DEVELOPMENT OF NON-UNIFORM 3D WOVEN STRUCTURES TO ENABLE CHANGES IN MECHANICAL PROPERTIES FOR MARITIME STRUCTURES

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Introduction

3D weaving is a method used to fabricate three-dimensional woven performs. Unlike traditional 2D weaving, 3D weaving involves the interlacing of yarns in three directions (x, y, and z) to create thick performs (2).

There are three main architectures used which are Angled interlock, Layer to Layer and Orthogonal (3-4). The mechanical properties can be tailored by having different binder yarn paths (5). In 3D textiles, it is possible to weave near net-shape and complex structures.

3D weaving allows for the creation of structures with variable architectures, which can be optimised for different applications, such as hydrofoils. This can lead to improved performance, reduced weight, and lower costs compared to traditional manufacturing techniques. However, there is still limited knowledge of these non uniform structures

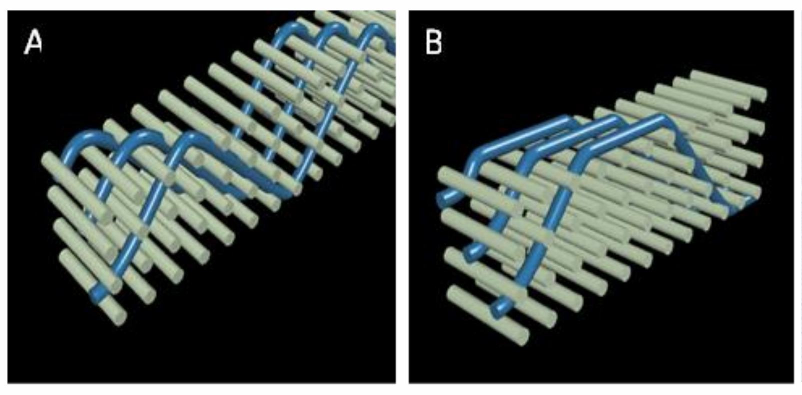

Figure 1 Change in Float Length

Figure 2 Artemis Technologies Hydrofoil (1)

Objectives

- To characterise and analyse the microstructure and properties of non-uniform 3D woven structures using experimental and/or numerical methods.
- To investigate the effects of design parameters such as pic density, interlacing pattern, and float length on the mechanical properties and behaviour of non-uniform 3D woven structures
- To develop and optimise fabrication techniques for producing non-uniform 3D woven structures with desired properties and performance.
- To evaluate the performance and potential applications of non-uniform 3D woven structures in fields such as maritime structures.
- To identify and address challenges and limitations associated with non-uniform 3D woven structures, such as defects and processing complexity.

