Micro-scale Quantities in Heterogeneous Stochastic Microstructures by Means of Wang Tiles

Lukáš Zrůbek, Anna Kučerová
Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague
lukas.zrubek@fsv.cvut.cz, anicka@cml.fsv.cvut.cz

Jan Novák
Experimental Centre, Faculty of Civil Engineering, Czech Technical University in Prague
novakj@cml.fsv.cvut.cz

Abstract

In engineering applications we are witnessing a steadily increasing pressure to the utmost materials performance. It can be achieved provided a detailed understanding of characteristic mechanical processes taking place on microstructural level and described by micro-scale quantities (e.g. stresses, strains or displacements). However the evaluation of these micro-mechanical fields in entire macro-scopic domain can be quite time consuming. Therefore we present approach based on the method of Wang tiles [1, 2] that compress the stochastic microstructure in to a small set of statistical volume elements – tiles [3]. Micro-mechanical fields are evaluated on tiles from which the fields for entire domain are synthesized via stochastic tiling algorithms [4].

Nevertheless this technique is not without difficulties. As the mechanical quantities are non-local the micro-mechanical fields of each tile depends on the surrounding tiles. Due to this fact the synthesized fields contain jumps and discontinuities and the underlying lattice of tiles is clearly visible. To prevent such phenomena the surrounding tiles of each addressed tile are included in evaluation and only results of the center tile are used for the following field reconstruction.

In our latest work we focus on how the characteristic microstructural lengths influence the convenient size of individual tiles and how the number of included surrounding layers of tiles affects the resultant error in synthesized field compared to the reference solution.

Acknowledgement: The authors gratefully acknowledge the financial support from the Grant Agency of the Czech Technical University in Prague, the grant "Algorithms for numerical analysis and modeling comprising uncertainties and spatial nonuniformities".

References

1. H. Wang. Proving Theorems by Pattern Recognition - II. Bell. Syst. Tech. J. 40 (1995) 1-4.
2. H. Wang. Games, Logic and Computers. Scientific American, 213(5) , 98-106, 1965.
3. J. Novák and A. Kučerová and J. Zeman. Compressing Random Microstructures via Stochastic Wang Tilings. Phys. Rev. E 86 (2012) 04010.
4. M.F. Cohen and J. Shade and S. Hiller and O. Deussen. Wang Tiles for Image and Texture Generation. ACM Transactions on Graphics, Citeseer, 287-294, ISSN 0730-0301, 2003.