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Unsaturated porous media freezing: numerical modeling and validation based on experimental data

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Ice formation in porous media is a phenomenon characterized by coupled heat and mass transport, which could lead to considerable deformations [1]. Studying such a process is important in many engineering applications. In cold regions where periodic freezing occurs, porous materials like road pavements and concrete are usually subjected to frost damage. Moreover, some techniques such as artificial ground freezing, which are widely used for ground-water control and temporary excavation support, can lead to heave and settlement of the ground surface.

In the underlying work, a numerical modeling framework that takes the multi-physical thermo-hydro-mechanical (THM) processes of ground freezing into account is presented. In this, an unsaturated soil is treated as a non-isothermal, deformable, triphasic porous material with a gas phase and a single fluid that can change depending on the thermal conditions between a solid ice and a liquid water state. The model is based on a coupled phase-field-porous media approach [2], where the main focus is laid on the temperature-driven processes that lead to the phase transition between water and ice and the freezing-related deformations. The governing equations of the macroscopic model are based on the well-founded theory of porous media (TPM) [3] extended by the phase-field modeling (PFM) [4]. The model proceeds from a small-strains assumption, whereas the pore-fluid can be found in liquid water or solid ice state with a unified kinematics treatment of both states [5]. Comparisons with the experimental data will demonstrate the ability and usefulness of the considered model in describing the freezing of unsaturated soils.

References
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Time Block Preference

Time Block A (09:00-12:00 CET)

References

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