Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

HDS04-P01 Room:Convention Hall Time:May 20 17:00-17:45

An application of the diffusion and advection equations for the evolution of a gravel slope

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The diffusion and advection equations were manually coupled to model the evolution of a gravel slope in Da-keng, Taichung, Taiwan. The two equations were discretized using finite difference method and coded in Matlab environment. Field topographical surveys of the gravel slope and previous digital terrain data were used for calibrating the diffusion and advection coefficients used in the equations. We show that the evolution of slope decline and parallel retreat can be well described the gravel slope evolution in Da-keng. A non-homogeneous slope was simulated by varying the corresponding diffusion and advection coefficients for the non-homogeneous slope.

Keywords: Slope evolution, diffusion model, advection model

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Fluctuation in excess pore water pressures triggered by earthquakes at the Busuno landslide

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1.Introduction

There are not many observations in pore water pressure induced by earthquake (EQ) at a landslide area. We observed seismic motions and coinstantaneous pore water pressures in a landslide area, and considered their relationships in some aspects.

2.Seismic motions and pore water pressures for analysis

We installed some piezometers at the Busuno landslide area in Niigata Prefecture, and observed five fluctuations in pore water pressures corresponded to following earthquakes: the Niigataken Chuetsu Earthquake in 2004 (EQ1), the strongest after shock of EQ1 (EQ1'), the Niigataken Chuetsu-oki Earthquake in 2007 (EQ2), the Naganoken Hokubu Earthquake in 2011 (EQ3) and the strongest after shock of EQ3 (EQ3'). Since we started a seismic observation from 2010 at the Busuno landslide site, the strong motions by EQ1 to EQ2 were estimated based on that from National research institute for earth science and disaster prevention K-net Yasuzuka (NIG 024). To estimate the peak ground acceleration and peak velocity acceleration of the Busuno landslide, we have adopted the attenuation relationships using the shortest fault distance (Si and Midorikawa, 1999). Five piezometers were installed at the middle block from 2002, and observed pore water pressures for EQ1, EQ1' and EQ2 every 10 minutes. Since they were broken by heavy snow in 2005, two were newly-installed and observed them for EQ3 and EQ3'.

3.Results and discussions

All piezometers showed ?uctuations in pore water pressures at the time of five earthquakes. For EQ1, EQ1, and EQ2, the pore water pressures showed spike-like fluctuations by receiving rapid elastic compression in the low permeability layer. The pore water pressures fluctuated larger as the peak acceleration becomes larger. The highest peak ground acceleration was observed by EQ3 (NS 236 gal, EW 382 gal and UD 108 gal with a dominant frequency of 3Hz), and the largest rise in pore water pressure (15 kPa) was observed. Other earthquakes caused much lower fluctuations in pore water pressure less than 1 kPa even in maximum. We considered the possibility of a snow pack effect on the slope. The landslide area was covered by around 3 m depth of snow when EQ3 occurred (March, 12, 2011). Therefore, higher pressure acted on the sliding surface during EQ3. Okamoto et al. (2006) reported that the high pore water pressures remained for 8 to 24 hours both after EQ1 and EQ2 at the site, and referred that was because it was consisted of two components which are the transform elastic compression (spiking ?uctuations) and the plastic compression (remaining high pressure) of the ground at the time of the earthquake. The similar fluctuations were observed by EQ3 and EQ3'

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Keywords: landslide, earthquake, excess pore water pressure, peak ground acceleration

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The sandbox experiments to understand Self-Potential changes associated with water flow

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Landslides are one of the most severe natural disasters in the world and there are two types; rainfall induced landslides and landslides triggered by an earthquake. In this research, basic study on early warning system for landslides will be performed to understand rainfall-induced landslide process by hydrological and electromagnetic changes. The final goal of the research is to develop a simple methodology for landslide monitoring/forecasting using self potential method. Conventional methods for monitoring landslides are based on geotechnical and hydrological approaches measuring pore pressures and displacements on the surface. In these methods, boreholes are required in general which may disturb the subsurface water system. Making boreholes is costly and it is not so practical for field applications. On the other hand, self potential measurement using two electrodes is easy to set up and run continuously.

