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Ice-modeling in saturated phase-transiting porous media

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ABSTRACT

A pure ice constitutive model embedded in saturated porous media is presented to simulate the freezing mechanism for frozen soil. Conventionally, various empirical constitutive models have been adopted to simulate the complicated mechanical behavior of freezing-thawing porous media by introducing ad hoc internal variables. Such a variety of constitutive models has shed light on deepening our understanding of frozen soil, but still, capturing complex phase-transition phenomena of frozen soil remains a challenging task. In this study, frozen soil has been considered as a mixture saturated with pore water in which crystallized ice plays a mechanical role with an additional mechanical constitutive model along with a soil constitutive model. In other words, saturated non-frozen soil follows the conventional soil model, while the mechanical behavior of frozen soil is governed by combined responses of both the soil and ice constitutive models. This concept has been tested in a coupled thermo-hydro-mechanical framework, in which the freezing-thawing of pore water is captured based on the phase-field method. The performance of this model has been compared with previous experimental data of frozen soil. Additionally, the applicability of the proposed methodology is also showcased with a practical numerical example.

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