Frost susceptible soils are vulnerable to frost action in seasonal freezing as well as permafrost regions: they may experience large deformations upon temperature changes. Frost heave and strengthening occurs as the soils freeze, whereas settlement and thaw weakening is expected during the melting process. As a result, significant damage to infrastructure in cold regions can be caused by freezing-thawing cycles. Therefore, accounting for soil behavior during freezing and thawing is essential for engineering design and minimizing frost-related damage.

An elastic-plastic constitutive model with a modified porosity rate function is developed. The constitutive relationship is temperature-dependent, capable of capturing the deformation behavior and strength evolution of the soil subjected to arbitrary loading as well as freezing and thawing temperature. The yielding of the frozen soil is described using the critical state concept, with the pore ice content being an important parameter affecting the yield function. The porosity rate function is used to simulate the ice lenses formation, leading to frost heaving.

The model has been implemented in a finite element system, with a thermal-hydro-mechanical framework being used to capture the multi-physics processes of soil freezing and thawing. The model was calibrated using available laboratory test data, and it can be used as a tool to solve complex boundary value problems related to engineering practice. Example simulations will be presented.