THESIS ABSTRACT

MODELING AND DESIGN OF MULTI-STABLE COMPOSITE STRUCTURES

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Starting from their initial state, multi-stable structures can morph into a new stable configuration as a result of a snap-through elastic instability triggered by an adequate external energy input. Great interest has recently been shown towards this special class of compliant structures, due to the possibility to harness the snap-through buckling as a source of energy and motion in a wide range of applications. A major obstacle to the full exploitation of multi-stable structures is represented by their complex mechanical response, resulting in computationally expensive design and optimization procedures. To address this issue, the development of a novel numerically efficient structural modeling approach for the analysis of bistable composite beams is discussed in this thesis. The beam kinematics is modeled by means of a Unified Formulation, which allows the relaxation of classical kinematic assumptions by including higher-order terms in the expression of the displacement field. At first, the potential of the formulation is assessed in the linear regime with regards to the mechanical and thermo-mechanical analysis of composite beams. In the second place, Green-Lagrange geometric non-linearities are accounted for, in the framework of a total Lagrangian approach, since the capability to analyze structures under large displacements is essential for the prediction of bistability phenomena. By means of Unified Formulation, accurate predictions of stable geometries, snap-through loads and stress fields in bistability analyses can be obtained with no loss of accuracy and reduced computational costs when compared to two- and three-dimensional finite elements solutions. The potential of the proposed modeling framework for a refined analysis of multi-stable composite structures is, therefore, highlighted.