PHYSICAL AND CHEMICAL PROPERTIES OF SLIP SURFACE IN LANDSLIDES TRIGGERED BY HEAVY RAINFALL AT HITA, OITA, JAPAN

Mega Lia ISTIYANTI [1], Satoshi GOTO [2]

[1] Graduate Student, Civil and Environmental Engineering, University of Yamanashi (Takeda 4-3-11, Kofu, Japan)
E-mail: g18dtk06@yamanashi.ac.jp

[2] Faculty of Engineering, Civil and Environmental Engineering, University of Yamanashi (Takeda 4-3-11, Kofu, Japan)

***Key Words**: physical properties, mechanical properties, minerals, slip surface, tuff breccia*

1. INTRODUCTION

On Early July, 2017, more than 100 mm heavy rainfall occurred in northern Kyushu (**Fig. 1**). Many landslides occurred caused by heavy rainfall and those disasters was the largest in Northern Kyushu for five years.

Until last month, landslides still occurred in northern Kyushu especially Oita Prefecture. The landslides materials in this area is andesite and tuff breccia which the important materials to identify the characteristics of slip surface and mechanism of landslides also interest to identify.

The research which focused on characteristics of slip surface have a purpose to try to explain the mechanism of landslides based on characteristics of slip surface.

2. RESEARCH AREA

This research identified two location of landslides. First landslide is located in Joguyama Mountain (645 m) and near with Ono river (**Fig. 2**). This landslide contains of two kinds of rocks; tuff breccia and andesite. In this research, this landslide is called as Ono landslide. Ono landslide is located in N 33°23'23.53" E 130°56'7.25".

Second landslide is located in near with Yanase in Ohtsuru, Hita City, Oita Prefecture (**Fig. 2**). Same with Ono landslide, this landslide also contains of tuff breccia and andesite. In this research, this landslide is called as Ohtsuru landslide. Ohtsuru landslide is located in N 33°23'6.16" E 130°54'0.53".

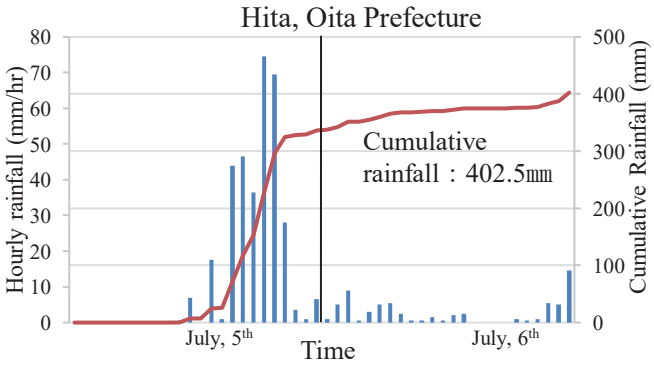

Fig. 1 Precipitation data at study site by Japan Meteorological

3. GEOLOGICAL SETTING

The research locations have not passed by active fault zone. However, Nishiyama fault zone is located near research location. This active fault zone distributed from Okinoshima to Asakura. The length of section from Kaho-gun Katsuragawa-cho until

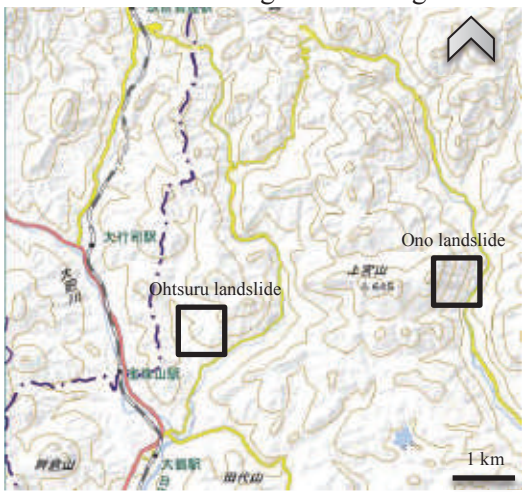

Fig. 2 Locations map of the research area (htpps://maps.gsi.go.jp)

