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THERMO-MECHANICAL AND FATIGUE DAMAGE OF LAMINATED COMPOSITES

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Abstract. Intralaminar damage in laminated composites is the first mode of damage encountered in most applications and it is particularly severe under thermo-mechanical and cyclic loads. It precipitates other modes of failure such as delamination and fiber fracture. Also, intralaminar cracks are responsible for increases of permeability, exposing fibers to environmental attack. Therefore, accurate prediction of initiation and evolution of intralaminar matrix cracks under thermo-mechanical and fatigue loads is fundamental for the prediction of material and structural strength, fatigue life, and so on.

An analytical solution of the equations of elasticity in a representative volume element coupled with an incremental homogenization technique form the core of the modeling strategy to be presented. Also, by analyzing the stress-softening problem with a strain-hardening formulation, a single fracture criterion is proposed for both damage initiation and evolution without hardening parameters, thus reducing the number of material properties that need to be tested.

Novel aspects of homogenization will be presented that allow for accurate prediction of thermo-mechanical damage. Effect of temperature-dependent material properties will be described. Identification of material properties from meso-mechanical experimental data for monotonic thermal loading and thermal fatigue will be presented. Further, coupling intralaminar damage with a fiber fracture model allows for prediction of ultimate load capacity of open-hole tension specimens. Key for those predictions are the objectivity of the model, which eliminates mesh dependency and enables damage localization. Emphasis will be made on the fact that just two material properties are needed to track transverse damage initiation and evolution, and that no characteristic length is needed to achieve objectivity.