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Proposal for a model to assess the effect of seismic activity on the triggering of debris flows

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Landslide triggered by earthquakes is a serious threat for many communities around the world, and in some cases is known to have caused 25-50% of the earthquake fatalities. Seismic shaking can contribute to the triggering of debris flows either during the seismic event or indirectly by increasing the susceptibility of the slope to debris flow during intense rainfall in a period after the seismic event. The paper proposes a model to quantify both these effects. The model is based on an infinite slope formulation where precipitation and earthquakes influence the slope stability as follows: (1) During the shaking, the factor of safety is reduced due to cyclic pore pressure build-up where the cyclic pore pressure is modelled as a function of earthquake duration and intensity (measured as number of equivalent shear stress cycles and cyclic shear stress magnitude) and in-situ soil conditions (measured as average normalised shear stress). The model is calibrated using cyclic triaxial and direct simple shear (DSS) test data on clay and sand. (2) After the shaking, the factor of safety is modified using a combined empirical and analytical model that links observed earthquake induced changes in rainfall thresholds for triggering of debris flow to an equivalent reduction in soil shear strength. The empirical part uses data from past earthquakes to propose a conceptual model linking a site-specific reduction factor for rainfall intensity threshold (needed to trigger debris flows) to earthquake magnitude, distance from the epicentre and time period after the earthquake. The analytical part is a hydrological model for transient rainfall infiltration into an infinite slope in order to translate the change in rainfall intensity threshold into an equivalent reduction in soil shear strength. This is generalised into a functional form giving a site-specific shear strength reduction factor as function of earthquake history and soil conditions. The model is suitable for hazard and risk assessment at local and regional scale for earthquake and rainfall induced landslide.

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