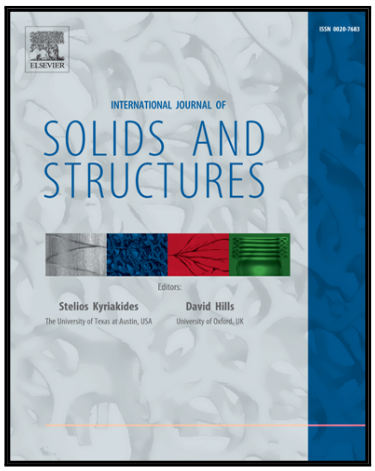

Establishment of strain gradient constitutive relations by using asymptotic analysis and the finite element method for complex periodic microstructures

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Establishment of strain gradient constitutive relations by using asymptotic analysis and the finite element method for complex periodic microstructures

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Abstract :

In this study, we present a method of numerical homogenization, combining asymptotic analysis and finite element modelling, to establish constitutive laws of heterogeneous materials with periodic microstructures tacking into account high-order strain gradients. By performing asymptotic analysis, the problem of local homogenization was split up into differential equations of different orders, which were solved using finite element modelling. This approach allows researcher to accurately calculate high-order stiffness tensors from representative volume elements (RVEs) with complicated microstructures and geometrical forms. The efficiency and accuracy of this approach were verified by means of numerical examples. The mechanical implications, consistency, and strain energy convexity of the strain gradient constitutive laws, obtained using the proposed approach, are analyzed on the basis of the numerical results.

Keywords :

Homogenization; strain gradient theory; asymptotic analysis; finite element method; size effect.

1 Introduction

Composites with complex microstructures have important applications in many engineering designs and products. These composites often have a periodic feature in microscopic or mesoscopic scales and can be considered as a spatial repetition of basic cells. In physical modelling, it is convenient to regard such cellular materials as a generalized continuum on a microscopic scale. The physical properties related to these special architectures can be evaluated by homogenization methods using the properties of their components.