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Virtual Approach to Simulating Geotechnical Problems under Both Static and Dynamic Conditions

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Abstract : Recent studies on the numerical simulation of geotechnical problems show the importance of considering the soil micro-structure. At this scale, soil is a discrete particle medium where the particles can interact with each other and with water flow under external forces, structure loads or natural events. This paper presents research conducted in a virtual laboratory named SiGran, developed at IREQ (Institut de recherche d'Hydro-Quebec) for the purpose of investigating a broad range of problems encountered in geotechnics. Using Discrete Element Method (DEM), SiGran simulated granular materials directly by applying Newton's laws to each particle. The water flow was simulated by using Marker and Cell method (MAC) to solve the full form of Navier-Stokes's equation for non-compressible viscous liquid. In this paper, examples of numerical simulation and their comparisons with real experiments have been selected to show the complexity of geotechnical research at the micro level. These examples describe transient flows into a porous medium, interaction of particles in a viscous flow, compacting of saturated and unsaturated soils and the phenomenon of liquefaction under seismic load. They also provide an opportunity to present SiGran's capacity to compute the distribution and evolution of energy by type (particle kinetic energy, particle internal elastic energy, energy dissipated by friction or as a result of viscous interaction into flow, and so on). This work also includes the first attempts to apply micro discrete results on a macro continuum level where the Smoothed Particle Hydrodynamics (SPH) method was used to resolve the system of governing equations. The material behavior equation is based on the results of simulations carried out at a micro level. The possibility of combining three methods (DEM, MAC and SPH) is discussed.

Keywords : discrete element method, marker and cell method, numerical simulation, multi-scale simulations, smoothed particle hydrodynamics
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