SPH modeling and experimental verification of entire process of landslides triggered by earthquakes based on a unified constitutive model

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Abstract

The dynamic process of landslide triggered by earthquakes can be divided into three stages: initiation, high-speed movement of geo-materials and final deposition. To better understand the dynamic evolution rule of landslide, the paper constructs a smoothed particle hydrodynamics (SPH) model of landslide based on a unified constitutive relationship and then verify it using the shaking table tests. The feasibility analysis is carried out from two aspects: the governing equations in SPH and the unified constitutive model. The unified constitutive model simulates the different status of materials, and is composed of an elastic–plastic model and a viscous constitutive model. Seismic wave is applied to the bottom boundary particles through the format of velocity and the bottom boundary is set as no-slip boundary. Meanwhile, free field boundary is chosen to reduce the reflection of seismic wave. Then Tangjiashan landslide triggered by earthquake is simulated and analyzed by the model. The results shows that a continuous slip surface formed at about 15 s. The sliding body gains speed as it enters the fluid state. About 50 s later, the mass gradually stops moving reaches a steady state and returns to a solid phase. To further verify the SPH model, a series of shaking table tests are used to produce the entire process of landslides. Particle image velocimetry (PIV) is adopted to capture the velocity of any point at any time with accuracy within the observation region. Furthermore, one can get more information about the dynamic response and motion feature during the entire failure process of slope under earthquakes. More data of velocity and displacement are measured and compared with SPH numerical results.

Keywords: Entire process analysis, Smoothed particle hydrodynamics, Unified constitutive model, shaking table tests, Particle image velocimetry