

## 長期滞在型共同研究（課題番号：30L-02）

課題名： Unraveling the mechanisms of rainfall-induced landslides under different climate conditions and advanced approaches to predict them

（異なる気候条件下における降雨時地すべり発生機構の解明および予測手法の高度化）

研究代表者： Ivan Gratchev

所属機関名： Griffith University, Australia

所内担当者名： 王 功輝

滞在者（所属）： Ivan Gratchev

滞在期間：平成30年12月15日～平成31年1月15日

滞在場所： 斜面災害研究センター

共同研究参加者数： 9名（所外3名，所内6名）

- ・大学院生の参加状況： 4名（修士1名，博士3名）（内数）
- ・大学院生の参加形態 [ 研究打ち合わせの参加，研究成果の紹介および議論 ]

研究及び教育への波及効果について

Four graduate students participated in this project, three of them from graduate school of science, Kyoto University, and one from Griffith University. Through involving this project, the students elevated their understanding not only on landslide dynamics, but also on the methodology in conducting scientific research.

研究報告

(1) 目的・趣旨

Rainfall-induced landslides cause damage to infrastructure worth millions and affect the community well-being through the cut of major transportation routes. A better knowledge of this phenomenon can significantly improve current models to prevent or mitigate this type of natural disaster. The current literature indicates that the mechanism of rainfall-induced landslides is complex; it involves changes in the shear strength of soil when the landslide mass becomes saturated during rainfall. It is thus necessary to consider the three-phase (soil, water, air) interaction and the effect of soil suction on strength properties of unsaturated soil. Unfortunately, most of previous research has only considered the soil-water interaction, following the assumption that the potential landslide mass is fully saturated. Only recently, a few systematic studies have been performed to understand the behavior of unsaturated soils, in which the effect of soil suction was considered. Yet, up-to-date, the number of such studies is very limited. In addition, this type of research is time-consuming and costly. For this reason, experimental data on the properties of unsaturated soils remain limited and, as a result, the mechanism of such rainfall-induced landslides remains unclear.

This study will combine Australian and Japanese expertise to generate advanced laboratory and field dataset that will help better understand the effect of soil suction on stability of natural slopes under different climate conditions. Through a combination of field surveys and laboratory studies, this research will produce a calibrated approach to accurately evaluate the possibility of landslide hazard caused by rainfall events.

(2) 研究経過の概要

At first, Dr. Gratchev and two graduated students at Griffith University conducted field investigations on some slope failures occurring in Queensland and New South Wales (Australia), and geotechnical testing had also been performed on samples taken from some landslides in Queensland.

As part of this project, continuous field monitoring on the moisture within the tephra layers on a slope in Minami Aso, Japan, had been conducted by the cooperating team in Disaster Prevention Research Institute, Kyoto University. Many large fissures were triggered on this slope by the 2016 Kumamoto Earthquake, although the slope did not suffer from landsliding with large distance. The moistures were monitored at four locations, and at each location three tensiometers were installed at three different depths (1 m, 2 m and 3 m, respectively). The monitoring system also measures air pressure, rainfall data, and downslope movement of the slope.

A joint field trip was conducted when Dr. Gratchev was staying in Disaster Prevention Research Institute, Kyoto University. Dr. Gratchev and Dr. Wang went to Nishiikawa landslide in Awaikeda Town, Tokushima Prefecture. Detailed field monitoring had been conducted on this landslide for about 4 decades, and numerous data had been obtained on the landsliding, variation of ground water table, geological, topographical and hydrological conditions of the landslide area. Some newest geophysical approaches have been also testing for the identifying the possible precursor for the start of landsliding and also for unraveling the network of flowing underground water.

A small seminar had been performed. Dr. Gratchev gave an introduction on the research results on landslides obtained by his research team, and also shared the experience of teaching, education, and doing research. Three graduated students from the Graduate School of Science, Kyoto University, also introduced their research activities and results, and had fruitful discussion with Dr. Gratchev.

### (3) 研究成果の概要

Through the field investigation on some slope failures in Australia, it was found that most of rainfall-induced landslides occurred in the area of weathered rocks on relatively steep slopes. While being stable during dry periods, such slopes typically experience stability issues during rainfall events. Laboratory examination of soil samples collected from some of these landslides indicated a significant decrease in soil strength as the moisture content of soil increased. This emphasizes the important role of moisture and soil suction on the stability of natural slopes in Australia.

The monitoring data obtained from the slope in Minami Aso revealed that within the shallow soil layers, the moisture content varied, but the deeper layer (around 3 m) showed ignorable, if any, variation, when the rainfall is little. However, perched water table was formed in deeper soil layer (around 2 m deep) on some locations. This indicates that shallow landslides could be triggered by heavy rainfall locally on some area of the slope. The monitored displacement showed that the slope suffered movement when the daily rainfall reached at 43 mm, although the sliding distance was very small. In addition, decrease of air pressure might also play role in the triggering of landsliding. Although further detailed analysis on these data is still on-going, it is clear that these data provided valuable information for us to understand the possible initiation of landsliding on unsaturated soil layers.

During the joint field trip to Nishiikawa landslide, the locations and working statues of different transducers for the monitoring of groundwater table, surficial and vertical displacements, ground temperature, and soil moisture, etc, had been re-checked, and the long-term monitoring data had been successfully re-sorted. The possible further cooperating research work based on these data obtained from this landslide had been discussed and the research topics had been figured out.

Through the seminar, Dr. Gratchev got deeper understanding on the research topics that are being conducted in Research Center on Landslides of Disaster Prevention Research Institute, and also gave valuable comments to the graduated students' research activities. Through communication with Dr. Gratchev, the students also widened their knowledge on landslides and enhance their confidence in doing research. It is also decided that Dr. Gratchev will send one PhD student from Griffith University to Disaster Prevention Research Institute to conduct experimental work to examine the initiation and movement mechanism of some typical landslides triggered by rainfall in Australia. Namely, international cooperation will be continued with the involvement of young landslide researchers.

(4) 研究成果の公表

Based on the results obtained through this collaborating research project, one or two scientific papers will be drafted for possible publication on international journals.