Numerical simulation of the Jiufengershan landslide, triggered by the Chi-Chi earthquake, Taiwan, 1999

Kuo-Jen Chang
Institute of Earth Sciences, Academia Sinica

Abstract

The Jiufengershan rock-and-soil avalanche was triggered by the 1999 Chi-Chi Taiwan earthquake, mobilizing a 60 m thick and 1.5 km long sedimentary layer dipping ~22˚SE toward a transverse valley. The initiation and propagation of the avalanche were simulated using a novel approach based on a discrete element method (contact dynamics), which integrates the following parameters and processes: a) the structure and rheology of rock layers; b) the pore pressure in the granular media; c) the drop in shear strength resulting from frictional heating at the rupture surface; c) seismic shaking; d) the geometry and friction coefficient at the original ground surface (OGS).

Three rheologies were tested in the granular model: a) intact rock, b) weathered rock, and c) partially weathered rock. The Mohr-Coulomb behaviour was calibrated using biaxial numerical tests on cohesive granular samples. Five topographic profiles across the debris deposit were compared to results from simulations. The best fit between observed profiles, field data and simulations was obtained using the partially weathered rock rheology, a water table height above the rupture surface hw=30 m, and a friction coefficient at the OGS of μGS=0.2. The destabilization of the slope during the earthquake is enhanced by raising the water table or decreasing rock strength. Avalanche triggering is associated with a pop-up structure observed at the foothill. As the avalanche propagates, the pop-up is progressively deformed into an overturned fold, which overrides the OGS along a décollement level. The displaced mass forms a wedge that is pushed forward as deformed rocks are accreted at its rear, and showing a buckling induced slope failure situated closed middle of the slope.