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A unified Lagrangian formulation for solid and fluid dynamics and its possibility for modelling submarine landslides and their consequences

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1 A unified Lagrangian formulation for solid and fluid dynamics and its
2 possibility for modelling submarine landslides and their consequences

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16
17 14 Abstract

18
19 15 Consequences of submarine landslides include both their direct impact on offshore
20 infrastructure, such as subsea electric cables and gas/oil pipelines, and their indirect impact
21 via the generated tsunami. The simulation of submarine landslides and their consequences
22 has been a long-standing challenge majorly due to the strong coupling among sliding
23 sediments, seawater and infrastructure as well as the induced extreme material deformation
24 during the complete process. In this paper, we propose a unified finite element formulation
25 for solid and fluid dynamics based on a generalised Hellinger-Reissner variational principle
26 so that the coupling of fluid and solid can be achieved naturally in a monolithic fashion. In
27 order to tackle extreme deformation problems, the resulting formulation is implemented
28 within the framework of the particle finite element method. The correctness and robustness
29 of the proposed unified formulation for single-phase problems (e.g. fluid dynamics problems
30 involving Newtonian/Non-Newtonian flows and solid dynamics problems) as well as for
31 multi-phase problems (e.g. two-phase flows) are verified against benchmarks. Comparisons
are carried out against numerical and analytical solutions or experimental data that are
available in the literature. Last but not least, the possibility of the proposed approach for
modelling submarine landslides and their consequences is demonstrated via a numerical
experiment of an underwater slope stability problem. It is shown that the failure and post-

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