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Impact of triangular irregularity on the dispersion of SH-waves in a monoclinic crustal layer overlying a dry sandy medium

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ABSTRACT

In the present paper, a comprehensive study of dispersion characteristics of SH-waves in a monoclinic crustal layer lying over a dry-sandy half-space, with special emphasis on the effect of a triangular irregularity at the interface, has been conducted. We have considered both isotropic and monoclinic layer for the analysis of SH-wave propagation with or without sandiness in the half-space. The governing equations representing equation of motion of SH-waves in a monoclinic medium, is formulated to develop dispersion relation. Further, the results are analyzed and discussed for the variation in various physical parameters such as depth of triangular irregularity, sandiness and the directional dependencies in the monoclinic medium. Moreover, a comparative study has been conducted to assess the extent to which these parameters affect SH-wave propagation differently in monoclinic and isotropic layers. These results are illustrated graphically to highlight the importance of considering interfacial irregularity in seismic wave studies.

Keywords: SH-waves, dispersion, triangular irregularity, monoclinic medium, dry-sandy half-space.

INTRODUCTION

As is well known, SH-waves are seismic waves that move horizontally through the Earth's surface. These waves are particularly useful for studying underground structures as they travel within layered boundaries. It is essential for geophysicists to understand the behavior of such waves in the solids beneath Earth's surface. These solids in the Earth's interior are commonly referred to as minerals or mineral rocks. Minerals with distinct geometric structures are known as crystals. Although crystals can take various forms namely, hexagonal, triclinic, monoclinic, orthorhombic, cubic, tetragonal, and trigonal, nearly one-third of the minerals in the Earth's interior belong to the monoclinic crystalline form. Hence, there is a need to study SH-wave behavior in such media. Several authors have analyzed the dispersion of seismic waves through the monoclinic medium in their studies (Chattopadhyay and Saha, 1996; Kaur and Tomar, 2004). In a related work, Kalyani et al. (2008) presented a model for seismic wave propagation in monoclinic media using the finite difference method. It demonstrated that the anisotropy in the monoclinic medium, hinders the phase velocity of the medium. Sethi and Sharma (2016) discussed the dispersion of SH-waves in a non-homogeneous monoclinic layer over a semi-infinite isotropic medium. Recently, Khan et al. (2021) examined the influence of initial stress on the propagation of SH-waves over a heterogeneous monoclinic half-space. In their work, they studied the variation in the depth of irregularity and non-homogeneity on the phase velocity of the waves. Pradhan et al. (2023) investigated the SH-wave propagation due to a point source at the interface between monoclinic and heterogenous media. They showed that the heterogeneity hinders the phase velocity. Further, Pradhan et al. (2025) extended their study to a two layered structure of functionally graded viscoelastic and monoclinic media, demonstrating the impact of various gradient parameters on dispersion curves, phase velocity, group velocity, and wave number of SH-waves.

The study of seismic waves in the half-space beneath the Earth's crust provides valuable information about the structure of Earth, which plays an important role in the propagation of SH-waves. Although these half-spaces are primarily composed of solid rocks, some may also contain unconsolidated dry sand. Generally, it is observed that SH-waves propagate more slowly through dry sandy media due to energy absorption by the sand grains. Several researchers have considered dry sandy media to study the propagation of seismic waves. For example, Tomar and Kaur (2007) investigated the reflection and transmission of SH-waves at the interface between a dry sandy and an anisotropic half-space. Pal et al. (2016) analyzed the effects of the sandiness parameter and material inhomogeneity on the dispersion of SH-waves propagating through a dry sandy layer, sandwiched between an inhomogeneous isotropic and a homogeneous isotropic half-space. More recently, Madan et al. (2023a) analyzed SH-wave propagation in an orthotropic elastic layer confined between a dry sandy layer and a half-space, highlighting the effect of various parameters on dispersion. Further, in the same year, Madan et al. (2023b) examined Rayleigh waves in an isotropic sandy layer overlying a semi-infinite sandy medium, showing the influence of sandiness on phase velocity.

In earlier studies, different authors in their work assumed interfaces to be perfectly uniform. However, in actual scenarios, geological interfaces are rarely smooth. The Earth's subsurface consists of layered materials with irregularities at the interfaces between different media. The propagation of SH-waves in such layered geological structures is significantly influenced by these geometric irregularities. Numerous studies have examined such irregularities, which affect dispersion of waves with varying layer properties and shapes of the