16th International Conference on Composite Structures
ICCS 16
A. J. M. Ferreira (Editor)

APPLICATION OF A TWO-WAY MULTISCALE ANALYSIS FOR COMPOSITE STRUCTURES IN ABAQUS

Sina Berg[*], David Chrupalla[†], Luise Kärger[†], Eelco Jansen[*] and Raimund Rolfes[*]

[*] Institute of Structural Analysis (ISD)
Leibniz Universität Hannover (LUH)
Appelstr. 9A, 30167 Hannover, Germany
e-mail: s.berg@isd.uni-hannover.de, web page: http://www.isd.uni-hannover.de

[†] Institute of Composite Structures and Adaptive Systems
German Aerospace Center (DLR)
Lilienthalplatz 7, 38108 Braunschweig, Germany
e-mail: david.chrupalla@dlr.de, web page: http://www.dlr.de

Key words: Composite structures, Loose coupling, Multiscale analysis, Submodeling.

Summary. *This abstract proposes a homogenization-based two-way loose coupling approach and its implementation within the commercial finite element program Abaqus. The multiscale method is used to describe the global behavior of composite structures taking relevant local effects into account.*

1 INTRODUCTION

For composite aircraft structures reliable designs as well as reasonable development costs are demanded. Therefore on the one hand sufficiently accurate finite element (FE) models with fine meshes are required for the reliable simulation of failure and damage progression. On the other hand FE models with coarse meshes and linear elastic material models are needed for a fast computational analysis and thus, an economic design process. Those two opposed requirements are fulfilled in multiscale analysis, where coarse global models and fine local models are coupled. For an overview of existing multiscale techniques refer to [2]-[3]. Within multiscale analysis two different coupling techniques are feasible: loose coupling and tight coupling. The main feature of loose coupling is the separation and indirect connection of the global model and the refined local models. Here the global and the local systems of equations describing the models are solved separately, whereas in tight coupling the local models are integrated in the global model and hence only one system of equations is solved.

2 MULTISCALE PROCEDURE IN ABAQUS

In the context of loose coupling non-automatic and one-step procedures are state-of-the-art. Commercial FE software like Abaqus provides independent solutions for the way forth from the global to the local level (submodeling) and for the way back (substructuring), see [1].

However these functionalities omit an exchange of updated information between the models of different refinement and fidelity, e.g. within a global-to-local transfer via submodeling there is no feedback from local to global level. Furthermore the detection of critical global areas as well as the generation of local models is left to the user's manual operation.

The main innovation is to perform an interaction of the global and the local analysis and thus, to include the influence of local effects to the global scale. The commercial code Abaqus will be employed to carry out this approach, using the available functionalities of the code [1]. The existing Abaqus functions are completed and connected by user-defined routines. At first a suitable failure criterion is used to detect critical global areas, which need to be investigated via local models. Depending on this information the size and location of the local models are determined and the local models are generated. For the global-to-local transfer the global analysis is interrupted and global displacements are imposed as boundary conditions on the local edge nodes via submodeling. The local-to-global transfer is realized by assigning modified material properties averaged from the effective local values to the respective global integration points and, subsequently, by a restart of the updated global model.

3 APPLICATION

The proposed procedure will be tested upon a simple test case, which is a thin square composite plate composed of 16 layers with a length and width of 0.2 m and a thickness of 0.0016 m. The plate is simply supported and vertically loaded with a constant pressure load of 50000 N/m². The fixed global model consists of bilinear shell elements with reduced integration including four nodes (S4R), whereas the variable local model contains solid elements with linear shape functions comprising eight nodes (C3D8).

The application of the procedure using Abaqus illustrates the feasibility and benefits of the presented multiscale approach. The efficiency of the analysis within a commercial FE code is hampered, since in general a full access to the source code is not available to the user. Future implementation within the open-source code B2000++ will make it possible to fully exploit the functionality and capability of the homogenization-based two-way multiscale approach.

4 ACKNOWLEDGEMENTS

Research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n°234147.

REFERENCES

[1] ABAQUS Version 6.8 Documentation, ABAQUS 6.8.1, 2008
[2] P. Kanouté et al., *Multiscale Methods for Composites,* Archives of Computational Methods in Engineering, Vol. 60, pp. 31-75 (2009).
[3] V.G. Kouznetsova, *Computational homogenization for the multi-scale analysis of multi-phase materials,* Proefschrift, Technische Universiteit Eindhoven. Eindhoven (2002).