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A novel soil erosion apparatus for high-velocity surface erosion and fissure-containing soil-structure interfaces

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Soil erosion is a natural geomorphological process, consisting of soil particle transport in the presence of water runoff. Despite its inherency, intensive human activity as well as acute climate change has led to an acceleration of soil erosion, and this becomes a major threat to environment and sustainability. In recent years, a rapid increase of rainfall frequency at the global scale enhances the production of surface runoff, thus yielding an active surface flow with higher velocity. Wetting-dry cycle induced by climate shifts also contributes to a vast distribution of fissure-containing surfaces, especially on soil-structure interfaces. Erosion triggered in this position can be detrimental, as the structure may lose its resilience against flood and earthquake, or even fails to maintain its gravitational stability. We herein introduce a novel laboratory-scale apparatus designed to investigate the surface erosion under high flow velocity, as well as the erosion of soil-structure interfaces featuring fissures. Our apparatus comprises three modules: a water circulation system, a testing chamber, and a set of data acquisition module. The testing chamber accommodates specimens measuring up to 24×80×80 mm with adjustable fissure widths. Monitoring module of particle removal and transport is emphasized in our study. With the reliable performance regarding repeatability tests using clayey soil, we found that the size of fissure significantly impacts the soil loss process, while its effect on the overall degree of erosion is minor. At different flow velocity intervals, similar successive steps, which involve alteration of single particle detachment and particle aggregate removal were witnessed at the soil surface. This was further validated by images captured by high speed camera and particle removal collection results. We believe that despite the simple framework of test apparatus, it is of great potential to further explore the surface erosion mechanism and the fissure development between soil-structure interfaces.