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A BIO-INSPIRED EMBEDDED COMPOSITE STIFFENER FOR IMPROVED DAMAGE TOLERANCE

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ABSTRACT

In this work we develop a bio-inspired stiffened composite panel which exhibits superior damage tolerance in comparison to a traditional stiffened composite panel. A variety of structures use composite panels which are stiffened via bonded or co-cured composite stiffeners. However, these structures are vulnerable to suffering from rapid debonding of stiffeners, particularly when a fracture propagates to the stiffened region.

In the branch-trunk attachment of trees, such as the Pinus radiata pine tree shown in Figure 1, the fibrous material of the branch is interleaved within the fibrous trunk material. This embedding of the branch results in a connection which exhibits remarkable damage tolerance [1].

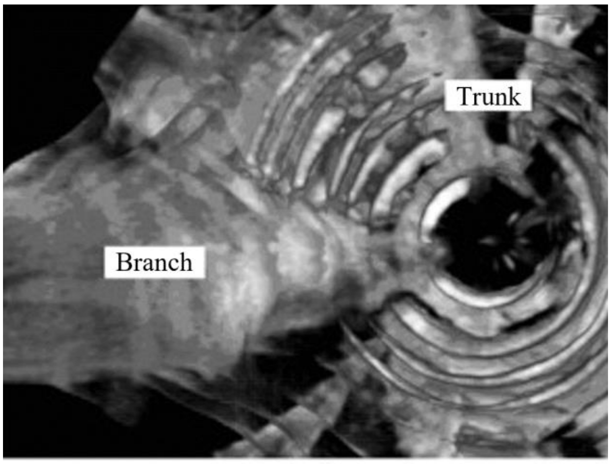

Figure 1: CT scan of a Pinus radiata pine tree showing how the branch is integrated into the trunk. [1]

In this work, we employ this bio-inspiration to develop an embedded composite stiffener, with the objective of achieving significantly improved damage tolerance. The ply-drop strategy shown in Figure 2 shows how the composite stiffener is embedded into the panel. The result is that the interface between stiffener and panel is no longer existent; meaning that fracture propagation can no longer result simply in debonding of the stiffener. The terminated plies are interleaved between the continuous plies to prevent coalescence of delaminations which may initiate at ply terminations.

Industry are embracing Automated Fibre Placement (AFP) as a manufacturing route for composites, due to the benefits that the automated process can offer. In this work, the bio-inspired design and co-cured baseline were manufactured using Automated Fibre Placement (AFP). A foam core for the stiffener additionally serves as a layup mould to enable AFP manufacture.

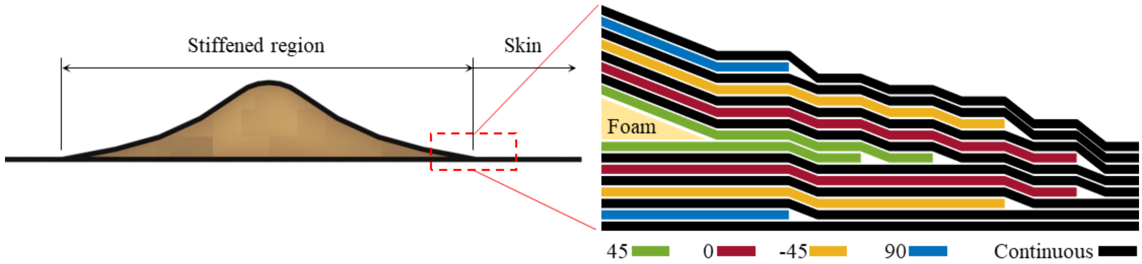

Figure 2: A section of the bio-inspired stiffened panel and the ply-drop strategy. The layup used for the skin remote from the stiffened region is $[45/0/-45/90]_S$.

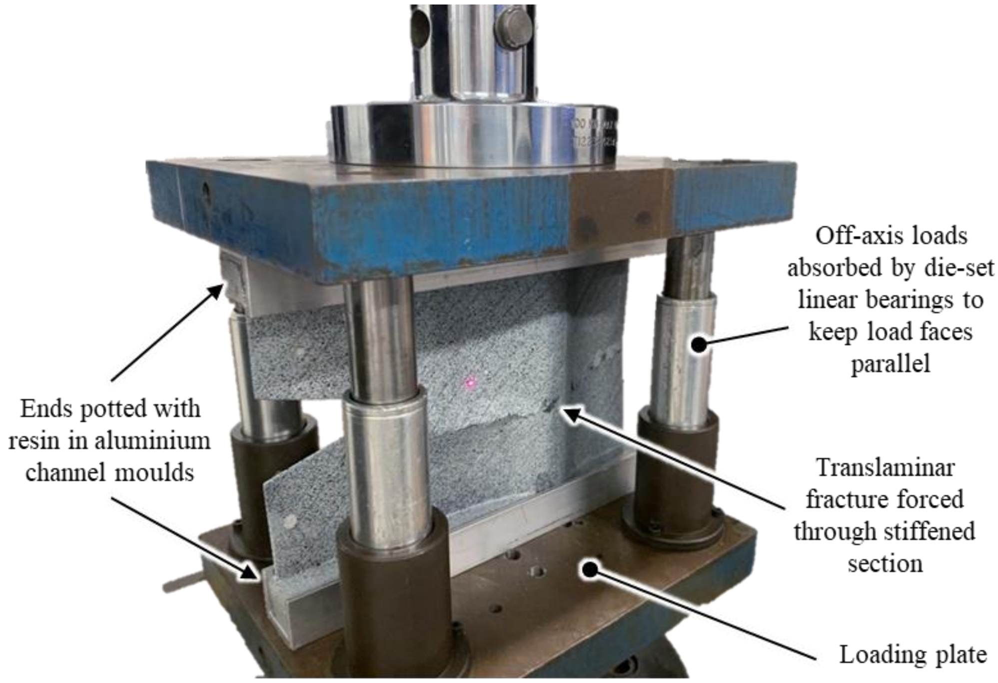

Figure 3: Experimental notched compression test set-up. Initial testing has demonstrated the bio-inspired design forces the fracture through the stiffened region.

The stiffened panels are tested using a notched compression test as shown in Figure 3; the notch is manufactured into the skin with the tip 5mm away from the stiffened region. Initial testing results have demonstrated that, whilst the baseline suffers the traditional debonding failure, the bio-inspired design forces the translaminar fracture through the stiffened region. This shift in failure mechanism is a significant step towards damage tolerance structures; we are currently performing further experimental work to further evaluate this design, including a quantitative analysis.

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