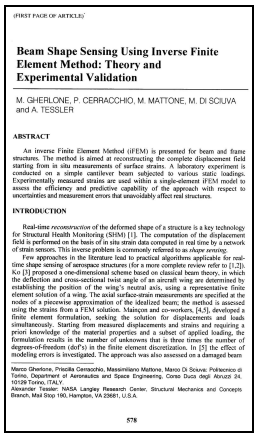

(FIRST PAGE OF ARTICLE)

Beam Shape Sensing Using Inverse Finite Element Method: Theory and Experimental Validation

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ABSTRACT

An inverse Finite Element Method (iFEM) is presented for beam and frame structures. The method is aimed at reconstructing the complete displacement field starting from in situ measurements of surface strains. A laboratory experiment is conducted on a simple cantilever beam subjected to various static loadings. Experimentally measured strains are used within a single-element iFEM model to assess the efficiency and predictive capability of the approach with respect to uncertainties and measurement errors that unavoidably affect real structures.

INTRODUCTION

Real-time *reconstruction* of the deformed shape of a structure is a key technology for Structural Health Monitoring (SHM) [1]. The computation of the displacement field is performed on the basis of in situ strain data computed in real time by a network of strain sensors. This inverse problem is commonly referred to as *shape sensing*.

Few approaches in the literature lead to practical algorithms applicable for real-time shape sensing of aerospace structures (for a more complete review refer to [1,2]). Ko [3] proposed a one-dimensional scheme based on classical beam theory, in which the deflection and cross-sectional twist angle of an aircraft wing are determined by establishing the position of the wing's neutral axis, using a representative finite element solution of a wing. The axial surface-strain measurements are specified at the nodes of a piecewise approximation of the idealized beam; the method is assessed using the strains from a FEM solution. Mainçon and co-workers, [4,5], developed a finite element formulation, seeking the solution for displacements and loads simultaneously. Starting from measured displacements and strains and requiring a priori knowledge of the material properties and a subset of applied loading, the formulation results in the number of unknowns that is three times the number of degrees-of-freedom (dof's) in the finite element discretization. In [5] the effect of modeling errors is investigated. The approach was also assessed on a damaged beam

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Ключевые слова:

Содержание.

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