Tribological effects in granular materials and their impact on the macroscopic material behaviour

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ABSTRACT

Solid like granular materials generally comprise a high number of particle-particle and particle-environment contacts. The frictional behaviour of these contacts has a high influence on the macroscopic behaviour of the material. In the sense of a tribological system friction is influenced by several parameters like contact normal load, relative motion, surface roughness, contact temperature and contact conditions (dry, wet, lubricated contact conditions, etc.).

The discrete (distinct) element method (DEM) is a frequently used approach for modelling the mechanical behaviour of such solid-like granular materials. The frictional behaviour of the contacts is considered by application of Coulomb's law. Here the coefficient of friction (COF: ratio between shear (τ) and normal stresses (p) where sliding occurs) is the only input parameter, which is assumed to be constant over all contacts of a certain material combination. This constant COF is identified in the literature as a crucial parameter regarding the macroscopic shear behaviour; see e.g. [1]. The approach of a constant COF is simple but can lead to insufficient results in certain cases. This contribution presents the first step towards a more realistic friction modelling.

Investigations on the frictional behaviour of wheel-rail contacts (steel-steel) showed that the assumption of a constant COF is not sufficient to reproduce results observed at experiments. For example, increasing the normal load leads to a considerable decrease of the COF, compare the ratio between shear (τ) and normal stresses (p) in the Figure 1 (a) and (b). This dependency is implemented into a tribological model described in [2] and is applied to DEM simulations in this work by consideration within the tangential contact force models. The macroscopic shear behaviour of granular materials consisting of steel spheres is investigated by simulation of shear tests. A parameter study is conducted, highlighting the differences in the results assuming constant COFs (state of the art) on the one hand and applying the newly proposed tribological friction model on the other hand. These differences are investigated, e.g. for different sphere radii and confinement pressures.

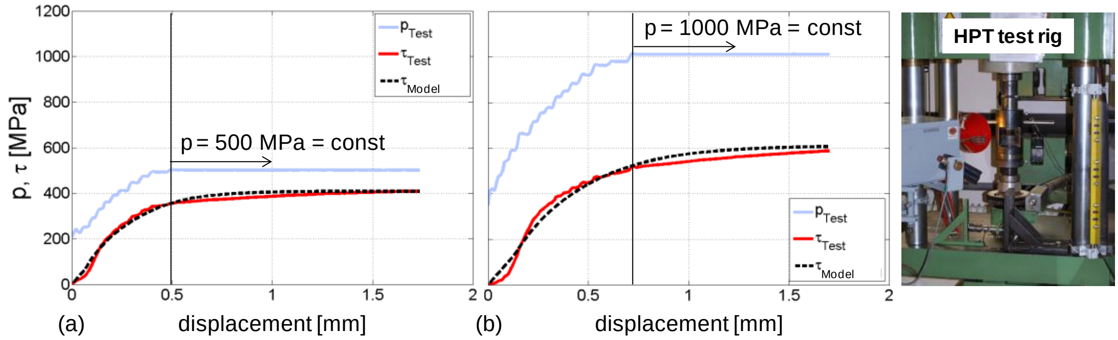

Figure 1: High Pressure Torsion (HPT) tests where two steel-discs are rotated against each other; measurement of normal stress (p) and shear stress (τ); increasing normal stress reduces ratio p/τ (COF), comparision to results from model [2].

REFERENCES

[1] A. S. J. Suiker and N. A. Fleck, *Frictional Collapse of Granular Assemblies*, *J. Appl. Mech.*, **71**, 350-358 (2004).

[2] K. Six, A. Meierhofer, G. Müller and P. Dietmaier, *Physical processes in wheel-rail contact and its implications on vehicle-track interaction*, *Vehicle System Dynamics*, Special Issue on *"Modelling of Traction in Railway Vehicles"*. (2015), in press, accepted manuscript.