Modeling of granular-flow in silos as a strongly-coupled system of DEM-FEM interaction

Jigar Dhabalia*, Felix Ockelmann†, Sven Reinstädler†, Dieter Dinkler†

* Institute of Structural Analysis
TU Braunschweig
Beethovenstr. 51, 38106 Braunschweig, Germany
e-mail: j.dhabalia@tu-bs.de, web page: https://www.tu-braunschweig.de/statik

† Institute of Structural Analysis
TU Braunschweig
Beethovenstr. 51, 38106 Braunschweig, Germany
web page: https://www.tu-braunschweig.de/statik

ABSTRACT

Silo-structures, filled with granular material, generally exhibit dynamic excitation during discharge. Although civil engineers might be interested in the pressure affecting the structure, process engineers must ensure that the granular material discharges as a mass flow. Consolidated granulars may build inner slots and cause "dead zones" if the funnel-shaped discharge zone is not well-suited for mass flow. These inner slots, if appear close to the silo wall, will lead to an unsymmetrically loaded structure which may cause overload and failure. The geometry of the silo structure thus needs to be optimised with respect to stress states in granular material to reduce the intensity of the dynamic excitation during discharge.

A staggered approach is presented to solve the fluid-structure interaction problem, where the granular material and the silo-shell structure are modelled using different discretization schemes. The discrete element method (DEM) is applied to describe the flow behaviour of the granular material. The collision-contact model of Cundall [1] is extended to three dimensions and used to describe the granular media in silo. The contact forces and displacements are calculated by tracing the particle movement.

The finite element method (FEM) is applied to evaluate the stress-deformation behavior of the thin-walled silo-shell. The silo-shell is modelled using a continuum approach and is considered to be of solid elastic material. A semi-discretization method is applied, where the weak form of the governing equations are discretized using spatial finite element methods, followed by time integration using the generalised-alpha method.

The proposed DEM-FEM methodology is applied to the three-dimensional investigation of different loading conditions during silo-discharge.

REFERENCES

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

[2] S. Reinstädler, D. Dinkler. *Modeling of silo discharge as strongly-coupled fluid-structure-system.* ECCOMAS 2012.