Two-dimensional DEM-LBM modelling of surface erosion and scouring by a submerged jet impinging a granular soil with cohesion

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ABSTRACT

Impinging jets are widely used in engineering processes, particularly in the geotechnical field, where the Jet Erosion Test (JET) can be regarded as the most commonly used device to quantify the resistance against erosion of cohesive soils [1], and ultimately to prevent erosional failures of earthen hydraulic structures (e.g. earth-dams, levees and dikes). Several interpretation models have been proposed in order to estimate the erodibility of soils (i.e. the erosion rate coefficient and the critical fluid shear stress) based on a linear erosion law dependent on the excess of shear-stress. However, these models are still relying on over-simplified assumptions of questionable validity and purely empirical correlations.

With this background, we have adapted a previous micro-scale numerical simulation approach, which combines the Lattice Boltzmann Method (LBM) for the fluid flow and the Discrete Element Method (DEM) for the granular materials [2], to investigate the micromechanical origins of erosion. This model has been enriched with an intergranular cohesion model [3] and a damage evolution scheme [4]. The numerical tool is robustly accelerated using a GPU-based approach.

In the present study, we provide an insight into cohesive particle erosion focusing on impinging jets in the laminar regime. The scope is put first on the erosion threshold, which is shown to be well described by an extension of the classical Shields criterion used for cohesion-less materials to weakly cohesive soils. Then, the subsequent scouring process is investigated using image processing techniques. Furthermore, a 2D analysis of the evolution of the scour depth (erosion rate) versus the fluid shear stress at the upper bed surface is provided, following the same mathematical model given in [5] for the Jet Erosion Test (JET), which allows implicitly to derive at the macro scale the erodibility parameters of soils (i.e. erosion coefficient and critical shear stress) for different micro cohesion strengths.

REFERENCES


