Title: The Effects of Fibre Architecture on Water Absorption Induced Degradation in CFRP Laminates

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Composites are found to be attractive materials for many sectors and have good performance under certain environmental conditions when compared with other construction materials. Water absorption has a major potential environmental effect on many aerospace, automotive, and marine products made of fibrous polymeric composites. Polymers are the first to react to this environmental damage by the hydrolysis process and degradation, whereas fibres are found to influence the ingress mechanism in which the degradation process is active. The factors that influence water absorption are predominantly water contents (such as salt), temperature, exposure time, fibre type, fibre structure and polymer type. It is essential to understand the potential effects of each of these factors in order to avoid any unexpected failures. The focus of this study is to investigate the influence of fibre architecture on the water absorption of CFRP materials and their mechanical properties. Three types of fibre architecture are investigated: unidirectional CFRP, plain weave CFRP, and twill weave CFRP. All of these contain the same fibre type (TR50S) and epoxy resin system (K51) under the same environmental conditions. Samples are immersed in hot water and weight gain is monitored in line with the ASTM D5229 standard. Subsequently matrix dominated mechanical properties of impact, compression and short-beam strengths are determined and compared with the as manufactured properties. The impact testing was conducted in an Instron 9250-HV drop tower in line with the ASTM D 7137 standard. The compression strength was assessed using a combined loading compression fixture in line with the ASTM D 6641 standard. The short-beam strengths were assessed in line with ASTM D2344 standard. Additionally, the fibre volume fraction and void content have been assessed for each material by matrix digestion using nitric acid in line with ASTM D3171.

The results have shown that the fibre architecture has an impact on the weight gain capabilities of CFRP specimens and their mechanical properties. It was observed that the crimp style of fibres in woven specimens have reduced the penetration of water within the structure, particularly in the interfacial region. In terms of impact damage, a greater level of delamination was obtained for UD specimens whereas woven specimens showed more of fibre breakage. It was observed that the type and size of damage play a significant role in the water absorption in CFRP components distinguishing different resistance capabilities of water uptake levels in woven CFRP when compared to UD to certain impact energies as presented in Figure 1.

In terms of compressive and short-beam strengths. Reductions in the mechanical properties are observed in wet specimens promoted by the degradation of polymers within the structure. The failure modes obtained for compressive and short-beam specimens are better understood and analysed with the use of digital microscopy images as illustrated in Figure 2.

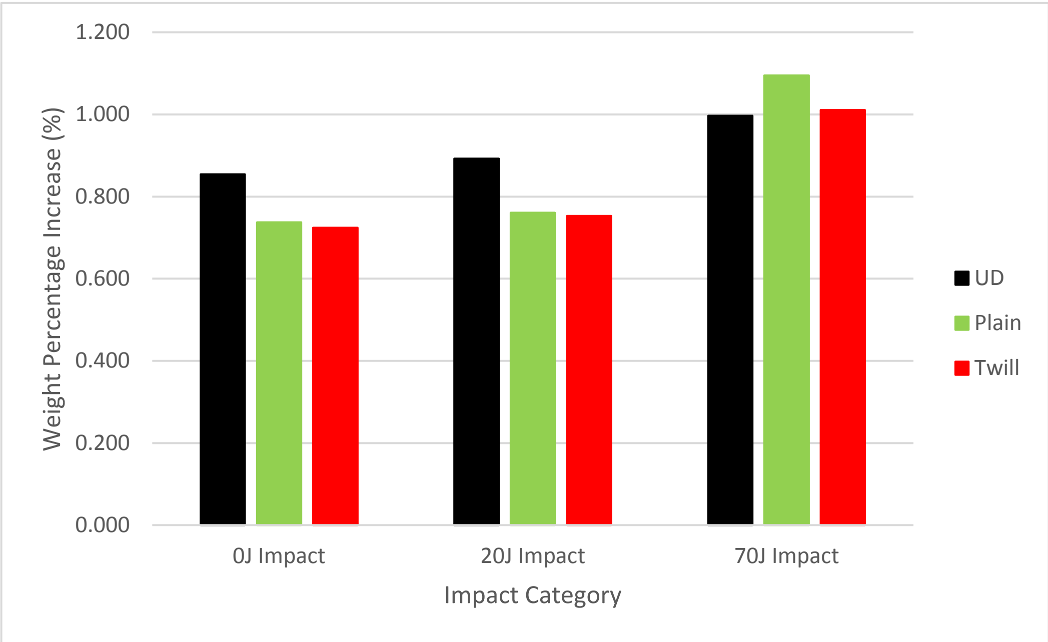

Figure 1: Water uptake for undamaged, after 20 joules impact damage, and after 70 joules impact damage for CFRP specimens.

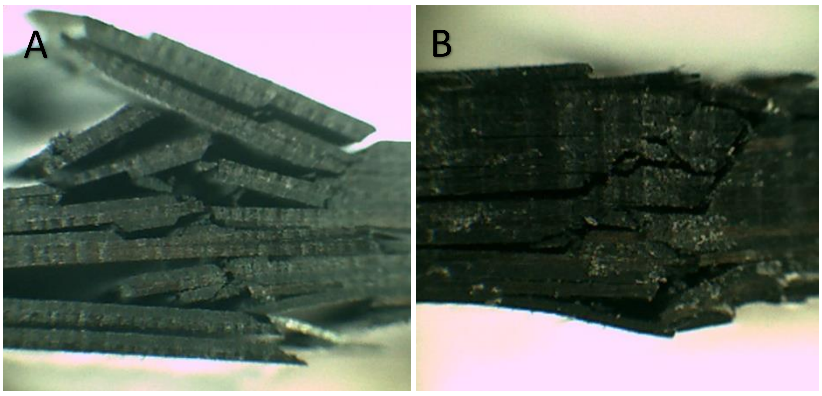

Figure 2: Failure modes obtained for UD specimens after the compression test: A is wet and B is dry.