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Numerical Analysis of the Response of Thin Flexible Membranes to Free Surface Water Flow

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Abstract : This work is part of a major research project concerning the design of a light temporary installable textile flood control structure. The motivation for this work is the great need of applying light structures for the protection of coastal areas from detrimental effects of rapid water runoff. The prime objective of the study is the numerical analysis of the interaction among free surface water flow and slender shaped pliable structures, playing a key role in safety performance of the intended system. First, the behavior of down scale membrane is examined under hydrostatic pressure by the Abaqus explicit solver, which is part of the finite element based commercially available SIMULIA software. Then the procedure to achieve a stable and convergent solution for strongly coupled media including fluids and structures is explained. A partitioned strategy is imposed to make both structures and fluids be discretized and solved with appropriate formulations and solvers. In this regard, finite element method is again selected to analyze the structural domain. Moreover, computational fluid dynamics algorithms are introduced for solutions in flow domains by means of a commercial package of Star CCM+. Likewise, SIMULIA co-simulation engine and an implicit coupling algorithm, which are available communication tools in commercial package of the Star CCM+, enable powerful transmission of data between two applied codes. This approach is discussed for two different cases and compared with available experimental records. In one case, the down scale membrane interacts with open channel flow, where the flow velocity increases with time. The second case illustrates, how the full scale flexible flood barrier behaves when a massive flotsam is accelerated towards it.

Keywords : finite element formulation, finite volume algorithm, fluid-structure interaction, light pliable structure, VOF multiphase model
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