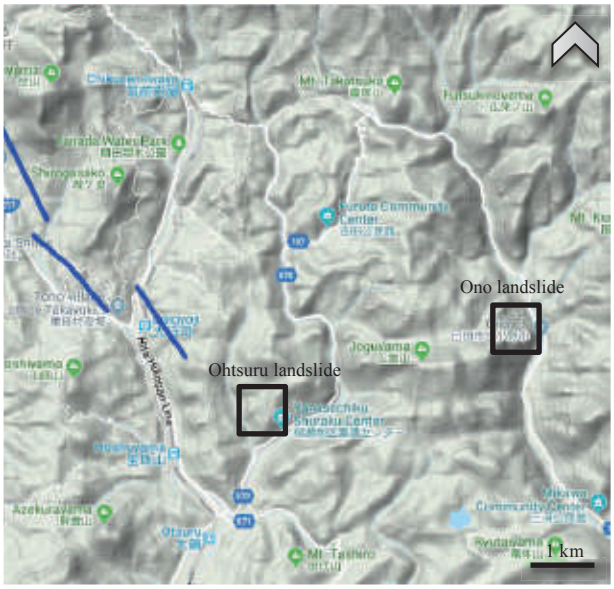

Fig. 3 Active fault zone map near research location (https://gbank.gsj.jp)

Asakura-gun Toho-mura, Asakura-shi is 29 km (**Fig. 3**) (http://gbank.gsj.jp).

The landslide materials in research area (tuff breccia and andesite) are volcanic rocks which erupted from Late Miocene-Pliocene (7.246-2.588 Ma) (https://gbank.gsj.jp).

4. METHODS

Soil hardness test was performed with Yamanaka Fujiwara Seisakusyo, Ltd soil hardness tester. Soil hardness was measured in soil layers at field observation locations (Ono landslide: A, B, and C layer; Ohtsuru landslide: Highly weathered andesite, weathered andesite, and tuff breccia) and obtained ten measurements at each layer. Soil physical properties analyses were performed in Atterberg limits analysis and density of soil particles. Soil chemical properties analyses were performed ignition loss analysis. Furthermore, to measure the minerals on the soil layers, X-ray diffraction analysis was performed.

5. RESULTS AND DISCUSSION

(1) Ono landslide

The dimension of Ono landslide is 30,000 m^2 with volume landslide 300,000-450,000 m^3 (Japan Society of Erosion Control Engineering, 2017). On the geomorphological analysis with contour map, the landslide movement started from the highest of contour around 400 m going collapse down to around 200 m (**Fig. 4**). The assumption for slip surface on cross section in figure 4 was determined from elevation on field observation.

Photo 1 shows the landslide in Ono and the surface of the landslide. The surface of the landslide

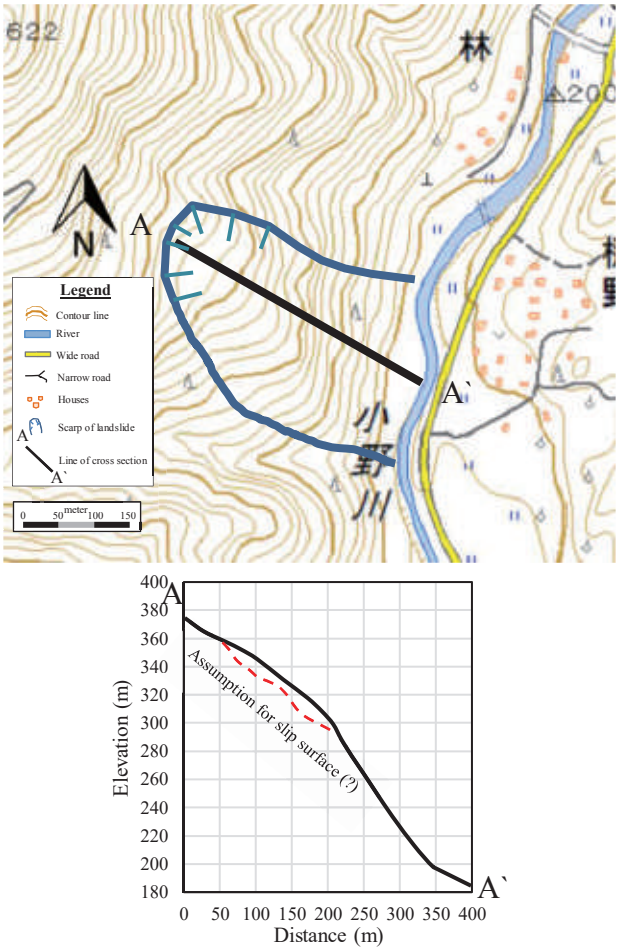

Fig. 4 Geomorphology analyses and cross section in Ono landslide (https://maps.gsi.go.jp)

