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Hydro-mechanical mechanism and thresholds of rainfall-induced unsaturated landslides

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The devastating Ms 8 Wenchuan earthquake in 2008 created the greatest number of co-seismic mountain hazards ever recorded in China. However, the dynamics of rainfall induced mass remobilization and transport deposits after giant earthquake are not fully understood. Moreover, rainfall intensity and duration (I-D) methods are the predominant early warning indicators of rainfall-induced landslides in post-earthquake region, which are a convenient and straight-forward way to predict the hazards. However, the rainfall-based criteria and thresholds are generally empirical and based on statistical analysis,consequently, they ignore the failure mechanisms of the landslides.

This study examines the mechanism and hydro-mechanical behavior and thresholds of these unsaturated deposits under the influence of rainfall. To accomplish this, in situ experiments were performed in an instrumented landslide deposit, The field experimental tests were conducted on a natural co-seismic fractured slope to 1) simulate rainfall-induced shallow failures in the depression channels of a debris flow catchment in an earthquake-affected region, 2)explore the mechanisms and transient processes associated with hydro-mechanical parameter variations in response to the infiltration of rainfall, and 3) identify the hydrologic parameter thresholds and critical criteria of gravitational erosion in areas prone to mass remobilization as a source of debris flows. These experiments provided instrumental evidence and directly proved that post-earthquake rainfall-induced mass remobilization occurred under unsaturated conditions in response to transient rainfall infiltration, and revealed the presence of transient processes and the dominance of preferential flow paths during rainfall infiltration. A hydro-mechanical method was adopted for the transient hydrologic process modelling and unsaturated slope stability analysis. and the slope failures during the experimental test were reproduced by the model, indicating that the decrease in matrix suction and increase in moisture content in response to rainfall infiltration contributed greatly to post-earthquake shallow mass movement. Thus, a threshold model for the initiation of mass remobilization is proposed based on correlations between slope stability and volumetric water content and matrix suction As a complement to rainfall-based early warning strategies, the water content and suction threshold models based on the water infiltration induced slope failure mechanism. the proposed method are expected to improve the accuracy of prediction and early warnings of post-earthquake mountain hazards