Case Study of Renovation on Alishan Route 18 after Typhoon Morakot

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ABSTRACT: Typhoon Morakot has brought Taiwan tremendous rainfall in a hundred-year recurrence period. The roads and houses in the middle and southern part of Taiwan have suffered from landslides, debris flows, and floods. Erosion of road foundations, sliding of slopes, and collapse of bridges have paralyzed the road system. Using Alishan Route 18 as an example, this paper discusses different causes, types, and renovation methods of slope disasters for future reference.

KEYWORDS: Typhoon Morakot, Road, Slope, Disaster, Remediation measures

1. INTRODUCTION

Typhoon Morakot invaded Taiwan from Aug. 6 to Aug. 10 in 2009. The typhoon had brought tremendous rainfall, which had set new rainfall records in some part of Taiwan. From Aug. 7 to Aug. 10, Alishan and Zhuqi Township in Chiayi, Taoyuan District in Kaohsiung, and Sandimen Township in Pingtung had reached accumulated rainfall of 2,500mm (more than the average annual rainfall in Taiwan). The accumulated rainfall had reached 3,000mm in Alishan and the daily rainfall had exceeded 1,400mm in Sandimen on Aug. 8, set a daily rainfall record in Taiwan. Figure 1 shows accumulated rainfall distribution within typhoon period. It can be observed that the most disastrous areas are Chiayi, Kaohsiung, and Pingtung. Besides, the 72 hour rainfall accumulation of Typhoon Morakot almost reached the rainfall envelope of the world. Alishan Route 18 in Chiayi has suffered slope slides, road erosions, and debris flows, which is one of the most disastrous areas.

Taiwan's geological structure is complex and fractured, and the terrain is steep. According to the Central Weather Bureau, there are average 3 to 5 typhoons invading Taiwan every year in average. Due to the extreme weather phenomena in recent years, large torrential rainfall is bound to happen. Extreme rainfall on top of the fractured geology and steep terrain, slope disasters have become more and more serious. In the future, new build and renovation of road slopes shall consider the influence of extreme weather conditions and properly incorporate into design consideration. This paper presents the renovation case histories at mileage 37.5k, 59.1k, and 71.1k on Alishan Route 18 for engineers' future reference, as shown in Figure 2.

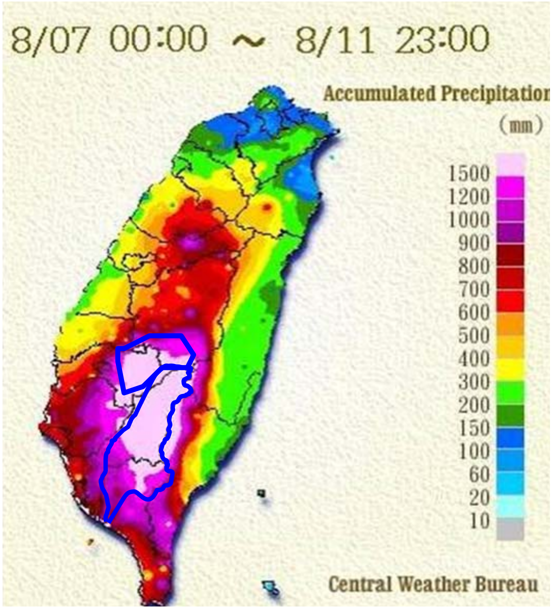

Figure 1 The accumulated precipitation distribution map of Typhoon Morakot. (NCDR)

