A multiscale and non-conforming interface coupling technique for the global-local analysis of heterogeneous structures

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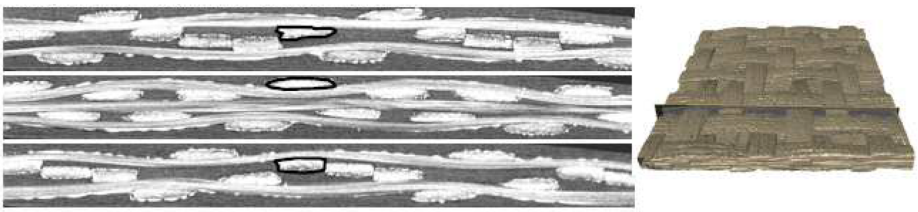
The main goal of this work is to propose a computational strategy that enables one to simulate the effect of a local mesoscopic model built for example from computed tomography data in critical zones on the response of a 'healthy' macroscopic homogenized model of the whole structure.



Tomography data example of a weaved composite material (source image [1])

This contribution presents an interface coupling technique between a heterogeneous microscopic (local) model and a first order homogenized (global) model, representative of the macroscopic behavior of a structure. It addresses the problematic of replacing a local part of the homogenized macroscopic model where the RVE (Representative Volume Element) is not fully representative of the microstructure or where the first order homogenization hypotheses are no longer valid.

The key point of this multiscale based coupling technique is that we operate a scale separation on the interfaces between models. The interface displacement and force distribution of each models are expressed on a quadratic macro basis [2]. Then, interface coupling conditions are ensured at each scale in order to satisfy that the displacements on local model are compatible with the second-order homogenization approach [3]. Then, we add a priori conditions on the microscopic interface quantities that depends on the locations and external loading of the microscopic details.

To illustrate the method, we consider the situation where the microscopic detail is far from the edges and submitted to a linear macro strain loading. The coupling technique is performed such that the local solution corresponds to the one of the standard second-order periodic homogenization. The validation of the method is done on a steady mechanical academic problem under linear elasticity assumption with matching geometries on the interface between local and global meshes.

[1] P. Badel, "Analyse mésoscopique du comportement mécanique des renforts tissés de composites utilisant la tomographie aux rayons X," INSA de Lyon, 2008.

[2] P. Ladevèze, O. Loiseau, and D. Dureisseix, "A micro-macro and parallel computational strategy for highly heterogeneous structures," *Int. J. Numer. Methods Eng.*, vol. 52, no. 1–2, pp. 121–138, 2001.

[3] V. Kouznetsova, M. G. D. Geers, and W. a. M. Brekelmans, "Multi-scale constitutive modelling of heterogeneous materials with a gradient-enhanced computational homogenization scheme," *Int. J. Numer. Methods Eng.*, vol. 54, no. 8, pp. 1235–1260, Jul. 2002.