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Microstructural randomness and scaling in mechanics of materials. (English)

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This book is devoted to research of randomness and scales in different problems of mechanics of materials. The book is divided into eleven chapters. The first two chapters present an introductions into different discrete and random processes connected with the microstructure research. Ch. 1 reviews basic concepts of discrete random processes and random geometry with next transition to construction of stochastic models of real structures, namely composites, polycrystals, granular, cellular and fibrous materials. At the same time, Ch. 2 presents random processes and fields having continuous realizations the with aim to discuss stochastic concepts and models such as stationarity, ergodicity and entropy. Some examples develop basic probabilistic ideas of micromechanics and statistical physics. Ch. 3 presents basic concepts and applications of planar lattice (spring) periodic networks. In particular, there are considered the antiplane elasticity, planar classical elasticity and planar non-classical elasticity. The chapter is finished by representing the mechanics of helix.

The disordered topologies are in the centre of Ch. 4. For lattice models, there are developed three themes connected with rigidity, randomness, dynamics and optimality, namely: (i) the spatial randomness is introduced into a lattice as a departure from an originally periodic geometry; (ii) a random depletion of bounds leads to loss of the lattice rigidity; (iii) statics is generalized to dynamics due to nodes acting as quasi-particles. Finally, the material optimality is discussed in relation to loading and support conditions. The definition of effective moduli for composites in two-dimensional materials is goal of Ch. 5. As examples, there are considered a plate perforated by holes, and also some extensions to the cases of body force fields and thermal stresses.

The next chapter outlines the basic theory of micropolar continuum models, both as unrestricted as restricted (couple-stress) ones. It covers several topics not yet collected in a book form, including the passage from a microstructure to an effective micropolar continuum. Ch. 7 considers the passage from statistical volume element SVE (a domain mesoscale relative to the microscale andboundary conditions applied to this domain) to a representative volume element RVE (implying the existence in disordered microstructure of some scale larger than the microscale to ensure a homogenization limit). Some methods dealing with solution of macroscopic boundary value problems having the mesoscale SVE as input are presented in Ch. 8. These stochastic problems lead to a formulation of random fields of material properties from the SVE information stating so-called stochastic finite element and stochastic finite difference methods.

Ch. 9 continues the scaling consideration of Ch. 7 and states hierarchies of mesoscale bounds for nonlinear elasticity, elastoplasticity, rigid-plasticity, elastic-brittle damage, viscoelasticity, flow in porous media and thermoelasticity, generalizing thermodynamics with internal variables to random media. A comparison of SVE with RVE leads in Ch. 10 to a stochastic formulation of thermomechanics with internal variables. The final part of this chapter discusses continuum-type equations of fractal media. Ch. 11 considers partial problems of waves in random media, namely: (i) two cases of wavelengths when they are much longer or much shorter than the heterogeneity; (ii) the concept of stochastic spectral finite elements is introduced providing a setting for analysis of steady-state vibrations in random structural elements; (iii) the transient waves in piecewise constant random media; (iv) the evolution of acceleration wave fronts whose thickness is not infinitesimal, etc.

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Keywords : representative volume element; mesoscale domain; effective micropolar continuum; statistical volume element
Classification :
∗74-02 Research monographs (mechanics of deformable solids)
74A40 Random materials and composite materials
74E35 Random structure
74E30 Composite and mixture properties