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Catastrophic Hsiaolin landslide in southern Taiwan triggered by Morakot Typhoon: Insights from 3-D discrete element simulation

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The Typhoon Morakot on August 8th 2009 bought a heavy rainfall in southern Taiwan and caused a catastrophic rock debris avalanche which buried Hsiaolin Village of Kaohsiung County in southern Taiwan and caused a mortality of more than 400 people. The landslide initiated at Shamdushan from a slope of about 500 m to 900 m above the riverbed and huge amount of slide materials moved quickly downward and became a rock debris avalanche. The major sliding surface was estimated to be 80 m in depth and a part of rock debris destroyed the highland of 590 m and spread on the hillslope along the two gullies separated by 590 m Highland. In this study, we used 3D discrete element method with granular particle assemblage (PFC3D) to simulate kinematic process and mechanics of this catastrophic landslide. Our numerical model was compose of about 27,000 spherical elastic particles with radius of 4~5 meter that were bonded together to create an pre-slid rock mass on the triangular facets based on the topography from 5 m Digital Elevation Model. The landslide volume was estimated to be 200 million cubic meter. According to the 3-D numerical simulation, Hsiaolin village might be buried in 60 seconds after the triggering of landslide in Shamdushan. Most debris kept downward movement along the sothern gully and reached the Chishan River, and blocked the main stream forming a dammed lake. The predicted maximum velocity is about 80 m/sec and the average sliding velocity is 70 m/sec. The predicted maximum runout is 1983 m and the average runout is 1520 m. In addition, the rock debris could reach to the other side of the Chishan River and consequently a dammed lake was formed. From the viewpoint of the assessment of catastrophic landslides, the investigation of the impact area induced by gigantic landslide event is a crucial topic, thus several numerical scenarios were done to elucidate the mechanics and kinematics of landslide process.