Investigation on slope disaster and failure mechanism of Yi-Shing area in Taiwan

Kai-Chun Yang, Ph.D[1]; Sheng-Chuan Chen, PhD[1]; I-Feng Chiu, M.S.[2]; Chao-Wei Chen, M.S.[2]; Chao-Chin Pai, M.S.[1]; Fang-Tzu Kuo, M.S.[1]

INTRODUCTION

Yi-Shing area in Taiwan is a river terrace located in elevation of about 100~120m near the Da-Han river, and the mainly protected targets are Yi-Shing community with 20~40 habitants and Yi-Shing dam the important hydraulic structure in Da-Han river. Under the influence of river erosion of Da-Han river for a long time, the disasters of slope collapse and agricultural land subsidence often occurred in Yi-Shing region in the past years especially in 2001 and 2004. In September 2001, a strong typhoon named Nari struck this area and brought heavy rain with accumulated rainfall of 1,580mm to cause collapse with 200m long and 20~35m wide and bring about road subsidence with 0.5~1m. Another typhoon named Avery in August 2004 attacked this area again and still brought heavy rain to cause collapse in Yi-Shing tribe and lead to Yi-Shing power plant damaged. In order to understand the scope of the disaster and the causes of the collapse, many works were performed in this paper. Disaster Photos shown in Fig.1 and Fig.2.

METHODS

In order to understand the history of disaster, disaster type and mechanism, Yi-Shing region of aerial images at different times in the past were collected. From these images, there were two creeks on slope speculated to be debris flows before, and Yi-Shing tribe was discovered to be located on alluvial river terrace accumulated by these debris flows. Besides, because of the damage of Yi-Shing dam located on the toe of this area with river erosion for a long time, these problems including mentioned above could be the key issues to the stability of slope. To clarify the key issues of the degree of impact on the Yi-Shing region, site survey, geological exploration including 5 geological drilling wells with 230m long and 2 ground resistance survey with 600m long, groundwater investigation and observation from 2014 were executed.

RESULTS

Base on the geological exploration results, Yi-Shing region was classified into two areas. (1) Area II: The region of disaster caused by Nari typhoon. The layer deposits of Yi-Shing region consisted of rock, river terrace and debris flow deposit layer based on the results of geology bore drilling . Slope landslide had been occurred here in early years mentioned above, and cliff had affected the above roads and houses. So the river terrace and debris flow deposit layer behind the cliff was easily to develop back progressive slope failure. The collapse mechanism was considered as landslide. (2) Area II: The toe of the slope erosion by river. Two existed groups of joints showed high dip angles and rock mass were crushing. The joint plane was sandwiched mud with shear crack and water leakage could be observed, and this was likely a symptom of slippage. In addition to wedge failure or overturning failure, it is considered that the joint parallel to the slope connected together to form a sliding surface will possible trigger a large scale landslide disaster again.

According to the preliminary survey results, the factors of collapse could be summarized into three reasons. (1) Poor geological conditions: There were mainly two groups of joints in the rock layer based on geological survey results. One of the trend of joint was roughly parallel to slope, another was approximate vertical to slope, and both showed highly steep angles. As a results, rock mass was crushing and more easily weathered due to the cuts of joints. The attitudes of bed plane and joints were intersected to form wedge failure initially. Furthermore, joints could continue weathering and led to rock slide. (2) River attacking shore: Toe of slope of Yi-Shing region was located on the attacking shore of Da-Han river. Under the long-term

affecting of lateral erosion, the foundation layer under the check dam were scoured out, which reduced the stability and security of slope toe. (3) Groundwater conditions: Layers of Yi-Shing region mainly consisted of rock, river terrace and debris flow deposit layer, and groundwater could be accumulated between layers due to low permeability of rock, thus, reduce slope stability.

