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二维SH波方程的半解析解及其数值模拟

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Semi-analytical solutions and numerical simulations of 2D SH wave equation

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摘要

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摘要 本文以波动理论为基础, 半解析化求解地震勘探中常用的SH波方程. 获得的主要结果包括: 给出了二维均匀介质中SH波方程的解析解; 利用Cagniard-de Hoop方法详细推导了二维双层介质中SH波方程的解析解, 获得了透射波的解析解表达式. 同时, 基于SH波方程的解析表达式, 给出了包含各种波(如直达波、反射波、首波以及透射波)的解析解和波形图. 对于比较复杂的积分型解析解, 利用数值积分方法给出了数值结果, 并与优化的近似解析离散化方法(ONADM)和4阶Lax-Wendroff修正方法(LWC)的数值结果进行了比较, 以验证解析解的正确性. 本文的研究成果有望在检验波动方程数值新方法的有效性、波传播理论分析等方面得到应用.

关键词 SH波, 解析解, 半解析解, Cagniard-de Hoop方法

Abstract: In this paper, we show the analytical solutions of the SH-wave equation based on wave propagation theories. The main results include the analytical solutions of 2D SH-wave equations in the homogeneous medium, the analytical solutions of reflected SH-wave in a two-layer medium derived in detail by using the Cagniard-de Hoop method; we also obtain the analytical solutions for the transmitted SH-wave. Meanwhile, we present some waveforms of various waves including direct wave, reflected wave, head wave, and transmitted wave computed by the analytical solutions of the SH-wave. We present some numerical results by using numerical integral algorithms for the complex integral solutions, and compare the analytical solutions with the numerical results computed by the numerical methods including the optimal nearly analytical discrete method (ONADM) and the fourth-order Lax-Wendroff correction (LWC) scheme to verify the correctness of the numerical methods. The analytical solutions obtained in this paper have great potentials in the applications of testing the new methods for solving the wave equations and the theoretical analysis of wave propagation.

Keywords SH-wave, Analytical solutions, Semi-analytical solutions, Cagniard-de Hoop method

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