8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

EFFECT OF THE PARTICLE SIZE IN DEM SIMULATIONS OF THE MATERIAL FLOW IN HOPPER

***Robertas Balevičius[1], Rimantas Kačianauskas[2]**

[1] Dept of Reinforced Concrete and Masonry Structures, Vilnius Gediminas Technical University,
Vilnius, Sauletekio av. 11, Lithuania
Robertas.Balevicius@st.vgtu.lt

[2] Laboratory of Numerical Modelling, Vilnius Gediminas Technical University,
Vilnius, Sauletekio av. 11, Lithuania
rkac@fm.vgtu.lt

Key Words: *Granular Material, Discrete Element Method, Particle size, Macroscopic parameters, Wedge-shaped hopper.*

ABSTRACT

The discrete element method (DEM) pioneered by Cundall [1] became recently recognized as a powerful numerical tool. Contrary to the continuum approach, presentation of the granular material by assembly of discrete elements was seen as a more realistic in simulating of their behaviour.

The main disadvantages of the DEM technique are related to limited computational capabilities caused by a small time step required for time integration equations of motion. As a rule, straight forward solution of real hopper problems requires a relatively huge number of particles. Therefore, different up-scaling technique is employed for modeling purposes. It is nevertheless true, that even applying a small amount (~2000) of particles, a sufficiently adequate representation of continuum-based flow parameters was obtained by investigating the granular material flow in hoppers [2], [3].

The current analysis was focused on the study of the effect of particle size in terms of their contribution to the particular material parameters by implementing the following approach. In particular, the total mass of particles and particle volume were held a constant for all models. Thus, three samples of granular material having approximately equal masses, but composed by the particles of different size were considered. Particular samples were characterized by 20400, 10000 and 1980 particles. The granular material composed of poly-dispersed particles was generated by using an uniform distribution, keeping the ratio of the maximal and minimal radii of particles as a constant for all models. The minimal and maximal radii of particles were found by multiplying the average radius of particle by the initially assumed proportions. The average radii of particles, different for all models (equal to 0.0324 m, 0.0189 m and 0.0149 m, respectively), were found from the assumption on a constant particle mass provided for the number of particles. Finally, the generated the total mass of particles yielded smaller than 0.5% difference from the expected value.

Non-cohesive frictional visco-elastic model for the spherical particles was applied in simulation by using original code DEMMAT. Here, the particle interaction is

considered in terms of mutual contacts, while the particles motion is described by linear translations and rotations integrated explicitly.

The above models were applied for simulation of the filling and discharge in the wedge-shaped hopper. As the illustration on the analysis performed, the filled material is shown in Fig. 1. The color bar shows a sum of particle contact forces. In these plots, it can be observed that distribution and the values of particle contact forces depend on the number of particles involved.

a) b) c)

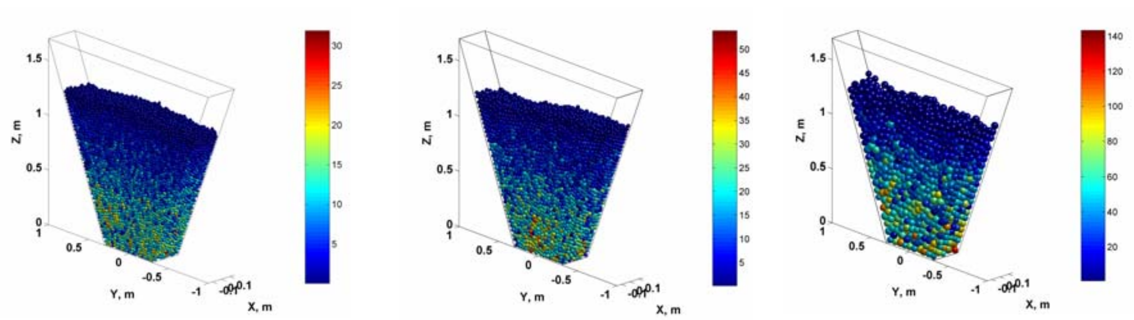

Fig. 1 The models considered: a) main model (20400 particles), b) comparative model (10000 particles), c) comparative model (1980 particles).

The particle structure and flow parameters, such as, the system total kinetic energy, the mean coordination number of particle, hopper wall reactions and stresses were studied for characterization of the size effect.

On the basis of the results obtained some concluding remarks have been drawn. The decrease in particles number (with increasing the particle radii) produces an additional friction and results in an increased dissipation. This effect has a minor influence on the wall reactions as well as on the wall pressures, i.e., the differences of the above parameters in all models was insignificant and can be neglected for practical purposes. However, the portion of the additional friction produces the increased material porosity. The mean coordination number of the particle linearly decreases with the decreasing of the mean particles radii. In particular, the mean coordination number is equal to 6.26, 6.57 and 6.64, respectively.

In addition, the highest total energy dissipation and discharge flow rate were observed for the model having minimal number of particles while the differences between 10000 and 20400 number models were insignificant.

Thus, the preliminary results obtained for the models with different amount of particles indicates that the modification of particle friction coefficient in terms of particle minimal and maximal radii could be developed to obtain the similarity of the models.

REFERENCES

[1] P.A. Cundall and O.D.L. Strack, “A discrete numerical model for granular assemblies”, *Geotechnique*, Vol. **29,** pp. 47-65, (1979).

[2] R. Balevičius, R. Kačianauskas, Z. Mróz, I. Sielamovicz, “Discrete element method applied to multiobjective optimization of discharge flow parameters in hoppers”, *Structural and Multidisciplinary Optimization*, Vol. **31**(3), pp. 163-175, (2006).

[3] R. Balevičius, R. Kačianauskas, Z. Mroz, I. Sielamowicz, “Microscopic-macroscopic analysis of granular material behaviour in 3D flat-bottomed hopper by the DEM”, *Archives of Mechanics*, Vol. **59**(3), pp. 231-257, (2007).