Modelling VARTM process induced variations on bending performance of composite Omega beams

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Introduction

Vacuum assisted resin transfer moulding (VARTM) poses challenges to produce aerospace graded composite structures. The associated quality variations are void, resin rich pocket and varied thickness, shown in Figure 1. The influence of these quality variations on the structural performance requires a close correlation, in order to prioritise and improve the process parameters for aerospace applications. This paper presents an efficient finite element modelling approach to predict the experimentally observed variations [1].

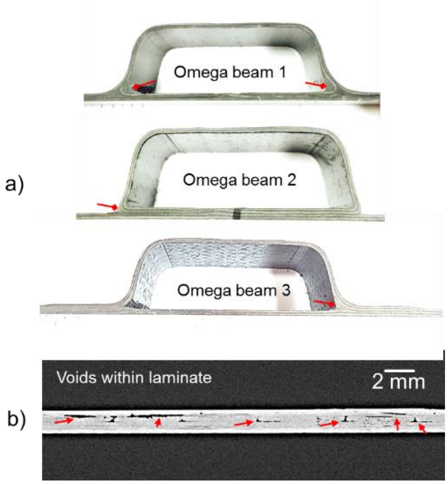

Figure 1. *Photographic evidence of manufacture induced defects: a) Diamond arrows pointing to resin rich noodles; and b) normal arrows pointing to voids within laminate.*

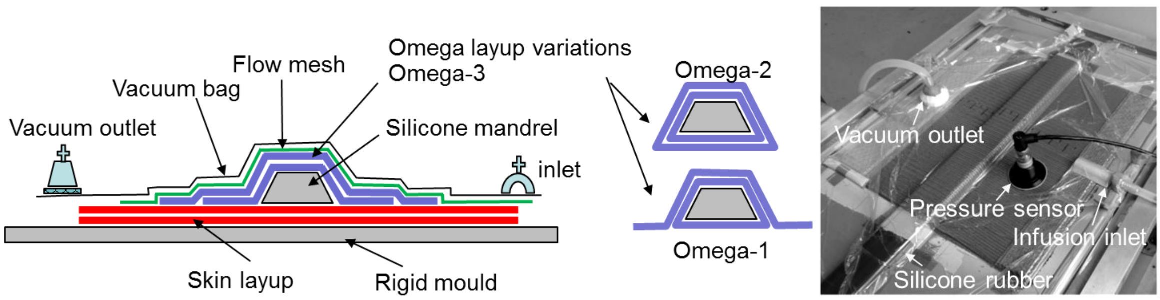

Figure 2. *Sketch (Left) and actual setup (Right) of vacuum assisted resin transfer moulding for manufacturing Omega beam 1, 2 and 3*

Experimental and numerical analyses

The experimental and numerical study focuses on composite Omega beams as an example of an aero structure subcomponent. We investigated three variations in omega stiffener layups, shown in Figure 2. The four-point bending tests revealed that the layup variations had significant influence on the bending performance of the Omega beams. The experiments also demonstrated large scatter in bending stiffness (+/-15%) and bending strength (+/-25%) within the samples from the same Omega layup. Likely, this scatter related to the variation in void, resin rich pockets and thickness in the omega beams. The numerical study later confirmed the correlation.

The finite element model employed continuum shell elements for representing individual lamina. Cohesive zone contact was applied to model the delamination behaviour between laminas and the interface between resin rich pocket and laminas. In the first stage, the study investigated the numerical strategies to gain computational efficiency. By comparing mesh size 1mm, 1.5mm and 2 mm, the study found that the coarse mesh was accurate and effective, provided the numerical cohesive strength was adapted. For all three Omega layups, the finite element model predicted extremely well for the entire load-displacement curves and the delamination configurations in the experiments. After the validation, the model further incorporated the separate changes in resin pocket, thickness and void. The predicted bending performances matched well with the scatter observed in the experiments. The modelling method provides a useful guide for composite processing towards better structural performance.

