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Fluid-Structure-Interaction problems including "added-mass effects"

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ABSTRACT

A monolithic formulation for treating elastic solids and fully incompressible fluids in a unified form is presented. The formulation allows treating solid and fluid sub-domains indistinctly in fluid-structure interaction (FSI) situations including free surface flows.

The main goal is to solve the equations for both the fluid and solid domains using the same Lagrange formulation. This basically means that the analysis domain, containing both: incompressible fluid and elastic solid sub-domains which interact with each other, is seen as a single continuum domain with different material properties assigned to each of the interacting sub domains (i.e. the fluid and solid regions). This allows making no distinction between fluids and solids for the numerical solution and a single computer code can be used for solving the coupled problem. The pressure unknown for the incompressible domain is treated in a segregated way, allowing solving a Laplace type equation separately from the unified domain.

Nevertheless, the most important conclusion of this lecture is to stand out the topology of the matrices involved in the coupled problem of FSI. The formulation shows clearly the need to include an interface Laplace type matrix on the boundary between the incompressible flow and elastic boundary. In several cases, for instance the applications in biomechanical problems where the added-mass effect is present, this matrix is essential to obtain a convergent procedure.

The concluding remark concerning the interface Laplace type matrix may be also applied to FSI problem solved in a partitioned (staggered) way. This last conclusion makes the results more impressive.

The resulting differential equations are solved via the Particle Finite Element Method (PFEM) [1-3]. The PFEM is an effective technique for modeling complex interactions between floating and submerged bodies including free surface flows, accounting for splashing of waves, large motions of the bodies and frictional contact conditions.

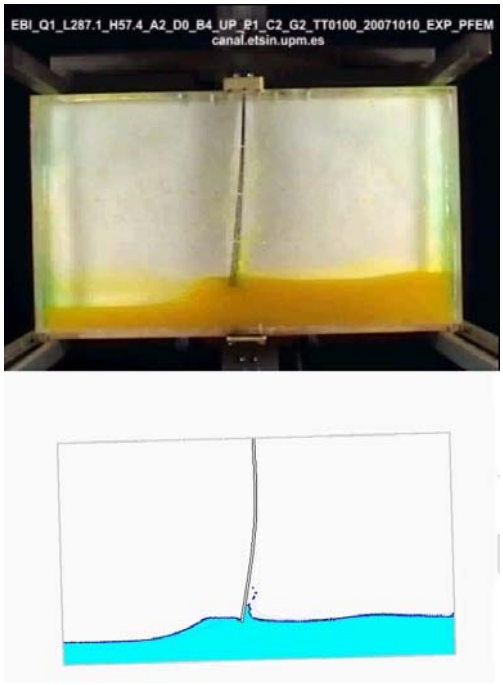

Fig. 1 *Hanging elastic beam in shallow water: experimental versus numerical comparison*

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