Contribution ID: **810** Type: **not specified**

Coupled CFD-DEM modelling of granular porous media under shear: implications for dynamics of faults with granular gouge

Granular porous materials subjected to shear stress are involved in many geological catastrophes including earthquakes, landslides and avalanches. The dynamics of a sheared granular layer is controlled by its particle properties, loading configuration, temperature and pore fluids. While field and laboratory experiments have studied the role of pore fluid in granular interactions within geological systems, they lack detailed information about pore- and grain-scale mechanisms that dictate mechanics of deformation and evolution of macroscopic characteristics. Here a 3D coupled Computational Fluid Dynamics-Discrete Element Method (CFD-DEM) is used to model stick-slip dynamics in a granular porous system, saturated with fluids, aiming to better understand the hydro-mechanical influence of fluid flow. Our focus here is dedicated to the effect of fluid flow on the characteristics of slip events i.e. friction coefficient drop, potential energy drop, thickness change etc. that are measured and analysed statistically using information of hundreds of slip events in a drained system. Our results show that, slip events are characterized by a higher drop in friction coefficient, in potential energy and thickness of the granular porous layer compared to the dry conditions. Our results show a fluid-assisted type of particle mobilization in the fluid saturated system, where the high dynamic fluid pressure is found to stem from the fast fluid flow during slip caused by particles rearrangements. The spatial correlation of regions with high fluid velocity, particle-fluid interaction and particle kinetic energy during slip demonstrates the strongly coupled mechanisms of particle rearrangement, increase of fluid pressure and particle-fluid interaction forces. This study emphasizes the important role of fluid-particle interactions at play in sheared granular porous media present at tectonic fault damage zones showing how numerical models, and in particular the coupled CFD-DEM approach, can help understand the hydro-mechanical processes that dictate fault slip from a grain-scale point of view.

References

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Track Classification: MS 7 Mathematical and numerical methods for multi-scale multi-physics, non-linear coupled processes