11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

THE CAUGHLEY ABSORBING LAYER METHOD – IMPLEMENTATION AND VALIDATION IN ANSYS SOFTWARE

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Key Words: *Elastic Wave Propagation, Finite Element Method, Absorbing Boundary Layer, Spurious Reflections, Unbounded Domains.*

The numerical analysis of the wave propagation problem, from elastic to electromagnetic waves, is often faced with the problem of dealing with unbounded media. Since the domain of finite-difference and finite element methods must be itself finite, various truncation techniques have been proposed over the last decades, such as absorbing boundary conditions (Lysmer and Kuhlemeyer[1]), infinite elements (Bettess [2]) and absorbing boundary layers (such as the Perfectly Matched Layer, or PML, introduced by Bérenger [3]).

In this paper, the Caughey Absorbing Layer Method (CALM), proposed by Semblat *et al.* [4], is implemented in the commercial finite element software Ansys, using an implicit dynamics formulation. It is tested for one- and two-dimensional problems and its efficiency is compared with that of the Lysmer-Kuhlemeyer absorbing boundaries. The dependency on material parameters, loss factor and load frequency is also tested.

The CALM uses an absorbing boundary located at the boundaries of a medium to attenuate elastic waves in solids before they reflect at the Dirichlet boundary. The layer has the same material proprieties of the medium being studied, but with added Caughey damping, which can be constant or increase along the layer. In the present implementation, the particular case of Rayleigh damping is used, with the damping coefficients tuned for the frequency of the waves.

Compared to the PML, the Caughey absorbing layer is characterized by being intrinsically multi-directional and having a straightforward numerical implementation: unlike the PML, it can be implemented with finite elements in the time domain without use of complex-valued properties, split-field formulations or convolutions in the time domain, simply by defining the damping matrix as a combination of the mass and stiffness matrices.

However, the Caughey layer is not perfectly matched, so reflections will occur at the interface between the medium of interest and the absorbing layer, a problem that is aggravated by the discretisation inherent to the finite element method. To mitigate this problem, different variations of damping along the layer's length are tested and their efficiency compared. The CALM is also frequency-dependent, whereas the PML (before discretisation) is not.

By analysing the maximum displacement and the L^2 norm of the displacement field, the implementation of the CALM in Ansys is shown to be effective at mitigating the problem of spurious wave reflection at the boundaries. Their performance is clearly superior to the Lysmer-Kuhlemeyer absorbing boundary conditions, but at a greater computational cost due to the additional degrees of freedom.

The quadratic variation of the Rayleigh damping has proved to be the most effective, and an estimate of the optimum loss factor as a function of the length of the layer in relation to the wavelength to absorb was proposed. Although the optimal damping is frequency dependent, it was shown to work well even if the frequency is overestimated or greatly underestimated. Further study revealed that the CALM is particularly efficient at filtering the high frequency content of the waves.

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