Characteristics of mechanical response and acoustic emission during granular shearing

Yao Jiang\(^1\) and Gonghui Wang\(^2\)

\(^1\)Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China (yjiang@imde.ac.cn)
\(^2\)Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan (wanggh@landslide.dpri.kyoto-u.ac.jp)

The shear behavior of granular materials has drawn considerable attention due to its great potential for various geophysical processes such as landslides and debris flows. Field and remote sensing observations reveal that the progressive maturation of these geophysical events may involve different styles of movement, such as stable creep, periodic slow sliding or accelerative sliding. Laboratory experiments also suggest that the mechanical conditions of granular materials may play a significant role in controlling diverse frictional behaviors, such as shear-rate weakening or strengthening. Furthermore, the granular frictional processes may involve abrupt perturbations of internal forces and release of strain energy. Such energy release events are manifested in the generation of high frequency (kHz-MHz) elastic waves, termed acoustic emissions (AEs), which deliver important information concerning the physical processes of granular shearing deformation.

A significant, though still inconclusive, body of research has been directed toward revealing possible mechanisms of AEs occurring on rock or among granular materials in shear. These studies attributed the generation of AEs to the formation of microcracks in intact rocks, the breaking of asperities between solid surfaces or the rearrangement of grain contacts. In this study, we performed laboratory tests on granular analogues composed of spherical glass beads in a ring shear configuration under conditions of room temperature and atmospheric humidity to examine whether the AE events are correlated with mechanical response. For measurements of elastic waves, a high-frequency AE transducer was installed near the shear plane. AE signals and mechanical data were synchronously sampled at the rate of 1 MHz using an additional recording system.

The results show that (1) there is a strong correlation between the stress drop and the main acoustic burst; (2) the primary frequency bands are in the tens of kHz ranges for acoustic signals generated during granular shearing; (3) the onset of AE amplitudes precedes the impending global mechanical failures by several milliseconds.