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PROJECTION-BASED REDUCED ORDER MODEL FOR THE PARAMETRIC ANALYSIS OF HYDROELASTIC VIBRATIONS OF LIQUID-STORAGE TANKS

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This work concerns the numerical simulation of the hydroelastic vibrations of a flexible tank containing a free-surface liquid, around a nonlinear equilibrium configuration considering the structural prestress due to the weight of the liquid. The objective is to build an efficient reduced order model allowing a low-cost prediction of the vibration response of the coupled system parametrized by the filling rate of the tank. The numerical methodology is decomposed in two main steps. Firstly, a prestressed equilibrium state is computed by solving a geometrical nonlinear problem in which the hydrostatic pressure exerted at the fluid-structure interface is computed from a non-uniform follower force defined as a function of the fluid height in the tank [1]. In a second step, the hydroelastic vibrations are calculated around this prestressed state considering the added mass effect of the fluid [2]. This hydroelastic vibration problem, which depends both on the tangent stiffness and added mass operators, should be evaluated for each fluid height and is therefore numerically expensive. The original reduced order model developed in this contribution consists in projecting the hydroelastic prestressed problem on a modal basis containing only the dry modes, and then estimating the added mass operator by computing the response of the fluid domain to those structural modes. As the dimension of the reduced model depends on the number of selected dry modes, an original Proper Orthogonal Decomposition (POD) is also proposed and directly applied on the tangent stiffness and added mass operators to reconstruct the hydroelastic solution from a very low amount of data. This numerical approach is validated and analysed on a simple example whose experimental results are available in the literature [3].

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