PREFACE

This unique volume presents the state of the art in the field of multi-scale modelling in solid mechanics with particular emphasis on computational approaches. Contributions from leading experts in the field and younger promising researchers are reunited to give a comprehensive description of recently proposed techniques and of the engineering problems which can be tackled with them. The first four chapters provide a detailed introduction to the theories on which different multi-scale approaches are based, Chapters 5–6 present advanced applications of multi-scale approaches used to investigate the behaviour of non-linear structures. Finally Chapter 7 introduces the novel topic of materials with self-similar structure. All chapters are self-contained and can be read independently.

Chapter 1 by V. G. Kouznetsova, M. G. D. Geers and W. A. M. Brekelmans is a concise but comprehensive introduction to the problem of mechanical multi-scale modelling in the general non-linear environment. This chapter presents a *computational homogenization strategy*, which provides a rigorous approach to determine the macroscopic response of heterogeneous materials with accurate account for microstructural characteristics and evolution. The implementation of the computational homogenization scheme in a Finite Element framework is discussed.

Chapter 2 by Qi-Zhi Xiao and Bhushan Lai Karihaloo is limited to *linear problems: higher order homogenization theory* and corresponding consistent solution strategies are fully described. Modern high performance Finite Element Methods, which are powerful for the solution of sub-problems from homogenization analysis, are also discussed.

Chapter 3 by G. K. Sfantos and M. H. Aliabadi presents a multi-scale modelling of material degradation and fracture based on the use of the *Boundary Element method*. Both micro and macro-scales are being modelled with the boundary element method. Additionally, a scheme for coupling the micro-BEM with a macro-FEM is presented.

Chapter 4 by J. C. Michel and P. Suquet is devoted to the *Nonuniform Transformation Field Analysis* which is a reduction technique introduced in the field of multi-scale problems in Nonlinear Solid Mechanics. The flexibility and accuracy of the method are illustrated by assessing the lifetime of a plate subjected to cyclic four-point bending.

Chapter 5 by M. Lefik, D. Boso, and B. A. Schrefler presents a *multi-scale approach for the thermo-mechanical analysis of hierarchical structures.* Both linear and non-linear material behaviours are considered. The case of composites with periodic microstructure is dealt with in detail and an example shows the capability of the method. It is also shown how *Artificial Neural Networks* can be used either to substitute the overall material relationship or to identify the parameters of the constitutive relation.

Chapter 6 by P. B. Lourenço, on recent advances in *masonry modelling*: micro-modelling and homogenization, addresses the issue of mechanical data necessary for advanced non-linear analysis first, with a set of recommendations. Then, the possibilities of using micro-modelling strategies replicating units and joints are addressed, with a focus on an interface finite element model for cyclic loading and a limit analysis model.

Finally Chapter 7 by R. C. Picu and M. A. Soare deals with the mechanics of materials with self-similar hierarchical microstructure. Many natural materials have hierarchical microstructure that extends over a broad range of length scales. Performing efficient design of structures made from such materials requires the ability to integrate the governing equations of the respective physics on supports with complex geometry.