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Numerical modelling of collision of particle-filled structures

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With growth in traffic of ships, the risk of collision is increasing. Efforts are being made to improve their crashworthiness and one promising design approach is to use granular materials in the cavity of double hull ships.

Numerical modelling of such a problem can be challenging as it requires implementation of a robust contact and a realistic material model. Furthermore, a particle-based method is also required to model granular materials. In this study, a mortar based method, as implemented in [1], is used for the contact formulation which involves a segment-to-segment strategy with weak enforcement of contact constraints. Regarding the material behaviour, a finite strain based elasto-plastic model is considered, where a multiplicative split of the deformation gradient is applied. Furthermore, material degradation of ship structure during collision is accounted by inclusion of gradient-enhanced damage model.

For numerical modelling of granular materials, the discrete element method (DEM) is used where the analysis of particles is carried out at the micro-mechanical level. In this study, expanded glass granular materials are considered, where the bulk and particle level properties of such materials were studied in detail in [2]. These are multicellular grains which are produced by thermal expansion process of recycled glass. The DEM-FEM coupling, as discussed in [3], is employed to study the load transfer between granular particles and the confining structure. Finally, a homogenization technique for granular materials will be presented, where macroscopic quantities are derived from volume averaged properties of particles.

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