Methods

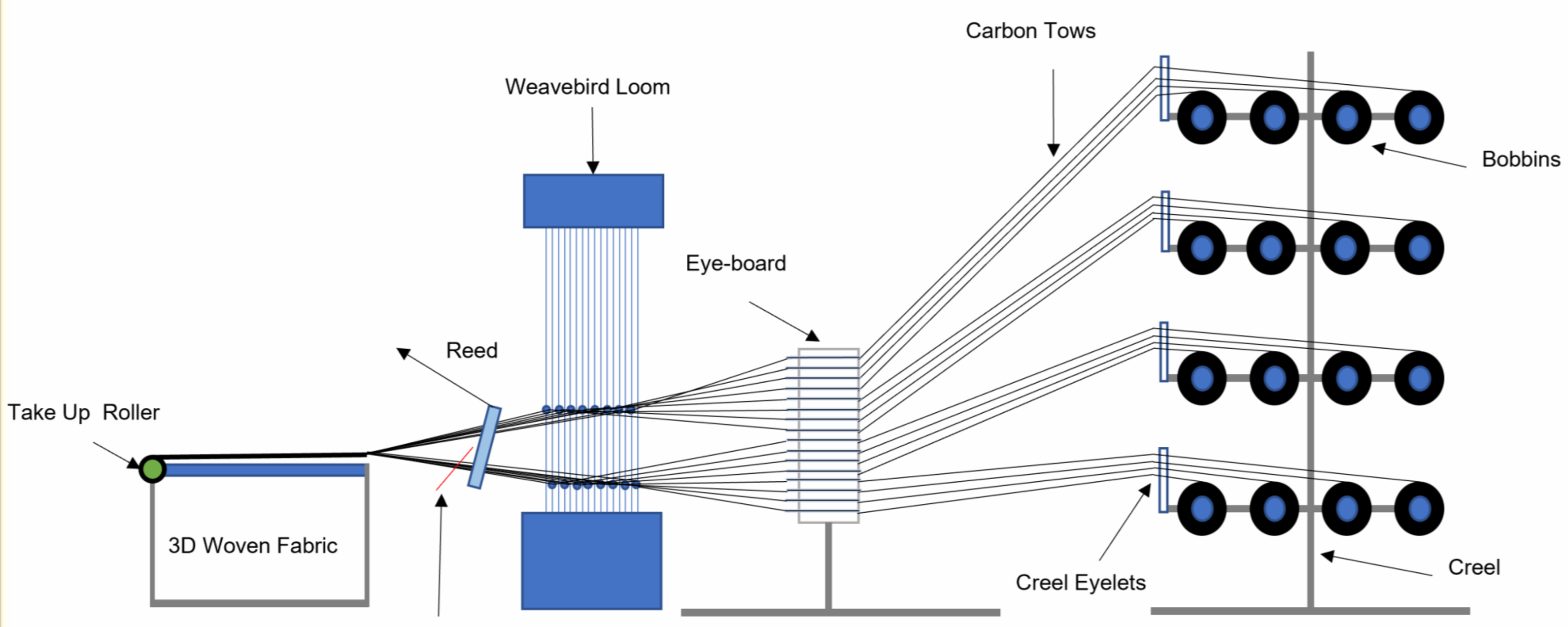

Figure 3 Weavebird Loom Setup

- Three 3D woven performs where manufacturing on a Weavebird Loom using 12 shafts and 28 heddles per shaft, T700s 50c 24k was used for both the warp and weft insertion.
- The three layer to layer architectures (Base LL1, MOD1 LL1 and MOD1 LL3) were designed using three warp yarns and 4 weft yarns per group, giving 12 warps/cm. The final performs had an average thickness of 3.5mm when compressed and a final Vf of 48%.
- The modified layer to layer architectures were designed to change the float length from one to three. In MOD1 LL1, the float length of three is on the top and in MOD1 LL3 the float length of three is on the bottom.

