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Flexural behaviour of 3D-printed carbon fibre composites: Experimental and virtual tests - application to composite adaptive structure

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Abstract
Flexural properties of 3D-printed carbon fibre (CF) composites are investigated, experimentally and numerically. A series of 3-point bending experimental tests are conducted on CF composite specimens, and a series of 3-point bending virtual tests are simulated in LS-DYNA using a composite modelling approach, which is user defined integration points through the composite thickness. The flexural stress-strain results are compared, and they show good agreement within the elastic region. In the plastic region, the experimental flexural modulus reduces significantly, which remains constant for a certain range of flexural strain, before structural failure. A new hypothesis on the flexural properties of the 3D-printed CF composite is suggested, which is the specimen behaves as two stacks of individual beams, after yielding/delamination. The hypothesis is supported by another series of FE simulations on the composite, modelled as two stacked composite beams, and subjected to 3-point bending load. Then the capability of the composite 3D-printing to manufacture a structure with complex geometries and to manufacture several parts as a single structure, are exploited to fabricate a CF composite corrugated structure with a trailing edge section. The structure which represents an internal structure of a morphing aerofoil is actuated by a NiTi shape memory alloy (SMA) wire with a 1.6% recoverable strain. A trailing edge deflection of 6.0 mm is obtained, which is measured using an IMETRUM optical system. It is reasonably close to the predicted deflection of 7.3 mm shown in the FE simulation, using a newly developed UMAT for SMA-actuation, in an explicit LS-DYNA. © 2022

Author Keywords
3D-printed carbon fibre composites; FE modelling and analysis; Flexural behaviour; LS-DYNA; Morphing corrugated structure; NiTi shape memory alloy (SMA); UMAT

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