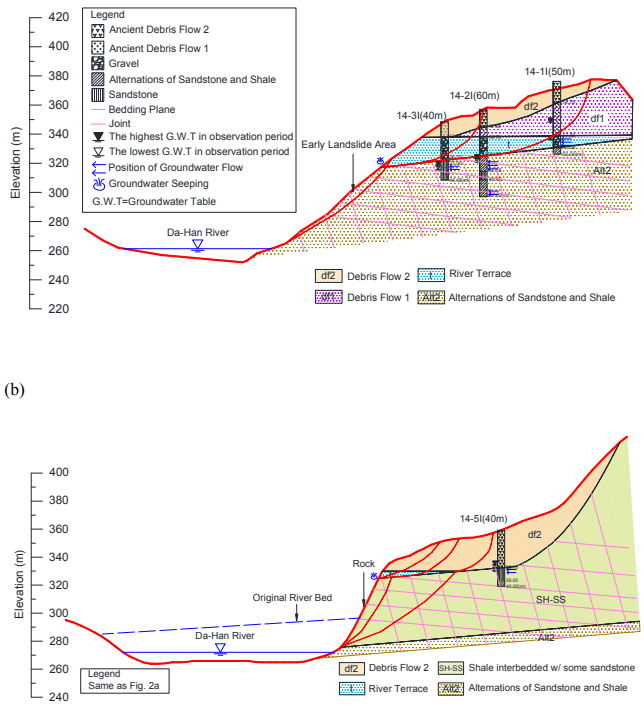

Figure 1. Cross section of landslide mechanism (a) Survey Area I and (b) Survey Area II

DISCUSSION

This paper has preliminary determined disaster type and disaster cause by in-site geological and groundwater investigations. However, due to less rainfall and not apparently movement of the slope during short term period of investigation, the relationships between rainfall and groundwater rising and the movement of slope caused by it are still unknown. For further understanding the depth of collapse, the scale of impact and the entire mechanism, inclinometer, water observation wells, piezometers and rain gauge had been installed to sustained monitor the slope.

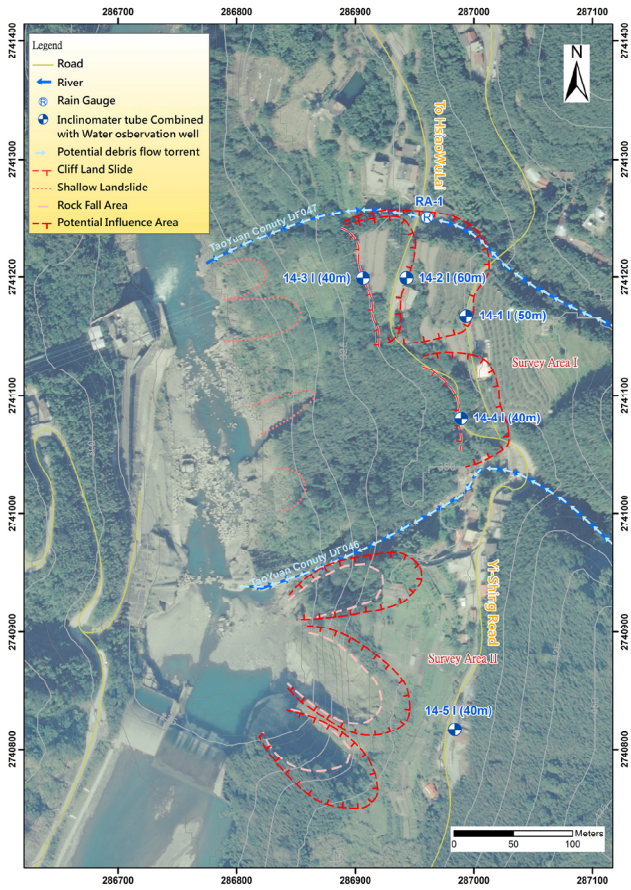

Figure 2. Plan view of the landslide range

KEYWORDS

Wedge Failure; Topple Failure; Geologic Investigation; groundwater

1 Taipei Branch, Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan., New Taipei City, TAIWAN, narc0816@gmail.com
2 Land Engineering Consultants, CO., LTD, TAIWAN