SYMCOMP 2023
Évora, 30-31 March 2023
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UNCERTAINTY QUANTIFICATION FOR ADVANCED PROGRESSIVE DAMAGE MODELS FOR COMPOSITES BY MEANS OF EFFICIENT EMULATORS AND BOOTSTRAPPING

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Keywords: Uncertainty Quantification, Computational Modelling, Bootstrapping

Abstract *The advanced finite element analysis tools for composite materials, which are based on various techniques such as Cohesive Elements, Continuum Damage Mechanics, Discrete Damage Modeling, and Smeared Crack Model, enable the modeling of both inter- and intra-laminar damage and enable simulation of the behavior of complex material systems at different scales, such as micro, meso, and macro. These computational models, which represent the cutting-edge of research and collaboration between academia and the aerospace industry, are the most powerful tools available to engineers. If the input parameters, such as material properties, geometry, and boundary conditions, are treated as deterministic values, the output of the computational model will also be deterministic. However, comparing this deterministic output with the results of a validation experiment does not provide a proper assessment of the agreement between the two, and hence, engineers might not use it confidently for calibration, exploring the design space, or optimizing the system under consideration. To accurately evaluate the model, the input parameters need to be treated as stochastic values and an Uncertainty Quantification and Management (UQ&M) analysis must be performed. This is especially important for composites, which are inherently random. A methodology was developed and validated to quantify the uncertainty in advanced progressive damage models for composites. It involves the use of efficient emulators, state-of-the-art computational models, and bootstrapping statistical techniques.*