In this study, the sandbox experiment has been conducted to understand the relation between water flow and self potential using a network of electrodes set in the tank. For the sandbox system, it is possible to control the water table and easily to drain water from the tank and infiltrate water into the tank. Controlling water flow in the tank, we conducted repeatedly experiments. In consequence, we could get the relation between the magnitude of water flow and self potential. The details will be given in our presentation.

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Geometry and pattern of slope failures at a fault scarp in analogue models

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A slope failure, which damages to human lives so much, is a natural phenomenon that a slope instabilized by geological and geomorphological factors is collapsed induced by torrential rain and earthquake motion. Therefore analyzing each factors related to slope instabilization and evaluating the risk of slope failures, are very important for preparing future torrential rains and earthquakes. In our research, we focused on the reverse fault, which is one of geological factors of slope failures, and performed analogue model experiments with dry sand to examine slope topography, development and failure induced by reverse fault activity. In the experiments torrential rain was reproduced, and the experiments were conducted in static condition so that influences such as earthquake motion could be ignored; we could consider only the activity of a reverse fault to evaluate the influences on slope development and failures.

In our experiment, a slope was reproduced that developed on the surface of the sedimentary layer on a basal rock. Wooden rigid blocks cut at the angle of 30 degree were put on the lower part of the experiment apparatus as basal rock, and dry sand is piled on the blocks. Reverse fault displacement was given to these blocks and a slope was induced on the surface of dry sand. During the experiment, slope development and failures are recorded with digital cameras from side and upside of the model at even intervals. The time series deformation process of the model was obtained by analyzing taken digital images using digital image correlation (DIC) technique, and 3D slope topography, patterns of slope failures and fault activity in cross section were related with each other.

The observation of 3D slope topography revealed that a steep area with constant width was at the foot of the slope regardless of slope length, or the level of slope development. On the other hand, fault activity, which is visualized by analyzing images taken from the side of the model, was always localized at the foot of the slope with constant width near surface. These results are very consistency, which suggests that specifying a steep area from slope dip distribution enable us to estimate the position and width of fault under a slope.

The generated slope on the dry sand was not linear but had certain curvature. On the area of the slope convex toward the hanging wall, hanging wall displacement was large and many large slides occurred, which are defined generate at the top of the slope accompanied with large failure areas, and vice versa on the area convex toward the foot wall. As the hanging wall displacement increased and the slope developed, the topography of the top of the slope deformed into one of emphatic initial slope curvature, while the foot of the slope increasingly became flat. Observed phenomena, including large slope failure, seem to be dependent on the initial slope curvature, which suggests the possibility that slope curvature on surface is applicable for quantification of the risk of large slope slide.

Keywords: analogue modeling, reverse fault, slope failure, DIC, 3D topography

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3D remote-sensing study of the spatial distribution of landslides in SE Weihe Basin, central China

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Many factors may be responsible for the occurrence of landslides, such as moderate to large magnitude earthquakes, typhoons as well as human activity. The landslides triggered by the earthquake are mostly concentrated in and around the epicentral area of large earthquakes over a distance of tens of kilometers, as well their distribution is strongly affected by the seismic faulting (e.g. Ren and Lin, 2010). To learn the distribution of landslides and its controlling factors is vital to make the risk assessments of landslide hazard, especially within the seismic active region.

Remote-sensing techniques have been applied to learn the spatial distribution of co-seismic landslides, based on cross-check of the refection features of images acquired before and after the earthquake. Meanwhile, Digital Elevation Model (DEM) data with world-wide coverage (e.g. 90-m SRTM data) were also used to learn the topographic features of locations where landslides occurred (e.g. Ren and Lin, 2010). However, most of by previous studies are limited to analyze in map-view. Here we present a case study of the distribution of landslides and its relation to the active normal faults in SE Weihe Basin, central China, by using the 3D remote-sensing techniques which has been previously applied to detect the locations of seismic faults associated with moderate to large magnitude earthquakes.

In this study, higher resolution remote-sensing images (1-m IKONOS and 0.5-m WorldView data) were processed and analyzed in 3D perspective views by draping them on the 30-m ASTER Global Digital Elevation Model (ASTER GDEM) data. High-resolution Google Earth images if available were also used to cross-check the spatial distribution of landslides. Based on the results of our analysis, we then conducted the fieldwork to validate the interpretations of the remote-sensing images.