in Ono which have the red color is an assumption for the location of slip surface.

a) Soil properties analyses

Ono landslide consists of 3 soil layers (**Photo 2**), the soil layers separated by color and grain size. Soil physical properties analysis results in **Table 1** shows

Photo 1. Ono landslide and the slip surface on the landslide

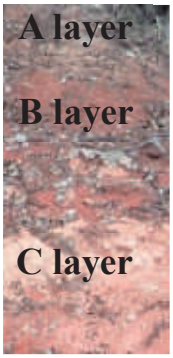

Photo 2. Soil layers in Ono landslides, the photo was taken in the slope of landslide

Table 1 Soil properties analysis results in Ono landslide

Soil Layer	ρ_s (g/cm^3)	PI	L_i (%)	Soil hardness (mm)
A	2.717	12.88	15.489	25.0
B	2.807	10.90	15.375	20.7
C	2.752	9.79	16.925	31.1

not specific different results. Soil hardness in A layer have a range between 23~28, B layer 18.5~22.5, and C layer 28~35. Soil hardness decrease from A layer to B layer, furthermore, increase from B layer to C layer.

The ups and down on the value of soil hardness represent the slip surface is located at B layer. The soft ground is easily to collapse.

b) Minerals analyses

The X-ray diffraction analysis shows the clay minerals more contains in A and B layer, moreover, C layer more contains hornblende and plagioclase (**Fig. 5**). Landslide materials in Ono, contain smectite, kaolinite, illite, illite-montmorillonite, hornblende, and hematite. Smectite, kaolinite, illite, and illite-montmorillonite are type of clay minerals.

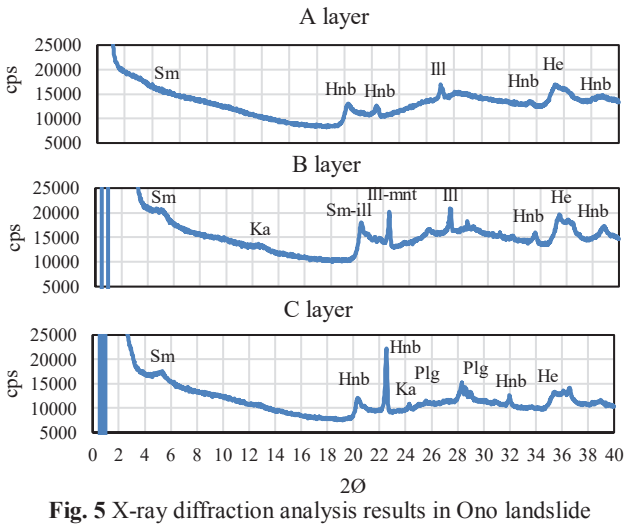

Fig. 5 X-ray diffraction analysis results in Ono landslide

Plagioclase and hornblende are kind for igneous rocks base minerals on Bowen reaction. On Mitchell and Soga (2005), Hematite is other clay minerals in oxides group.

On the soil properties analyses results, B soil layer represent the slip surface characteristics. However, on the minerals analyses results, different contain between A and B layer with C layer may represent the slip surface characteristics.

(2) Ohtsuru landslide

On the geomorphology analysis with the contour map, the landslide movement started from the highest of contour around 240 m was going collapse down (**Fig. 6**). From the contour line analysis, two water flow with opposite direction (brown color) were discovered. Those water flow can be an espousal factor for Ohtsuru landslide.

a) Soil properties analyses

The landslide materials in Ohtsuru landslide also divided into three soil layers: highly weathered andesite from 60 to 180 cm, weathered andesite from 180 to 520 cm, and tuff breccia from 520 cm to the bottom (**Photo 3**).

