NUMERICAL SIMULATION OF NATURAL LANDSLIDE DAM

PREDICTING THE HEIGHT OF THE DAM FOR THE PURPOSE OF ESTIMATING THE PEAK DISCHARGE IN CASE OF DAM BREAK

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INTRODUCTION

Landslide dams pose great threat to people and property. Recent examples of landslide dams, in Japan, are those formed due to the landslides induced by the 2008 Iwate-Miyagi Nairiku earthquake. There were more than 14 dams, ranging in size from 80,000 m^3 to 12,600,000 m^3.
Prediction of outflow hydrograph, in the event of dam break, is one of the crucial tasks in estimating the hazardous areas. While, the hydrograph depends on many factors such as inflow discharge, impounded water volume, shape and size of the reservoir formed in the upstream of landslide dam, etc, one of most influential parameters is the height of the dam. It can be seen, for example, in Costa's equation that the height of the dam is the main controlling factor of the peak discharge.
However, predicting the height of landslide dam is a difficult task, if a hazard map is to be prepared for future risks. Currently, it is the empirical practice in Japan, to assume that the height of landslide dam will be approximately equal to the maximum thickness of the landslide mass. While, intuitively, it may be reasonable to make such assumption, research is desirable by means of field investigation, experiments, and simulations to assess such assumptions.
The objective of this paper is to present results of preliminary study to examine the relationship between the thickness of the landslide mass and the height of the landslide dam through assessments of collected field data and numerical simulations.

METHODS AND PROCEDURES OF THE STUDY

The topographic data of the landslide dams of Iwate-Miyagi Nairiku earthquake were compiled to examine the relationship between the thickness of the landslide and the landslide dams. Furthermore, process of landslide dam formation was simulated by the distinct element method (DEM). This study is a preliminary attempt to assess the applicability of DEM in simulating the landslide dams and also to examine the relationship between the landslide thickness and the dam height. For the purpose of preliminary study, two dimensional simulation was performed, while the formation of the landslide dam is a three dimensional behaviour. Differences between the two and three dimensional simulations are to be assessed in the future.
A parallel bond model, available with the DEM code PFC3D, was applied to represent the mechanics of contact between the discrete rock blocks, gravels, and boulders. The parallel bond model accounts for both forces and moments between the particles.
First, reproduction simulation of the actual landslide dam was performed to estimate the probable range of shear strengths between the particles and the sliding surface. Second, formation of landslide dams was simulated for multiple cross sections with different thicknesses to examine the effects of size of the landslide on the dam height.

RESULTS AND CONCLUSIONS

Shear strengths parameters for the inter-particle model and the sliding surface were estimated by simulating the process of mass movements and deposition. The reproduction simulation of the actual landslide dam, which was formed during the Iwate-Miyagi Nairiku earthquake, showed that DEM is applicable in simulating the process of landslide dam. It is, however, noted that DEM may not be

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applicable in simulating landslide dams induced by heavy rainfall, since current DEM does not model complex interaction between water and the solids while flowing down.
An example of the simulation is shown in Figure 1. While the height of the dam varies along the cross section of the river, it can be seen that the height is similar to the thickness of the landslide. The compiled field data and the simulated results show reasonable correlation between the landslide thicknesses and the dam heights (Fig. 2). However, results of the simulations show that the height of the dam can be lower than the thickness of the landslide, depending on the mechanical characteristics of the solids and the gradients of the sliding surfaces. Further research is carried out study the factors that influences the height of landslide dams.

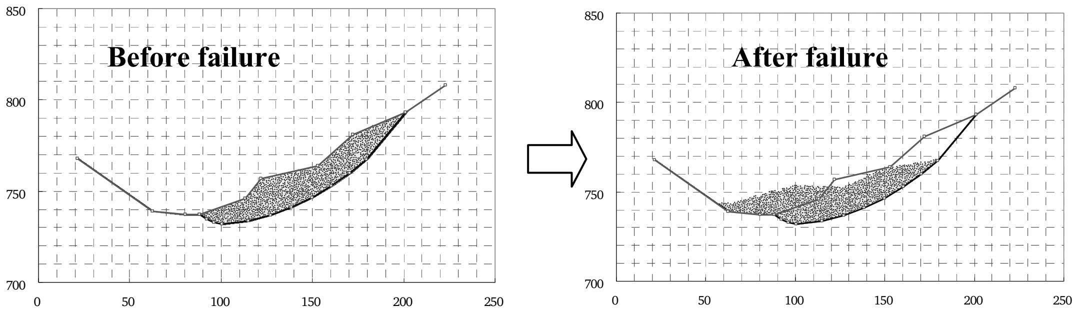

Fig. 1 Example of simulation of formation of landslide dam by DEM (Indicated as A-D in Fig. 2)

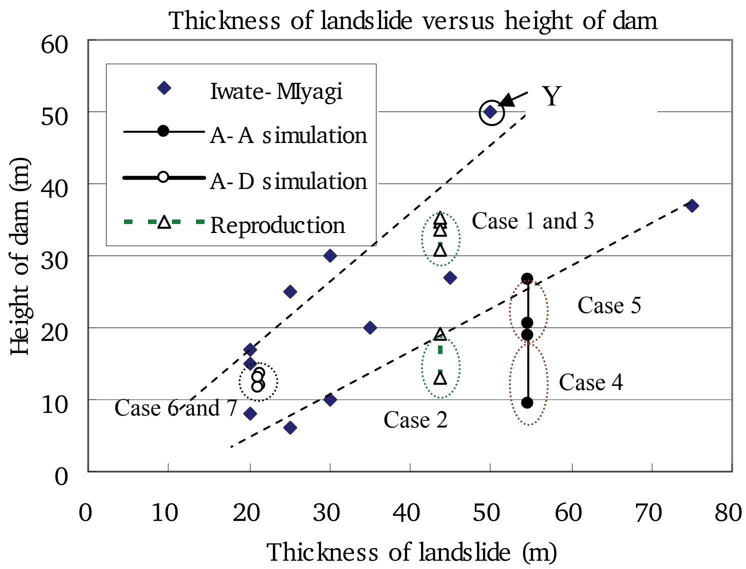

Fig. 2 The maximum thickness of landslide versus height of landslide dam: Differences in simulated heights for the same thickness are due to differences in the shear strengths of the particles and sliding surfaces.

Keywords: landslide, numerical simulation