Coupling implicit multi-time step Perfectly Matched Layers with FE explicit codes for seismic wave propagation in 2D unbounded domains

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Abstract

Perfectly Matched Layer (PML) is recognized as a very effective tool for modeling unbounded domains. Nonetheless, the computation time required by the PML may be large, especially when an explicit time integration scheme is adopted for dealing with the wave propagation problem both in the domain of interest and in the PML medium. In this paper, it is proposed to investigate subdomain strategies enabling the appropriate time integration scheme in the PML with its own time step to be chosen, independently of the choice of the time scheme in the domain of interest. We focus on explicit time integrator in the physical subdomain (Central Difference scheme) associated with a fine time step satisfying the CFL stability criterion. The PML formulation proposed by Basu and Chopra ([1]) for 2D transient dynamics, has been coupled with the interior physical subdomain using the dual Schur approach proposed by Gravouil and Combescure ([2]). Hybrid (implicit time integrator for the PML) asynchronous (multi time steps) PMLs have been derived.

In order to highlight the accuracy of the hybrid asynchronous PMLs, 2D numerical applications have been investigated such as Lamb's test, rigid footing on a half space and on a layered half space. Excellent agreement has been achieved in comparison to the full explicit computation with an extended mesh. The result accuracy decreases when large time steps in the PML are considered. Other PML formulations could be employed using the presented framework.
3D implementations of absorbing layers have been achieved to mimic the semi-infinite medium, based on either viscous damping Rayleigh formulation or PML formulation. The efficiency of the different methods was compared. Finally, weak coupling in time has been investigated on the basis of the recent works ([3], [4]), enabling to adopt more advanced time integrators as α methods for damping out the high frequencies due to the finite element discretization.

Keywords: Perfect Matched Layers (PML), elastic wave, 2D and 3D transient analysis, subdomain coupling, Hybrid Asynchronous PML

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