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Contribution ID: **216**   Type: **Oral Presentation**

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

Monday, 31 May 2021 15:25 (15 minutes)

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

[1] J. Bluhm, T. Ricken, M. Bloßfeld (2011). Ice Formation in Porous Media. Advances in Extended and Multifield Theories for Continua, pp. 153-174. Springer Berlin Heidelberg (ed.) B. Markert.

[2] A. H. Sweidan, Y. Heider, B. Markert (2020). A unified water/ice kinematics approach933for phase-field thermo-hydro-mechanical modeling of frost action in porous media. Computer Methods in Applied Mechanics and Engineering, 372, 113358.

[3] B. Markert (2011). Coupled Thermo- and Electrodynamics of Multiphasic Continua. Advances in Extended and Multifield Theories for Continua, Springer Berlin Heidelberg, 129-152.

[4] W. J. Boettinger, J. A. Warren, C. Beckermann, A. Karma (2010). Phase-Field Simulation of Solidification. Annual Review of Materials Research 32:163-9.

[5] A. H. Sweidan, K. Niggemann, Y. Heider, M. Ziegler, B. Markert (2021). Experimental study and numerical modeling of the thermo-hydro-mechanical processes in soil freezing with different frost penetration directions. Acta Geotechnica. Under revision.

Time Block Preference

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

References

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Student Poster Award

Primary author: SWEIDAN, Abdel Hassan

Co-authors: Dr HEIDER, Yousef (RWTH Aachen University); Prof. MARKERT, Bernd (RWTH Aachen University)

Presenter: SWEIDAN, Abdel Hassan

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Track Classification: (MS17) Thermal Processes, Thermal Coupling and Thermal Properties of Porous Media: modeling and experiments at different scales