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XFEM MODELING OF 3D COMPOSITE STRUCTURES AND INTERFACIAL DAMAGE

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ABSTRACT

The extended finite element method (XFEM) became a well recognized technique for the modeling of heterogeneous material structures and discrete damage phenomena. It allows for the modeling of discontinuities independent of the underlying FE mesh. The method is commonly linked to a level-set function, which is utilized to locate the discontinuity within the model domain. Since a closed analytical expression of such function is only available for special cases, e. g. for a cylinder or a sphere, the description of complex geometries can become challenging. Therefore, the authors developed a so called local level-set representation, where the the discontinuity is localized elementwise [1]. The nodal level-set values are calculated corresponding to an elementwise parametric function which is again defined by a set of discrete points of the actual interface. Such points can be easily obtained from a CT scan or a micrograph. The overall method has been extended to model curved, three dimensional structures. The usage of higher order shape functions reduces the discretization error and interelement discontinuities [2]. However, curved discontinuities require consistent integration techniques. To this end, different integration techniques have been examined regarding their error and convergence rate.

The derived method is utilized to capture the inelastic material behavior of fiber reinforced polymers. Since the macroscopic mechanical properties of such materials depend not only on the structure, but also on the inelastic material behavior of the individual constituents and damage phenomena on multiple length scales, a multiscale approach is applied. On the microscale a nonlinear fractional viscoelasticity model is used to capture the nonlinear strain rate dependence of the polymeric matrix material [3]. The damage mechanisms, e. g. interface and matrix failure, are modeled by a combination of XFEM with a cohesive zone law and a continuum damage approach.

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