DEM modelling of railway ballast under shear and compression

Klaus Six* and Bettina Suhr*

*Virtual Vehicle Research Center
Inffeldgasse 21/A, A-8010 Graz, Austria
e-mail: klaus.six@v2c2.at, web page: http://www.v2c2.at

ABSTRACT

In the DEM modelling of railway ballast, there are three main aspects which influence prediction quality: the geometry representation of the single grains, the used normal and tangential contact models and the parametrisation of the model including the principal experiments utilised for this purpose. If one of these points, e.g. geometry representation, is addressed with a much higher level of details than the others, one cannot expect to increase the quality of the overall DEM model. Therefore, in this contribution a balanced approach will be applied.

Particle shape will be modelled by rigid clumps of two equi-sized spheres. In a first step, the well-known simplified Hertz-Mindlin no-slip contact law will be used. Literature data of compression and direct shear tests, [1], will be the basis for DEM model parametrisation. It turns out that with one set of parameters either one of the two experiments can be approximated well, but not both at the same time, compare left part of Fig. 1.

To solve this problem, an advanced contact law will be applied. The so-called Conical Damage Model (CDM), [2], is slightly modified and reformulated for computational efficiency. In contact normal direction, this model has an elastic part, which coincides with the Hertz law. When a certain stress is reached, ideal plasticity is introduced: an adaption of the contact radii (plasticity/damage) increases the area of contact and saturates the stress at the contact to a certain limit. The change of contact area takes place only virtually at the contact, while the particles geometry in the DEM simulation remains unchanged. In contact tangential direction, a stress dependency of the particle-particle coefficient of friction can be introduced [3]. The parametrisation of the CDM model is more challenging than the Hertz-Mindlin law, because two additional parameters are introduced [4]. Using this contact law, DEM simulation results are in good accordance with both compression and direct shear tests using only one set of parameters, compare right part of Fig. 1.

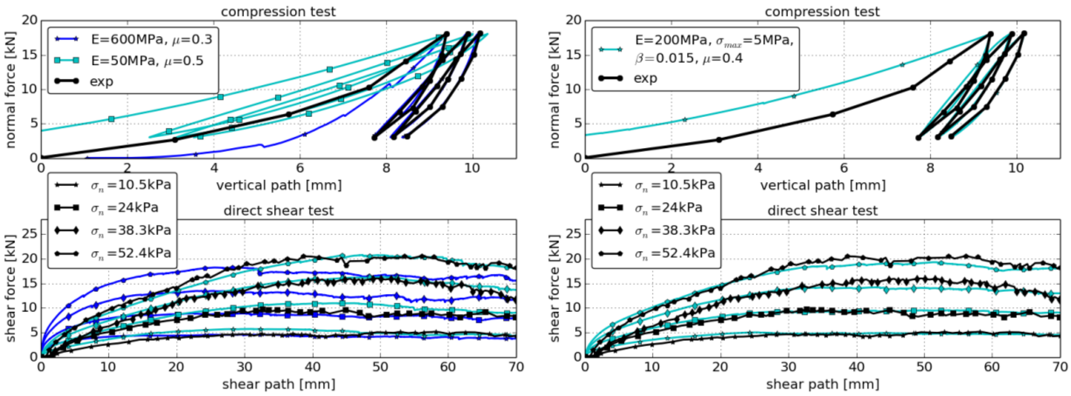

Figure 1: Comparison of experimental results of compression and direct shear tests to DEM simulations. Left: simplified Hertz-Mindlin model. Right: Conical Damage model. Experimental data taken from [1].

REFERENCES

[1] C. Coetzee, “Calibration of the discrete element method and the effect of particle shape”, *Powder Technology*, **297**, 50–70 (2016).

[2] J. Harkness, A. Zervos, L. Le Pen, S. Aingaran and W. Powrie, “Discrete element simulation of railway ballast: modelling cell pressure effects in triaxial tests”, *Granular Matter*, **18**, 1–13, (2016).

[3] B. Suhr, K. Six, “On the effect of stress dependent interparticle friction in direct shear tests”, *Powder Technology*, **294**, 211–220 (2016).

[4] B. Suhr, K. Six, “Parametrisation of a DEM model for railway ballast under different load cases”, *Granular Matter* (2017), submitted.