

Preface

The topic of this book is development, verification, and application of advanced computational tools based on the mesh-reducing boundary integral equation method for seismic wave propagation in continuously and discretely inhomogeneous and heterogeneous geological media. The BIEM, also known in the literature as the boundary element method, or simply as boundary elements, is a formulation that takes into account the entire wave path from the seismic source through the geological deposits and all the way up to the local site under consideration. The formulation itself is based on a limit process, whereby integral equations defined for the continuum become BIE by moving the two field points, namely the source and the receiver, to the boundary. These boundaries may be external (e.g., the free surface) or internal (e.g., a cavity). It is the subsequent numerical implementation of these boundary integral equations that are now singular, which gives rise to the BIEM. The mechanical models are elastic and poroelastic, the latter understood within the framework of viscoelastic isomorphism of Biot's model. The heterogeneities are either single or multiple cavities, cracks, and inclusions of arbitrary number, and geometry and location in finite, infinite, and semi-infinite domains with surface topography. Two-dimensional anti-plane and in-plane elastodynamic problems are considered by using the displacement and non-hypersingular traction BIEM formulations for continuously inhomogeneous media with different types of heterogeneities. In the BIEM formulations presented here, a library of fundamental solutions and Green's functions that account for different types of material gradient is seamlessly inserted, thus augmenting the potential of the method to treat problems of engineering interest.

The aim of the book is to solve seismic wave propagation problems with application in computational geophysics and civil engineering. To this end, the mechanical models employed describe the seismic response and local zones of dynamic stress concentration in inhomogeneous geological regions with layers, cracks, cavities, and inclusions. Numerical tools are developed based on the displacement and non-hypersingular traction BIEM formulations with analytically derived fundamental solutions/Green's functions for certain classes of graded geomaterials. These analytic derivations are based on either the Fourier

transformation or the Radon transformation, depending on the type of problem at hand. Different key factors affecting the development of the seismically induced wave fields are identified, namely the type and properties of the material gradient, heterogeneity in the wave path starting from the seismic source up to the free surface of the local geological profile, and mechanical behavior of the geomaterial and dynamic interactions between multiple heterogeneities such as cracks, cavities, and layers interfaces, and finally, free-surface and subsurface relief peculiarities are presented with simulations.

The book is intended as a text for graduate students and researchers. A certain basic level of knowledge of applied mathematics, theory of partial differential equations, continuum mechanics, fracture mechanics, computational mechanics, and wave propagation theory is a necessary prerequisite in order to follow the material presented here.

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Media by Boundary Elements

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