CILAMCE 2018 CONGRESS
11 – 14 NOVEMBER 2018, PARIS/COMPIÈGNE, FRANCE

PARALLEL LBM-DEM SIMULATION OF FLUID FLOW EROSION USING GPU

Zeyd Benseghier[1], Pablo Cuéllar[2], Li-Hua Luu[1], Stéphane Bonelli[1] and Pierre Philippe[1]

[1] IRSTEA, French Research Institute of Science and Technology for Environment and Agriculture, 3275 route de Cézanne, 13100 Aix-en-Provence, France.
[2] Federal Institute for Materials Research and Testing (BAM), Division 7.2 for Buildings and Structures, Unter den Eichen 78, 12205 Berlin, Germany.

Surface erosion of a cohesive granular soil by a fluid flow is investigated numerically by coupling the Lattice Boltzmann Method (LBM) [1] for the fluid phase and the Discrete Element Method (DEM) [2] for describing the motion of the solid particles. In addition, inter-particles cohesion is insured by a contact model featuring a paraboloidal yield surface [3]. The use of a fully resolved LBM-DEM coupling technique is currently limited due to the computational cost when simulating a large number of particles. This issue can be overcome using the graphics processing unit (GPU) thanks to its massively parallel hardware architecture. Here, we first present a 2D GPU implementation of LBM-DEM coupling for a granular assembly. The GPU implementations are approximatively 30 times faster than a single core CPU version. Then, we apply the parallelization technique to practical erosional cases, namely the jet erosion test (JET) [4] and the shear-driven erosion by a Couette flow. These numerical tests aim to relate micro parameters of a cohesive material (eg. cohesion) to macro parameters (eg. soil erodibility, mechanical strengths). Preliminary results show that micromechanical features indeed provide a novel insight of soil erosion phenomena.

References

[1] Lallemand, P. and Luo, L.-S. *Theory of the lattice boltzmann method: Dispersion, dissipation, isotropy, galilean invariance, and stability*. Phys. Rev. E, 61, 6546-6562, 2000.
[2] Cundall P.A. and Strack O. D. L. *A discrete numerical model for granular assemblies*, Géotechnique 29:1, 47-65, 1979.
[3] Delenne, J.-Y., El Youssoufi, M.S., Cherblanc, F. and Bénet, J.-C. *Mechanical behavior and failure of cohesive granular materials*, Int. J. Numer. Anal. Meth. Geomech., Vol. 28, pp. 1577-1594, 2004.
[4] Hanson, G. and Cook, K. *Apparatus, test procedures, and analytical methods to measure soil erodibility in situ*, Applied engineering in agriculture, 20(4), 455, 2004.