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The influence of hydrogeological condition on earthquake-induced rapid and long runout landslides

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In recent decades, lots of landslides were triggered by earthquake and caused severe damages to the society. Earthquake-induced-landslides become a hot topic in natural disaster research field. For example, the 1995 Hyogoken-Nambu earthquake triggered Nikawa landslide and Takarazuka Golf-field landslide, 1999 Ji-Ji earthquake in Taiwan triggered Chaolin landslide and Jiufengershan landslide, 2003 Sanriku earthquake in Japan triggered Tukidate landslide, 2004 Sichuan earthquake in China triggered lots of landslides including Donghekou landslide in Qingchuan county, Wangjiayan landslide in Beichuan county, 2009 September Indonesia Sumatra earthquake triggered lots of flowslides including Tandikek slide and Malalak slide. From those cases, the hydrogeological condition shows strong influence on the initiation and motion of the landslides.

1) Rapid and long runout landslides triggered by 2008 Sichuan earthquake in China

The 2008 Wenchuan earthquake triggered lots of rapid and long runout landslides, which directly caused great loss of property and human lives and were responsible for a large percentage of total damages caused by the earthquake. It was found that groundwater and valley water played key roles in the rapid motion and long runout process of this landslide during the great earthquake. It was also observed that hazardous effects from the slowing of movement and/or a short runout, due to various geologic and hydrologic conditions of other landslides caused by the Wenchuan earthquake, contrasts with those which caused more deaths and damage due to rapid, long runout movement.

2) Tandikek and Malalak flowslides triggered by 2009.9.30 Sumatra earthquake in Indonesia

Earthquake activity is intense in southwestern Sumatra. Four major earthquakes occurred in the area between 2004 and 2009. The first and largest of these was the M9.3 earthquake that occurred on 26 December 2004. This earthquake caused a major tsunami disaster over a wide area, and 227,898 people lost their lives. A M8.6 earthquake occurred on 28 March 2005, followed by a M8.5 earthquake on 12 September 2007, and a M7.6 earthquake on 30 September 2009.

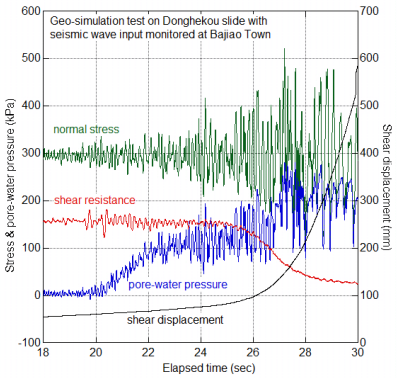
The 2009.9.30 M7.6 event was the smallest of these earthquakes, but it triggered many flowslides in the mountainous areas of Tandikek and Malalak. Those flowslides rapidly moved down slope, destroying villages at the fronts of the slopes, and killing many villagers. The distance from the epicenter is about 100 km. Padang is located almost midway between Cumanak and the epicenter. Among the landslides in the area, the Tandikek and Malalak flowslides caused most deaths. The common features of the two flowslides is that both occurred on steep source slopes of 30 to 40 degrees, movement was rapid, and villages located at the foot of the slopes were destroyed. This led to 132 and 32 fatalities at the Tandikek and Malalak flowslides, respectively.

Field investigation and ring shear tests indicate that, 1) Steep slope in the source area slope; 2) Continuous rainfall for three hours; 3) The strong seismic motion from the M7.6 earthquake; 4) The special structure, with the pumice layer overlying a stiff clay layer formed worst combination for flowslides.

3) Conclusions

Case study on Donghekou landslide triggered by 2008 Sichuan earthquake indicates the importance of hydrogeological condition on landslide initiation and motion. While case study on Tandikek flowslide and Malalak flowslide triggered by the 2009.9.30 M7.6 Sumatra Earthquake during rainfall shows that the worst combination of the following factors is the main reason for the flowslide occurrence and their rapid motion.

Through this study, we aim to call attention to similar slopes elsewhere. It is crucial to recognize the potential danger in those slopes, and locate the local residents in safe places.



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