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Flow regime comparison of a single clean smooth parallel fracture with and without overlying material in variably saturated conditions

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In saturated conditions, flow through the subsurface is dominated by movement through pores in soil material and movement through fractures in bedrock. However, the dominant flow regime in the intermediate fractured vadose zone cannot be as easily inferred. An important aspect to this puzzle is the overlying soil material on the fractured bedrock, which hydraulically connects the two media [1]. To aid in deciphering this puzzle, two physical models are constructed. The first model involves a smooth clean parallel vertical fracture with no overlying material, while the second model uses an identical fracture with overlying sand material.

Results for the fracture with no overlying material show that the fracture never reaches full saturation and that flow regimes observed, such as rivulets and droplets within the fracture, agree with variable saturated fracture flow findings by Su et al. [2]. With the addition of overlying material, similar flow regimes occurred through the fracture. However, the overlying material influenced the breaching into the fracture by providing preferential feeding channels to the interface, which resulted in multiple point breaches along the fracture. The localised point breaches promoted preferential flow within the fracture and ensured the fracture remained in a largely unsaturated state.

This physical modelling approach provides a unique opportunity to qualitatively observe flow occurring through unsaturated fractures and assist in improving the current conceptual models of fluid flow in the intermediate fractured vadose zone. The findings presented within hope to inspire and encourage future research in understanding the fundamental principles governing flow through the intermediate fractured vadose zone. As a firmer grasp of the underlying principles and influences will be invaluable in interpreting many areas of application, including slope stability, contaminant transport, waste disposal, groundwater recharge and excavations.

References:

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