Abstract

Laminated Kirchhoff nanoplates based on the strain gradient theory: development of conforming and nonconforming finite element models

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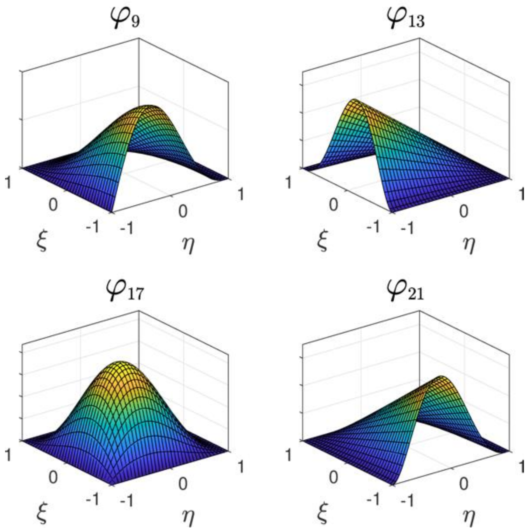
Nonlocal theories are becoming more and more popular due to the increasing use and analysis of micro- and nano-scaled structural elements. Classical continuum theories turn out to be inadequate to model such components. In particular, the mechanical behavior of these nanostructures is influenced by the material microstructure.



The strain gradient theory takes into account the micro/macro scale interactions by introducing the internal length into the definition of the three-dimensional stress components. Consequently, computational difficulties clearly arise from this constitutive assumption, due to the fact that stress-strain relations depend on the nonlocal nature of the model.

As far as plate structures are concerned, the strain gradient theory is limited to the analysis of isotropic and graded structures. General lamination schemes, as well as arbitrary boundary conditions, are not taken into account.

The main aim of this research is the development of a finite element code based on the strain gradient theory able to deal with thin laminated plates, extending the analysis to general stacking sequence and various restraints. Such studies are carried out in the theoretical framework provided by the Kirchhoff model.

Conforming and nonconforming finite elements are developed to this aim. In particular, higher-order Hermite interpolation functions are employed to approximate both membrane and bending degrees of freedom.

This numerical approach is validated by the comparison with the results taken from the literature for isotropic and simply supported laminated plates. Analytical solutions are available only for cross-ply and angle-ply lamination schemes. A simple and effective matrix notation is developed in order to simplify the computer implementation.