3D textile composite beams with a new weaving pattern

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EXTENDED ABSTRACT

1. Introduction

The main function of aircraft structural components is to resist the loads to which they are subjected and transmit these loads to other structural parts. It is among the main functions of these structures that these structures provide appropriate protection and effects against the critical loads created by the environmental conditions during the flight of the aircraft, such as the carrying and drag forces to which the aircraft will be exposed. As the wings are subjected to excessive loads during flight, they must be mechanically resistant. For this reason, the components that make up the blade internal structure must be in durable form. These structure needs to must resist bending, compressive and torsional loads without buckling. For this reason, longitudinal reinforcement elements such as spar, rib, web, stiffener, and stringer, and transverse frame structures are used inside the wing in order to encounter these loads [1]. The spar which is the most important part of these structures composing the form of I-beam, which provides high strength, which ensures that the spars have an enormous function in terms of carrying loads along the wing [2,3]. Generally, composite and aluminium alloys materials are used in the material selection of these structures in terms of load carrying. Nevertheless, as a result of the comparison of these two materials in the spar part, it is seen that the composite material provides 40% lighter to aluminium wings. In addition, using composite material in wing structure provides fuel savings between 5% and 8% [4]. The advantages of composite material in spar structure are obvious. Nonetheless, delamination problems are commonly encountered in the stiffener region that forms the middle part of the spar structure. In the corner radius of the stiffener part, the matrix cracks that extend parallel to the fiber axis cause stresses, and thus corner radius delamination occurs [5]. 3D weaving is another innovative solution method to improve the inter-lamination properties of composite structures by eliminating the delamination as a result of the orientation of the fibers directed on the x and y axes to the z axis (through-the-thickness reinforcement) [6]. Some common types of 3D preforms are slightly modified to conventional looms, allowing preforms to be woven as shapes with near-shaped complex geometries, such as 2D woven fabrics and I, T or C beam beams, which can be used as 3D load-bearing in aerospace structures. The use of 3D weaving method for stringer and stiffener components in spar is a method that can eliminate the delamination problem that will arise [7].

Since the load bearing of the structure of I-beams is due to the middle wall, the middle wall was named as the load-bearing wall in our research. The I-beam preforms produced using 3D weaving, there is a crosslink point on the load-bearing walls as seen in the weaving pattern and this point is in a linear direction along the middle wall [6]. Based on the current literature research we have done, most of the studies on these 3D woven profile beam structures have a crosslink point in their load-bearing walls [6, 8, 9].

The main purpose of our study is on how the mechanical properties and wetting mechanisms of load-bearing I beam, which have the different architecture of the weave patterns, are affected, as shown in Figure 1. After obtaining a load-bearing wall without crosslink point, the compression, flexural and void tests were performed in order to investigate mechanical properties. The 3D glass fiber composites were fabricated as composites by VARTM method.

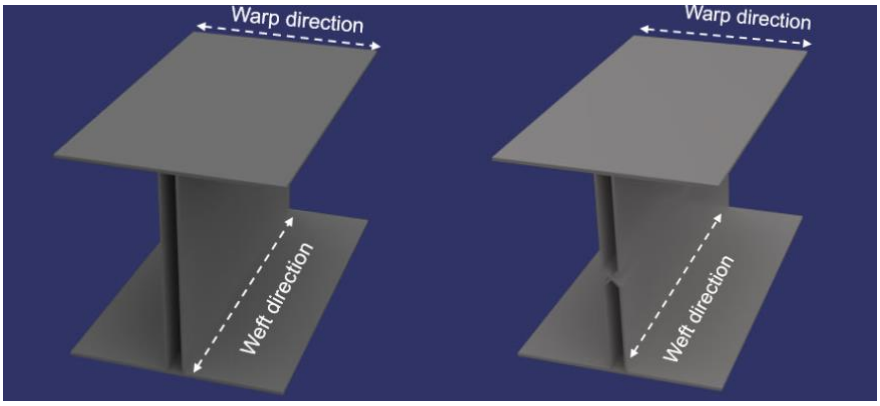


Figure 1: The architectural pattern of II and X I beams

The most important disadvantage of glass fiber reinforced composites is delamination. With an innovative approach, 3D woven I-beams are produced using glass fiber. CNTs were grown on I-beams with chemical vapor deposition (CVD). 3D woven I-beams with CNTs grown on them were impregnated with epoxy resin and their electrical conductivity increased 6 times with a negligible increase in weight. After the CNTs growth, 44% decrease in tensile strength and 26% decrease in compressive strength occurred [10].

