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Nonlocal inflected nano-beams: a stress-driven approach of bi-Helmholtz type

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Abstract

Size-dependent bending behavior of Bernoulli-Euler nano-beams is investigated by elasticity integral theory. Eringen's strain-driven nonlocal integral formulation, providing the bending moment interaction field as output of the convolution between elastic curvature and bi-Helmholtz averaging kernel, is examined. Corresponding higher-order constitutive boundary conditions are established for the first time, showing inapplicability of strain-driven nonlocal integral law of bi-Helmholtz type to continuous nano-structures defined on bounded domains. As a remedy, an innovative stress-driven nonlocal integral elastic model of bi-Helmholtz type is presented for inflected Bernoulli-Euler nano-beams, by swapping input and output of Eringen's nonlocal integral elastic law. The proposed stress-driven nonlocal integral constitutive law is proven to be equivalent to a fourth-order linear differential equation in the elastic curvature, fulfilling suitable homogeneous constitutive boundary conditions. The corresponding elastic equilibrium problem of an inflected nano-beam is well-posed and numerically solved for statics schemes of nano-technological interest, under standard loading and kinematic boundary conditions. New benchmarks for nonlocal computational mechanics are also detected.

Keywords: Nonlocal elasticity; Stress-driven integral law; Size effect; Nano-beam; bi-Helmholtz kernel; CNT.

1. Introduction

Investigation of mechanical response of nano-structures is a topic of major interest in the current literature. Nonlocal continuum mechanics is a convenient methodology for evaluating small-scale effects exhibited by beam-like components in nano-electro-mechanical-systems (NEMS) [1-10]. This approach is still in the focus of

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