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Reissner Stationary Variational Principle for Nonlocal Strain Gradient Theory of Elasticity

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Abstract

The general form of Reissner stationary variational principle is established in the framework of the nonlocal strain gradient theory of elasticity. Including two size-dependent characteristic parameters, the nonlocal strain gradient elasticity theory can demonstrate the significance of the strain gradient as well as the nonlocal elastic stress field. Based on the Reissner functional, the governing differential and boundary conditions of dynamic equilibrium and differential constitutive equations of the classical and first-order nonlocal stress tensor are derived in the most general form. Additionally, the boundary congruence conditions are formulated and discussed for the nonlocal strain gradient theory. To exhibit the application value of Reissner variational principle, it is employed to examine the nonlinear vibrations of size-dependent Bernoulli-Euler and Timoshenko beams. In the case of immovable boundary conditions, employing the weighted residual Galerkin method, the homotopy analysis method is also utilized to determine the closed form analytical solutions of the geometrically nonlinear vibration equations. Consequently, the analytical expressions for the nonlinear natural frequencies of Bernoulli-Euler and Timoshenko nonlocal strain gradient beams are derived.

Keyword: Reissner variational principle; Nonlocal elasticity theory; Strain gradient theory; Size-dependent nonlinear beams; Nonlinear free vibration;