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ANALYSES OF VAT COMPOSITE STRUCTURES USING A LAYER-WISE 1D MODEL

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The research is engaged in the optimization of the composite laminates because of their extensive use in many engineering fields. Typically these materials are defined as Constant Stiffness Composite laminate (CSCL) characterized by the same stiffness, that is determined by the layers which compose the laminate, over the whole component. The new additive manufacturing technologies, such as the Automated Fibre Placement (AFP), offer new design rules that overcome the constraint of the classical laminates where the layers have straight fibers along one direction. AFP technology allows the fiber of each layer to be placed along a curvilinear path defined by the designer. This feature introduces a wide range of tailoring scenarios making possible to find more efficient solutions than before, in fact, Variable Stiffness Composite laminates (VSCL) can be achieved with no discontinuities in the material. These new class of composite materials, named Variable Angle Tow (VAT) composites are in the spotlights, and new models able to predict their mechanical behaviors have to be developed to not compromise the design process. Through the VAT composites, the designer has excellent control on several aspects such as the redirection of the stress fluxes, local stiffness increases, control of the vibrational behavior or the introduction of coupling effects. Because of the limited capacities of the classical theories, refined models are required to provide an accurate prediction of the complex mechanical behaviors of these materials. Besides, these models must be able to evaluate the material proprieties point by point over the whole component. Refined beam models based on the Carrera Unified Formulation (CUF) has been extended to the analyses of VAT composites in this work. The 1D CUF model uses expansions to approximate the displacement field over the cross-section in the definition of the model kinematics. Accordingly to the used expansion, equivalent single layer or layer-wise models can be achieved. The work proposes free-vibration analyses of VAT laminates using results from the open literature. Thin-walled boxes are also taken into account, and the influences of curvilinear fibers on the modal behavior have been evaluated.