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Suffusion-induced evolution of cyclic behaviors of subgrade using CFD-DEM

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ABSTRACT

In the face of extremely heavy rainfall, subgrade soils are vulnerable to particle loss through intense seepage flows, resulting in a deterioration in mechanical properties of soils. These changes pose considerable threats to the operational integrity of railway systems and the safety of life and property. This study addresses the above challenges through a computational fluid dynamics and discrete element coupling method (CFD-DEM), and developes a microscopic model for the evolution of suffusion catastrophes in sandy soils. By analyzing the stress-strain behaviors of specimens, as well as the evolution of their microstructural and porosity frameworks, this study elucidates the process and underlying multiscale mechanisms of sandy soil seepage erosion under varied initial stress conditions and stress histroies. In addition, a modified suffusion criterion is presented. Furtheremore, the cyclic shear responses of eroded soils subjected to different magnitudes and frequencies of external stresses are investigated. The micro-mechanisms of suffusion-induced cyclic shear behaviors changes of subgrade soils are analysed through the microstructural evolution within the soil. This study provides a novel approach to the investigations of suffusion-induced particle loss and the resultant failure of geotechnical engineering structures under variable conditions, offering substantial guidance for the macroscopic and microscopic, as well as multiscale analysis of catastrophic failure processes within geotechnical engineering frameworks.

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