One-dimensional nonlinear equation for P-wave propagation in heterogeneous medium

Renan André Peres*, Post-Graduate Program in Environmental Engineering, Federal University of Espírito Santo, Vitória, ES, Brazil.
Antônio Manoel Ferreira Frasson, Post-Graduate Program in Environmental Engineering, Federal University of Espírito Santo, Vitória, ES, Brazil.
Carlos Friedrich Loeffler, Post-Graduate Program in Mechanical Engineering, Federal University of Espírito Santo, Vitória, ES, Brazil.
Fábio Pavan Piccoli, Post-Graduate Program in Environmental Engineering, Federal University of Espírito Santo, Vitória, ES, Brazil.
Julio Tomás Aquije Chacaltana, Post-Graduate Program in Environmental Engineering, Federal University of Espírito Santo, Vitória, ES, Brazil.

Abstract

The signal released by the pressure source (boomer) propagates through the different layers of ocean water and through the different strata that make up the earth. During wave propagation, the processes of interaction with the fluid medium and the earth's strata occur, among all processes the one of greatest interest is the wave reflection, which causes part of the signal to return to the initial generating medium. The return of the signal is captured and recorded by hydrophones or geophones, a signal that contains valuable information on the means by which it crossed until its registration. Thus, of great importance is the modeling of P-wave propagation in media with complex geological structure. The principles of solid mechanics are applied to develop a non-linear equation for the one-dimensional P-wave propagation in a heterogeneous medium, including a pressure source term. The numerical solution is performed by the finite element method applying the Petrov-Galerkin weighted residue formulation, using linear and parabolic approximation basis functions. In wave generation, two different types of pressure source term were implemented, the Ricker type (CHACALTANA, 2015; PICOLLI, 2020) and the sinusoidal type. Furthermore, Neumann's reflective (natural) and Absorbing Boundary Condition (ABC) boundary conditions based on Reynolds' (1978) non-reflective edges were implemented and tested. A numerical code in Fortran language was developed, as well as a graphical interface in Octave for analysis of the results. Numerical results are obtained at discrete points representing a one-dimensional mesh of non-uniform elements generated by the GMSH mesh generator. The results of the numerical simulations are compared with those of the analytical solution and with the existing numerical ones in the literature. A good agreement between them is found.

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