A system to support decision makers in rainfall-induced landslide hazard early warning in Halong city- Vietnam

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1. Introduction

Landslides cause hundreds of thousands of deaths and injuries every year all over the world. Among them, Vietnam with its geographical position and climate characteristics is highly vulnerable to various types of landslides, seriously hampered the rapid economic development and urbanization. Hence, an early warning system for predicting landslides is essential if Vietnam were to move out of the shadow of the landslides.

This research is attempting to develop an early warning system for landslide hazards based on soil testing (by using the ring shear apparatus ICL 1) and the landslide model LS-RAPID (The Integrated Landside Simulation Model). Although the applications of ring shear apparatuses (9 versions: from DPRI 1 to DPRI 7 and ICL1, ICL2) and LS-RAPID model are widely used to investigate the landslide mechanisms and simulate the process of single landslides, the potential capacity of these for an early warning system of rainfall-induced shallow landslide hazard in vulnerable areas has not been exploited.

2. Study area

The pilot area is a catchment where a shallow landslide happening in July 2015 after 2 days of heavy rain buried 3 houses and killed 8 people in Cao Thang ward, Halong City. The city is located in the center of the Quang Ninh province - Vietnam with the complex and diverse topography including mountain, delta, coastal and island. The North and North East are covered by mountain containing 70% city's area. Landslides have become an obstacle for the activities of socio-economic development of the city.

3. Methodology

Field surveys in the study area, especially the sliding zone were first conducted to examine the geological and topographical characteristics. Due to the similarity of geological characteristics in the area, a soil sample was collected from the sliding surface and considered as a representative for the whole area to be tested by the ring shear apparatus ICL1. The initial shear stress and the normal stress due to the weight of the soil mass above the potential sliding surface were reproduced in the shear box. During the shearing process, the ring shear apparatus indicated the friction angle of the peak failure, the friction angle during the motion, excess pore-water pressure, mobilized shear resistance and displacement.

A soil depth map was generated from soil depth and slope (based on 12 soil drill locations), and updated by field survey.

After obtaining topography map, soil parameters of the area, the LS-RAPID model was applied for 3D simulating the initiation and motion of the rapid shallow landslide to create hazard maps of landslide disaster. The specific characteristic of the LS-RAPID model is to conduct landslide simulation based on laboratory testing (Sassa et al. 2010). Hazard scenarios with different water pressure values (landslide triggering factor) will be applied to identify potential landslide initiation zones and hazard areas.

Piezometers (or groundwater-level gauges) are planned to be installed at the identified potential landslide initiation zones to monitor the pore water pressure (or groundwater level).

Base on the near real-time data from the monitoring instruments at vulnerable areas and prepared scenarios from LS_RAPID, provided information would be then made use to inform the local authorities about real situations via a WebGIS.

4. Preliminary results and discussion

Based on soil parameters obtained from the ring-shear apparatus, several scenarios for landslide hazards in the study area were generated. The whole study area will be safe if the excess pore water pressure ratio only reaches to 0.12 (the excess pore water pressure ratio $r_u = \Delta u/\sigma$ where Δu is the pore water pressure acting at the potential sliding surface and σ is total normal stress acting on the potential sliding surface).

Figure 1: Simulation result with r_u reaches to 0.15

Figure 2: July 2015 landslide in Halong city (URL1)

However, when r_u rises to 0.15, a shallow landslide will occur (Figure 1). The initiation location of this simulated landslide is quite coincident with the real landslide occurred in July 2015 (Figure 2) while its runout path is significantly longer. This main difference may due to 3 houses (3 buried houses) blocked the landslide mass could not be simulated in the LS-RAPID model. (Due to the LS-RAPID model requires the rectangular mesh, all instability processes happening on the edges of the analyzed area can be considered unreal.)

It is worth to notice that if the excess pore water pressure ratio increase to 0.3, another landslide disaster is likely to happen and extend the hazard area (Figure 3).

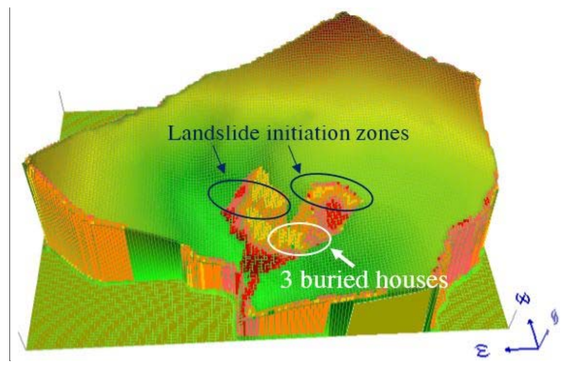

Figure 3: *Simulation result with r_u reaches to 0.3*

The simulation results pinpointed potential landslide initiation and hazard zones. This could be very useful for the land use planning or landslide disaster evacuation scenarios. Moreover, once piezometers (or groundwater-level gauges) are installed and calibrated at these potential initiation landslide locations, the proposed system could be a reliable system to support decision makers in rainfall-induced landslide hazard early warning.

Reference

Kyoji Sassa, Osamu Nagai, Renato Solidum, Yoichi Yamazaki, Hidemasa Ohta (2010). An integrated model simulating the initiation and motion of earthquake and rain induced rapid landslides and its application to the 2006 Leyte landslide in Landslides. Vol.7, No.3. DOI: 10.1007/s10346-010-0230-z

URL1: https://news.zing.vn/video-toan-canh-nui-lo-vui-lap-9-nguoi-trong-gia-dinh-quang-ninh-post563553.html