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ADVANCED FINITE ELEMENT METHOD FOR FREE SURFACE FLOW WITH APPLICATION TO SELF-INDUCED SILO DISCHARGE

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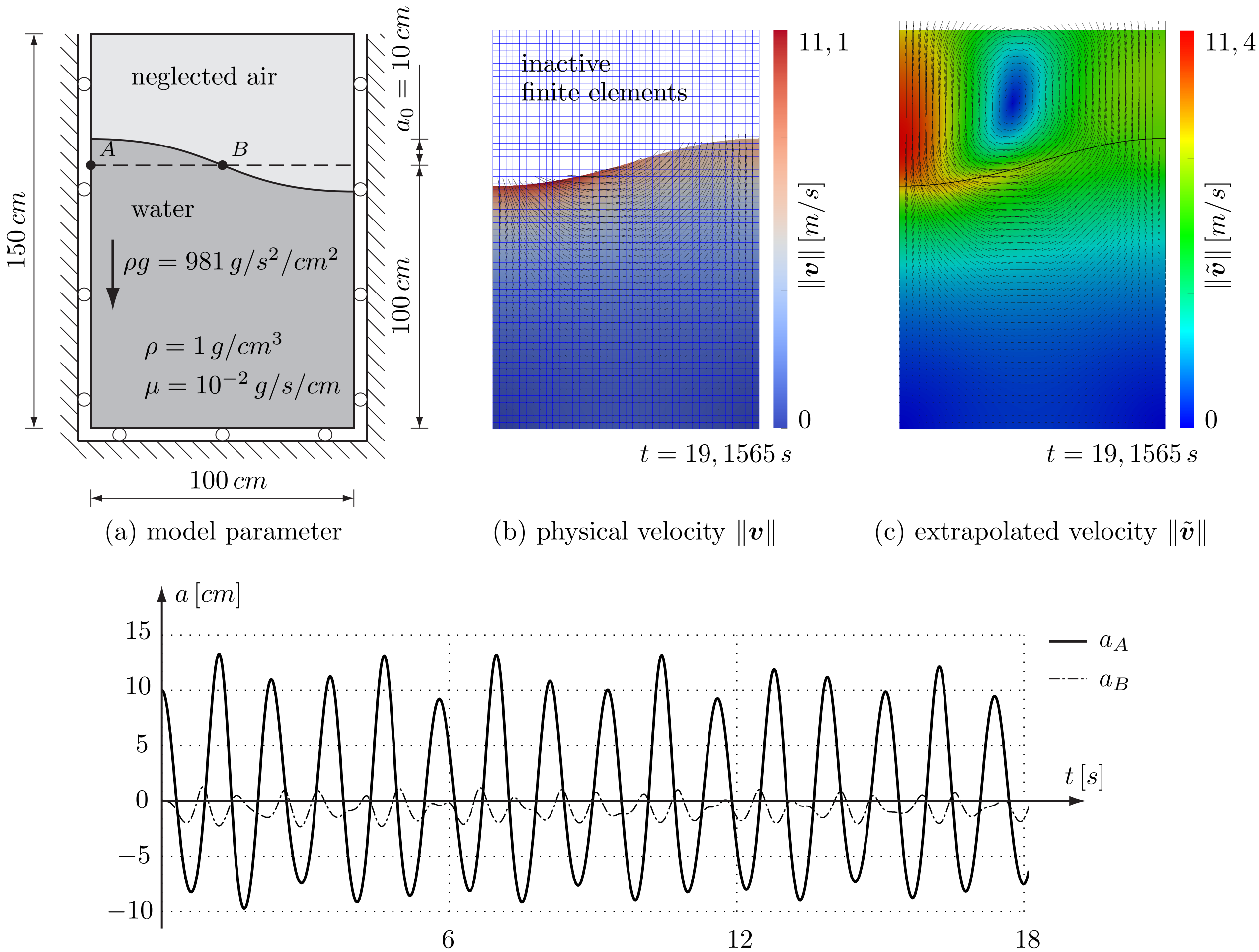
A monolithic approach to fluid-structure interactions based on the space-time finite element method (STFEM) is presented [1]. The method is applied to the investigation of stress states in silos filled with liquid material during discharge.

The thin-walled silo-shell is modeled in a continuum approach as elastic solid material considering large deformations, whereas the flowing liquid material is described by a model for viscoplastic compressible fluids. Between the fluid and solid, advanced slip boundary conditions including friction are taken into account.

To solve the governing equations of the fluid and solid model, involving the interface conditions in-between, the weighted residual method is applied, which is discretized by a stabilized time-discontinuous STFEM [2]. The discretized model equations are assembled in a single set of algebraic equations, considering the multi-field problem as a whole. Within the simultaneous solution procedure for the coupled fluid-solid mesh, the kinematic of both solid and fluid is described by velocities as primary variable [3].

The level-set method is used to describe the motion of the free surface during discharge. The air above does not affect the flow of the liquid material significantly, that the computational costs are reduced by switching off the related inactive finite elements. To ensure an accurate transport of the free surface within the level-set-method, a pde-based extrapolation is used for the velocity-field [4], see figure 1. The same method is applied to extrapolate the density of the compressible liquid into restarted neighboring finite elements in order to get valid initial values for the Newton-Raphson scheme. The proposed methodology is applied to dynamic behavior of silos under changing loading conditions during discharge.



(a) model parameter (b) physical velocity $\|\boldsymbol{v}\|$ (c) extrapolated velocity $\|\tilde{\boldsymbol{v}}\|$

(d) deflection of the free surface

Figure 1: Tank sloshing

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