A TWO-STEP PROCEDURE FOR HAZARD PREDICTION AND ASSESSMENT OF LANDSLIDE AND DEBRIS FLOW

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INTRODUCTION

Landslide occurrence and reactivation is conditioned by a number of terrain and geo-environmental factors such as rock and soil properties, weathering, jointing and structure, slope morphology, land cover/use, and water flow. Most debris flows originally occur in the form of rainfall-induced landslides before they move into valley channel. Slides that mobilize into flows usually are characterized by high-velocity movement and long run out distance and may present the greatest risk to human life.

In this paper, a two-step procedure to define landslide and debris flow susceptibility in a mountainous region has been attempted (Fig.1). Firstly, a GIS-based three-dimensional limit equilibrium stability analysis model (Xie et al. 2003) is used to define the potential landslides. Then, using GIS-based two-dimensional numerical simulation model of debris flow (Wang et al. 2008), the inundated area across three-dimensional terrain is defined; and the potentially affected homes, streams and road sections are predicted.

LANDSLIDE SUSCEPTIBILITY MAP IN MINAMATA REGION, KUMAMOTO PREF., JAPAN

On July 19-20, 2003, a short duration high intensity rainfall event impacted the city of Minamata in Kumamoto prefecture, Japan. The slope failure and resultant debris flow at Hogawachi in Minamata was the largest and most damaging of these disasters. A moderatesized, 4-9m deep debris avalanche triggered the debris flow about 1.5 km upslope of where the casualties occurred. In an attempt to forecast a similar landslide related disaster in the future, this study will concentrate on landslide hazards around the site of the July 19-20 Minamata-Hougawachi landslide.

As the adjacent region has similar engineering geological conditions, we assume that the slope failure in this region has the same mechanism with the past landslide. The mechanism of the past landslide was analyzed and the mechanical parameters were calculated using GIS-based 3D limit equilibrium models (Xie et al 2006). The 2.5km by 3km study area was divided into slope units based on a GIS hydraulic model tool.

Using the same engineering geological conditions of the past landslide, and the same triggering factor (rainstorm), the minimum 3D safety factor is calculated for each slope unit. Since a single value of safety factor is not sufficient enough for evaluating the slope stability of a slope unit, the ratio of the number of safety factor values less than 1.0 to the total times of calculation is calculated as the failure probability of the slope unit. If the failure probability is more than 80%, the slope unit is clarified as unstable (Fig. 2).

DEBRIS FLOW HAZARD MAP

The landslide that occurred in Minamata City in July 20, 2003 transformed into debris flow. The debris flow was simulated using GIS-based 2D numerical model (Wang et al, 2008) (Fig. 3), and the material properties and rheological parameters were back-analysis calculated. Assuming the pattern of

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landslide disasters in the Minamata-Hougawachi region is the same as the landslide of July 20, 2003, namely, the slope sliding mass combining with the mountain torrent forms a debris flow passing along the stream valley, five stream valleys that are the most likely to be affected by these processes are recognized. For each stream valley, there are several potential landslides areas upriver. Because they are unlikely to fail at the same time, only one potential landslide was selected to simulate the inundated area for each stream valley (cases 1-5, numbered in Fig. 2). Using the parameters calibrated by the historic landslide, four debris flows from the unstable slope units are simulated (cases 2-5). The debris flow hazard zones are mapped in Fig. 4, in which the inundated areas of the debris flows, the potentially affected houses and road sections are shown.

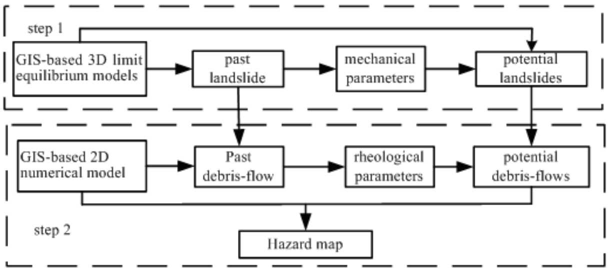

Fig. 1 Approaches for regional slope-failure hazard

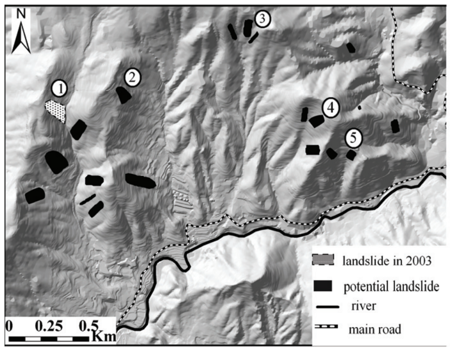

Fig. 2 Distribution of potential landslides

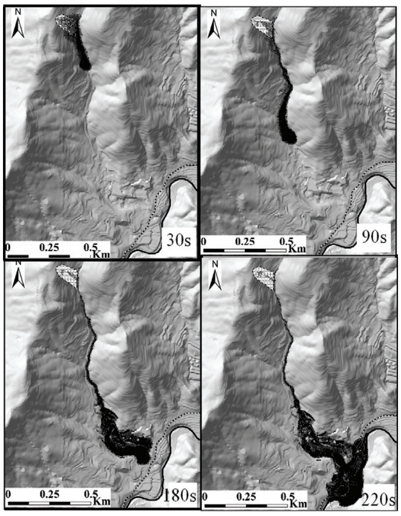

Fig. 3 Simulation of debris flow in July 2003

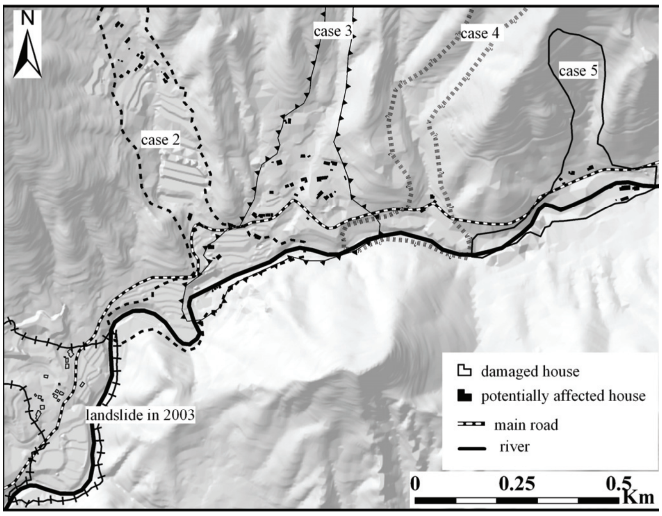

Fig. 4 Hazard map with distribution of houses, rivers and roads

REFERENCES

Xie M., Esaki T., Qiu C., Wang C. (2006). Geographical information system-based computional implementation and application of spatial three-dimensional slope stability analysis. Computers and Geotechnics 33(4-5): 260-274.

Wang C., Li S., Esaki T. (2008). GIS-based two-dimensional numerical simulation of rainfall-induced debris flow. Nat. Hazards and Earth Syst. Sci. 8(1):47-58.

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