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Three-dimensional dynamic Green's functions for a multilayered transversely isotropic half-space

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ABSTRACT

With the aid of a method of displacement potentials, an efficient and accurate analytical derivation of the three-dimensional dynamic Green's functions for a transversely isotropic multilayered half-space is presented. Constituted by proper algebraic factorizations, a set of generalized transmission–reflection matrices and internal source fields that are free of any numerically unstable exponential terms are proposed for effective computations of the potential solution. Three-dimensional point-load Green's functions for stresses and displacements are given, for the first time, in the complex-plane line-integral representations. The present formulations and solutions are analytically in exact agreement with the existing solutions given by Pak and Guzina (2002) for the isotropic case. For the numerical computation of the integrals, a robust and effective methodology which gives the necessary account of the presence of singularities including branch points and poles on the path of integration is laid out. A comparison with the existing numerical solutions for multilayered isotropic half-space is made to confirm the accuracy of the numerical solutions.

1. Introduction

The early work of Stoneley (1949) revealed the fact that wave propagation in a transversely isotropic medium gives rise to phenomena which greatly differ from the case where the medium is isotropic. Later, Synge (1957), Buchwald (1961) and Payton (1983) studied the elastodynamic problems pertinent to the transversely isotropic half-space under surface loadings. The approach, which was introduced by Buchwald (1961), has been used, with small changes, by Rajapakse and Wang (1993) and Shodja and Eskandari (2007). Rajapakse and Wang (1993) tackled the dynamic Green's function problem for a transversely isotropic elastic half-space subjected to interior time-harmonic loading. Shodja and Eskandari (2007) derived the axisymmetric time-harmonic response of a coated transversely isotropic half-space. While the issue of completeness of their representation was not addressed, they were able to reduce the equations of motion by means of three potential functions proposed by Buchwald (1961) to a set of two coupled partial differential equations and one separated partial differential equation. Rahimian et al. (2007) presented a new and efficient elastodynamic potential method for the determination of the displacement and stress fields in a transversely isotropic solid. Employing this potential method, Khojasteh et al. (2008a) recently studied the dynamic response of a transversely isotropic elastic half-space subjected to interior time-harmonic loading. But in many situations, waves originate and propagate in media having a layered structure, where interfaces between dissimilar materials exist. Seismic waves in a layered earth are an example, and important applications in structures also exist, such as waves in composite laminates. Also wave propagation in a three-dimensional horizontally multilayered solid of semi-infinite extent due to arbitrary internal sources is a subject of fundamental interest in applied mechanics and civil engineering because of its relevance to dynamic soil-structure interaction, geotechnical earthquake engineering, foundation vibration, seismology, and geophysical methods. For this class of mathematical problems, a variety of approaches related to isotropic materials have been presented. The reader is referred to Pak and Guzina (2002) for an extensive list of work in this area. As far as general solutions are concerned, however, the concept of the propagator matrix first employed by Thomson (1950) and Haskel (1953) is perhaps the most appealing. Pak and Guzina (2002) obtained explicit and effective expressions for the dynamic Green's functions for an isotropic multilayered half-space. To date, there are not many papers devoted to the problems of wave propagation and dynamic Green's functions of transversely isotropic and anisotropic layered media. Yang et al. (2004) studied three-dimensional Green's function for an anisotropic bi-material full-space, and

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