SILESIAN UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING

Department of Computational Mechanics and Engineering

PhD Thesis

Modelling and Optimisation of Inhomogeneous Materials Using Granular Computations

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ABSTRACT

The thesis aims to develop the granular computational homogenisation (GCH) and granular computational inverse homogenisation (GCIH) procedures, allowing the analysis, optimisation and identification of materials with uncertain microstructure parameters. Parameters uncertainty is assumed in the form of interval and fuzzy numbers. Model reduction methods based on response surfaces are used. Boundary-value problems are solved using the Finite Element Method. The correctness and efficiency of the proposed method is confirmed by numerical examples. The generated numerical models are related to fibre reinforced composites, particle reinforced composites, porous structures and auxetic materials. The thesis compares the obtained equivalent material properties with classic computational homogenisation based on the Finite Element Method and analytical methods for simple microscopic structures geometry. The proposed approach is applied to solve the microstructure optimisation problems for nonhomogeneous materials with imprecise properties data. For this purpose, the global optimisation techniques are used in the form of single- and multi-objective evolutionary algorithms. The presented numerical examples confirm the effectiveness of the presented approach. The combination of applied operations allows fast and accurate estimation of imprecise properties ranges of homogenised material. The application of the developed method enables effective usage of calculated material properties in the analysis of macroscopic mechanical systems described by linear and non-linear constitutive models.