Effect of spatially varying stochastic material properties on the post-buckling behavior of composite panels using a reduced order model

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Composite stiffened panels are typical components in aircraft structures. When exploiting the potential of post-buckled designs, essential information about the post-buckling characteristics, such as post-buckling stiffness and modal interactions, is required. Full non-linear analysis of the post-buckling behavior of a thin-walled panel can be done using standard Finite Element codes. The effect of stochastic parameters, such as geometric imperfections, imperfect boundary conditions and deviations of wall-thickness, fiber orientation and material properties, on the buckling and nonlinear post-buckling behavior can be assessed through probabilistic analyses, e.g. [1]. Probabilistic nonlinear analyses can be very time-consuming, in particular when they are combined with optimization in order to obtain robust designs.

Previous research [2] has shown the potential of a Finite Element implementation of Koiter's initial post-buckling theory to create efficient reduced order models for post-buckling analysis of plates and panels. This approach can be used advantageously in a design framework and for probabilistic analyses. Using this method gives directly essential information about the influence of geometric imperfections on the post-buckling stiffness and nonlinear modal interactions. Moreover, with this approach a very significant reduction in computational time can be achieved. In this contribution, this perturbation approach based reduction method is used in the probabilistic analysis of composite panels.

The effect of spatially varying stochastic material properties on the post-buckling behavior of composite panels is investigated. The random field method [3] is used to include the effect of the spatial variations in the material properties of the panel on the structural response. This work focuses on combining the influence of the variability in material properties with the influence of geometric imperfections, included in the spirit of the perturbation approach [2], in the post-buckling analysis. The effect of spatially varying material properties on the post-buckling stiffness and relevant modal interactions in the post-buckling region is assessed for typical composite panel-type structures.

References

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