Experiments on granular rheology: effects of particle size and fluid viscosity

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We report the results of shear experiments of a thick layer of dry and liquid-saturated glass beads, a simplified model of fault gouge, in order to clarify and to compare how the particle size and fluid viscosity affect the granular rheology. We sheared sorted glass beads and measured the temporal variation of stress that fluctuates due to stick-slip behavior. We found that the stress drop and slip recurrence intervals increase with the particle size because of larger static bulk friction. The forms of stress - time series data for different particle size are not self-similar; it changes towards a saw-tooth-like temporal variation as the particle size increases, which can be characterized using two newly defined dimensionless numbers. In addition, we show that there is a continuous transition from constant slip velocity towards constant stress drop time as the particle size increases. We also determined the shear band width using the time-lapsed images of the sheared glass beads and found that the number of particles comprising the shear band decreases with the particle size. When the glass beads are saturated with viscous liquid, lubrication causes the rheology to change from frictional to viscous and to increase the slip recurrence interval, and these properties can be used to distinguish from the particle size effects. Under a fixed loading rate, there is a viscosity that minimizes the stress needed for shearing, at which we can separate the frictional and viscous regimes.

Reference:Higashi, N. and I. Sumita, JGR, 2008JB005999 (in press).