Preliminary analysis of hydro-mechanical coupling B-spline material point method for ionic rare earth in-situ leaching landslide

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Abstract

The ionic rare earth is one of the most important strategic resources, and its mining technology has experienced three stages: pool leaching, heap leaching, and in-situ leaching. Due to advantages of the high resource recovery rate and low production cost, the in-situ leaching has become the most popular mining technology of the ionic rare earth in the world. However, the mining benefit and safety are seriously restricted by the in-situ leaching landslide where the hydro-mechanical coupling plays a crucial role. In order to identify the failure and post-failure mechanism, accurate predictions of the pore water pressure and stress state of soil slope are necessary. Generally, it is difficult to model the behavior that involves large deformations for classical mesh based methods such as the finite element method (FEM) due to severe mesh distortion.

Combining the Eulerian description and Lagrangian description, the material point method (MPM), one of particle based methods, possesses many attractive features for solving large-deformation problems in geotechnical engineering. As a matter of fact, the original material point method suffers from the grid crossing error. The B-spline material point method (BSMPM) has been proposed to improve the accuracy of the MPM. In this paper, a two-phase B-spline material point method (tpBSMPM) is developed. Two sets of Lagrangian material particles are employed to discretize the soil skeleton and the pore water of the saturated rare earth, respectively. Based on Darcy's Law and Biot's theory, the governing equation of tpBSMPM is established where the solid skeleton and pore water are both described by the Lagrangian description with internal interactions and individual state of motion. The accuracy of the proposed method is tested by comparing the simulation results of the temporal evolution of the spatial distribution of hydraulic pressure for the one-dimensional oedometer test with the analytical results. The large deformation process of the in-situ leaching landslide would be further studied using the tpBSMPM.

Keywords: Material Point Method; B-spline function; Hydro-Mechanical model; ionic rare earth; in-situ leaching landslide