INFLUENCE OF SURFEACE STRESSES ON STABILITY OF NONLINEARLY ELASTIC ROD UNDER COMBINED LOADING

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Recently, for modeling the surface phenomena, especially in nanomechanics, the theory of elasticity with surface stresses has received development. In this theory, in addition to the ordinary stresses distributed in the volume, the independent surface stresses are also taken into account at the boundary of the body or its part. These stresses generalize the well-known in hydromechanics scalar surface tension to the case of solids. The introduction of surface stresses allows, in particular, describing the size effect typical for nanomaterials. The present research is dedicated to the buckling analysis of nonlinearly elastic rods with surface stresses. In the framework of Gurtin–Murdoch model, we have studied the stability of a circular rod under axial compression-tension and external pressure. From the mechanical point of view, this model of the body with surface stresses is equivalent to a deformable body with glued elastic membrane. The stress resultant tensor acting in the membrane can be interpreted as surface stresses in the Gurtin–Murdoch model. Accounting for surface stresses allows studying the buckling features of micro- and nano-sized rods and rods whose surface is coated, for example, with a nanofilm. The semi-inverse method was applied to determine the subcritical stress-strain state of a circular rod under finite strains. In the derivation of the neutral equilibrium equations, we used the linearization method, adapted to the problems of the nonlinear theory of elasticity. By numerical solution of the obtained linearized boundary-value problem for some materials, the critical curves and corresponding buckling modes have been found, and the stability regions have been constructed in the plane of loading parameters, which are the coefficient of axial compression-tension and external pressure. Using these results, we have analyzed in detail the size effect and studied the influence of surface stresses on the loss of stability for circular rods.

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