IMPACT OF MULTI-DIRECTION SHAKING ON SITE LIQUEFACTION: A MICRO-MECHANICAL INVESTIGATION

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Earthquake excitations are induced by a fault rupture at large depths, and results in elaborate patterns of seismic wave propagation. Near the ground surface, these waves are associated with complex strain and stress paths where the principal stresses change in both magnitude and direction. Experimental evidence shows that the liquefaction and lateral spreading of granular soil deposits loaded under multi-directional conditions is significantly more complex than when subjected to one-dimensional excitations. However, in nowadays practice the effects of multidirection shaking on triggering of liquefaction are still accounted for by using a simplistic strength reduction factor of 0.8 to 0.9.

This paper presents an investigation of the response and liquefaction of saturated granular deposits when subjected to multi-direction dynamic base excitations. These deposits are idealized using a coupled hydromechanical computational model recently developed by the authors. The fluid phase is modeled using an Eulerian formulation based on averaged Navier-Stokes equations. A Lagrangian (mesh-free) formulation utilizing the discrete element method (DEM) is used to model the solid phase as an assemblage of particles. The interphase momentum transfer is quantified using established relationships. The model is employed to analyze the response of both level and sloping semi-infinite saturated deposits of loose cohesionless particles. The (per unit of volume) kinetic energy of the input motion is used as a metric to assess the liquefaction potential under such excitations. Numerical simulations were conducted to assess the validity of this new metric and the impact of multiple direction excitations. These simulations showed that liquefaction of level ground deposits is highly dependent on the amount of input energy. Nearly identical rates of pore pressure build-up were obtained when a deposit was subjected to one- or two-direction excitations with equal input kinetic energy. Further research is underway to assess the validity of these findings under more general loading conditions.

Keywords: DEM, Liquefaction, dynamics