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Investigation of strain localization in sheared granular material using 3D numerical discrete element model

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We used three-dimensional numerical simulations of the discrete element method (DEM) to investigate slip localization in sheared granular faults under seismic velocities. An aggregate of non-destructive spherical particles with assigned contact properties is subjected to direct shear with periodic boundary in horizontal directions. To investigate whether particle size distribution (PSD) influences slip accommodation, three distinct PSDs, namely Gaussian, log-normal, and power-law with fractal dimension D ranging from 0.8 to 2.6, are employed. In additional simulations, we impose a thin layer of particles with smaller grain size along the boundary as well as in the middle of the granular assemblages to simulate boundary and Y shears occurring in both natural and laboratory fault gouges. Transient microscopic properties, such as particle motion and contact forces, as well as macroscopic properties, such as friction, of the granular layer, are continuously monitored during numerical shearing. Results show that no visible slip localization is observed for all different PSDs based on the current particle motion analysis. On the other hand, we find that much more strain (i.e., displacement) is accommodated in the finer-grained layer even with a small contrast in grain size. Up to 90 % of the displacement is localized in a finer-grained layer when the contrast ratio of the grain size is 50 %. Since more frictional heat will be generated in the localized slip zone, the results provide crucial information on the heat generation and associated slip accommodation in sheared gouge zones. A possible mechanism of slip localization in the simulations is the transfer of the momentum across the granular system. We conclude that the occurrence of a weaker, fine-grained layer within a dense fault zone is likely to result in self-enhanced weakening of the fault planes. Ongoing work includes (1) varying the thickness, grain size, and internal friction of the thinner layer; (2) applying triangulation methods to further analyze the microscale stress and strain tensor between particles; (3) changing the rolling friction of particles.