Bruce Podwal Seminar Series

Mechanics of anisotropic thawing and freezing of frozen soils in changing climate

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Civil Engineering Department, Room 105, Steinman Hall

https://ccny.zoom.us/j/85839128635?pwd=YXQ4TW9VY1RncVF1UjN4R1g0MkhFQT09

Abstract Soils near the ground surface in northern climates experience freeze-thaw action annually. As the temperature fluctuates, ice crystals form and thaw inside the pore space of soils within each thermal cycle. The cryo-suction effect and the expansion of ice may both affect the consolidation process of soils and lead to thawing settlement and frozen heave, which increasingly impact the life cycle of infrastructures due to the changing climates. To understand this mechanism across length scales, we propose a multi-physics model to simulate the growth and thaw of ice lenses and the resultant frozen heave and thaw settlement in frozen clay and validate the simulation results with experiments. The growth of segregated ice inside the freezing-induced fracture is implicitly represented by the evolution of the two-phase fields that indicate the locations of segregated ice and the damaged zone, respectively. Unlike phenomenological material models that indirectly capture the freezing influence on the shear strength, the multiphase-field model introduces an immersed approach where both the homogeneous freezing and the ice-lens growth are explicitly captured. By leveraging the rich experimental data from the micro-CT images during the freezing process, we compare simulation results obtained from models with and without the evolving anisotropy mechanism. Our findings indicate that capturing the anisotropy triggered by the cryo-suction and the growth of the ice lens is crucial for accurately estimating the settlement and heave of soil at the macroscopic scale.

Biography: Dr. Sun is an associate professor Civil Engineering & Engineering Mechanics at Columbia University. He obtained his B.S. from UC Davis (2005); M.S. in civil engineering (geomechanics) from Stanford (2007); M.A. (Civil Engineering) from Princeton (2008); and Ph.D. in theoretical and applied mechanics from Northwestern (2011). From 2011 to 2013, he worked as a senior member of the technical staff in the mechanics of materials department at Sandia National Laboratories in Livermore, California. Dr. Sun's research focuses on theoretical, computational, and data-driven mechanics for geological materials and composites. He received the IACM John Argyris Award (2020) and the ASCE Walter Huber Civil Engineering Research Prize (2023) and ASCE EMI Leonardo da Vinci Award (2018).