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# An elastoplastic model for saturated freezing soils based on thermo-poromechanics

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## Abstract:

An elastoplastic theory for saturated freezing soils is presented on the basis of thermoporomechanics. A saturated freezing soil considered as an open system and both Eulerian and Lagrangian formulations considering the phase transition between ice crystals and unfrozen water are given for mass conservation, momentum balance, kinetic energy theorem, first and second thermodynamics, the Clausius-Duhem inequality and conduction laws for fluid mass and heat. Using the Lagrangian saturation and considering solid-fluid interface interactions, a constitutive model for poro-elastoplastic saturated freezing soils is formulated based on the irreversible process. For isotropic linear thermo-poro-elasticity and ideal plasticity, the stress strain relationship for saturated freezing soils considering the influence of temperature and interface energy is proposed. In addition, for hardening plasticity, the general stress strain relationship is formulated under the conditions that the associated or non-associated flow rule is assumed, and a corresponding constitutive model is presented to model the cryogenic triaxal compression of saturated frozen soils. The constitutive theory proposed here provides a potential basis for modelling thermo-hydro-mechanical coupling interactions of saturated soils during the freezing process.

**Keywords**: Thermoporomechanics; Saturated freezing soils; Constitutive model; Elastoplastic theory;