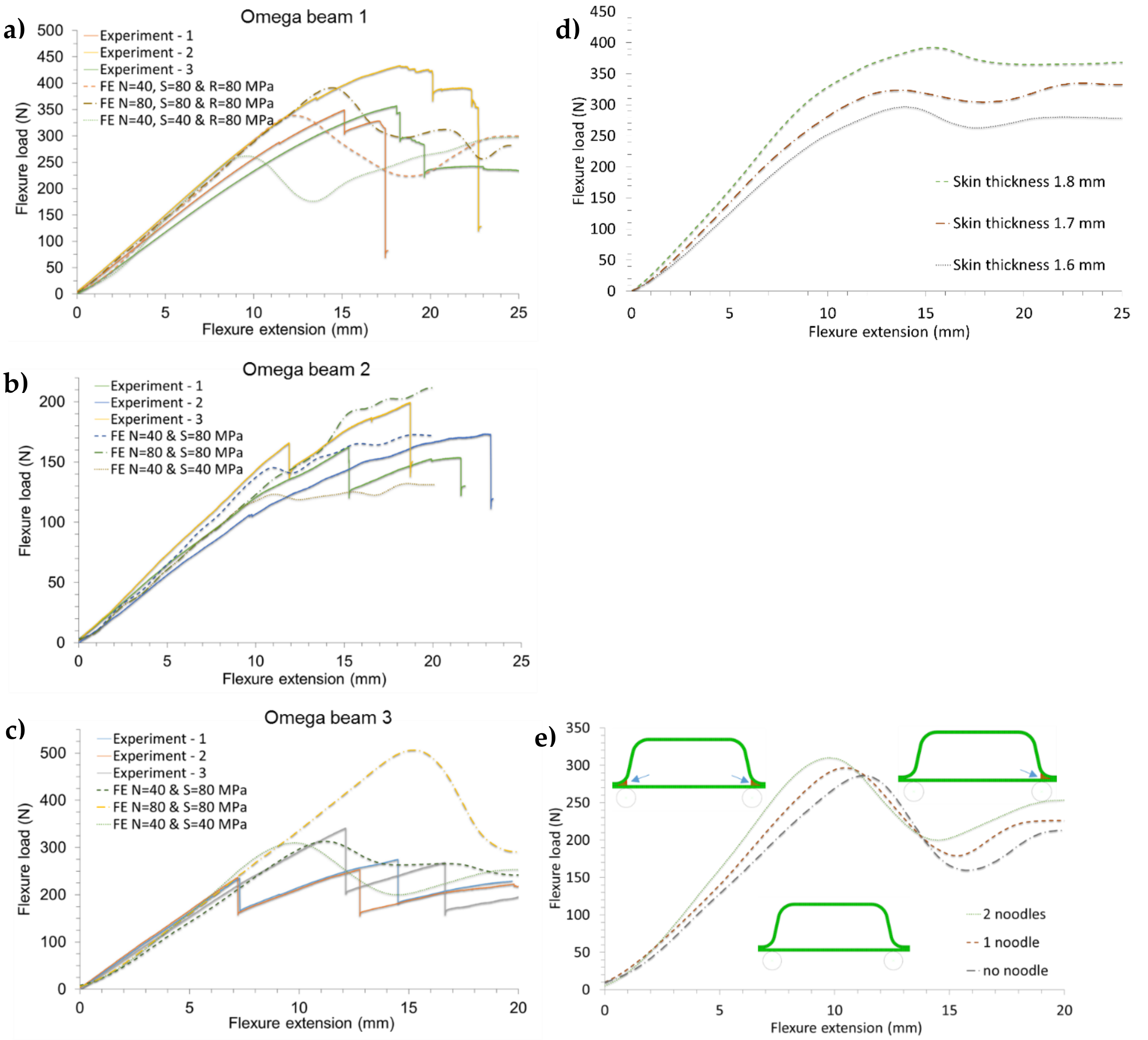

Figure 3. *a, b, and c) Curves of flexure load vs flexure extension from experiment and FE prediction; d) Influence of skin thickness on the 4-point bending performance of Omega beam 1; e) Influence of resin rich noodles on the 4-point bending performance of Omega beam 3.*

References

[1] X. Zeng, P. Schubel, J. Lorrillard, Modelling VARTM process induced variations on bending performance of composite Omega beams, Composites Part A, (*Accepted*) 2016