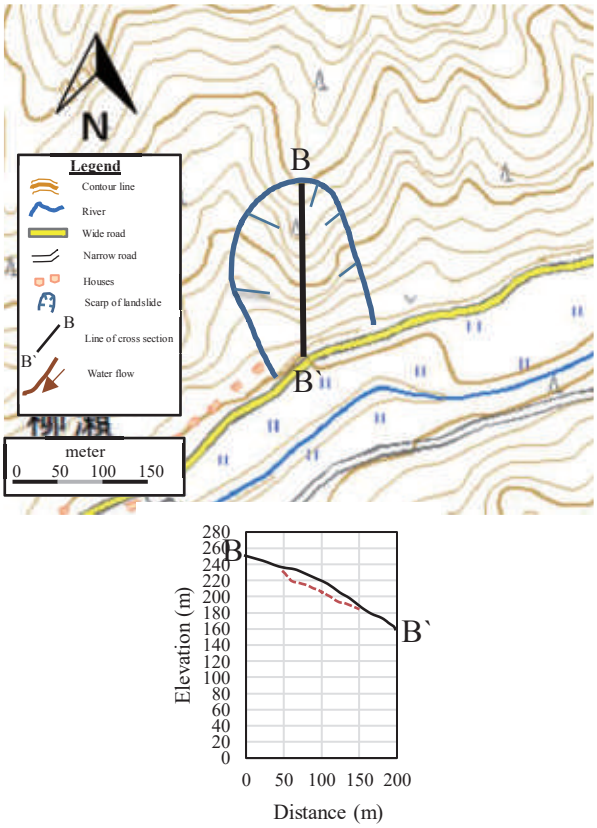

Fig. 6 Geomorphology analyses and cross section in Ohtsuru landslide (https://maps.gsi.go.jp)

Soil physical properties analysis results in **Table 2** shows not specific different results. However, the results are different from Ono landslide. Plasticity Index value is decrease from highly weathered

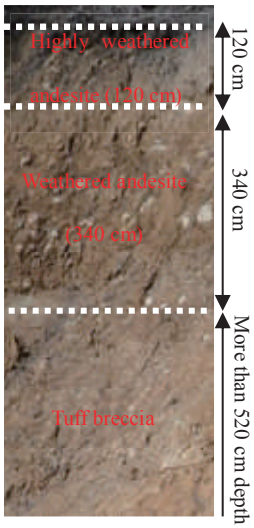

Photo 3. Soil layers in Ohtsuru landslide

Table 2 Soil properties analysis results in Ohtsuru landslide

Soil Layer	ρ_s (g/cm^3)	PI	L_i (%)	Soil hardness (mm)
Highly weathered Andesite	2.745	11.70	10.002	13.4
Weathering Andesite	2.754	8.93	12.699	12.7
Tuff breccia	2.717	11.41	11.623	22.0

andesite layer to weathered andesite layer. From weathered andesite layer to tuff breccia, Plasticity Index value is increase. Soil hardness in highly weathered andesite have a range between 10~17, weathering andesite 10.5~16, and tuff breccia 18~23. Soil hardness decrease from highly weathered andesite to weathering andesite, furthermore, increase from weathering andesite to tuff breccia. However, the soil hardness value in tuff breccia layer is high.

Soil physical properties analysis results in **Table 2** shows not specific different results. However, the results are different from Ono landslide. Plasticity Index value is decrease from highly weathered andesite layer to weathered andesite layer. From weathered andesite layer to tuff breccia, Plasticity Index value is increase. Soil hardness in highly weathered andesite have a range between 10~17, weathering andesite 10.5~16, and tuff breccia 18~23. Soil hardness decrease from highly weathered andesite to weathering andesite, furthermore,

