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# Multiscale Modeling of Failure in Textile Composites

*** Christian Hühne, Gerald Ernst, Matthias Vogler and Raimund Rolfes**

Institute for Structural Analysis, Leibniz University Hannover
Appelstr. 9a, 30167 Hannover
c.huehne@isd.uni-hannover.de

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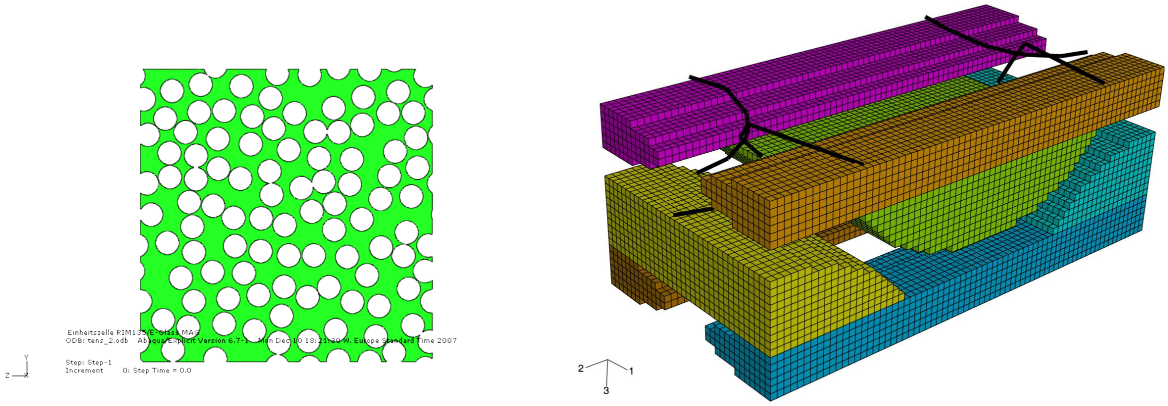
## ABSTRACT

Textile composites describe the broad range of polymer composite materials with textile reinforcements, from woven and non-crimp commodity fabrics to three dimensional textiles. In production they offer a great potential cost reduction but due to their complex three-dimensional structure the experimental determination of material parameters is more difficult than for prepregs. Not only the number of constants increases, but especially through-thickness parameters are hardly quantifiable.



(a) Micromechanical RVE with stochastic fiber distribution (b) Mesomechanical unit cell of weft-knitted fabric

Figure 1: Representative volume elements (RVE)

Therefore an information-passing multiscale approach for computation of textile composites is presented as an enhancement of tests, but also as an alternative to tests. The multiscale approach consists of three scales, micro-, meso- and macroscale, and includes unit cells on micro- and mesoscale. With the micromechanical unit cell stiffnesses and strengths of unidirectional fiber bundle material can be determined. For the elastic properties representative volume elements with a stochastic fiber distribution are investigated, see Figure. 1(a). The mesomechanical unit cell describes the fiber architecture of the textile composite and provides stiffnesses and strengths for computations on macroscale. Figure 1(b) shows the unit cell of a weft-knitted fabric. By comparison of test data and results of numerical analysis

the numerical models are validated. The strengths computed on the mesoscale serve as input parameters for the failure criterion of Juhasz [1] that is used on the macroscale for the evaluation of failure.

To consider the special characteristics of epoxy resin and fiber bundles two material models are developed. Both materials exhibit load dependent yield behavior, especially under shear considerable plastic deformations occur [2]. This non-linear hardening is considered via tabulated input, i.e. experimental test data is used directly without time consuming parameter identification. A quadratic criterion is used to detect damage initiation based on stresses. Thereafter softening is computed with a strain energy release rate formulation. To alleviate mesh-dependency this formulation is combined with the voxel-meshing approach.

Firstly, an isotropic elastoplastic material model regarding a pressure dependency in the yield locus, see Figure 2, is presented for epoxy resin. As the assumption of constant volume under plastic flow does not hold for epoxy resin, a special plastic potential is chosen to account for volumetric plastic straining.

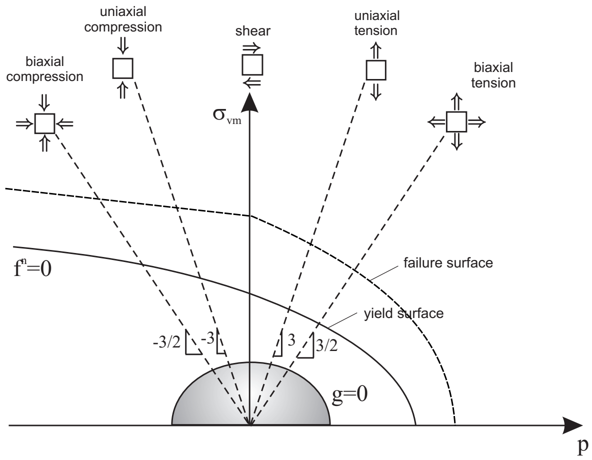


Figure 2: Yield surface for epoxy resin

Secondly, a transversely isotropic, elastoplastic material model is developed for fiber bundles. Following [3], by the use of structural tensors the transversely isotropic constitutive equations are formulated as isotropic tensor functions. Once again hardening curves are provided as tabulated data which can be obtained by experiment, if available, or by simulations performed with the micromechanical model. Together with the failure criterion of Juhasz, these material models make it possible to model failure of textile composites on all scales of the presented multiscale model.

## REFERENCES

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