Micromechanical analysis of the surface erosion of a cohesive soil by means of a coupled LBM-DEM model

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ABSTRACT

The geomechanical assessment of the surface erodibility of cohesive soils is usually performed empirically, often by means of standardized experimental devices (e.g. Jet Erosion Tests [1] or Hole Erosion Tests [2]). The erodibility is then commonly quantified in terms of the average hydrodynamic stress at the soil surface in relation to a certain threshold, the critical shear stress, for the initiation of erosion. However, the derivation of reliable empirical formulae for the prediction of both the critical stress and erosion rate has often been hindered by the large number of soil properties that are relevant for the cohesive forces between grains and their complex relationships [3].

From the theoretical side, most of the numerical approaches that have been employed so far on this subject depart from a macromechanical perspective considering both water and soil as continuous media and employing different techniques in order to track the transient evolution of their interface [4]. However, such numerical models often present difficulties for the precise definition of the hydro-mechanical variables at the interface and may be afflicted with remeshing issues [4].

The work presented here aims to analyse numerically the erosion of a cohesive soil from a micromechanical perspective, focusing on the discrete interaction of single solid particles with the eroding fluid. This permits not only the detailed investigation of the stress thresholds and rates of detachment of particle aggregates at the soil surface but also the analysis of the different factors driving the elemental mechanisms of erosion.

The approach proposed here combines the computational efficiency of the Lattice Boltzmann Method (LBM) for the fluid analysis with the relative simplicity of the Discrete Element Method (DEM) for the consideration of the solid particles (see e.g. [5]). Different relationships for modelling the inter-particle cohesion shall be considered and discussed on their application to surface erosion tests with cohesive soils.

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