A study of a role of gouge on fault strength using the DEM simulation

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The friction of the faults is governed by a lot of factors such as slip velocity, surface roughness, gouge layer, and so on. The relationship between them is known as friction law. Slip rate- and state-dependent friction laws suggest that a positive velocity step gives an immediate positive friction change (direct effect) and then it is attenuated to steady state value (evolution effect).

In order to make clear their relationship, the effects of each factor must be studied independently. However, it is difficult to know the role of gouge between slipping rock in laboratory work. Thus, we study the role of gouge in fault sliding using the DEM simulation.

We use 2-D DEM model in which cylindrical elements are used as gouge materials. The elements are assumed to be elastic body with same physical properties and Amonton-Coulomb friction law is applied to each elements. A fault surface is controlled to move so as to maintain constant normal load and shear velocity and the other surface is fixed in position. Frictional coefficient is defined by the ratio of shear stress to normal stress applied to moving surface.

Our simulation shows the consistency with the empirical slip rate- and state-dependent friction laws, that velocity step gives frictional step (direct effect), and succeeding gradual attenuation to steady state frictional value (evolution effect). The slip distance in attenuation (correspond to the critical slip distance) is almost the same scale to that of surface roughness. A kinetic energy of gouges (shear, normal direction and rotation) during slipping increase in proportional to slip velocity of wall in low velocity conditions, and shear direction kinetic energy dominates in higher velocity conditions. This is interpreted that predominant energy loss is caused by shear slipping among elements at high velocity, and by dissipation accompanying with elastic deformation of elements in low velocity. The change in energy state by slip velocity may be explained by the transition to the stable state of fault surfaces.