11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

MULTISCALE MODELING OF PROGRESSIVE DAMAGE IN ELASTO-PLASTIC COMPOSITE MATERIALS

Johannes Spahn[1,2], Heiko Andrä[1,*], Matthias Kabel[1], Ralf Müller[2] and Christian Linder[3]

[1] Fraunhofer Institute for Industrial Mathematics (ITWM), Department Flow and Material Simulation, Fraunhofer-Platz 1, 67663 Kaiserslautern, Germany
spahn@itwm.fraunhofer.de

[2] Institute of Applied Mechanics, Technische Universität Kaiserslautern
Gottlieb-Daimler-Straße, 67653 Kaiserslautern, Germany

[3] Department of Civil and Environmental Engineering, Stanford University
473 Via Ortega, Stanford, CA 94305, USA

Key Words: *Multiscale analysis, Computational homogenization, Elastoplastic continuum damage mechanics, Fast Fourier transforms, Composite materials.*

Modeling failure and progressive damage of composite materials presents a challenging task. Phenomenological macroscale models are state of the art for failure investigations in many practicable applications. These models assume homogeneous material behavior and are usually based on macroscopic failure criteria.

Furthermore, multiscale modeling and simulation techniques were developed to capture nonlinear material effects directly on a finer length scale. One of these techniques is the FE^2 approach [1] which considers by means of a fully coupled micro-macro simulation process different length scales of the material structure. Due to the increased computational costs coming along with the application of the multiscale framework an effective solution of the micro boundary value problem (BVP) is necessary.

In this contribution we propose an alternative multiscale framework similar to FE^2 which uses the Fast-Fourier Transformation (FFT) to solve an equivalent elastic micro BVP formulation, the so called Lippmann-Schwinger equation (see [2]). Advantages of this method are its efficiency in terms of memory consumption and computational time. The calculation is carried out on a regular voxel grid which can be obtained from 3D images like tomographies without using any complicated mesh generation. The fine scale problem is integrated in a standard Finite Element framework which is used to solve the macroscopic BVP. For both structural phases simple isotropic constitutive laws are formulated. Based on the work of Spahn et al. [3] a multiscale method for elastoplastic fiber reinforced composite materials including progressive damage is presented. Finally, the simulated results are compared with experimental data obtained from injection molded specimens.

REFERENCES

[1] F. Feyel and J.L. Chaboche, FE^2 multiscale approach for modelling the elastoviscoplastic behaviour of long fibre SiC/Ti composite materials, *Computer Methods in Applied Mechanics and Engineering*, Vol. 183, pp. 309-330, 2000.

[2] H. Moulinec and P. Suquet, A numerical method for computing the overall response of nonlinear composites with complex microstructure, *Computer Methods in Applied Mechanics and Engineering*, Vol. 157(1-2), pp. 69 – 94, 1998.

[3] J. Spahn, H. Andrä, M. Kabel, R. Müller, A multiscale approach for modeling progressive damage of composite materials using fast Fourier transforms, *Computer Methods in Applied Mechanics and Engineering*, Vol. 268, pp. 871-883, 2014.