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high speed friction experiments of granular layers

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In a microscopic view, natural faults generally consist of gouge layers, the frictional properties of which are much richer than the celebrated rate-state friction law. One of such examples is intermediate-to-high slip velocity (mm/sec-m/sec) regime, where anomalous weakening and, at the same time, strengthening are reported; the results differ from experiments to experiments. In order to understand such a complicated phenomenon, one must carefully control the physical processes that potentially affect the frictional properties.

In this study, friction experiments of the glass-beads layers at slip rate of 10um/s-1m/s were conducted. The aim of this experiment is to validate the power-law friction in closely-packed granular materials found by one of the authors (Hatano, 2007) by a numerical experiment using the discrete element method. Experiments were performed at constant normal stresses of 10-50kPa using a ring shear apparatus with inner/outer diameters of 15mm/25mm. We used spherical soda-lime glass beads of diameter 200-300um.The thickness of beads layer is about 2000 um. Temperature beneath the lower plate was set to 25 degrees C and kept constant with Peltier Plate.

It is found that the power-law dependence of the friction coefficient on slip velocity overwhelms the logarithmic rate dependence which originates from the rate-state friction law. Friction coefficient decreases with increasing slip velocity in low slip velocity regime (10um/s˜1cm/s) with velocity dependence of about -0.01 per decade of slip velocity. In high slip velocity regime (1cm/s˜1m/s) it becomes velocity strengthening. Granular layer dilates with increasing slip velocity in higher velocity regime (larger than 100um per decade of sliding velocity) and this velocity dependence of dilatation is lager than that of usual rate- and state- dependent friction.