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Morphologic analysis and numerical simulation of the earthquake-induced Jiufengershan debris avalanche, central Taiwan

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Landslides pose significant threats to communities and infrastructure in Taiwan. Among possible triggering factors, heavy precipitation and earthquakes are the most important. The 21st September 1999 Chi–Chi earthquake, ML=7.3 with depth of eight kilometers, was associated with the reactivation of the Chelungpu thrust fault. The earthquake caused massive landslides; the Jiufengershan is one of most important event. The Jiufengershan landslide area which located at the western limb of the Taanshan syncline is a typical dip-slope failure. The main rock formation consists of inter-bed sandstone and shale. About 43 million m3 rock mass moved downward slope to the Sezikeng river valley and formed three dam lakes, the landslide resulted in 39 deaths, and it is a serious threat that will damage public's life and property. This study is divided into two phases: The first phase is to use the aerial photographs before and after the Chichi earthquake to construct the different periods of the Digital Terrain Model (DTM), the 2m resolution LiDAR images taken in 2002 are integrated with this study. The precision and the accuracy of the aerial triangulation parameter were estimated according to the post landslide LiDAR DSM. In the meanwhile, the quality of the aerial photo derived DSM is analyzed accordingly. In order to calculate the landslide cut-and-fill volume, to simulate the landslide dynamic process, the DSM before earthquake is adjusted according to the LiDAR-DSM. Thus the calculated the slid volume and the deposit volume is about 39 and 47 million cubic meter, respectively. The second phase is to simulate the landslide behavior of the Jiufengershan by using the 3D Particle Flow Code (PFC3D) in order to acquire the parameters which play an important role. In this research, we tested and analyzed different parameters, such as: wall stiffness, particle parameters, pore water pressure, wall friction coefficient, and particle elements bonded parameters. Through using the built model, it can simulate the whole dynamic process of Jiufengershan landslide event and exhibit the steady-state accumulation patterns and its range.