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Design and Manufacturing

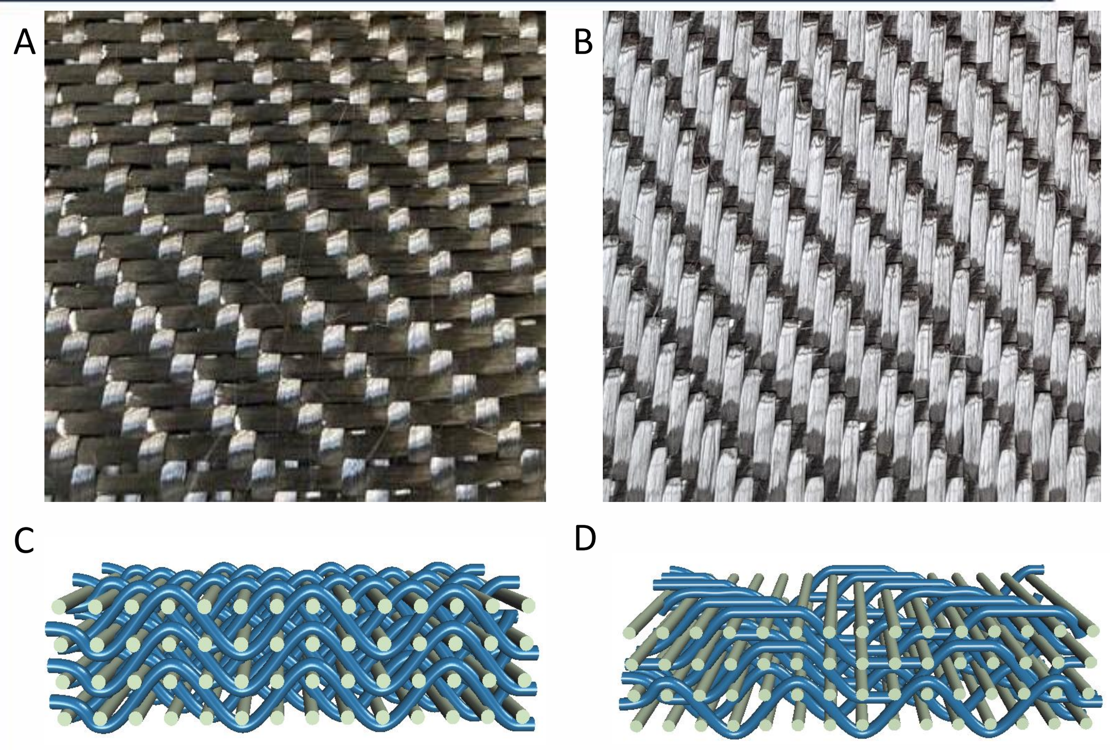

Figure 4 Layer to Layer Dry Perform (A), Modified Layer to Layer Dry Perform (B), Scotweave Base LL1 Design (C) and Scotweave MOD1 LL1-3 Design (D)

