複合災害科学部門　災害機構解析分野

Shearing rate effect on residual shear strength of natural soils obtained from mudstone landslide areas of Niigata, Japan

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1. Introduction

Residual shear strength of a soil specimen depends on many factors that include but not limited to mineralogical composition, pore water chemistry, physico-chemical effect and shearing rate. Very few articles in the literature are available that show variations in residual shear strength for slow shearing rates (below 1 mm/min). None of the articles in the literature presented information on shear strength variations with shearing rates lower than 0.01 mm/min. The main objective of this study is to carry out the shearing rate effect on residual shear strength. Results pertinent to the experimental verification of shearing resistance of soil specimens from three different landslides are presented in this paper. All of these landslides were triggered in mudstone formation.

2. Study Area

Soil samples were collected from Mukohidehara, Nakayama and Okozu landslides of the Niigata Prefecture. The sliding surfaces of all the landslides were developed along the mudstone formation. Mukohidehara Landslide was triggered several decades ago at the interface between the weathered and unweathered mudstone. The Nakayama Landslide was triggered by a torrential rain on 13th July, 2004. The sliding surface is observed at the depth of approximately 2.5m below the ground level. The Okozu Landslide is developed by the toe undercutting by the Okozu diversion channel.

3. Soil Sampling and Testing procedure

Soil samples collected from the sliding surfaces were remolded and were remixed to a moisture content equal to 120% of liquid limit to make slurry samples. Those slurries were set into the drained type Ring shear device of the RINHDR laboratory. The slurry was then consolidated at the consolidation pressure of 250 kPa until 100% consolidation was achieved. Then, different specimens consolidated in this manner were sheared at the shearing rates of 0.001, 0.01, 0.1and 1 mm/min. A shearing rate of 0.01 mm/min is considered as the minimum shearing rate to ensure fully drained conditions during shearing. Multi-stage ring shear tests were performed by lowering the normal stress to 200 kPa, 150 kPa, 100 kPa, and 50 kPa. The residual shear stress values were recorded for each stage to obtain the residual shear envelope.

4. Results and discussions

The shear stress-horizontal deformation curve obtained at the normal stress of 200kPa for the soil specimen of Mukhohidehara landslide, while sheared at the rate of 1mm/min as presented in Fig. 1. The mobilized residual shear stress was attained at a displacement of 400mm. The stress-deformation curve at the normal stress of 200kPa for the soil from Nakayama landslide, which was sheared at the rate of 0.001mm/min is presented in Fig. 2. The residual shear stress was mobilized at the horizontal displacement of 20mm.

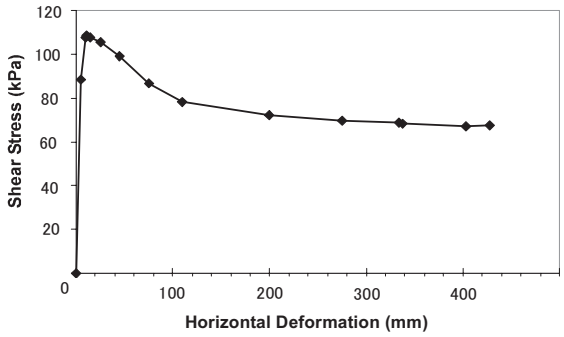

Fig. 1 Shearing rate of 1mm/min

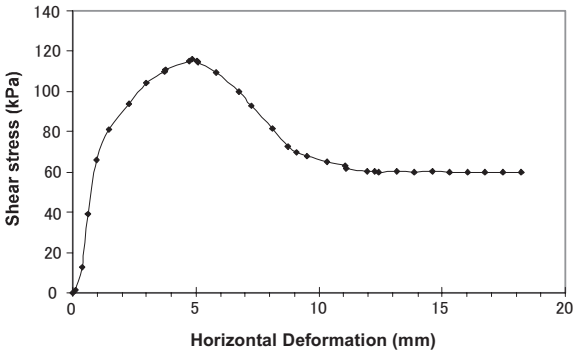

Fig. 2 Shearing rate of 0.001mm/min

Figure 3 as shown below shows the comparison of shear envelopes of soil samples from the Nakayama landslides sheared at 0.001, 0.01, 0.1 and 1mm/min. Figure 4 as shown below shows the variation in residual friction angle with the shearing rate of different landslides soil samples.

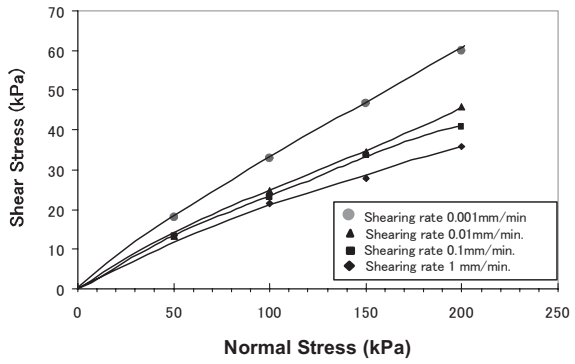

Fig. 3 Comparison of shear envelopes

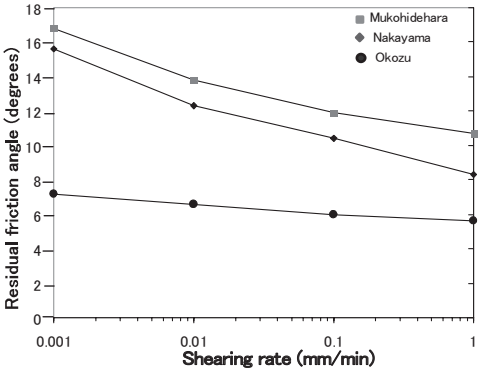

Fig. 4 Variation in friction angle with shearing rate

The result shows that there is linear decrease in frictional resistance with a logarithmic increase in shearing rate. The interesting phenomenon that was observed in this study is the requirement of less displacement to attain residual shear stress in case of very slow shearing rate. The development of the pore pressure at the higher strain rate might have caused the shear stress to decrease. Therefore, it is essential to measure pore water pressure for higher shearing rate in drained condition type ring shear machine too. (This paper was presented in the International Conference on Ground Improvement and Ground Control, 30th Oct. -2nd Nov. 2012, Wollongong, Australia)