Session: 2-2-5

Precursor Process and Triggering Mechanism of Rapid Landslides under Extreme Weather Conditions, and an Attempt of ICT-Based Participatory Joint Mapping of Past Landslides with Experts in Developing Countries

Hiroshi Fukuoka and Atitkagna Dok

Research Center on Landslides, Disaster Prevention Research Institute, Kyoto University
E-mail: fukuoka@scl.kyoto-u.ac.jp

This paper introduces the recent extreme rainfall-induced landslide disasters and results of ring shear tests showing the triggering mechanism of rapid and long run-out landslides. Then, authors introduce an attempt of ICT-based landslide micro-topography mapping using Google Earth. It may provide new participatory work and learning for creating better and reliable hazard mapping.

Keywords: heavy rainfall, landslides, triggering mechanism, hazard mapping, ICT

1. Introduction

In recent years, the frequency of extreme weather, such as extra-ordinary heavy rainfall events and following induced landslide disasters are apparently increasing not only in Japan but in many of the countries. Typical recent ones are Aso city (2012), Kii peninsula (2011), Shobara city (July 2010), Hofu city (July 2009), Seoul city, Korea (July 2011), Rio de Janeiro, Brazil (January 2011), El Salvador (2009). Besides, in Indonesia and Malaysia where daily showers and monsoon heavy rainstorms are most frequent, they have a lot of rain-induced landslides every year.

2. Landslide Triggering Mechanism of in 2009 Hofu and 2010 Shobara Disaster

A heavy rainstorm caused by a stationary front (Bai-u front) attacked Chugoku district and northern Kyushu district in late July 2009. Extra-ordinary intense rainstorm was recorded in Hofu city of Yamaguchi Prefecture from 6am–12am of July 21, which could occur once in a period of 200–600 years statistically. It induced many debris flow disasters in the city, claiming lives of 14 residents. Most of the debris flows were triggered by small-scale debris slides at the head of the stream, then scraping torrent deposits to increase its mass (**Fig. 1**). Those debris flows took place in a area of 10 km × 10 km. This could be affected by both the geology distribution and the relatively small heavy rainfall area.

Fig. 1. Source area of a landslide induced by extreme rainfall which caused debris flows which attacked a house for elders in Hofu city.

Fig. 2. Debris slide – debris flows in Shobara city of Hiroshima prefecture, induced by extreme rainfall in July 2010.

Similar but more localized disaster took place in Shobara city of Hiroshima Prefecture (**Fig. 2**). At least 200 landslides were induced in extremely small area of about 3 km × 3 km of mountainous remote village. Unfortunately, there was no rain gauge in this small area, however, we could guess extraordinary heavy precipitation according to the survivors witness and nearest rain gauge record as well as rain radar data.

Authors investigated one of the source sites of debris flow torrents in Hofu city which attacked a house-for-elders and killed 7 residents and took soil samples from the sliding surface. Those were subjected to pore-pressure

Fig. 3. The front view of the pore-water-pressure control ring shear apparatus (DPRI-7).

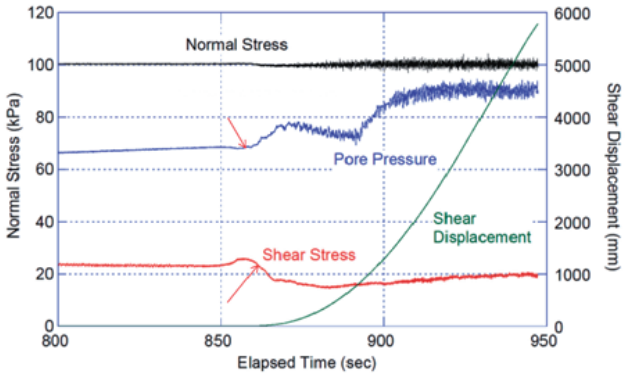

Fig. 4. Temporal change of stresses and shear displacement of the soil sample from of a landslide source area in Hofu city.

control ring shear test for reproducing the initial initiation and acceleration to confirm the mechanism of the rapid landslide motion. **Figs. 3** and **4** show the apparatus and temporal change of the stresses. In this test, soil sample was fully saturated and initial static normal and shear stresses were given corresponding to the potential sliding surface inclination. Then, back pressure (pore water pressure) was raised at a constant rate (100 kPa/hour). When the stress condition reached the failure criteria, sudden pore pressure rise was observed and soon after it reached about 90% of normal stress, that which strongly implies occurrence of liquefaction. Such liquefaction taking place in the vicinity of sliding surface is called "sliding surface liquefaction (SSL)." It should be highlighted that the sudden pore pressure rise is excess pore pressure arising from grain crushing and soil skeleton collapse, and the generated excess pore pressure remained as high as far as undrained condition is maintained. This could be interpreted as sliding surface liquefaction.

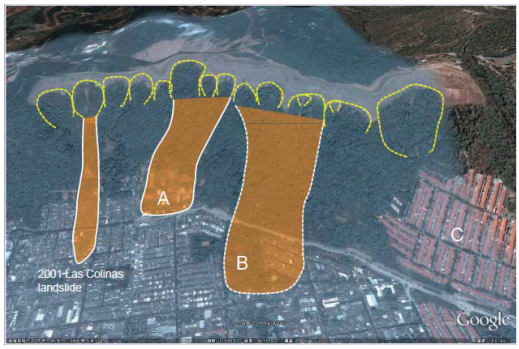

Fig. 5. Extracted landslide scars along Santa Tecla, Nueva San Salvador city of El Salvador. A : las Colinas landslide induced by 2001 earthquake, B: old landslide scar and debris deposit hill.

3. An Attempt of Ict-Based Participatory Joint Mapping of Past Landslides

In this section, recent efforts to develop interdisciplinary and participating approach to create effective landslide hazard maps and advanced early warning of rain-induced landslides using satellite data are introduced. (1) The Google Earth is the most effective SaaS hazard mapping tool for extracting landslide micro-topography on the local scale. In most cases, it allows to extract landslides larger than 30 m–100 m depending on resolution of the area. Combining these maps and local landslide history experienced by the residents provides economical, reliable hazard maps for community residents in developing and developed countries. Author proposed a possibility of joint work for extracting landslide topography by experts in developed and developing nations through telecommunicating in the net (**Fig. 5**). (2) The early warning system based on Tropical Rainfall Measuring Mission (TRMM) Multisatellite Precipitation Analysis (TMPA) and the Japanese soil-water index (SWI) gives empirical but most reliable threshold for issuing landslide alert to the residents of the area that especially very few or no rain gauges are implemented. If these methodologies are combined with recent achievement in "sliding-surface liquefaction" mechanism, above-mentioned efforts shall contribute to more resilient the society against landslide disasters.

Acknowledgements

Authors appreciate support for field work and data collection by the Civil Defense department of Government of El Salvador, Central America.

References:

[1] H. Fukuoka, H. Yamamoto, Y. Miyata, F. Wang, and G. Wang, "Preliminary Report on landslide disaster in Hofu city, Yamaguchi Prefecture, Japan triggered by the July 2009 Chugoku-Northern Kyushu District Heavy Rainstorm," Natural Disaster Science, Vol.28, No.2, pp. 185-201, 2009.

[2] H. Fukuoka, "Application of ICT to Contribution to Resilient Society Against Landslides," Journal of Disaster Research, Vol.5, No.6, 2010.