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GEOMETRICALLY NONLINEAR EFFECTS ON A FLUID-STRUCTURE COMPUTATIONAL MODEL WITH SLOSHING AND CAPILLARITY

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The analysis of structures partially filled with liquids (liquid-propellant rockets, liquid cooling systems, etc ...) is of the most interest for the industrial domains like transports or aerospace (aircrafts, satellites, rocket launchers, etc ...). Many experimental and computational research have been performed to better understand the behavior of such coupled fluid-structure systems. Some crucial aspects when analyzing the dynamical vibrations of a fluid-structure system are the sloshing and capillarity phenomena in fluid containers (see for instance [1]) and have received a great attention these last years. This work is devoted to a computational nonlinear dynamical analysis of a fluid-structure system taking into account surface tension and sloshing effects. The formulation used is the one lately introduced in [2] that allows for taking into account the weak geometrical nonlinearities of the structure through the use of an adapted nonlinear reduced-order model. The fluid-structure computational model is obtained by using the finite element method for which the boundary value problem is expressed in terms of the displacements of the structure, the pressure in the fluid, and the elevation of the free surface of the fluid. The construction of the reduced-order model is based on a projection basis constituted of the linear elastic modes, the linear acoustic modes, and the linear sloshing-capillarity modes. Such construction involves solving generalized eigenvalue problems. For large-scale fluid-structure systems, an optimized computational strategy has been proposed allowing for reducing the computational costs of this calculation. Note that the operators of the nonlinear reduced-order model are explicitly constructed in the finite element context. Finally, a numerical application consisting of a cylindrical tank partially filled with water such as the one investigated in [3] is presented. The computational results obtained, are coherent with the discussion proposed in [3] that, at the best knowledge of the authors, have not still been confronted with numerical results. These results show that an unexpected high-amplitude sloshing of the fluid at low frequency appears when the fluid-structure system is excited at medium frequency exciting structural modes.

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