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EVALUATION OF EFFECTIVE MATERIAL PROPERTIES OF RANDOM COMPOSITES BY SBFEM

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Composite materials exhibit random geometrical features at the meso- and microstructural level, respectively, which determine their macroscopic behaviour. In engineering applications, effective properties of homogenized micro-heterogeneous materials are required.

In this contribution, effective material properties of composites with random meso- and microstructural features are evaluated using the scaled boundary finite element method (SBFEM). Here, concrete is modelled by randomly distributing circular or spherical inclusions in a homogeneous matrix [1], where the aggregate size follows a distribution based on realistic grading curves. Ceramic matrix specimens are modelled by overlapping of circular particles using a modified random sequential addition scheme [2]. For each random topology, a structured quadtree or octree mesh is generated using image-based modelling techniques [3]. Such meshes are beneficial when highly irregular geometries prevail and allow for a rapid transition in mesh size when geometrical features of very different scale are present. Quadtree or octree meshes can also be obtained automatically from digital images of real micro-structures, such as X-ray CT-scans.

Due to the existence of hanging nodes, standard FE formulations cannot be used directly on structured meshes. This is overcome by the scaled boundary finite element method, which requires discretization on the boundaries of square or cubic cells only. Linear elastic analysis is used to obtain the effective properties. The extension to nonlinear problems based on the construction of generalized polygon and polyhedral elements will also be outlined. In combination with automatic mesh generation techniques the SBFEM provides a potentially highly efficient alternative approach to uncertainty quantification of effective properties. This will be illustrated using several numerical examples.

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