International Research (Project No.: 2020W-01)

Project name: On the rock pulverization during shearing and its implication for the initiation of catastrophic rock avalanches and larger earthquakes

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Research period: April 1, 2020 to March 31, 2022

Research location: Research Center on Landslides, DPRI, Kyoto University; Daguangbao Giant landslide triggered by 2008 Wenchuan Earthquake, China; Outcrop of Median Tectonic line in Awa-Ikeda, Tokushima, Japan; Outcrop of Alpine fault in South Island, New Zealand

Number of participants in the collaborative research: 7 (DPRI staff: 3, non-DPRI staff: 4)

- Number of graduate students: 9 (Master students: 3, Doctor students: 6) (Included number)
- Participation role of graduate students [assistant in experimental works, data analysis, and discussion]

Implementation status in FY2020

The purpose and significance of this study: In recent years, earthquakes and landslides due to the shear failure of earth materials occurred frequently, resulting in devastating damages to local society and human life. However, for those giant coseismic landslides, it is almost impossible to perform countermeasures to prevent or reduce their possible resultant disaster. Therefore, understanding their initiation and movement mechanisms and then elevating the precision of hazard maps for them become crucial. On the other hand, it is normally understood most of the inland earthquakes results from the shear failure of existing active faults. Unraveling the repeated shear failure behavior of fault gauge is of great importance for understanding the initiation of inland earthquake. In this study, we plan to examine the shear failure behavior of rocks with wide grain size distribution (from gravel to nano size) under different shear rates (from 0.001 mm/s to 2.3 m/s). Although the pore-fluid pressure and frictional heating are widely accepted as the mechanisms reducing frictional resistance in faults and landslides, this study will try to examine the role of associated intense rock pulverization on the shear behavior of earth materials. We assume that the high-frequency elastic body waves, radiating from breaking fragments, recycle energy to mimic high-pressure mechanisms. This may be what really reduces the friction, making crushing rock a lubricant. We propose experiments with dense granular flows to determine levels of grain-breakage intensity at which recycled elastic wave energy reduces shear resistance. By listening to breaking rocks, we expect to learn how they help lubricate earthquakes and landslides.

Research activities and results in 2020: To achieve above-mentioned research targets, we conducted field surveys at first on some mage-landslides triggered by the 2008 Wenchuan earthquake in Sichuan, China, examined the internal structures of the landslide deposits, and took samples from the layers near the sliding surface. We also took samples from the fault gauges of Median Tectonic line that outcropped in Awa-Ikeda, Tokushima, Japan. The grain sizes of these samples had been performed. By using the almighty ring shear apparatuses developed in Disaster Prevention Research Institute, Kyoto University, we also conducted fast shear tests on the sample taken from a mega landslide in Sichuan, China, on halite (~5 mm in diameter) and nano materials (nano silica material, and tube-shaped halloysite). Through shear these samples at different shear displacement rates, the shear behaviors of these materials were examined. By using a 3D X-ray CT, the internal structure of the shear zones formed during the shear tests on clayey material and halite had been examined and analyzed. Basing on these results, the possible mechanism for the shear weakening of shear resistance with shear rates had been examined.

Implementation plan in FY2021

To realize the research targets as proposed, in FY2021, following items will be conducted.

1) Continuing the shear tests on differing samples with different grain size and/or brittleness, to examine their shear behaviors under different shear rates.
2) Shearing halite at different normal stress and shear displacement, to examine the variation of shear resistance with progress of shear zone. X-Ray CT will be used to examine the internal structure of the shear zone in the test subjected to different shear displacement.
3) AE sensors will be installed to monitor the progress of shear failure from the point of view acoustic emission.
4) Shear tests will be conducted on the same sample repeatedly to examine the recovery of sheared samples and also to examine the dissipated energy during the shear process. The dissipated energy will provide us an approach to evaluate the possible failure mobility of landslides, or the initiation of larger earthquakes.
5) Summering the results and submitting papers for possible publication on internal journals.