Desiccation Crack Formation Analysis by Weak Coupling of Diffusion and Failure

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ABSTRACT

Particular patterns of cracks can be often observed on the surface of dry-out soil (e.g., deserts, mudflats, paddy rice fields). When the soils dry up, the surface is divided into polygonal cells by the cracks and the size and the shape of the cells are not completely random. Instead, particular size and shape can be observed. This pattern formation implies the multi physics behind it.

In laboratory observations, the crack pattern changes depending on its boundary constraints, the specimen size, and the evaporation speed. However, the relationships between the pattern formation by the cracks and these conditions are not clear. The authors consider that the desiccation crack phenomenon is a coupled problem of water movement and fracture. Specifically, most of the permeable soils change its volume depending on its water content. When the water evaporates from the surface of the soil, inhomogeneous water distribution and/or boundary constraints causes non-uniform shrinkage. This inhomogeneous volume change could result in excessive stress which could generate cracks in soils. Cracks can be regarded as newly created evaporative surface and at the same time, permeability is completely lost across the crack. Thus, water diffusion and fracture are highly coupled.

Weakly coupled numerical simulation of water diffusion and fracture has been performed on three-dimensional soil specimen. The characteristic pattern (i.e., polygonal cells formed by cracks) was observed on the top surface and the crack pattern changed depending on each conditions. The tendency of this change is consistent with experimental results. The numerical simulation of 3D model can visualize the crack pattern and the water or stress distribution in depth direction.

Through the simulation, the authors observe the (i) crack formation process, (ii) interaction between water diffusion and fracture of the soil and (iii) effect of each condition on crack patterns.

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