Coupled DE-FE approach for numerical simulation of the collision of particle-filled double-hull ships

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

* Institute of Continuum Mechanics
Leibniz University Hannover
30167 Hannover, Germany
e-mail:chaudry@ikm.uni-hannover.de

† Numerical Structural Analysis with Application in Ship Technology (M-10)
Hamburg University of Technology
21073 Hamburg, Germany
e-mail:christian.woitzik@tuhh.de

ABSTRACT

Due to growth in maritime traffic, incidents of ship collision are increasing. Recently, various strategies were proposed to increase the crashworthiness of ships and one promising design approach is to use granular materials in the cavity of double hull vessels [1]. In context of numerical simulation of such a problem, different modeling aspects have to be considered. For instance, during the collision process, degradation/damage of interacting bodies can occur. In this contribution, such a phenomenon is accounted for by a gradient enhanced ductile damage model, where growth of damage is based on a combination of stress triaxiality and total accumulated plastic strain. Since standard lower order formulations based on three-dimensional elements do not perform very well for bending dominated thin structures, enhanced strain formulation based elements will be used instead [2]. In order to demonstrate the effectiveness of such an element for ductile damage, several examples will be presented where comparison with standard element formulations will be carried out.

For the current problem, numerical modeling of granular materials is based on discrete elements. Since for large scale problems numerical modeling of granular materials can be computationally expensive, an Arlequin method based coupling of the discrete element and finite element method will be employed [3]. For such a coupling, the region with small deformation will be modeled with continuum based Mohr-Coloumb material model, while the region with large deformation/localization will be modeled with the discrete element method. Finally, for such a coupling, a representative example of ship collision will be presented. For validation of our simulation approach a comparison with experimental results will be done, where realistic material properties of granules [4] and ship structure will be used.

REFERENCES

[1] M. Schöttelndreyer, I. Tautz, W. Fricke, E. Lehmann. Side Structure filled with multicellular glass hollow spheres in a quasi-static collision test. Collision and Grounding of Ships and Offshore Structures (Ed: J. Amdahl, S. Ehlers, B. Leira), 101-108. Taylor & Francis Group, London, 2013.

[2] J. Korelc, U. Solinc, P. Wriggers. An improved EAS brick element for finite deformation. Comput. Mech., 46 (2010), pp. 641-659

[3] C. Wellmann, A two-scale model of granular materials using a coupled DE-FE approach.Ph.D. thesis, Institut für Kontinuumsmechanik, Leibniz Universität Hannover

[4] M. A. Chaudry, et al., Experimental and numerical characterization of expanded glass granules. J. of Comp. Part. Mech, 2017. doi: 10.1007/s40571-017-0169-0.