Particle Finite Element Response Sensitivity Analysis of Fluid-Structure Interaction by the Direct Differentiation Method – PARTICLES 2015

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ABSTRACT

The Particle Finite Element Method (PFEM) is well-suited to simulating fluid-structure interaction (FSI) because it uses a Lagrangian formulation of the fluid domain. Considerable research has been performed on numerical improvements of the PFEM; however, far less attention has been paid to the development of gradient-based algorithms that use the PFEM to evaluate objective functions of fluid-structure response. Despite great strides in the numerical performance of PFEM simulations, using finite differences to evaluate gradients, or sensitivity, of FSI response remains prohibitively expensive. To evaluate gradients of FSI response accurately and efficiently, the direct differentiation method (DDM [1]) is applied to the PFEM. With the DDM, analytical derivatives of the governing PFEM equations of mass conservation and momentum balance are implemented in the numerical code alongside the ordinary response at both the global and element levels [2]. Combined with existing sensitivity formulations for nonlinear structural finite elements, implementation of the DDM for PFEM analysis allows for reliability and optimization applications of coastal infrastructure subjected to various levels of tsunami and flood hazards. Verification examples are presented along with a representative application in first order reliability analysis for a coastal reinforced concrete building.

REFERENCES

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