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BOOK REVIEW

Micromechanics: Overall Properties of Heterogeneous Materials, S. Nemat-Nassar and M. Hori, North-Holland, Elsevier Science Publishers, Amsterdam, The Netherlands, 1993, 687 pages, $120.00

Recent development of high performance materials requires one to estimate overall properties of heterogeneous materials based on micromechanics. This book presents not only fundamental principles but also the state-of-the-art progress in this field.

A comprehensive overview is given in this book toward a fundamental understanding of micromechanics of the overall response and failure modes of materials. This book consists of two parts. The first part reviews solids with microdefects such as cavities, cracks, and inclusions, as well as elastic composites. The second part focuses on fundamentals of continuum mechanics, particularly linear elasticity, which forms the basis for the development of small deformation micromechanics.

Part I, which includes four chapters, introduces a fundamental and general framework for quantitative analysis of the overall response and failure modes of heterogeneous solids. A linear elastic matrix containing linear elastic inclusions, which may be aggregates or microcracks, is considered. The basic idea of a heterogeneous representative element (RVE) is discussed in Chapter I. The concept of average stress and average strain over RVE is presented. Governing equations for a heterogeneous solid with small deformation are then introduced. Overall strain energy and complementary energy, which are functions of average stresses and strains on RVE, are then discussed.

Chapter II discusses the elasticity and compliance tenors which describe the overall mechanical response of a linear elastic matrix containing microcavities and microcracks. Two simple models that are used to approximately obtain these tenors include the dilute distribution model and the self-consistent model. The former assumes that inhomogeneities such as microcavities and microcracks are small and far away. As a result, interaction among inhomogeneities can be neglected. On the other hand, the latter takes into account the interaction among inhomogeneities in an approximate manner. The relationship between the two models is discussed in terms of special problems such as porous, linear elastic solids. Chapters I and II provide fundamentals for micromechanics.

In Chapter III the authors discuss linear elastic solids with randomly distributed microinclusions. The concepts of eigenstrain and eigenstress, which are required to homogenize the heterogeneous RVE, are introduced. The upper and lower bounds for the overall elastic moduli are presented based on the Hashin-Shtrikman variational principle. When either the eigenstrains or the eigenstresses are used to homogenize the heterogeneous RVE in the principle, two functionals are derived. One is associated with the eigenstrains for a given uniform boundary traction, and the other is associated with the eigenstresses for a given linear displacement at the boundary. Some applications are also discussed in this chapter. The principles discussed in this chapter can be directly used to evaluate overall elastic properties of concrete, including randomly distributed aggregates as well as different types of defects. Properties of concrete reinforced with randomly distributed short fibers can also be predicted using these principles.

The principles discussed in Chapter III are extended to heterogeneous elastic solids with periodically distributed inhomogeneities such as fibers and cracks in Chapter IV. These results could be useful for cement based materials reinforced with continuous fibers, and could be used to predict the mechanical response of reinforced concrete structures with multiple cracks under loading, such as concrete tensile members and beams with an adequate amount of steel reinforcement.

Part II of the book briefly discusses the basic theory of elasticity. Certain basic elements of the mathematical theory of elasticity, which provides an essential background for the micromechanics covered in Part I, are presented in this part. By combining basic equations of elasticity, which includes geometric, equilibrium, and constitutive relations, as well as boundary conditions, governing equations of elasticity are derived. These equations may be solved either as boundary-value problems or from variational principles. For the readers who are not familiar with elasticity, this part is an excellent introduction to elasticity. It is also suggested that the readers who already know elasticity may quickly go through part II before studying part I, because part II presents the theory of elasticity in the same format as that in part I.

The book is available from the Amsterdam address, or in the United States and Canada from Elsevier Science Inc., P.O. Box 945, Madison Square Station, New York, NY 10159.

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