NUMERICAL SIMULATION (DEM) OF SOIL FOR ANALYS SOIL-WHEEL INTERACTION

Nowadays the soil-wheel interaction plays an important role in the agricultural researches because it occurs often in practice. With the recent evolution of the information technology there are some method to model this phenomenon.

To achieve the aims of my research the literature of this topics was reviewed first. Based on this the soil deformation under shear stress and resistance to vertical load need to be modelled accurately to analyse the interaction correctly. The measurement methods to determine the soil's bearing capacity and shear strength were introduced and the in situ cone penetration test and laboratory direct shear box test were chosen to describe the soil behaviour because these are commonly used in practice. To simulate these tests, the numerical method called Discrete Element Method (DEM) was applied. The main aim of the research was to set up the soil model to achieve similar results to the measurements from the calculations.

The Linear and Parallel Bond and the Hertz-Mindlin and Parallel Bond contact models were commonly used nowadays to simulate cohesive soil material. The main problem is that the setup (the so-called calibration) of the contact properties is very difficult, there are no process to calibrate these parameters in case of direct shear box and cone penetration test as well. To create such process, the effect of the contact properties on shear force-shear displacement and soil penetration resistance-penetration depth functions were investigated using spherical discrete elements. As a result the contact properties are determined that have effect on these functions and the contact parameters as well that do not have any significant changes on these curves. In the next phase a calibration process was developed to calibrate the Hertz-Mindlin and the Parallel Bond contact properties step by step to achieve similar results to real direct shear measurements. The equation of the shear force-shear displacement was determined that fit very well to the measurement values and the parameters of this formula can be used to calibrate the contact properties of the soil model. While using this process these properties are calibrated to the behaviour of the soil under given normal load. On the other hand, the soil's mechanical properties (namely cohesion and internal friction angle) are commonly used to calibrate the contact parameters so this is a new approach for the calibration processes.

With the numerical cone penetration simulations, it was proved that the boundary, namely the cross section of the soil model has an effect on soil penetration resistance while using spherical particles. The size of the model's cross section was determined that minimize this effect on simulation results. In the other hand the model's height was investigated as well and it was proved that these dimension has negligible effect on the penetration resistance-penetration depth curve.

In the last phase of my research it was checked that how do the soil models behave under rolling wheels on them which are calibrated to the results of the direct shear box and penetration test respectively. Analysing the deformation of the soil model it can be asserted that the simulation results were similar to the measurement values in case of soil model which was calibrated to the direct shear box test. The simulations are able to estimate the rigid wheel rolling resistance only in case of wheel velocity around of 0,5 m/s.

Summarizing it can be asserted that the results of my work can be used in the future to investigate the soil-wheel interaction efficiently with discrete element method.