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The post-failure sliding behavior of Tsao-Ling Landslides induced by Chi Chi earthquake, Taiwan

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During the 1999 Chi-Chi earthquake, extensive slope failures were triggered by the earthquake in central Taiwan. Among those, a large-scale dip-slope slide in Tsao-Ling occurred, which involved mass movement of 120 million cubic meters. From the field investigation, it was found that the dip angles measured on remained slope ranged from 12 to 14 degree, and the main sliding occurred in the Cho-Lan formation. However, only 25-million cubic meters (20 %) of the sliding mass dropped into the valley of the Ching-Shui River at the toe of the slope. The remaining sliding mass of about 100-million cubic meters slid pass the Ching-Shui River, and landed on the remains of old landslide dam. Residents who lived near the crest of the slope, flied with their house on the sliding rock block and landed on top of the landslide dam through a distance of 3100 m away. 32 people were killed and 7 survived after the “sliding-landing” process.

In this study, the mechanism of post-failure sliding of Tsao-Ling landslide was studied using Newmark’s sliding block method. The critical acceleration of the sliding mass was initially determined using the peak strength of the material. As the acceleration exceeded the critical acceleration and the displacement of the rock mass occurred. A total of 90 seconds records of the ground acceleration including both horizontal and vertical directions were used in the computation. As the displacement increased, the strength of the material was considered as decreasing with the sliding process, and gradually changed from the peak strength to the residual strength over the time record. As a result, the critical acceleration decreased during the process, and the slid rock block gained velocity and displacement.

Results of the seismic analysis indicated that the effect of the material properties degrading from peak strength to residual strength is significant on the velocity of sliding block. In the stage of post-failure sliding, the strength of sliding surface was close to the friction angle obtaining form Ring Shear testing. Under this circumstance, the sliding velocity of rock block could be larger than 200 km/hr, which dimmed the occurrence of “sliding-flying-landing” process for the sliding rock block possible with such high velocity.