

Analysis of geological and geomorphological characteristics of landslides triggered by 2004 Chuetsu earthquake in Japan

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INTRODUCTION

One of the most significant effects of the 23rd October 2004 Chuetsu, Mid Niigata prefecture earthquake (M6.8) was the triggering of the thousands of landslides over a wide-ranging area, including surface failure ($depth \leq 1m$), shallow landslide ($1m < depth < 10m$) and deep-seated landslide ($depth \geq 10m$). A great number of houses collapse in town of Kawaguchi by this earthquake. A very large number of landslides occurred in the upland village of Yamakoshi, destroying the entire village. Slope failures and landslides triggered by the Mid Niigata prefecture earthquake have been previously analyzed from the various viewpoints such as topography, geology and forest or field vegetation however geological and geomorphological characteristics of landslides have not been studied sufficiently. The purpose of this study was to identify correlations between landslide occurrences with geologic and geomorphologic conditions using two indexes based on Geographical Information System (GIS). Total collapse area and landslide occurrence ratio (LOR), defined as the percentage of the area affected by landslides were used to analyze the relations of the distribution of these landslides using various parameters, such as distance from an earthquake source (epicenter fault line), topographic parameters (slope steepness, slope morphology) and geological units and distance from rivers and ponds.

STATISTICAL ANALYSIS OF LAND SLIDE DISTRIBUTION

In this analysis, LOR was defined to express the influence of landslide occurrence. In the study area, slopes steeper than 50° occupied a smaller area whereas slopes ranging from 20° to 35° covered a much larger area. Most of the deep seated and shallow landslides have occurred on slope angles between 25° and 35° . However, 54.45% of surface failures have occurred on slopes between 40° and 45° . In Chuetsu earthquake most commonly, landslides have occurred on slope angle lower than 45° (Fig.1).

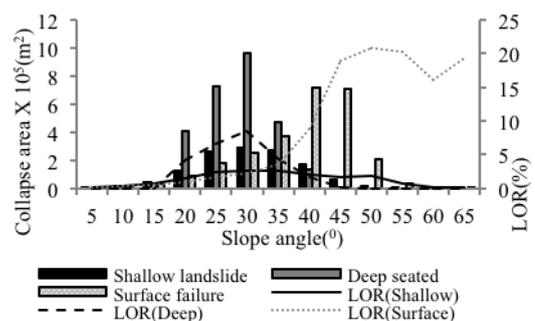


Fig. 1 Landslide occurrence ratio and collapse area in viewpoint of slope angle

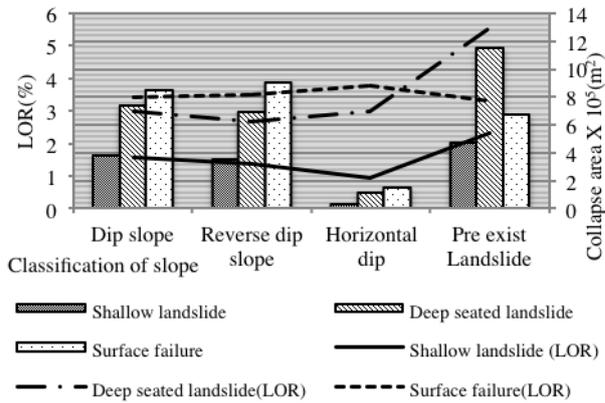


Fig. 2 Landslide occurrence ratio and collapse area in viewpoint of slope morphology

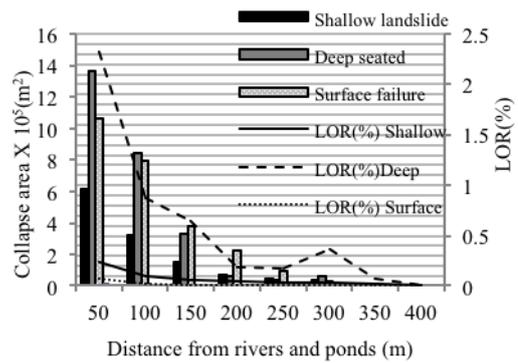


Fig. 3 Landslide occurrence ratio and collapse area in viewpoint of distance from rivers and ponds

In this analysis, we classified landslide slopes into three as dip slope, reverse dip slope and horizontal dip slope (considering the strata inclination direction and terrain slope direction), and examined the LOR with respect to slope morphology. Dip slopes are more prone to the occurrence of shallow landslides. Surface failures showed the highest occurrence ratio in horizontal dip slopes. It could be seen that deep-seated landslides occurrence ratio was higher in dip slopes than other slopes (Fig.2). In this study, we assume that the ground water level is very high near rivers and ponds. It can be seen from Fig.3 that several landslides have occurred close to rivers and ponds. To investigate the correlation between position of source and landslides occurrences, data were arranged the distance from epicenter fault line. According to the obtained results surface failure shown better relationship with distance from epicenter fault line but for deep deformation it doesn't show the good relationship.

CONCLUSIONS

Analysis of the landslides triggered by the 2004 Chuetsu earthquake provides valuable insights to the characteristics of seismically triggered landslides in Chuetsu region of Niigata prefecture. Even though the most common type of landslides recorded in the study area was surface failure on steep slopes, this event has triggered 141 deep-seated landslides and 609 shallow landslides also. According to the obtained result that the slope angle is strongly correlated with the occurrence of surface failures induced by earthquake. Influence of preexisting landslides, slope morphology and geology are not significant for occurrence of surface failure. Rocks and strata of the study area have played an imperative role in the generation of deep-seated landslides which are far from the epicenter. It can be seen from Fig. 2 that most of the deep seated and shallow landslides have been occurred due to the reactivation of existing landslides. Dip slopes have more pronounced (shallow and deep seated) landslide occurrence ratio compared to the other slopes.

Keywords: Landslide occurrence ratio (LOR), Shallow landslide, Deep-seated landslide, and Surface failure