Computational modelling of granular materials during confined compression with application in ship building

Mohsin A. Chaudry*, Christian Woitzik†, Alexander Düster† and Peter Wriggers*

* Institute of Continuum Mechanics (IKM)
Leibniz University Hannover (LUH)
Appelstraße 11, 30167 Hannover, Germany
e-mail: chaudry@ikm.uni-hannover.de, web page: https://www.ikm.uni-hannover.de/

† Numerical Structural Analysis with Application in Ship Technology (M-10)
Hamburg University of Technology (TUHH)
Am Schwarzenberg Campus 4 C, 21073 Hamburg, Germany
e-mail: christian.woitzik@tuhh.de, web page: https://www.tuhh.de/skf/

ABSTRACT

Granular materials have applications in a variety of fields which includes among others metallurgy, civil engineering, food industry and pharmacy. Recently, it has been proposed that these materials can be used to increase the crashworthiness of double hull ships [1]. However, their usage requires better understanding of their mechanical properties under different loading conditions. In this contribution, the behaviour of granular materials during confined loading is studied.

During confinement these materials are susceptible to communition, where compressive loads exceed the strength of the material. Numerical simulation of this complex phenomenon can be performed with the Discrete Element Method (DEM) where the analysis is carried out at the micro-mechanical level [2]. Here, for numerical simulation, a DEM framework based on the work of Wellmann [3] is employed. In DEM, grains referred here to as particles, are treated as rigid bodies which have translational and rotational degrees of freedom assigned to their center of mass. The constitutive response of granular material used in the current problem (prior to crushing) is characterized by inelastic behaviour, which is accounted for by inclusion of an elasto-plastic model. The calculation of the contact force between particles in the elastic regime is based on the Hertz-Mindlin theory whereas for the inelastic regime an elasto-plastic model based on the work of Thornton [4] is used.

Compression tests provide ample insight into the mechanical behaviour of granular materials. This can be investigated through numerical simulation of oedometric or triaxial test. During such tests granular materials are subjected to a high confining pressure. Depending on the critical strength of the particles, extensive comminution is observed. Furthermore, in the framework of the DEM, computational aspects of comminution in such tests will also be discussed.

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