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An Onset Mechanism for Pore Propagation in a Saturated Particle Bed towards Quicksand

Shin-Ruei Lin[1]*, Fuling Yang[3], Chuin-Shan Chen[2], Shang-Hsien Hsieh[4]

[1,3,4]Department of Civil Engineering, National Taiwan University, Taiwan (R.O.C.)
[2]Department of Mechanics, National Taiwan University, Taiwan (R.O.C).

*Corresponding author: sonic@caece.net

Quicksand forms in a saturated solid particle bed when subjected to external loading during which the solid particles are liquefied and the bed loses its strength. This phenomenon has caused serious damages to the infrastructure built on top of the solid bed but its onset mechanism and the transient development still remains unsolved. Hence, this work attempts to address this issue by numerical simulation where the motions of coexisting solid particles and incompressible Newtonian liquid are solved by coupled Discrete Element and Lattice-Boltzmann (DEM-LBM) method. We adopt immersed boundary method (IBM) to handle the solid-liquid interface. The saturated particle bed was prepared by randomly packing 3000 identical solid spheres in a thin box filled with Newtonian liquid and the final packing height is roughly 2/3 of the box height. Constant upward pressure gradient was then applied to the packed bed and the current simulation allows us to study the fluid-body interaction at particle size level.

When pressure gradient is firstly applied, the induced rising flow is trapped in the bed voids (space between bet particles) and those in larger voids may turn to create locally high vorticity field. It is the vorticity-induced lateral force—Saffman lift force—that moves nearby spheres horizontally to destroy local packing configuration through which liquid penetrates and a zone of loose particles forms a *pore* (richer in liquid) in the packed bed. The penetrating liquid will then be trapped again in a higher layer and the same process of lift force induced packing destruction occurs again to let the pore propagate further upwards. By repeating this, liquid pore can propagate through the particle bed and emerge from the bed surface to result in global quicksand phenomenon during which spheres flow agitatedly and loosely with the fluid in a convection cell.

Keywords: Quicksand, Saffman lift force, onset mechanism, Discrete element method, Lattice Boltzmann method