies

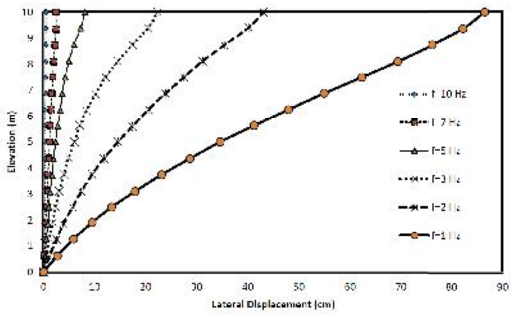

Figure 5. Variation of lateral displacement in depth for various frequencies

REFERENCES

Arulmoli K, Muraleetharan MMH and Fruth LS (1992) VELACS Laboratory testing program - Soil data report, Earth Technology Corporation, Project No. 90-0562, Irvine, California

Biot MA (1955) Theory of elasticity and consolidation for a porous anisotropic solid, *J. Appl. Phys.*, 26: 182-185

Chan AHC (1998) A unified finite element solution to static and dynamic geomechanics problems, Ph.D. Thesis C/Ph/106/88, University College of Swansea

Pastor M, Zienkiewicz OC and Chan AHC (1990) Generalized plasticity and modeling of soil behavior, *Int. J. Numer. Anal. Meth. Geomech.*, 14: 151-190

Taslimian R, Noorzad A and Maleki Javan MR (2014) Numerical simulation of liquefaction in porous media using nonlinear fluid flow law, To be appeared in *International Journal for Numerical and Analytical Methods in Geomechanics*

Zienkiewicz OC, Chan AHC, Pastor M, Schrefler BA and Shiomi T (1999) Computational Geomechanics with Special Reference to Earthquake Engineering, John Wiley and Sons Ltd., Chichester