The landslide Risk Analysis of the Lushan Hot Spring District

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ABSTRACT

Landslides often occur in the mountain areas of Taiwan, which are affected strongly by geography, environment and climate. Especially, the slope failure induced by heavily rain is frequent. Because of limited land and crowded population, the inhabitants of the mountain areas and traffic facilities fail to avoid thoroughly the landslide potential area which results in serious damages. Thus, the slope stability and risk evaluation are important issues for land development and use in the mountain areas of Taiwan. In this paper, the Lushan hot spring district is taken as a case study and used to evaluate the landslide risk. First, the limit equilibrium method and reliability index are used to calculate the landslide probability of the top slope above the hot spring district. Next, the road and structure losses are estimated based on the field investigation as the landslide will happen in the future. Finally, the landslide probability and loss calculation are integrated to express the landslide risk.

KEY WORDS: Landslide, Risk, Reliability index, Probability

INTRODUCTION

It has been an unavoidable tendency towards the development and use of hillside land in Taiwan because of limited plain land and crowded population. Subject to geography, environment and climate, however, the occurrences of several slope hazards are frequent, especially the rain-induced landslide in the colluvium and weathered rock stratum. It is rather unfortunate that the residence locations and traffic facilities fail to keep away form the landslide districts, which often results in serious damages. The landslide induced by the Morakot typhoon, which occurred in Jiaxian township, Taiwan in August, 2009, is a significant example. Thus, it is deeply concerned for evaluating the slope stability and landslide risk in the process of land development and use. This paper focuses on the landslide risk evaluation. The Lushan hot spring district located in Nantou, Taiwan is used as an example for evaluating the slope stability and landslide risk. The Lushan hot spring district constructed along the Ta-luo-wan River has been a popular scenic spot in Nantou, Taiwan (http://www.nantou.gov.tw). Upper slope of the hot spring district is an old landslide, which often slides as a heavy rain happens. Therefore, when large-scale landslide will occur in the future, the Lushan hot spring district will confront serious damage.

The landslide risk is a synthetic manifestation of the probability of slope failure and hazard loss. First, the probabilistic approach for slope stability analysis proposed by Lee et al. (2009), which involved the limit equilibrium method and reliability index is employed to calculate the failure probability of upper slope of the Lushan hot spring district. The possible loss of lands and buildings is estimated based on the results of field investigations. Finally, the landslide risk of the study case is presented by the results of the failure probability multiplied by loss. The results of the case study provide some guidance for future land use in the mountain land and migration hazard prevention.

GENERALIZED METHODS FOR EVALUATING THE SLOPE STABILITY

The generalized methods of slices (e.g. Fellenius, 1936; Bishop, 1955; Spencer, 1967, Juan, 1956; and Morgenstern-Price, 1965) are often used to evaluate the slope stability, especially in the colluvium and weathered rock. The slice methods are based on the limit equilibrium concept, which considers the shear strength and shear stress on the failure plane. It is meant that the slope is stable as the shear strength is greater than the shear stress; otherwise, the slope is unstable as the shear strength is less than the shear stress. In these methods of slices, a circular / noncircular slip surface is assumed to calculate the safety factor (FS) by the iteration procedure, where FS is the ratio of the resistance to the demand force. By assuming different slip surface, a number of solutions for FS can be found. The slip surface with minimum FS is the critical slip surface. Yamagami and Ueta (1988) indicated the methods of slices can be viewed as a nonlinear optimization problem and used four optimization approaches to find the critical slip surface using the Morgenstern-Price method. The Monte Carlo simulation technique is available to evaluate the slope stability and search the critical slip surface (e.g. Greco, 1996; Husein Malkawi et al., 2001; Xie et al., 2003). Since the deterministic FS analysis does not explicitly reflect the parameter uncertainties, Low et al. (1998)