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Impact of Sand-Hydrogel Mixtures Swelling on Shearing Behaviour: An X-ray CT Study

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Hydrogels also known as superabsorbent polymers (SAPs) are crosslinked hydrophilic polymers characterized by a three-dimensional polymer network structure. These polymers are capable of absorbing water to thousands of times their own weight. Hydrogels can either be synthetic (polyacrylic acid) or natural such as biopolymers (xanthan gum). The use of hydrogels has been found to have increased utilization in diverse fields such as agriculture, environmental science, petroleum, and civil engineering. The key attractions in the use of hydrogels in these fields include the ability to absorb substantial amounts of water, selectively attracting and binding to pollutants and facilitating particle aggregation. Most previous studies have consistently demonstrated that during wetting swelling of hydrogel leads to restructuring of the soil particles and these studies claim that results of wetting affect the soil stiffness, increases erodibility, and reduces shear strength. However, we lack a more comprehensive understanding of the complex micromechanical processes that govern the behaviour of hydrogel-treated soils during wetting. This knowledge gap hinders our understanding of the interaction of hydrogels with soil and the effective use of hydrogels in soil remediation and geotechnical engineering applications. This study aims to unravel the swelling process of hydrogel in soil, how it leads to restructuring of soil particles and the resulting impact on the mechanical behaviour of hydrogel-treated soils. We employ a miniature triaxial cell connected to a humidifier and a peristaltic pump to supply humid air during saturation of the sand-hydrogel mixture. We utilize an X-ray Computed Tomography (CT) scanner to unveil the four-dimensional (3D + time) perspective of swelling-induced disturbance and its impact on the shearing behaviour. Preliminary results show that hydrogel swelling dramatically reduce sand-to-sand contacts, resulting in a much smaller peak strength. We further adopt image processing algorithms to denoise, segment phases (sand, hydrogel, and air), and label sand and hydrogel particles for performing quantitative analysis such as displacement and strain fields.

KEY WORDS: Hydrogels; Swelling; Shearing behaviour; Soil restructuring; X-ray tomography.

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