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Stress-driven two-phase integral elasticity for torsion of nano-beams

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Abstract

Size-dependent structural behavior of nano-beams under torsion is investigated by two-phase integral elasticity. An effective torsional model is proposed by convexly combining the purely nonlocal integral stress-driven relation with a local phase. Unlike Eringen's strain-driven mixture, the projected model does not exhibit singular behaviors and leads to well-posed elastostatic problems in all cases of technical interest. The new theory is illustrated by studying torsional responses of cantilever and doubly-clamped nano-beams under simple loading conditions. Specifically, the integral convolution of the two-phase mixture is done by considering the special bi-exponential kernel. With this choice, the stress-driven two-phase model is shown to be equivalent to a differential problem equipped with higher-order constitutive boundary conditions. Exact solutions are established and comparisons with pertinent results obtained by the Eringen strain-driven two-phase mixture and by the strain gradient theory of elasticity are carried out. The outcomes could be useful for the design and optimization of nano-devices and provide new benchmarks for numerical analyses.

Keywords

Torsion; nonlocal integral elasticity; mixtures; nano-beams; size effects; Hellinger-Reissner variational principle; analytical modelling.

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