Zohdi, Tarek I.; **Wriggers, Peter**
Introduction to computational micromechanics. (English) Zbl 1085.74001
Lecture Notes in Applied and Computational Mechanics 20. Berlin: Springer (ISBN 3-540-22820-9/hbk). x, 196 p. (2005).

This book is devoted to state-of-the-art mathematical modeling and simulation of heterogeneous microstructures. The book is divided into ten chapters.

The first introductory one includes basic concepts of statistical approach and micro-macroscopic modeling. Moreover, there is a historical overview of interval estimations of elastic properties of effective medium with particulates. Ch. 2 presents basic statements of continuum mechanics, laws and ideas used to describe stress-strain state of solids with different deformations (not only infinitesimal ones). Due to the true solutions in the mechanics of heterogeneous solids are nonsmooth, the third chapter is devoted to introduction of weak forms, which are designed to accommodate irregular data and solutions with aim to use numerical methods, for example the finite element method (FEM).

Different methods and concepts of micro-macromechanics approximations are presented in Ch. 4. A testing procedure is derived to compute the constitutive tensor, which provides the structural scale constitutive properties of a micro-heterogeneous material and yields mapping between the average stress and strain measures. The approximation technique in the framework of FEM to solve equations of elasticity is considered in Ch. 5. The authors present all stages of the FEM scheme from consideration of weak form to space discretization and FEM interpolation, including discussion of accuracy of FEM and accelerating of computation methods. Due to uncertainty in the effective property bounds, in the next chapter the authors study the numerical simulation of mechanical responses of the micro-heterogeneous solids formed by aggregates of particulates suspended in a binding matrix. A technique employing potential energy principles is developed to interpret the results of testing samples. 3-D numerical examples employing FEM illustrate the overall analysis and computational testing process.

Ch. 7 is devoted to different ways of partitioning and iterative domain decomposition-type strategies with estimation of statistical characteristics of this process. The projection of approximate globally kinematically admissible solution on the interior subdomain partitions is carried out in Ch. 8. The subdomain boundary value problems are solved with the exact microstructural representation contained within their respective boundaries, but with approximate displacement boundary data. The total microstructural solution is defined by the subdomain solutions restricted to its corresponding subdomains. In Ch. 9 a computational strategy is developed to simulate and accelerate the associated trial and error development of tailored dispersed-type materials. The authors develop a procedure to determine multiple possible microstructures that can deliver the same prespecified effective linear elastic response. The study concentrates on the parametrization of microscale parameters in particulate materials, with the goal to computational optimization of material microstructure.

The final chapter is devoted to modeling of coupled multifield processes. The error due to incompletely resolving the coupling between multifield equations describing time-dependent thermo-chemo-mechanical processes in solids possessing irregular heterogeneous microstructure is characterized in such a way to be amenable to a relatively simple method of adaptive control.

In total, this book could be very useful to post-graduate students studying numerical methods and also to creators of FEM-based approaches.

Reviewer: I. A. Parinov (Rostov-na-Donu)

MSC:

74-01	Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mechanics of deformable solids
74M25	Micromechanics of solids
74Q15	Effective constitutive equations in solid mechanics
74S05	Finite element methods applied to problems in solid mechanics

Keywords:

heterogeneous solids; energy approach; statistical approach; finite element method

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