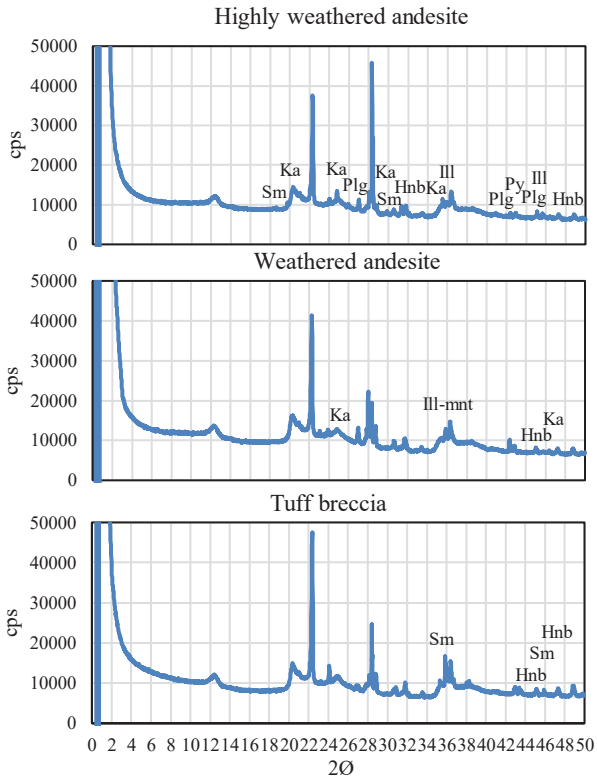

Fig. 7 X-ray diffraction analysis results in Ohtsuru landslide

increase from weathering andesite to tuff breccia. However, the soil hardness value in tuff breccia layer is high.

Different with slip surface in Ono landslide, the slip surface in Ohtsuru landslide is represent with high Plasticity Index. The water flows are the reason for the location of slip surface. Even the tuff breccia has a high soil hardness value, the accumulation of water from water flows can triggered the soil layer to collapse.

b) Minerals analyses

X-ray diffraction analysis results shows many kinds of minerals are contained in highly weathered andesite, different with other soil layer (**Fig. 7**). Weathered andesite and tuff breccia are contained a few of minerals such as kaolinite, illite-montmorillonite, hornblende, and smectite.

Tuff breccia contains a smectite which have a swelling ability. The water flow may have located at the boundary of tuff breccia and andesite layer and have a reaction with smectite in tuff breccia. The swelling ability on smectite can triggered the collapse of tuff breccia layer.

6. CONCLUSION

Ono landslide and Ohtsuru landslide triggered by same heavy rainfall. However, the characteristics of slip surface on landslides are different.

The slip surface of Ono landslide has a low soil

hardness. B layer which have a low soil hardness value was slip surface in Ono landslide. Position of B layer is outflanked with A and B layer, moreover, the soil hardness value in both A and B layer is higher than B layer. That can be an assumption for the collapse of B layer.

Different with Ono landslide, slip surface of Ohtsuru landslide has a relation with water flow, smectite, and Plasticity Index. During heavy rainfall, the accumulation water from water flows near the boundary of andesite and tuff made a swelling reaction on tuff breccia layer. The tuff breccia layer contains of smectite. The high Plasticity Index value in tuff breccia represent the tuff breccia has an ability to swell.

ACKNOWLEDGMENT: The completion of this paper could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Part of this study was carried out by JSPS KAKENHI Grant Number JP17H03303 and by research and development grand for river management and erosion control engineering (Ministry of Land, Infrastructure, Transport and Tourism) and Center for Instrumental Analysis in Yamanashi University. We would like to express our acknowledgment to the members concerned.

REFERENCES

1) Japan Society of Erosion Control Engineering: Learn from sediment-related disasters caused by torrential rain in the Northern part of Kyushu, 2017.
2) Mitchell, J. K. and Soga, K.: Fundamentals of soil behavior, ISBN-13:978-0-471-46302-3, 2005.
3) Istiyanti, M. L. and Goto, S.: Physical properties of weathered tuff breccia on the landslide triggered by rainfall in Ono, Hita, Oita Prefecture, Annual meeting Civil Engineering 45th Kanto Area, pp.III-59, 2018.
4) Istiyanti, M. L and Goto, S.: Soil physical properties of igneous rock stratigraphy in landslide induced by rainfall in Ohtsuru site, Hita, Oita Prefecture, 73rd Japan national conference on Civil Engineering, 2018.

(Received May 18, 2018)