Micromechanics of normal hydroerosion processes

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ABSTRACT

A number of hydro-mechanical erosion processes of particular interest in geonvironmental engineering and petroleum engineering refer to situations in which a porous domain is eroded in the vicinity of a free-flow region, under the action of the outward seepage flow across the relevant interface. Such processes, which we refer to as normal hydroerosion processes, are being studied for example in relation to the backward erosion mechanism responsible for the upstream-oriented propagation of piping erosion in embankment dams and dykes [1,2]. Sand production in petroleum engineering is a further such phenomenon, which significantly affects the productivity of oil wells and can result into damage to equipment, plugging of wells, etc. [3,4]. In a recent work we proposed a preliminary discrete numerical model of the aforementioned backward erosion mechanism [2]. The two-dimensional model was based on the coupling of DEM with the Lattice Boltzmann Method (LBM), for the description of the granular- and the fluid phase, respectively. On this background, we recently developed more advanced two-dimensional numerical models of a variety of normal hydroerosion configurations, in reference to both, the backward erosion and sand production phenomena. We present herein a micromechanical analysis of the results provided by these models: we focus on the validation of previously conjectured resistance and degradation mechanisms (e.g. force chain arching, crack coalescence) and seek for the main non-dimensional parameters controlling the erosion kinetics. The general architecture of the in-house DEM-LBM code is also discussed, along with the technical solutions enabling an effective implementation of the hydro-mechanical coupling and a convenient description of the boundary conditions.

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