Chapter 14

Anti–Plane Shear Wave in Microstructural Media:
A Case Wise Study of Micropolarity, Irregular, and Non–Perfect Interface

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ABSTRACT

The present chapter encapsulates the characteristic behavior of anti-plane shear wave propagation in a micropolar layer/semi-infinite structural media. Two types of interfacial complexity have been considered at the common interface which give rise to two distinct mathematical models: (1) Model I: Anti-plane shear wave in a micropolar layer/semi-infinite structure with rectangular irregular interface and (2) Model II: Anti-plane shear wave in a micropolar layer/semi-infinite structure with non-perfect interface. For both models, dispersion equations have been deduced in algebraic form and in particular, the dispersion equation of new type of surface wave resulted due to micropolarity has been obtained. The deduced results have been validated with classical cases analytically. The effects of micropolarity, irregularity, and non-perfect interface on anti-plane shear wave have been demonstrated through numerical study in the present chapter.

INTRODUCTION

Micropolar theory suggested by Eringen (1966) differs from the classical continuum due to its involvement of microrotations of the material rigid particles. Platelet composites, aluminium epoxy, soils, liquid crystals with rigid molecules, concrete with sand, animal bloods and many other materials do not exhibit properties of classical continuum accurately due to their granular or molecular structure of the DOI: 10.4018/978-1-7998-0117-7.ch014
body. This inaccuracy, hence, micromechanics has been ignored in engineering fields for many years, but, in recent decades, micropolar theory has attracted attentions of many researchers and engineers.

Askar (1972) suggested that if shear wave is induced at one end of a micropolar crystal, and by strain gauges, if the incoming waves are detected at the other end, then some of the energy will be found missing. The reason for this experiment was that some of the translational energy has been transformed into rotational energy through the coupling between these two modes and strain gauge cannot detect rotations. This clears the very necessity of the question that why the consideration of micropolar theory is needed in engineering applications. For any engineering applications involving macrostructures, information on microstructural properties are essential for stability and non-destructive testing. Eringen (1999) stated that to deal with the measurement of microscopic-level quantities in high frequency and short-wavelength regions, doing experiments with micropolar constants requires precision and more elaborate instrumentation. As a result, the development of engineering and pragmatic applications regarding microstructures is very humble. Hence, any theoretical development on microstructures will be of great concern now-a-days, especially, in civil, mechanical and seismic engineering applications.

In aspect of wave propagation phenomena, it has been observed that if the wavelength and the average dimension of the microelements are of same order of magnitude, the fundamental motion of the microelements gets affected significantly (Eringen, 1966). If wave propagation gets affected by the spin inertia of micropolar body, it gives rise to new-type of surface waves not reported in the classical elasticity. Hence, the study of wave propagation in micropolar continuum is very much essential in the vicinity of finding these new-type of surface waves. Although several models can be found consisting of microstructural continuum in the literature, but, in aspect of wave propagation phenomena, very few works can be mentioned. In the vicinity of our present work, a great attention has been given on the work of Midya (2004). Midya (2004) have studied Love wave propagation in micropolar layer/half-space configuration. This layer/half-space configuration is very popular and essential for the propagation of surface waves. It is to be noted that within classical elasticity, anti-plane surface waves do not exist in an elastic semi-infinite space (Achenbach, 1973), but in a layer/semi-infinite configuration, anti-plane shear horizontal waves (viz. Love wave) can propagate provided the phase velocity should be greater than bulk shear velocity of upper layer and lesser than that of lower semi-infinite space (Love, 2013). However, in micropolar elasticity, wave propagation is possible in half-space due to microrotations, but authors are more interested in dispersive nature of waves. Hence, in the present chapter, emphasis has been given more on the layer/half-space configuration due to anti-plane shear waves.

Interfacial complexity in man-made structures is based on real world scenario and could arise due to aging of glue at the interface of two solids, microdefects, diffusion impurities, and other forms of damages in several engineering problems. The study of non-parallel boundaries in context of wave propagation in elastic media is also essential to geophysicists in order to make analysis and prediction for the seismic behavior at continental margins and mountain roots. Due to abrupt thickening, many shapes and sizes of irregularity can be found at the interface between two media, viz. rectangular, parabolic, triangular notch, corrugation etc. On the other hand, non-perfect bonding occurs due to “slip” condition between two media at the interface where the interfacial shearing stress can be balanced by the slip (Murty, 1976). However, considering such complexity in mathematical model creates challenges.

The main objective of the present chapter is to study propagation characteristics of anti-plane shear horizontal surface wave in a homogeneous micropolar layered structure by introducing interfacial complexity. Two distinct models can be considered having different types of interfacial complexity (i.e. irregular boundary (Model I) and non-perfect boundary (Model II)) along with source of disturbance and studied
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