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On the Surface Anti-Plane Waves in Media with Initial Surface Stresses

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Abstract: We discuss the propagation of surface waves in an elastic half-space with surface stresses modelled within the framework of the Gurtin-Murdoch surface elasticity. The main attention is paid to the analysis of initial surface stresses. To this end we consider the linearized surface elasticity model. The analysis of initial stretching/compression on the dispersion relation is provided.

Keywords: surface elasticity, Gurtin-Murdoch model, anti-plane surface wave, initial stresses, nonlinear elasticity

1. Introduction

Nowadays it is well-established that the surface elasticity may capture a deviation of the material properties at small scales, see e.g. [1-3]. One of the most used model of surface elasticity was proposed by Gurtin and Murdoch [4, 5]. From the physical point of view this model describes finite deformations of an elastic solid body with attached elastic membrane. In particular, this model can forecast size-effects [1-3]. It was also shown that within this model such new phenomenon as anti-plane surface wave may exist. The analysis of influence of surface stresses on surface waves within various models was given in [6-10], see also the references therein.

The aim of the lecture is consider the influence of the initial surface stresses on the dispersion relations which relate the phase velocity to a wave number.

2. Results and Discussion

Following [6] we formulate the boundary-value problem for an elastic half-space with surface stresses. Here we introduce independently constitutive relations in the bulk and on the surface. The latter include initial surface strains. For the analysis of infinitesimal waves we provide the linearization of the problem. As a result, we get a linearized boundary-value problem which essentially depends on the initial surface strains.

Using the approach similar to [6, 10] we consider harmonic solution in the form

$$u(x,z,t)=U(x,z)\exp(\mathrm{i}\omega t), \quad (1)$$

where u is a infinitesimal displacement, x, z are Cartesian coordinates in the current placement, t is time, and ω is a frequency. After solution we obtain a dispersion relation in the form

$$D(k, \omega; \lambda_1, \lambda_2)=0, \quad (2)$$

where k is a wave number and *;* λ_1, λ_2 are initial principal surface stretch parameters. We provide a detailed parametric analysis of Eq. (2).

3. Concluding Remarks

We have shown that initial (residual) surface stresses may essentially affect the dispersion relation for the anti-plane surface waves. In particular, some surface instabilities may occur which block the propagation of surface waves.

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