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Al-Khoury, Rafid; Musivand Arzanfudi, Mehdi

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Freezing and thawing in deformable porous media

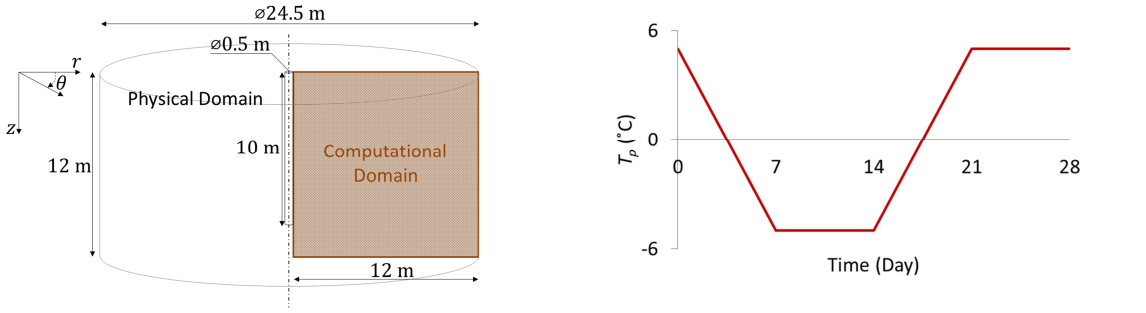
Rafid Al-Khoury* and Mehdi Musivand Arzanfudi†

*, † Faculty of Civil Engineering and Geosciences, Delft University of Technology, P.O. Box 5048, 2600 GA Delft, The Netherlands

e-mail: r.i.n.alkhoury@tudelft.nl, webpage: TU website - alkhoury (www.tudelft.nl)

ABSTRACT

A coupled soil freezing and thawing model capable of simulating all important thermo-hydro-mechanical phenomena occurring in freezing and thawing in a soil mass has been developed [1]. It considers phase change, fluid mass transport, convective-conductive heat transfer, solid phase deformation, porosity and permeability change, melting point depression, unfrozen water content and cryogenic suction. The averaging theory has been utilized for describing the balance equations, and the constitutive relationships include the water equation of state (EOS) and the soil freezing characteristic curve (SFCC). The governing equations are solved using a mixed discretization scheme in which the standard finite element method (FEM) and the extended finite element (XFEM) are coupled. The freezing/thawing model is utilized to simulate the thermo-hydro-mechanical behaviour of an energy pile embedded in a soil mass, Fig. 1a. The energy pile is subjected to extreme boundary conditions with a cyclic freezing and thawing as shown in Fig. 1b. Fig. 2 shows the distribution of temperature, cryosuction, porosity and deformation during freezing. More details of the model computational capabilities can be found in the referenced paper.



(a) (b)

Fig.1 Energy pile: (a) geometry, (b) boundary condition – freezing/thawing cycle.

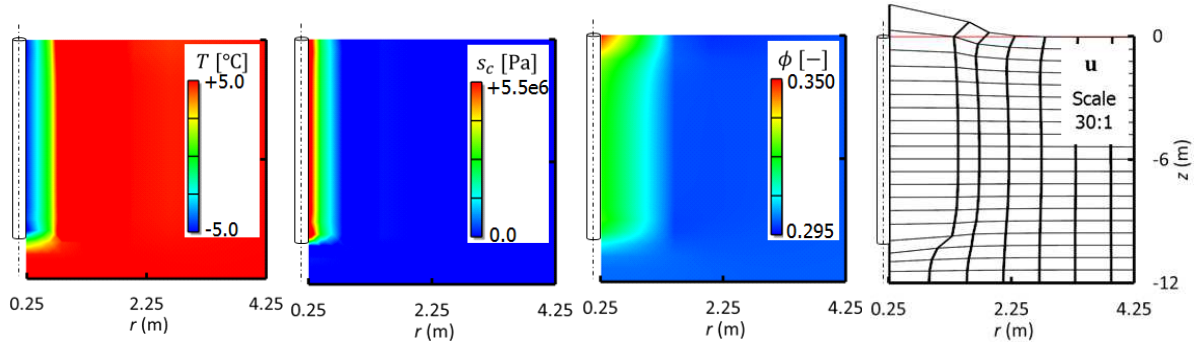


Fig.2 Temperature, cryosuction, porosity and deformation during freezing.

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