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PROGRESSIVE DAMAGE ANALYSIS OF LAYERED CARBON FIBER REINFORCED COMPOSITES

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Carbon fiber reinforced plastics (CFRP) have become very popular in numerous applications in aerospace, automotive, and maritime industry. They are typically composed of either unidirectional carbon fibers or textiles, in which the reinforcing fibers are woven or braided, embedded in an epoxy matrix material. These composites are advantageous due to their ease of manufacture, damage tolerance, and relatively low cost.

However, physics-based modeling of their mechanical behavior is challenging. While in the unidirectional case all fibers are considered as perfectly aligned in one particular direction, textile composites introduce additional geometric complexities, which cause significant local stress and strain concentrations. Since these internal concentrations are primary drivers of nonlinearity, damage, and failure within textile composites, they must be taken into account in order for the models to be predictive.

In this paper, an anisotropic continuum damage model is presented in a thermodynamically consistent framework. Additionally, it enables accounting for the interaction of damage evolution in different directions by introducing six independent damage variables. Further, mesh independent results can be achieved due to use of an fracture energy based regularization scheme.

It is shown that the model can be successfully applied on different scales. While on the micro-scale of unidirectional CFRP it is applied in an isotropic manner for the matrix material, on the meso-scale of textile composites the same model can be used in an orthotropic version to describe the damage behavior of the yarns. Moreover, on the macro-scale the model allows the prediction of delamination in layered composites such that no additional elements, e.g. cohesive zone elements are required [1-2].

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