Summary

With the increasing computational power of computers, numerical simulation of granular materials have reached the stage where it has become feasible to simulate large scale particle processes. A numerical simulation of granular material can be used to optimize and redesign bulk handling equipment, investigate soil mechanics and to perform research on the fundamentals of particle processes. The Discrete Element Method (DEM), a numerical simulation method, uses several input parameters to compute particle behavior, and the results produced by the DEM depend on the input parameters used. Unfortunately, these input parameters differ for each material and contacts between different materials, making reliable parameters and therefore reliable results hard to achieve.

This report investigates the possibilities of acquiring reliable parameters through calibration simulations, analyzing the sensitivity of the parameters used. Parameters analyzed are the shear modulus, coefficient of restitution, static and rolling friction coefficients, Poisson's ratio and the particle density. Numerous simulations have been performed using different combinations of parameters to study the influence of each parameter. Based on this sensitivity analysis three sets of parameters are selected and used in validation simulations using particles of different size. Physical experiments using glass beads are used to verify the results of the validation simulations. The angle of repose of glass beads is the bulk behavior characteristic measured in the experiments and simulations of this study.

The sensitivity analysis showed that both static and rolling friction coefficients have the largest influence on the angle of repose in this setup. When friction (static or rolling) was increased this would lead to a steeper angle of repose, meeting expectations. The coefficient of restitution only affected the angle of repose when very low values were used, which implies very high damping. The effect of the shear modulus started to come into effect when values of 10,000 times smaller than the original value were used. As the timestep depends on the shear modulus, decreasing the shear modulus with a 1,000 times reduced the time needed for computing the results with a factor of 33, while still

producing the same results. The other parameters appear to have a negligible influence on the angle of repose.

Three different sets of input parameters were created, varying only the two friction coefficients and compared to experiments. All sets showed the same trend observed in experiments: the angle of repose increased when the particle size increased. Some predictions made by the validation simulations were very accurate, others less but still within 6% accuracy. Predictions for the smallest particles produced inaccurate results, possibly due to incorrect experimental results, possibly the absence of electrostatic forces in the simulations or an possible error in the method of applying calibrated parameters to much smaller particles. Calibrated DEM parameters based on the findings of a sensitivity analysis can be used in simulation using particles with a different size, although the admissible difference in size is limited. Based on the results of this report, multiple sets of parameters can produce the same results.