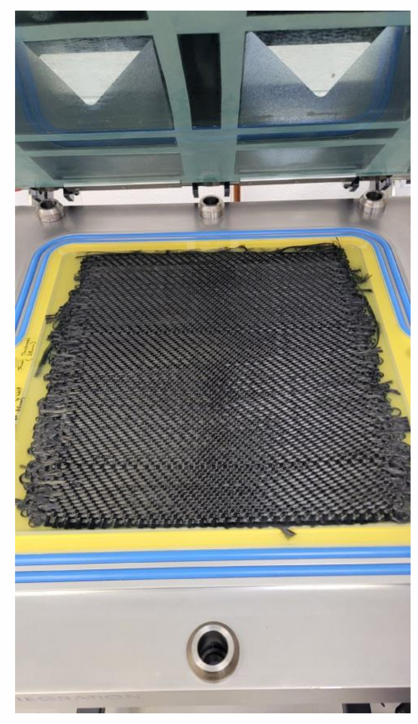

Figure 5 Finished Perform After RTM

Results

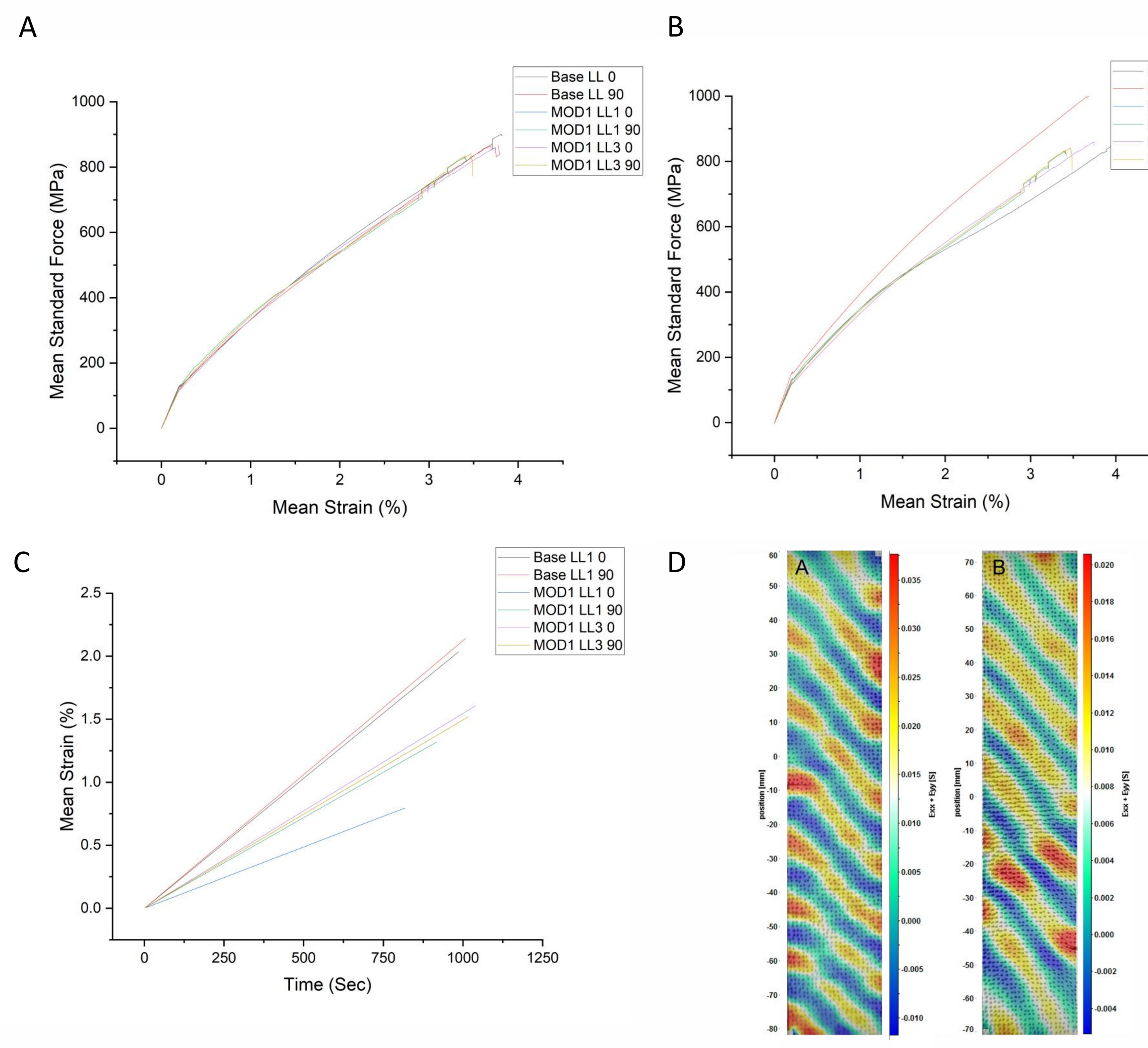

Figure 6 Tensile Results Base LL1 Vs MOD1 LL1-3 (A), Flexural Results Base LL1 Vs MOD1 LL1, DIC Tensile Results Base LL1 Vs MOD1 LL1-3 (C) and DIC Images Base LL1-0 (DA) MOD1 LL1-0 (DB)

Conclusion

- The results from the tensile tests have shown that, by changing the float length, one of the warp layers, either on the top or bottom, can have both a positive and negative effect on the results. In the warp direction, there was a 14% drop in Fmax between Base LL1 and MOD1 LL1-3. However, if you compare the difference between Fmax between the warp and weft directions, Base LL1 has a 21% difference, but MOD1 L1-3 has a 2.5% difference.
- When comparing the flexural modulus in the warp and weft directions between Base LL1 and MOD1 LL1, there has been a change. In the warp direction, the modulus has increased, however, in the weft direction, it has decreased. It has also shown a similar trend in that the effect of warp and weft has decreased.
- The DIC results show the effect of the float length on the strain during tensile testing, increasing the float length decreases the strain (%) in both the warp and weft directions, as this causes more of the fibre to align towards the direction of loading.

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