二種類の火山性地すべり土における完全軟化強度定数の差異
The variation of fully softened shear angle in two soils of volcanic origin

Shriwantha Buddhi VITHANA*, Shinya NAKAMURA**, Sho KIMURA*** and Kazuhito SAKAI**

Introduction
The study of mobilized friction angle in first-time slides (Φ) is important in the engineering design of their containment works. Although Φ may be assumed to be equal to the peak strength of the soil, in many cases, it may be lower than the intact peak strength. It may, thus, be crucial to understand that aspect of the first-time landslide related issues to execute a more appropriate pre and post disaster planning and construction. We have strived to investigate a number of landslide soils to understand the relationship between Φ and the platy layer silicate mineral (PLSM) content available within the sub 425μ particle size range, especially with a view to establish some correlation between the two parameters of fully softened shear angle (Φfs) and PLSM. In this article, we only wish to present some of the findings that we have made regarding landslide soil material that have a volcanic origin to it.

Materials and Methods
Of the two landslide soils that we wish to discuss here, the Kamenose landslide, located in Kashihara, Osaka, Japan, is geologically composed of the Miocene volcanic rocks and conglomerates overlying the granitic rocks of the Paleocene era (Yamaguchi, 1980, JLS, 2002). The second landslide discussed here is the Hitamiwa landslide that is located in the Oita Prefecture of Japan, which is underlain by pyroclastic flow deposits. The soil samples were air-dried in the laboratory and milled to and passed through the standard sub 425 µm sieve. The grain size analysis was performed according to the standards set out by the Japanese Geotechnical Society (2010), which are in general agreement with the ASTM standards. The grain size distribution was measured by ultrasonic wave vibration of a soil suspension followed by sedimentation. Subsequently, the clay and silt fractions were siphoned and separated and the sand fraction was separated by sieving. The mineralogical composition was analyzed by X-ray diffraction described by Egashira et al. (2000). The ring shear test used in the study is in agreement with the ASTM standards for torsional ring shear testing outlined in the ASTM D 7608-10, which commissions the ring shear test for the relatively rapid determination of the drained fully softened shear strength, considering the short drainage path through the thin specimen and failure occurring near the top porous stone.

Results and Discussion

Grain size distribution, Plasticity Index and Mineralogy
Table 1 summarises the plasticity indices (PI) and grain size fractions of the two samples of Kamenose Landslide soil (Tuff) and the Hitamiwa landslide soil (Pyroclastic deposits). PI in Kamenose sample is almost 8 times more than that of Hitamiwa sample. Although there is not much of a difference between the silt content between the two samples, there is conspicuous differences in terms of clay fraction (CF) and sand content. Table 2 presents the mineralogical breakdown of the two samples. Evidently, the Hitamiwa sample is dominated by quartz, feldspar and other sand-sized mineral particles (98%), whereas the Kamenose sample is dominated by smectite clay (77%).

Difference in Fully softened shear angle
The average fully softened shear angle (Φ_{fs}) has shown a vast difference between the Hitamiwa and Kamenose samples, which is a direct manifestation of their respective mineral constitution. As can be seen in fig. 1, the fully softened shear angle measured in the two samples below and above an effective normal

*鹿児島大学大学院連合農学研究科 *The United Graduate school of Agricultural Sciences, Kagoshima University,* **琉球大学農学部 *Faculty of Agriculture,* ***琉球大学農学部協力研究員 *Researcher at Faculty of Agriculture, University of the Ryukyus*
キーワード：土の静力学的性質，完全軟化強度，リングせん断試験

stress of 150 kN/m^2 has decreased almost by half in the Kamenose sample over the Hitamiwa sample. This prominent decrease shear angle values can be expected from such soils as Kamenose, where the mineralogy is predominantly composed of platy layer silicate minerals like smectite. As against the rolling mode of particle-to particle interaction during shear is considered, the sliding of parallel aligned plate-like particles tend to produce low shear angles and correspondingly low shear strengths in soils, especially at large displacements in the order of hundreds of milimeters. What is seen here with these results is that even the Φ_{fs}, which is achieved in relatively much shorter displacements of a few millimeters, has been significantly lower in PLSM rich soils like Kamenose compared to soils that are completely devoid of or have relatively small amounts of it. The explanation is such that in the case of PLSM rich soils, the random particle orientation even at the fully softened stage may be mostly parallel to each other and could, thus, produce very low shear angles from the beginning of shear as is evident from these results.

Table 1. Plasticity Index and Grain Size Distribution of Samples

No.	Landslide	Code	PI	CF%	Silt%	Sand %
1	Hitamiwa	PYR	8.7	45.2	25.4	29.3
2	Kamenose	TF	64.0	79.2	17.8	9.0

Table 2. Mineralogy and Total Platy Layer Silicate Content of Samples

No.	Landslide	Code	PLSM%	St	Vt	Ch	Mc	Sp	Qz	Fd	Oth
1	Hitamiwa	PYR	2.0	0	0	0	2	0	66	16	16
2	Kamenose	TF	79.0	77	0	0	2	0	14	3	4

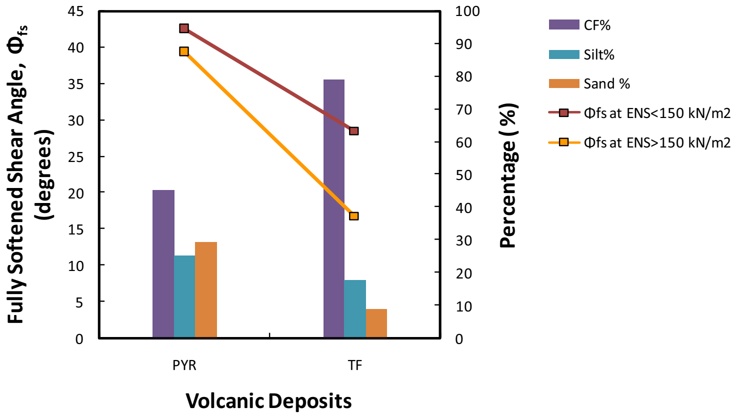

Fig. 1. Fully Softened Shear Angle (Φ) in Relation to Grain Size

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