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A Refined Nonlocal Strain Gradient Theory for Assessing Scaling-Dependent Vibration Behavior of Microbeams

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Abstract : A size-dependent Euler–Bernoulli beam model, which accounts for nonlocal stress field, strain gradient field and higher order inertia force field, is derived based on the nonlocal strain gradient theory considering velocity gradient effect. The governing equations and boundary conditions are derived both in dimensional and dimensionless form by employed the Hamilton principle. The analytical solutions based on different continuum theories are compared. The effect of higher order inertia terms is extremely significant in high frequency range. It is found that there exists an asymptotic frequency for the proposed beam model, while for the nonlocal strain gradient theory the solutions diverge. The effect of strain gradient field in thickness direction is significant in low frequencies domain and it cannot be neglected when the material strain length scale parameter is considerable with beam thickness. The influence of each of three size effect parameters on the natural frequencies are investigated. The natural frequencies increase with the increasing material strain gradient length scale parameter or decreasing velocity gradient length scale parameter and nonlocal parameter.

Keywords : Euler-Bernoulli Beams, free vibration, higher order inertia, Nonlocal Strain Gradient Theory, velocity gradient
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