Erosive phenomena at the mesoscale – Perspectives and challenges using coupled LBM-DEM models

Pablo Cuéllar*, Li-Hua Luu†, Zeyd Benseghier†, Florian Brunier-Coulin†, Pierre Philippe†, Stéphane Bonelli† and Jean-Yves Delenne‡

* Federal Institute for Materials Research and Testing (BAM)
Division 7.2 for Buildings and Structures
Unter den Eichen 78, 12205 Berlin, Germany
e-mail: pablo.cuellar@bam.de, web page: http://www.bam.de/

† IRSTEA, French Research Institute of Science and Technology for Environment and Agriculture
3275 route de Cézanne, 13100 Aix-en-Provence, France

‡ INRA/CIRAD/Montpellier Supagro/UM2
2 place Pierre Viala, 34060 Montpellier, France

ABSTRACT

The physical phenomena related to the erosion of granular materials by a fluid flow are ubiquitous and often present major challenges and threats to a wide range of civil engineering constructions and infrastructures. Catastrophic earth-dam failures and large sinkholes are just some of the possible outcomes of the different forms of erosion (a.o. surface erosion, suffusion, piping, backwards erosion, etc…) [1]. However, little is known about the actual mechanical origins of erosion, while the assessment of erodibility is generally performed by means of experimental tests and empirical correlations (see e.g. [2]).

Here we provide a general overview of some current research models aiming to clarify the micromechanical phenomena and their macromechanical consequences taking place in different erosion scenarios [3, 4]. The employed numerical techniques rely on the coupling of two well-stablished particle methods for the fluid and solid phases, namely the Lattice Boltzmann Method (LBM) and the Discrete Element Method (DEM) respectively. Further ingredients of our numerical models include an elastoplastic cohesion model for intergranular solid bridges [5] and a subcritical debonding model for the simulation of transient damage processes within the soil matrix [6].

REFERENCES

[1] R. Fell and J.-J. Fry, *Internal Erosion of Dams and Their Foundations*. Taylor & Francis, London (2007)

[2] N. Benahmed and S. Bonelli, "Investigating concentrated leak erosion behaviour of cohesive soils by performing Hole Erosion Test". *European Journal of Environmental and Civil Engineering*, **16**(1), pp. 43-58.

[3] P. Cuéllar, L.-H. Luu, P. Philippe, F. Brunier-Coulin, N. Benahmed and S. Bonelli, "Micromechanical features of jet erosion - A numerical perspective". Proc. 8th Int. Conf. on Scour and Erosion, ICSE2016, Mathematical Institute, Oxford, UK (2016)

[4] L.-H. Luu, P. Philippe, G. Noury, J. Perrin and O. Brivois, "Erosion of cohesive soil layers above underground conduits". Proc. 8th Int. Conf. on Micromechanics of Granular Media, Powders & Grains 2017 (2017)

[5] P. Cuéllar, P. Philippe, S. Bonelli, N. Benahmed, F. Brunier-Coulin, J. Ngoma, J.-Y. Delenne, F. Radjai, "Micromechanical analysis of the surface erosion of a cohesive soil by means of a coupled LBM-DEM model". Proc. 4th Int. Conf. on Particle-based Methods, PARTICLES 2015 (2015)

[6] P. Cuéllar, Z. Benseghier, L.-H. Luu, S. Bonelli, J.-Y. Delenne, F. Radjai, and P. Philippe, "Numerical insight into the micromechanics of jet erosion of a cohesive granular material" Proc. 8th Int. Conf. on Micromechanics of Granular Media, Powders & Grains 2017 (2017)