2. Experimental

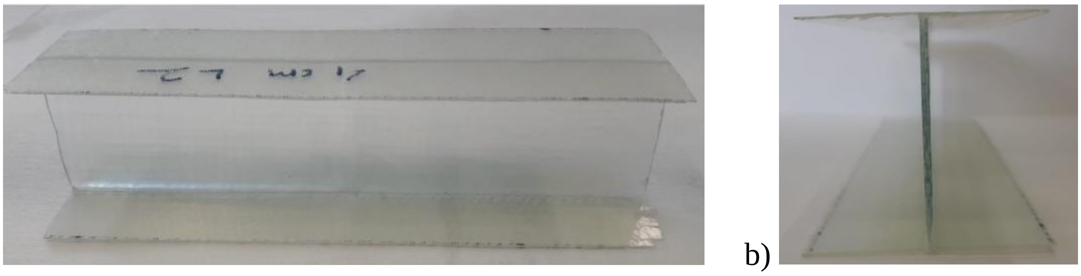
3D structures with an I-profile were woven using single-ended E-Glass fiber rovings having 600 TEX linear density. Two types of specimens were produced: in the first type of specimen, the load-bearing wall cross-linked in an X-shaped, while in the second type of specimen it made a double-I shaped. Samples of the first type will be denoted by X, while the second type will be denoted by II. For these two types of weaving architecture, warp density in flanges is 8 cm^{-1} and weft density is 4 cm^{-1}. For intermediate walls, the warp density is 4 cm^{-1} and the weft density is 4 cm^{-1}. For mechanical tests, the flange width is 6 cm in total, 2 cm in height, and 16 cm in length. I-profile woven beams will be made into a composite with the VARTM process. Teflon-coated molds, peel ply, and infusion mesh will be used for this stage. With the selected epoxy and hardener, varying epoxy + hardener ratios were used and fed into the system. The wetting times during composite production and the wetting mechanisms of LB-X and LB-II beams were examined with the applications made according to the formulations. Three-point bending and compression tests were applied to obtain information on the mechanical properties of composites.

3. Results and Discussion

The importance of the middle wall in terms of load bearing is very significant in I beams. For this reason, any development to be made on that part is of great importance in terms of the strength of the structure against loads. In particular, the stiffener and stringer components in the spar where I beam is used must have structures that can support large compression loads caused by axial and bending effects [1]. As demonstrated in the study of Mountasir [6], when I beams and 3D weaving preforms with hollows are exposed to excessive load, micro or macro breaks occur in the central web region [10].

Altering the architectural weave patterns of the load-bearing wall-X of I-Beam composites with crosslink points is expected to improve the mechanical properties of the structure. As shown in the figure 2, the load bearing-II I beam was fabricated by using VARTM method.

It is predicted that the load-bearing wall-II I beam will be more durable, based on the expected results after the compression and 3-point bending tests, because there is no linear gap in the load-bearing wall. Additionally, it is predicted that critical results will be obtained as an important result of the examinations of wetting mechanisms to be carried out. It will be promising research in terms of investigating how the effects of resin flow rate in terms of wettability of LB-X and LB-II, the permeability values by geometric structure during the producing to composite of 3d weaving preforms. This examination will provides more insight into the different configurations of beams used in aerospace structures.



b)

Figure 2: The a) left view and b) front view of LB-II I beam composites

4. Conclusion

In this study, the wetting and mechanical properties of the altering architectural weave pattern for the load-bearing walls with crosslink points during and after composite production were investigated. In I beams with load-bearing walls, we expect more durable load-bearing walls I beams with the creation of LB-II structures by changing the architectural patterns of the middle wall. Considering different wettability and permeability values are provide to fabricate high-quality 3D woven I beam structures. Another issue that needs attention in our study is the cutting of the fabrics after weaving. Using tools for cutting allows the transfer of fibres to the VARTM process without disturbing the configuration.

In the future, it is possible to make different mechanic improvements with different approaches to these studies. It is possible to produce more statically durable aerospace materials with the help of some processes applied to the fibres before weaving, and will be discussed later.

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