# Multiscale modeling of a sphere-plane contact based on local third-body simulations

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**Abstract**

The friction coefficient is often mandatory for many applications involving the numerical modeling of two bodies in contact. However, particularly for dry contact, this coefficient is often not well understood. Indeed, even for two given materials, the friction coefficient can vary significantly according to several parameters (humidity, temperature, etc.). Moreover, even if the coefficient value is known, the relationship between normal and tangential force sometimes differs from the well-known Coulomb friction law. Finally, this coefficient is usually reduced to an average value for the whole contact, whereas its value can vary locally. In this work, we propose to determine the friction coefficient locally (at the scale of the third body), and to implement a local friction model at the scale of the whole contact.
First, using a multibody meshfree approach (MELODY), dry contact is modeled at the scale of the third body (the contact is not fully considered). This makes it possible to model the third body explicitly and derive a local friction coefficient (which is an output and not an input of the model). A parametric study was carried out and a friction coefficient model was derived. This model especially takes into account three material parameters, which are the Young modulus, a cohesion coefficient describing the strength of the third body, and a damping parameter. Kinematics (which varies from viscous to visco-plastic flow) is described by a scalar, which can also be evaluated from the friction coefficient model.

This local friction model is implemented in a semi-analytical model (ISAAC) to study the whole contact. The use of the previous friction model permits the study of the local friction coefficient, which gives a shear profile that differs from the classical theory (Hertzian profile multiplied by a scalar). The results show that the local friction coefficient decreases with increasing contact pressure. Consequently, it is lower at the center of the contact (where the pressure is higher) and higher at the boundaries. In severe cases, such as when contact pressure is very high, shear can even become constant within the contact, since the local friction coefficient decreases in the same proportion as the pressure increases.
Information on the kinematics of the third body is also kept at the upper scale. Kinematics is highly dependent on maximum contact pressure. For silicon nitride and relatively "low" maximum contact pressure (0.10 times Young modulus), kinematics is uniform within the contact and shows that half the energy is dissipated by material relaxation, the other half by plastic phenomena. As contact pressure increases, energy is increasingly dissipated by plastic phenomena at the center of the contact, and remains unchanged at the contact boundaries.

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