

Ultra tough architected joints through single step bonding process with tunable properties

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Many complex structures such as airplanes are made of dissimilar materials to meet panoply of expected properties. This involves combining composites offering high strength and stiffness at low weight, with metal cladding offering temperature, erosion resistance and high mechanical resistance. Adhesive bonding is an interesting technology to bond dissimilar materials, but it suffers from time and labour-intensive processes and results in joints with low to moderate fracture toughness [1]. Toughening can be achieved through bondline architecturing [2] while simultaneous bonding and composite curing could significantly improve the process efficiency. In this research, a patterned thermoplastic (TP) film with large pores is inserted between two composite parts. Upon Resin Transfer Moulding process, the composite parts cure and bond while the cavities contained in the TP film can be filled or not with the resin. The mode I fracture toughness of these joints is investigated using Double Cantilever Beam tests.

The internal architecture results in a stick-slip behaviour with three fracture toughness regimes. The first regime, the weakest, corresponds to a fracture toughness at the order of aeronautic adhesives while the third regime results in unexpectedly high values. Fractography and finite element models reveal their micromechanical origin. Joint shear properties are investigated based on this model, revealing a key advantage of the joints: the fine tuning of the joint properties by controlling the filling of the film cavities.

[1] Zwebben, C., Composites, 12, 235 (1981).

[2] Heide-Jorgensen, S., et al., Compos. Sci. Technol., 160, 97 (2018).