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Composite Laminate and Thin-Walled Beam Correlations for Aircraft Wing Box Design

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Abstract : Composite materials have become an important option for the primary structure of aircraft due to their design flexibility and ability to improve the overall performance. At present, the option for composite usage in aircraft component is largely based on experience, knowledge, benchmarking and partly market driven. An inevitable iterative design during the design stage and validation process will increase the development time and cost. This paper aims at presenting the correlation between laminate and composite thin-wall beam structure, which contains the theoretical and numerical investigations on stiffness estimation of composite aerostructures with applications to aircraft wings. Classical laminate theory and thin-walled beam theory were applied to define the correlation between 1-dimensional composite laminate and 2-dimensional composite beam structure, respectively. Then FE model was created to represent the 3-dimensional structure. A detailed study on stiffness matrix of composite laminates has been carried out to understand the effects of stacking sequence on the coupling between extension, shear, bending and torsional deformation of wing box structures for 1-dimensional, 2-dimensional and 3-dimensional structures. Relationships amongst composite laminates and composite wing box structures of the same material have been developed in this study. These correlations will be guidelines for the design engineers to predict the stiffness of the wing box structure during the material selection process and laminate design stage.

Keywords : aircraft design, aircraft structures, classical lamination theory, composite structures, laminate theory, structural design, thin-walled beam theory, wing box design
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