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PII: S0263-8223(15)00552-8
DOI: http://dx.doi.org/10.1016/j.compstruct.2015.07.010
Reference: COST 6587

To appear in: *Composite Structures*

08.06.2015

Using Non-Local Timoshenko Beam Theories for Prediction of Micro- and Macro-Structural Responses

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ABSTRACT:

This paper presents the developments of the non-local sandwich beam theories that can be used to assess the micro- and macro-structural responses. The paper utilizes homogenization-localization, modified couple stress, and thick-faces beam theories. The homogenisation derives prevailing differential equations from displacements through strains and stresses to external loading. This enables accurate localization process that recovers the microstructural effects from the homogenized solution and couples them to the global response. Some case studies are supported by computational experiments: the shortest beams have only four unit cell along their length. The present solution converges to the physically correct solution in the cases of infinite and zero shear stiffness. The limit of zero shear stiffness is important because there the traditional Timoshenko beam theory fails to predict the response correctly. Some difference in the solutions is observed on very short beams at intermediate rotation stiffness between the faces and the core, where the wavelengths of the global and local responses heavily interact. Present theory can be extended to different microstructures and to plates. The benefit of the present approach is that it is analytical which enables identification of the physical parameters.

Keywords: couple stress; stress analysis; Timoshenko beam; homogenization;

INTRODUCTION

Lightweight design requires new structural configurations. Sandwich panels with periodic, unidirectional core, have the benefit of having voids in the panel that enable lightweight design and also integration of functions within the panel [1[2[7[8]. In weight and space critical structures, such as ships and aeroplanes, these qualities enable very efficient, integrated structural designs. Due to the fact that the face plates in these panels are far from neutral axis, they provide increased bending stiffness, but they also suffer from significant warping-induced secondary responses; see [13[16[19[20[22[23[46]. Typical materials in these panels are wood, cardboard, GFRP, steel or