A POTENTIAL-BASED CONSTITUTIVE INTERFACE MODEL FOR APPLICATION IN REDUCED ORDER NONLINEAR HOMOGENIZATION

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Composites are employed in a broad range of contemporary engineering applications. While these materials show a heterogeneous microstructure, the constitutive behavior is often regarded as homogeneous from a structural point of view. The derivation of the effective material response, referred to as homogenization, can be challenging, particularly when physical nonlinearity comes into play.

A novel homogenization method for viscoplastic materials from the class of *standard dissipative solids* was recently proposed by the authors [1]. Herein, the reduced-order approach of the *nonuniform transformation field analysis* [2] is combined with an incremental variational principle in the spirit of [3] which relies on the potential structure of the viscoplastic material model.

While the microscopic displacement field is assumed to be continuous in [1], phenomena such as decohesion at the particle or fiber boundaries are frequently observed in real composite materials. Therefore, an extension of the method to microstructures with singular surfaces is intended, requiring a potential-based constitutive model for the interface behavior.

A well-known reversible interface model defined by a single potential was proposed in [4] and improved with respect to mixed-mode decohesion in [5]. In contrast to these models, in the non-potential-based approach of [6], damage and elastic unloading can be described. These dissipative effects are controlled by a dual dissipation potential in a new constitutive model lately developed by the authors. For that, the concept of *generalized standard materials* was applied to the modeling of interface behavior. Special effort has
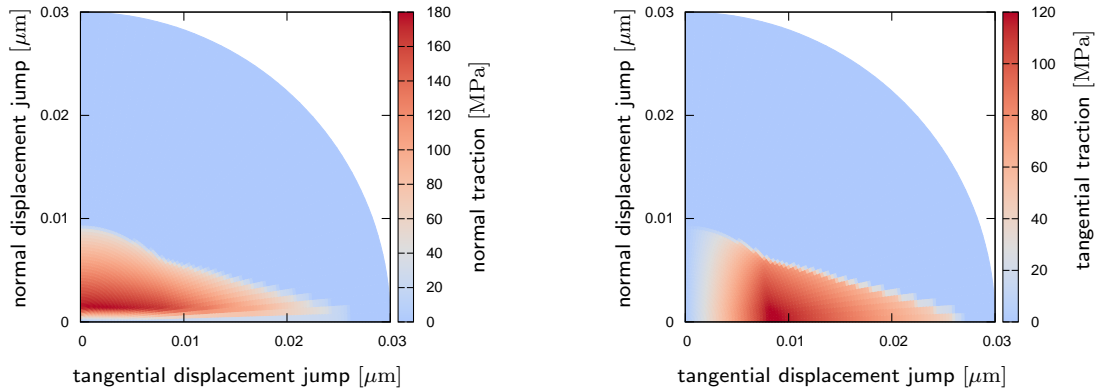
Figure 1: Traction-separation surfaces of the potential-based transversely isotropic cohesive interface model. The parameters were fitted to the model of [5] with normal work of separation $\phi_\mathrm{n} = 1\,\mathrm{J\,m^{-2}}$, tangential work of separation $\phi_\mathrm{t} = 2\,\mathrm{J\,m^{-2}}$, maximum normal traction $t_\mathrm{n}^\mathrm{max} = 180\,\mathrm{MPa}$ and maximum tangential traction $t_\mathrm{t}^\mathrm{max} = 120\,\mathrm{MPa}$.

been undertaken in order to find a proper description of mixed-mode loading cases for transversely isotropic cohesive interfaces (Fig. 1). Numerical examples of both, the constitutive model itself and finite element simulations employing it, will be presented. Possible size effects in the context of homogenization, emanating from the fact that any interface model contains a length scale, will be discussed.

REFERENCES

[1] F. Fritzen, M. Leuschner. Reduced basis hybrid computational homogenization based on a mixed incremental formulation.
Comput. Methods Appl. Mech. Engrg., Vol. **260**, 143–154, 2013

[2] J.C. Michel, P. Suquet. Nonuniform transformation field analysis.
Int. J. Solids Struct., Vol. **40**, 6937–6955, 2003

[3] C. Miehe. A multi-field incremental variational framework for gradient-extended standard dissipative solids.
J. Mech. Phys. Solids, Vol. **59**, 898–923, 2011

[4] X.-P. Xu, A. Needleman. Void nucleation by inclusion debonding in a crystal matrix.
Model. Simul. Mater. Sci. Eng., Vol. **1**, 111–132, 1993

[5] M.J. van den Bosch et al.. An improved description of the exponential Xu and Needleman cohesive zone law for mixed-mode decohesion.
Eng. Fract. Mech., Vol. **73**, 1220–1234, 2006

[6] N. Valoroso, L. Champaney. A damage-mechanics-based approach for modelling decohesion in adhesively bonded assemblies.
Eng. Fract. Mech., Vol. **73**, 2774–2801, 2006