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Shiaolin landslide induced by the 2009 Typhoon Morakot, Taiwan

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Typhoon Morakot induced Shiaolin landslide, which killed 439 people in the south of Taiwan on 9 August 2009 (National Disasters Prevention and Protection Commission, 2009). To understand the causes of this event and its movement, we conducted field surveys, laboratory tests and inspections of hydrological and seismological data on the study.
The cumulative rainfall reached to 1676.5 mm in about 3 days, when Shiaolin landslide occurred. That was about one day after the peak of rainfall intensity. The landslide occurred on a dip slope, which is underlain by late Miocene to early Pliocene sedimentary rocks consisting of silt shale, massive mudstone, and sandstone. These beds, which trend NW-SE and dip at 20-25 degree to SW, are located on the east limb of a syncline trending NNE-SSW and plunging to SSW.
The landslide was 3 km long, 0.8 to 1.5 km wide, with an apparent friction angle of 14 degree It started as a slide upslope and transformed into debris avalanche downslope. The runout distance is about four times the total fall height. The source area was the upper third of the landslide and is divided into major southern part and the minor northern part, which are separated by E-W trending joints aligned en echelon.
Interpretation of topography before the landslide suggests that the source area showed hummocky surface, which is indicative of gravitational slope deformation before the event. In addition, calcite was extensively precipitated on the river bed coming out from the source area. This suggests that calcite, which is contained in the rocks, was dissolved by the groundwater in the source area so that the rocks had been deteriorated before the landslide, providing the basic causes for the gravitational deformation and landslide.
The debris avalanche was a large bulk of mostly rock debris deriving from the southern major part. The start time of the landslide was estimated to be close to 06:16 AM and its end 06:17 AM on the basis of eyewitness and the record of a small earthquake induced by this landslide. By using this time and the runout distance, we obtained a velocity from 24.4 to 34.9 m/s.
The debris avalanche crossed the flat terraces below the source area and pushed out or buried the village below the terrace. It buried the narrow river channel with about 80 m width and then ran 8 0 m up the opposite slope, making a 60 m high landslide dam, which breached at 07:00 AM, on 9 August (Shieh et al., 2009) and flooded the village area. The debris consisted of fragments of mudstone, shale and sandstone, and interestingly they had clayey materials at the bottom. These clayey materials had no swelling clay minerals and is assumed to have played an important role for the transportation.

Keywords: Landslide, Dip-slope, Rainstorm, Gravitational slope deformation