Design Exploration Methodology for Ultra Thick Laminated Composites

J. CARRASCO-MUÑOZ Y GUERRA, K. HUGHES*
and R. VIGNJEVIC

Key words: Ultra-thick composites, design exploration

1. INTRODUCTION

Laminated composites have been extensively used in the aerospace and automotive industries for weight saving purposes. However their scope of application is normally limited to thin applications, which do not account for the out-of-plane stresses required to fully characterise the structural behaviour of the so called Ultra Thick Laminates (UTL) structures, nowadays considered in primary structures design for instance. A good understanding of the capabilities and limitations of layered solid element, currently available in various commercial FE codes, is required for an accurate prediction of the out-of-plane delamination failure associated with this type of structures (mainly due to the transverse shear stresses and interlaminar stresses).

The overall objective of this work is:

- To present a parametric design exploration methodology for constant thickness UTL composite components, that accounts for the orientation at a ply level of a varying and repeatable stacking sequence (represented by means of layered solid elements), in order to assess the design implications on performance.

The abovementioned methodology considers a commercial FE tool (ANSYS), and a data management system and optimisation tool (ISIGHT), so as the utilization of layered solid elements (SOLID191, 20-node layered solid element). Application of manufacturing design rules (in order to reduce the number computational expense of the analysis) and manufacturing design constraints are also considered.

The methodology proposed was applied on the design exploration and performance optimisation of a Non-Crimped Fabric UTL composite specimen (symmetric layup, 120 plies (30mm thick)) under a 3-point bending test (linear static analysis), for which experimental results were available. The individual ply orientations are the design variables considered, and the performance was assessed through the vertical displacement of the component and the maximum transverse shear stress value.

This exploration of the design space did identify other possible configurations that may have a better performance than the baseline, considering only the maximum transverse shear stress values as directly responsible for the delamination failure. However, these improved designs may present a higher number of plies failed or a higher failure index (Tsai-Wu failure criteria). Further experimental studies are required to further explore the design space, but this work represents the starting point and possible approach for development of robustness is proposed.

---

*Department of Applied Mechanics and Astronautics, Crashworthiness, Impacts and Structural Mechanics Group, Cranfield University, MK43 0AL, UK
e-mail: k.hughes@cranfield.ac..uk; web page: http://www.cranfield.ac.uk/soe/departments/simd/ structures/ index.html