

萌芽的共同研究（課題番号：28H-05）

課題名：New Experimental Insights into Frictional Behaviour and Acoustic Emission of Locally Sheared Granular Materials:
Implications for Landslide Dynamics

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研究場所：Research Center on Landslides, Disaster Prevention Research Institute, Kyoto University

共同研究参加者数：5 名（所外 1 名，所内 4 名）

- ・大学院生の参加状況：1 名（博士 1 名）（内数）
- ・大学院生の参加形態 [Conduct tests, analyze data, summarize results, and write papers for publication]

研究及び教育への波及効果について

Understanding the mechanical behaviors of granular materials in shear has attracted considerable interest in the context of landslide dynamics. Modern insight into the granular shearing processes has been provided by new evidence, showing that the fluctuations of internal forces involve the release of stored elastic energy. According to the purposes of the present research project, we measured the stress fluctuations and acoustic emissions (AEs) under a range of shear rates for granular assemblies with different particle sizes by performing ring-shear friction experiments. Experimental results show that the shear behaviors can be affected by both shear rate and particle size. The observations of AEs reveal that the main acoustic bursts are strongly correlated with the major mechanical failures. The maximum absolute amplitudes of AEs generally increase with increase of the magnitudes of stress drops, and greater average occurrence rates of AEs are observed for smaller particles and higher shear rates. The primary AE frequency bands are in the tens of kHz ranges for the granular materials, and more acoustic energy is released with increase of shear rate and particle size. By scrutinizing the time difference between the main AEs and major mechanical failures, it is found that the onset of AEs precedes the impending global mechanical failures by several milliseconds. This sequence suggests that local failures within granular materials may occur first, and then result in the generation of AEs. The findings of the present study provide further understanding of the mechanical behaviors of stressed granular materials so may prove useful for hazard assessment and mitigation.

研究報告

(1) 目的・趣旨

One of enduring questions in landslide physics is that of how to better understand the progressive failure processes, and subsequent rapid phenomena of constituent granular materials. In general, the granular materials can gain frictional forces via the interaction of grains to resist motions, and they also can fail in a way that shows instability (such as periodic stick-slip, random or stepped fluctuations) or stable sliding. Over the past several decades, a large body of efforts has been motivated to reveal the involving physical processes and failure mechanisms during granular deforming, and the observations of acoustic signals have been gradually approached to these aspects. In the present study, we seek to examine the correlations between mechanical behaviors and AEs for locally sheared granular materials with varying particle sizes and to identify the time sequence between the mechanical response and acoustic energy release. The issues of primary concern include (1) whether the AE events are correlated with instability events, (2) whether the AE events are dependent on shear rate and particle size, and (3) whether the AE events are precursors or resultant phenomena of mechanical failures.

(2)研究経過の概要

We used cohesionless glass beads to remove particle shape as a variable and isolate the role of particle size, and one intelligent ring shear apparatus (DPRI-5) were employed to meet the demands of a wide range of shear speeds. All dry granular assemblies with uniform particle size ranging from 0.1~5 mm were sheared under the room temperature and humidity. Significantly, for measurements of elastic waves, three high frequency AE transducers were installed near the shear plane, and AE signals were amplified by 40 dB and were digitized with a sampling rate of 1MHz during the shear tests. By employing an additional recording system, the mechanical data and AE data were simultaneously recorded. With the help of Prof. Masahiro Chigira (DPRI, Kyoto University) and Mr. Yasuto Hirata (Graduate School of Science, Kyoto University), post-test SEM analyses were performed. Data were analyzed and discussed among all collaborative members, and more useful discussions were also carried out with Mr. William Schulz (U.S. Geological Survey) and Dr. Mauri McSaveney (GNS Science, New Zealand).

(3)研究成果の概要

Experimental results show that the mechanical behaviors of shear resistance, sample compaction and slip displacement, and the release of acoustic energy can be affected by both shear rate and particle size. The main AEs are strongly correlated with the global mechanical failure, and the maximum absolute amplitude of AEs generally increases with increase of the magnitude of stress drops. By analyzing the event sequences, it is found that the onset of AEs precedes the beginning of stress drop, which provided more useful information on the failure mechanisms of geologic granular materials. Through this New Exploratory Research Project, we introduced our research results on International Journals and conferences, some relating works have been already published and several other papers are under the processes of preparation.

(4)研究成果の公表

Jiang, Y., G. Wang, and T. Kamai, 2017. Acoustic emission signature of mechanical failure: Insights from ring-shear friction experiments on granular materials, *Geophysical Research Letters*, 44, doi:10.1002/2016GL071196.

Jiang, Y., G. Wang, T. Kamai, and M. McSaveney, 2016. Effect of particle size and shear speed on frictional instability in sheared granular materials during large shear displacement, *Engineering Geology*, 210: 93-102.

Jiang, Y., G. Wang, and T. Kamai, 2016. Experimental investigation on the frictional behavior of granular materials: Implications for better understanding landslide mobility. Annual Meeting of Japan Geoscience Union, Abstract: HDS05-11, Chiba.

Jiang, Y., G. Wang, and T. Kamai, 2016. New experimental constraints on frictional instability of simulated halite shear zones. Annual Meeting of Disaster Prevention Research Institute, Kyoto University. Abstract: D04. [Student Outstanding Presentation Award]