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On surface waves in a finitely deformed coated half-space

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Abstract: In this paper, the wave propagation in a finitely pre-deformed elastic half-space overlain by a thin coating layer (or surface film) is considered. The coated half-space is subjected to a particular uniform pre-deformation such that it is kept to be tractions-free on its surface. The first-order effective boundary conditions are introduced to approximate the effect of the overlying surface film. Then the Stroh formalism and Barnett-Lothe theory are adopted to study the surface wave characteristics. In particular, general criteria are established to identify the existence of surface waves of different modes by taking advantage of the surface impedance matrix. As an illustration, surface waves in a coated soft half-space under biasing field are investigated. Both the surface film and the half-space are modeled by the Hadamard strain energy function for soft isotropic materials. Explicit conditions for the existence of different surface wave modes (including the first-order Rayleigh waves, second-order Rayleigh waves and Love waves) are obtained, and the corresponding wavenumber ranges are also determined. Our theoretical analysis and numerical simulations show that both the surface film and the pre-deformation could remarkably affect the propagation of surface waves as well as the stability of the coated elastic half-space. Particularly, it is proved that, distinguishing from Rayleigh waves, the velocity of Love waves varies linearly with pre-stretch for a given frequency, a striking feature which is highly desirable in the sensor designs.

Key words: coated half-space, finite pre-deformation, surface waves, existence, stability

1. Introduction

Guided wave propagation in an elastic substrate coated with a thin surface layer has been investigated intensively by researchers with diverse applications in earth science, mechanical engineering, and solid state physics, to name a few. The substrate

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