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PROBABILISTIC STRENGTH ANALYSIS OF FIBER COMPOSITE STRUCTURES USING LAMINATION PARAMETERS

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The structural response of composite structures show comparatively large scatter of structural response. Therefore, probabilistic design approaches are promising to reduce conservatism in the sizing of composite structures. One source of scatter is the scatter of fibre orientations of each ply. When fibre orientations are considered as random parameters within a probabilistic analysis, the number of parameters obviously increases with the number of plies. When applying gradient based probabilistic approaches to structural response function for which the derivatives are not given analytically, the computational effort increase with the number of parameters and hence, with number of plies. Lamination parameters allow for describing the stiffness of any laminate with no more than 12 parameters [1]. Therefore, lamination parameters can be used to reduce the computational cost of gradient-based probabilistic analyses of composite structures [2]. However, when lamination parameters vary within a probabilistic analysis, the information of fibre orientations gets lost. This prevents applying typical failure criteria for composites structures, which are evaluated on ply level. Therefore, lamination parameters have mostly be used for stiffness problems like buckling. However, the more layers a laminate consist of, i.e. the thicker the laminate is, the more is material strength decisive for the structural performance. To the authors’ knowledge, the only strength criterion for lamination parameters is given by Ijsselmuiden et al [3], who incorporated the Tsai–Wu failure criterion into the lamination parameter design space. This requires certain conservative assumptions and is overly conservativefor bending dominated problems.

In the current contribution, the strength of composite structures is considered within a probabilistic analysis with lamination parameters without introducing conservative assumptions. Any time the set of lamination parameters varies within the probabilistic analysis, an optimization algorithm determines a discrete layup. Then, a failure criterion is evaluated on ply level. The efficiency improvement of the new approach is demonstrated by application to a use case that involves nonlinear finite element simulations for buckling and strength evaluation.

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