A cost-effective isogeometric approach for composite shell structures based on a stress recovery procedure

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ABSTRACT

Taking advantage of the accuracy and high-regularity properties of isogeometric analysis, in this work we propose a cost-effective stress recovery procedure for composite shell structures. This simulation strategy consists in using 3D isogeometric computations with a reduced number of elements in the thickness (namely, one) and a layer-wise integration rule, or, when possible, an homogenized approach. This coarse 3D analysis grants an inexpensive and accurate approximation through the thickness of the in-plane components of the stress, but not for the out-of-plane ones. Thus, based on the equilibrium equations in strong form, accurate out-of-plane stress components are recovered from the in-plane ones in a post-processing stage. This approach allows to drastically reduce the number of degrees of freedom and, accordingly, the overall computational time as compared to the standard full 3D layer-wise approach where every layer corresponds to an element through the thickness. The computational cost of the post-processing operation is negligible in comparison with the solution cost and it does not increase significantly with the number of degrees of freedom. Several numerical experiments are shown, both for plates and curved shell structures, revealing the very good accuracy-to-cost ratio of the method, which appears to be particularly effective on slender composite stacks with a large number of plies. In addition, a strategy for reducing the complexity of the stiffness matrix formation is presented: it is based on a pre-integration along the thickness reducing the problem complexity to the one of a 2D problem. Finally, based on the homogenized approach, the isogeometric collocation version is also discussed.