Distinct element modeling with granular material: case studies in Tsaoling landslide and fault-related folding induced by Chi-Chi earthquake

Jyr-Ching Hu, Chao-Lung Tang, Yi-Rong Yang

Department of Geosciences, National Taiwan University

Abstract

Using 2D distinct-element modeling (PFC^{2d} code), we try to simulate kinematic process of Tsaoling landslide. Our numerical model is composed of discs in 2D that were bonded together by parallel bonds to create an initial solid numerical rock mass. The initial boundary conditions are applied along the ball-wall contacts by using velocity integrated from the strong motion data with the duration of 160 seconds including the peak acceleration near Tsaoling area. We reduced the frictional coefficient after the peak acceleration occurred in order to simulate the effect of self-lubrication. Self-lubrication mechanism is suggested in our study to explain the low residual friction of about 0.15 which could result in a 125 million square meter of sliding block crossing over and smashed by striking the Chingshui River valley. The maximum velocity of sliding block can reach to about 50 m/sec. A quasi-rigid body sliding may explain the 7 people who survived after a sliding of 2,250 m. Furthermore we characterize the three different strengths of the parallel bonds during sliding. A model with weak bonding strength inside sliding block would break the sliding block and flow the particle during sliding. In this case, all of the upper layer particles would be flowed and be rolled, and no body could survive. In addition, the model with strong bonding strength, the majority of sliding material could not be disintegrated after striking the Chingshui River valley. As a consequence, the front part of sliding material could not reach to Daogiaoshan.

The fault-propagation folds are generally associated with blind faults and they have recently been recognized as extremely important for their seismic hazard potential. The Chi-Chi earthquake produced many monoclinal scarps by fault-propagation folding which caused great damage. The trishear kinematic model of fault-propagation folding appears to approximately represent the geometric development of some structures like monoclines, comparatively little is known of the mechanical controls on their development. Thus we construct a series of distinct-element models that consist of bounded assemblies of elastic particles that simulate the brittle deformation associated with fault-related folding over a rigid footwall. Here we attempt to predict the broad-scale features and basic characteristics of distributed deformation developed above blind contractional faults at depth. The initial rock mass is modeled by a series of discrete, non-uniform-sized circular, elastic, frictional particles, connected with each other by parallel bonds and capable of progressive fracturing during loading. The models reproduce the deformation patterns

with an evolutionary slip of rigid the basement fault in different strength of parallel bond representing the cementation of granular particles. We conclude that weak cover strength promotes cover flowage, wide zone of deformation and limited fault propagation while strong cover reproduce a narrow zone of deformation and faster fault propagation in the same fault slip rate. The cracks develop at the fault tip area and free surface in the initial stage for the models with strong cover, and then the growth of cracks tend to link these two parts to produce a fracture zone propagating to surface. In addition, in this study, we use the geological profile of the Chushan trench as a case study to investigate the coseismic deformation due to the fault propagation by a series of 2-D discrete element modeling.

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