Contribution ID: **225** Type: **Oral Presentation**

Role of Substrate Roughness in Soil Desiccation Cracking

Monday, 13 May 2024 13:40 (15 minutes)

Soil desiccation crack is ubiquitous in nature, yet the physics of its initiation and propagation remain under debate, as it involves complex interactions across multiple fields of mechanics, hydraulics, and thermals. Here, an experimental attempt is made to uncover the role of substrate roughness on the soil desiccation process. The substrate roughness is deliberately fabricated by 3D printing, whereas the thickness of sample and environmental humidity are controlled to eliminate the effect of large hydraulic gradient. Four types of soils with varying expansibilities were desiccated on substrates with varying roughness. It reveals that: (1) soil desiccation crack evolution can be conceived as a competing process between the shear failure of soil-substrate interface, i.e., slippage of interface, and the tensile failure of soil, i.e., crack initiation, in minimizing the total energy of drying soil; (2) substrate roughness alters the failure mode and shear strength of soil-substrate interface and its sensitivity to moisture, thereby it regulates the pattern of how soil crack propagates upon drying; (3) soil expansibility is recognized as a key factor governing the crack-initiation point in addition to the widely recognized air-entry, and flaws in soil are the sources for the 120° crack angle and bimodal crack angle distribution.

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Session Classification: MS04

Track Classification: (MS04) Swelling and shrinking porous media