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Estimating robustness of micromechanic localization models

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Within the last decades numerous studies, both laboratory and numerical, have revealed that the development of fault structures in granular materials such as fault gouge or soft sediments depends on a micro-scale level on many controlling factors, e.g. grain size distribution, grain shape, internal texture etc. However, to date, no accurate quantifiable description of the relationship between these grain-/texture specific key factors and the deformational characteristics of a granular material exist. Furthermore, comparability between most of these studies is hindered by the use of different methods, approaches, and experimental setups. This also implies a high variance in initial configurations, e.g. sample preparation, which also may influence the obtained results.

We investigate the localization of strain respectively the evolution of fault zones in a granular specimen on a microscopic scale with a numerical modeling technique, the Discrete Element Method (DEM). Major aim is to examine on a microscopic level if localization is influenced by extremely small changes in initial conditions, e.g. particle configuration or sample preparation respectively. Our model implements a very common and simple DEM approach, a numerical shear box which is built in resemblance to a laboratory direct shear test. The specimen within the shear box is similar to fine grained silt. We conduct numerous model runs with slightly changed particle packages to quantify their influences on deformation behavior and shear strength (coefficient of friction). Therefore, we analyzed our model results with a statistical approach - a cluster analysis. This enables us to detect similarities between model runs and to define specific groups which then can be assessed.

Our analysis reveals that for a sufficient number of model runs, distinct groups with very different localization features emerge while shear strength remains relatively unaffected. Deformation features encompass boundary shear und distributed deformation within the whole specimen. Our results indicate that localization analysis benefits from a statistical approach, as we need a minimum number of model runs for the different groups to emerge. Moreover, from a modeling point of view, we demonstrate the need for a multiple run approach.