The results of our analysis indicate that the landslides are mostly distribution in the regions between the Weinan and Huayin city, which was inferred as the epicentral area of 1556 M8.5 Huaxian earthquake. Meanwhile, the landslides (including the largest Lianhuashi and Zhangling landslides) are generally developed upon the steep slopes (30^o-65^o) within a narrow zone with width of ˜8-11 km and ˜3 km along the Huashan Piedmont Fault and Northern Margin Fault of the Weinan Loess Tableland, respectively. The distribution of landslides was affected by the active faults and slope morphology in study area. The devastating 1556 M8.5 Huaxian earthquake caused widespread damages in the densely-populated region around the Xi'an city, an old capital of China, resulting in more than 830,000 deaths (largest total ever claimed), including the people killed by the giant landslides (e.g. Zhangling landslide). 3D remote-sensing techniques show their advantages to precisely constrain the spatial distribution of landslides and thus make the risk assessment of landslide hazard in the seismically active regions, such as the SE Weihe Basin.

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Keywords: landslides, active normal faults, 3D remote-sensing, SE Weihe Basin, central China

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Topographies of hazardous events on the bottom of Caldera Lake Kussharo, Hokkaido, Japan

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There are a lot of large caldera lakes in volcanic arcs such as Japan. Caldera lakes and their surroundings have good sceneries and hot springs; a lot of resorts located in their lakesides. However, the existence of abundant water in high elevation may provide the risk of the residences around the caldera lakes. The reasons are as follows: volcanic activities exist on the bottom of caldera lakes in many cases, and the inside of caldera rim is steep slope with large difference in elevation, their rims consist of lava and pyroclast which is preferred geology for catastrophic landslides. Volcanic activities and catastrophic landslides may cause overflow of lake water or tsunami. Their risk should be analyzed.

We are trying that analysis for Lake Kussharo in Hokkaido. Lake Kussharo is located in Kussharo Caldera which is the largest caldera in Japan. The lake has 79.3 km^2 in areas. The elevation of water surface is 121 m a. s. l. Only one river, Kushiro River flows from the lake to the downstream to Kushiro city. The resort area, Kawayu hot spring resort town is developed along lakeside. Volcanic activities are still active in this area. Mt. Atosanupuri erupted during the last few thousand years. The caldera rim has steep slopes and the highest part is 1000 m a. s. l. There are a lot of topographies of huge landslide masses and huge horseshoe shaped cliffs on the slope of rim. The terraces of old lake bottom lie on the wide area from the lakeside to the level of 150 m a. s. l. In addition, we found old terraces at the level of ca. 105-110 m a. s. l. and 95-90 m a. s. l. by our sonic survey. These terraces suggest that the level of water surface has repeatedly fluctuated.

We surveyed topography and geology of the ground surface and the bottom of lake using the sonic survey. In this presentation, we will mention about characteristic topographies related to past hazardous events. In particular, we found the mound-like hills in two areas. One area is ca 1 km in width from north to south and ca 1.5 km in length from east to west. This area has many small mounds, and their maximum size is ca 400 m in width and 20 m in height. Another area is ca 1.2km in width from north to south and ca 0.7 km in length from east to west. This area has also many small mounds, and their maximum size is ca 50 m in width and 20 m in height. These two areas are close to Nakajima Island which is the central cone of caldera. So, we deduce that both mound-like hills were flowed from Nakajima Is. by huge collapses. Also we found other topographies related to past hazardous events: landslide debris extended ca 2.5 km in width and ca 0.5 km in length near lakeside; a landslide involving bedded sediment; small eruptions with lava having width of ca 100 m; and topographies of depression associated with volcanic activities.

There are a lot of landslide masses and horseshoe shaped cliffs on the slope of rim. However, we could not find remains on their feet. Thus, most of their topographies on the rim do not concern recent hazardous events. The topographies we found are clear, so they probably formed after the formation of lake. Hazardous events formed their topographies could cause flood or tsunami, and then further events may occur around caldera lakes. Their risks should be considered for disaster prevention.

Keywords: Caldera lake, Landslide, Natural hazard, Lake Kussharo, Sonic survey