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Parameter fitting algorithm for composite laminates using a new material model with fiber reorientation

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Extended Abstract

Abstract

The effect of fiber reorientation under in-plane shear loading can play a crucial role in the behavior of composite laminates, as this phenomenon is the consequence of the transverse isotropic mechanical description. This fiber reorientation or draping further complicates the default non-linear behavior of such materials by making them appear stiffer or softer compared to the applied constitutive equations. In order to cope with this problem a new in-plane constitutive model has been developed and implemented in the LS-DYNA finite element solver, which can distinguish between tensile and compressive directions. Moreover, it applies non-linear elastic constitutive laws for the transverse and in-plane directions. In addition, the fiber reorientation is optionally taken into account. This model is being used in the in-house developed material model fitter framework. The software can determine the parameters of the constitutive laws by running the finite element models of the measurements and optimizing the parameter set, until the results of the simulations match with the measured curves. The next step of the fitting process is to obtain the best fitting first ply failure model with its appropriate parameters. This is done via gathering the critical stress states of the elements of the simulations at the failure load of the measurements, then using a

developed data-driven technique the best failure model is characterized. This technique involves a nominal fit of the preselected models on the available data, followed by an automated parameter identifiability and robustness check. This decides upon the theoretical model best suiting the available data. The fitting is finished by a numerically approximated Bayesian fit of the expected strength probability distribution functions. The draping effect typically occurs, when the specimen has a symmetric layup of ±θ degree. Furthermore, the fittings showed, that if a material model is used, which does not handle fiber reorientation, then the response to the mechanical load can be accurate, but tuning up the failure parameters based on the fitted model can be misleading, since the underlying physical phenomenon is changed. In reality, the fibers take over load from the matrix material, as they align to the loading direction. Consequently, the failure stress state is modified and fitting parameters without considering the draping effect can overestimate the strengths of the matrix material.

Keywords:

fiber reorientation parameter fitting composite laminates FEM