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Effect of structural modelling approximations on minimum weight design optimization of composite laminates

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This work introduces a new single-step methodology based on multilayer perceptrons artificial neural networks (ANNs) for the design optimization of composite structures [1]. A back-propagation algorithm is employed along with Monte Carlo simulations and advanced structural theories for training ANNs to replicate response surfaces and sensitive derivatives of laminated structures versus design parameters (lamination angles, layer thickness, etc.). Dataset and ANN training process is carried out by means of Carrera Unified Formulation (CUF), according to which structural theories with low-order accuracy (e.g., first order shear deformation theory) to layerwise models with enhanced 3D features can be implemented in a hierarchical and unified manner [2].

We demonstrate that the available multi-step optimization procedures of composite laminates may eventually bring to suboptimal solutions or even to violation of constraints. The reason is that – due to the lack of appropriate structural models and computer power – equivalent single layer structural theories, invariants and lamination parameters are generally used in modern practice along with gradient-based optimization algorithms, whereas stacking sequence is recovered by discrete procedures (e.g., genetic algorithms) in a second step. This approach severely shrinks the design space and limits the real advantages of the composite materials, i.e. stiffness-to-weight and strength-to-weight ratios as well as tailorability.

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