On the characteristics of the slopes with shallow landslides being triggered by Typhoon Tales, 2011 in the Nachigawa River Basin, Japan

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INTRODUCTION

In August 2011, Typhoon Talas arose in the Mariana Islands. The typhoon attacked the Kii Peninsula of Japan. One area was seriously affected by the typhoon was Wakayama Prefecture, the Kii Peninsula. In Nachigawa-river basin located in Wakayama Prefecture, several large-scale landslides and debris flow has occurred by the typhoon Talas. As a result, 29 people were killed and around 2400 buildings were damaged. In order to reduce or prevent these damages, it is necessary to clarify mechanism of the large-scale landslide that occurred in this basin. Therefore, in this study, we clarified roles of hydrological characteristics, topography and geology in large-scale landslide occurrence.

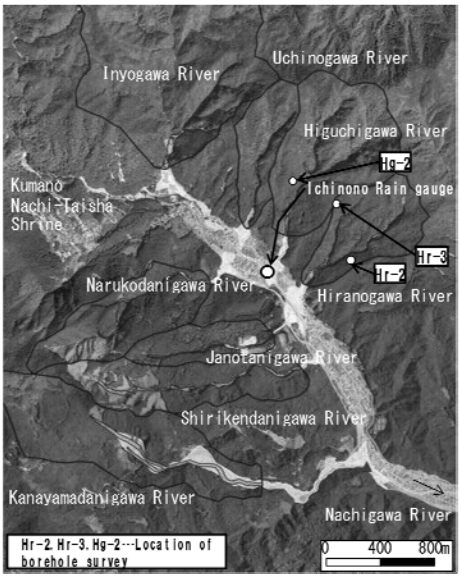

Fig. 1 Study Area

STUDY AREA

The study area is the Nachigawa River basin, located in Nachikatsuura Town, Wakayama Prefecture (Fig. 1, Area ~16.2 km^2, Mean longitudinal gradient of main channel of Nachigawa River ~9°). In the rainy and typhoon seasons, the monthly rainfall is >300 mm and annual rainfall is >2000 mm. The area is frequently attacked by typhoons. Additionally, the incidence of natural disasters due to typhoons and the heaviest rains has increased. Hence, extreme caution is required during heavy rainfall and typhoons.

The geology of this region is underlain by primarily of a Kumano acidic igneous rock layer formed by cooling of underground magma. The study area comprises granite porphyry and sedimentary rock of Kumano Group.

INVESTIGATIVE METHODS

In addition to the field survey, we conducted interview of local residents to elucidate the timing of landslide occurrence. First, we conducted field surveys to understand the conditions in the study area. Second, we carried out a photo interpretation using aerial photographs, to clarify the locations of the landslide areas and the distribution of sediment discharge. Third,

we conducted a borehole survey and specific resistance survey to study the structure beneath the ground surface. The specific resistance survey provides information on the distribution of groundwater and the geological boundaries. This information was also used to determine the position of the borehole survey. Finally, using the holes of the borehole study, we conducted groundwater level observations to investigate the relationships between groundwater and rainfall.

RESULTS

Our results showed the following:

The geological boundary of mudstone and granite porphyry was found at an elevation of 250 m a.s.l. and coincided with many landslide. In the Nachigawa River Basin, there were deposits from past debris flows . Hence, it appears that sediment transport phenomena such as debris flow have occurred many times in the past in the area. Using aerial photographs taken immediately after the disaster, we conducted a photographic survey. As a result, we found that most landslide moved down the slope in the form of debris flow, and reached the lower ends of valleys. To investigate the geological structure, we conducted a borehole survey and electric resistivity survey. The results revealed that the granite porphyry near the geological boundary displayed many cracks and groundwater. Hence, it appears that groundwater flowed near the geological boundary. Additionally, alternation of sandstone and mudstone was a low specific resistance zone and granite porphyry was a high specific resistance zone. Then, groundwater level variations depended on differences in the geology. Apparently, according to the conditions observed at the granite porphyry area, during heavy rainfalls, the groundwater level is high. The existence of overmuch groundwater appears to cause an increase in pore pressure in the soil. Hence, we conclude that these results explain many landslides in the granite porphyry area. Otherwise, the groundwater level along the geological boundary of the granite porphyry and alternation of sandstone and mudstone displays slight variation associated with rain falling over a short period.

CONCLUSIONS

The results of this study are as follows.

- Debris flow occurred at almost same time as the peak rainfall in this basin.
- Sedimentary rocks of mudstone of the low permeability distribution is lower, granite porphyry with high permeability were distributed in the upper.
- Cracks had developed the granite porphyry of the formation boundary.
- When Talas has hit, groundwater level and pore pressure increased. Then, it appears that landslides occurred.

Keywords: Large-scale landslide, alternation of sandstone and mudstone (sedimentary rock of Kumano Group), granite porphyry (Kumano acid igneous rock), geological boundary, groundwater level.