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# Simulation and Modeling the Mechanical Behavior of Textile Reinforced Composites by Combining the Binary Model and X-FEM

G. Haasemann, M. Kästner, J. Brummund, V. Ulbricht

## Summary

The material design process for novel textile-reinforced composites requires an integrated simulation of the material behavior and estimation of the effective properties used in a macroscopic structural analysis. In this context a combination of two potential alternatives to standard finite element modeling, namely the Binary Model and the Extended Finite Element Methode (X-FEM), is applied to model the complex mesoscale structure of composite materials reinforced by a biaxial weft-knitted fabric.

The use of biaxial weft-knitted fabric in composites is to the best advantage. For instance a high in-plain stiffness is assured by the biaxial warp and weft yarns. Furthermore, the weft-knitted structure prevents the composite from delamination and provides an improved out-of-plane stiffness.

The Binary Model can be characterized as a very efficient procedure which allows for an easy representation of complex reinforced structures using a mesh of regular volume elements which are superimposed by link elements. However, the resolution of the Binary Model is limited since the stress and strain gradient at the fiber-matrix interface cannot be analyzed.

On the other hand X-FEM takes a higher numerical effort but compensates the afore mentioned shortcoming. In contrast to a classical finite element model, local variations in stiffness are not represented by the alignment of element boundaries to the material interface. The mechanical behavior at a material interface is instead modeled using a regular mesh and a local enrichment of the displacement approximation. Nevertheless, the mesh of regular shaped finite elements has to be sufficiently fine to capture the geometry of the discontinuity using a level-set representation.

Due to the complex geometry of the biaxial weft-knitted reinforcement and the small cross section ratio of knit and warp or weft yarns, the application of X-FEM tends to result in a unreasonably fine mesh.

In order to be able to account for interface effects as well as the influence of knit yarns on the effective material behaviour, Binary Model and X-FEM are combined in a single modeling approach: A regular X-FEM mesh is used to model the warp and weft yarns while a mesh of link elements represents the knitting structure. Both meshes are coupled using kinematic constraint equations.