

## On the Study of Impulsive Waves Caused by Landslides

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### ABSTRACT

By extending LVOF to a two-phase model, we study impulsive waves created by landslides, based on our design of the mass-force coupling model (Li et al., 2007a; 2008). LVOF is a highly efficient Navier-Stokes solver, constructed by a novel VOF finite volume cut-cell approach that incorporates surface tension plus a dynamic subgrid-scale model (Li et al., 2004; 2007).

According to the fictitious domain method, the mass-force model represents the coupling of a moving body on the flow, by handling the rigid body distributed over the particle domain as a fluid. Additionally, a ghost cell method (GFM) is used to treat the boundary conditions near the particle-fluid interface.

Grid refinement studies are performed for test problems involving aerial landslides. Very encouragingly, the results agree well with measurements available. It is demonstrated that our results can provide valuable base for the analysis of near-field characteristics of landslide generated impulsive waves, by LVOF.

**KEY WORDS:** The mass-force model, landslides, impulsive water waves, a two-phase solver, the GFM, the fictitious domain method.

### INTRODUCTION

Typically, landslides are mass movements of rock (or soil) downslope. During its movement, an intrinsic feature is very short duration, leading to rapid response of the water surface, often subjected to localized high turbulence due to waves breaking. Based on fluid mechanics of a body moving in waves, the particular problem of interest can be classified as fluid-body coupling under surface water waves. It arises in many different areas of engineering (such as the maritime industry, ship and offshore structures). Theoretically, the relevant study mainly involves numerical modelling of moving boundary multiphase problems, related to the

air-water interface plus fluid-particle interface. Only its initial location and geometry are known a priori but the final state has to be determined as part of the solution. Consequently, the gross topology change (like undergoing the processes of merging and breakup) amplifies wave-structure coupling problems. This tends to be more difficult to be solved, especially in the case of a moving body.

For problems involving a moving body, the motion concerning the rigid body can be achieved with Newton's second law, in case the flow surrounding a body is solved by the Navier-Stokes equations. In the context of this theory, the hydrodynamic forces acting on the object, integrated over the surface of the object, will determine the particle velocity, according to two types of traditional approaches: a loosely (Robertson et al., 2003) or fully coupled algorithm (Kim and Choi, 2006). One exception is the so-called force motion, implying a prescribed state in the speed. Generally, methods based on explicit coupling can be unstable, whereas a fully coupled approach guarantees numerical stability (Kleefsman et al., 2005).

Recently advanced technique highlights many ways available for achieving the motion-related computations. One interesting study is that the particle in the flow is considered as a fluid that moves rigidly (Glowinski et al., 2001), implying that the fluid-particle motion is treated implicitly. Consequently, any model for fluid-particle interaction can be avoided, as the mutual forces cancel for the combined system (Sharma and Patankar, 2005).

We develop the mass-force model (Li et al., 2007a; 2008), that captures the effects of a moving body on flows, by specifying mass and force terms as one type of a net driving force. Similar to a fictitious domain method, the rigid body in our mass-force model is also assumed to be an incompressible fluid, that is classified into two categories. One is for one-phase model, in which the pressure over the particle domain is enforced as spatially constant and the velocity is specified in INPUT file, referred to as the force