Laboratory and numerical investigation of the direct shear box test

Dániel Horváth*, Tibor Poós† and Kornél Tamás+

*†Department of Building Services and Process Engineering
Budapest University of Technology and Economics (BME), Faculty of Mechanical Engineering
Bertalan Lajos street 4-6. Building D110, H-1111 Budapest, Hungary
*e-mail: horvath.daniel@mail.bme.hu, † e-mail: poos@mail.bme.hu
web page: https://www.epget.bme.hu/en/

+Department of Machine and Product Design
Budapest University of Technology and Economics (BME), Faculty of Mechanical Engineering
Bertalan Lajos street 4-6. Building MG300, H-1111 Budapest, Hungary
e-mail: tamas.kornel@gt3.bme.hu, web page: http://www.gt3.bme.hu/en/

ABSTRACT

In agriculture, food, chemical, plastic and pharmaceutical industries for designing and operating machines, it is essential to determine the mechanical parameters of the processed granular materials. In most cases, these characteristics are the internal friction angle, the contact cohesion developed by the surface moisture and the apparent cohesion occurred by the shape of the granular material. Further physical quantities are required to characterize the motion state of the particles, which were determined by laboratory measurements in this study. We used hulled millet for the measurements because its geometric shape can be modeled as sphere in the numerical investigations with good approximation. The porosity, the particle and bulk density of the hulled millet were determined by means of an air pycnometer in case of several moisture content. Using laboratory direct shear box test, under standard conditions, the shear strength of the cohesive liquid bridges and the internal friction angle in the bulk were determined. The results obtained were used for input parameters of a discrete element model.

Nowadays, the discrete element method (DEM) is the most applicable numerical method for examining the movement of a given bulk of grains. The essence of DEM is that the entire bulk is made from discrete particles, which have micromechanical setting parameters in the inter particle connections. The aim of this research was to determine these micromechanical parameters by simulation, based on the macromechanical results of the hulled millet bulk during laboratory measurements.

DEM numerical simulations were carried out using cohesive-frictional contact model. After developing the model of the direct shear box test and using the macromechanical parameters obtained from the laboratory measurements, micromechanical parameters were determined. These were the rolling and twisting resistance coefficients and the normal and shear strengths of the cohesive bonds depending on the moisture content of the material.

REFERENCES

[1] Coetzee, C.J.: *Calibration of the discrete element method and the effect of particle shape*. Powder Technology, vol. 297 (Supplement C), pp. 50–70., 2016.

[2] Horabik, J., Molenda, M.: *Parameters and contact models for DEM simulations of agricultural granular materials: A review*. Biosystems Engineering, vol. 147 (Supplement C), pp. 206–225., 2016.

[3] Tamás, K., Földesi, B., Rádics, J. P., Jóri, I. J., and Fenyvesi, L.: *A Simulation Model for Determining the Mechanical Properties of Rapeseed using the Discrete Element Method*. Period. Polytech. Civ. Eng., vol. 59, no. 4, pp. 575–582, 2015.