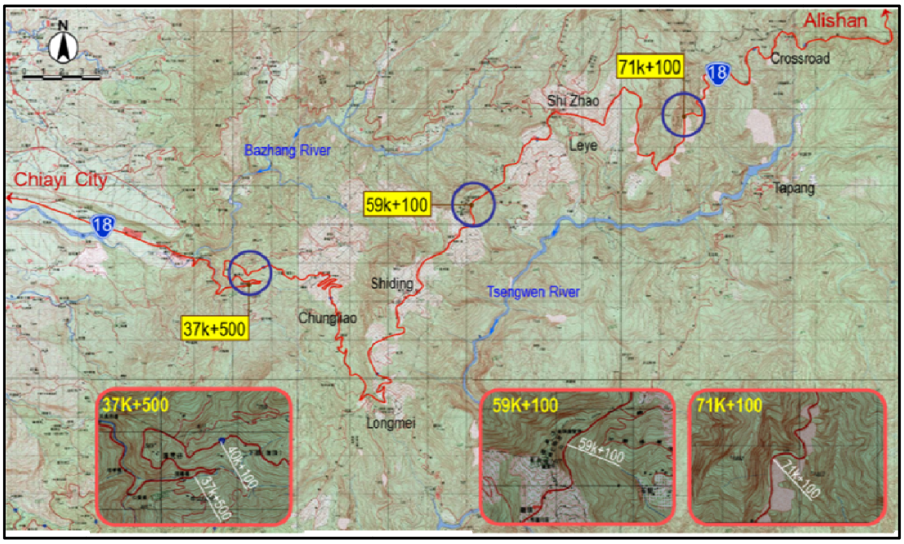

Figure 2 Renovation site of mileage 37.5k, 59.1k, and 71.1k on Alishan Route 18

2. DISCUSSION ON ALISHAN ROUTE 18 DISASTERS

Alishan Route 18 is an important Highway connecting Fenqihu, Alishan and Yushan mountain areas. All residents along route 18 depend entirely on the road for accessing, transportation of farm products and tourism. Thus, keeping the road unobstructed, ensuring road safety, and maintain transportation function are the main goals of renovation project.

2.1 Disastrous Conditions of Route 18

Typhoon Morakot had damaged more than 40 locations along Alishan route 18, including slope slides and road erosions. Mileages 37.5k~40.1k, 59.1k, and 71.1k are the three most disastrous sites. The main disaster types are upper and lower slope slides, and deep seated landslides. Figure 3~5 show aerial and site figures after Typhoon Morakot. After disaster, temporary road was constructed at the above road sections to maintain accessing. However, due to the unstable roadbed, the temporary road may be unable to withstand the erosion of heavy rainfall in the typhoon seasons.

2.2 Regional Geology

Based on existing references and surface geological survey, the rock outcrops at the landslide areas belong to Taban and Nanchuang formation of Miocene Epoch, and Tawo sandstone, Chinshui shale, and Cholan formation of Pliocene Epoch. The stratum is mainly interlayers of sandstone and shale, generally not bonded strongly. These areas are affected by Luku fault, multiple minor faults, and series of syncline and anticline geological structure, resulting in well-developed joints and fractured geology. The surface layer also subjects to serious weather erosion. The results of surface geological survey are shown in Figure 6~8.

Based on Central Geological Survey (Liu 2000), Luku fault outcropped at mileage 37.5k ~ 40.1k disaster area. The strike of fault is approximately northeast and the dip is 70 degree to southeast. The fault is a reverse fault and the Taban formation above the fault is thrusting to the west to lie on top of Tawo sandstone, Chinshui shale, and Cholan formation. The results of surface geological survey shows that the shattered fault zone outcrops at the disaster area. The fault zone is composed of impermeable materials which is disadvantageous for slope stability.

2.3 Causes of disaster and failure types

In accordance with site investigations, the ground surface runoff and erosion after continuous heavy rainfall is one of the main causes of slope failure. In addition, the ground water table rising derived from the rainwater infiltration may soften soil strength and reduce slide resistance of soil that will lead to a further slope failure. In general, slope failures can be divided into four types which includes slide in dip slope, falls and toppling, circular failure and mixed type landslide as shown in Figure 9. Summary of causes of disaster and failure types in this jobsite are given in Table 1.

Figure 3 Slope slide disaster photos at mileage 37.5k