PS-MRT Lattice Boltzmann Model for Direct Simulation of Granular Soils and Seepage Flow

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ABSTRACT

In geo-mechanics, a particle-fluid system exists in the form of solid particles and pore liquids or gases, which are characteristic of non-Brownian and highly concentrated suspensions. A deep understanding of such a system is a key to predict and control the various phenomena, such as sand boiling, weathering of rocks, internal erosion and liquefaction of foundations.

Here, the development of numerical simulation can help our understanding of such complex particle-fluid systems. Because of the importance of capturing properly the interactions between particle and fluid, micro-scale numerical method which can deal with the fluid flow at less particle scale is needed. In contrast, macro-scale methods have less computationally load and are suitable for an industrial application, but require a local averaging which loses the essential details of the fluid flow.

In this paper, we proposed an effective direct simulation method for both soils and seepage flow by using DEM (Discrete Element Method) and LBM (Lattice Boltzmann Method). Firstly, in order to stabilize the flow analysis and to improve the accuracy of the non-slip boundary condition, MRT (Multiple Relaxation Time) model [1] was introduced into the LBGK equation, which is standard solution of the non-compressible fluids. Secondlly, PS (Partially Saturated) model [2] was chosen as a solution of the moving boundary, which can maintain the inherent parallel nature of the LBGK equation. These two LBM models and the DEM were combined, and the validation of the model, PS-MRT lattice Boltzmann model, was performed through several types of simulations.

REFERENCES

[1] D'Humieres, D., 2002. Multiple relaxation time lattice Boltzmann models in three dimensions. Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, **360**(1792), 437-451.

[2] Noble, D. R. and Torczynski, J. R., 1998. A lattice-Boltzmann method for partially saturated computational cells. International Journal of Modern Physics C, **9**(08), 1189-1201.