20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

On the validation of experimentally-generated joint failure envelope through multi-connector Single-lap-shear tests

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Paper ID: 633
Symposium S2: Mechanics of composites: Experiments and modelling
Extended Abstract

Abstract

Previous experimental work on a state-of-art testing rig capable of testing different ratios of Bearing (BEA) and Pull-Through (PT) loading [1,2], coupled with pure BEA and PT tests, has led to the generation of a failure envelope for a UD IM7/8552 material system stacked in a traditional legacy Quad (Q) orientation. High fidelity models [1,3] have been shown to accurately predict the failure behaviour of the same material. The present work takes a new failure envelope recently generated using the same setup and parameters as in Refs. [1,2], but using a novel stacking practice known as Double-Double (DD). DD laminates, formed by two pairs of ply orientations, extend beyond the conventional (0/90/±45) configuration of Quad laminates, enabling greater design freedom, stiffness-tailored optimisation, and manufacturing simplification. Despite their predicted potential for weight and cost savings of up to 40% [4], their local fracture and energy absorption characteristics under joint loading remain underexplored. In the aforementioned testing campaign, Q laminates were tested against DD laminates with equivalent stiffness using the same material (UD CF-epoxy with 150 gsm). This failure envelope was used to feed the high-fidelity models from

[1,3]. However, these models are time-consuming and computationally-heavy. With this in mind, a simplified fast prediction framework was developed for modelling composite joint failure. The composite material is be represented using elastic homogenised elements, while the bolts will be modelled as node-to-node connectors. This approach allows for failure simulations in joints with multiple bolts, considering load redistribution from staggered bolt connection failures. This is suitable for the prediction of the ultimate failure load in larger components. This was also tested on a multi-bolt joint assembly. The results and computation times obtained using high-fidelity modelling and macro-scale failure criteria were also compared. Experimental single- and multi-bolt Single-lap shear (SLS) tests chosen to validate the prediction capabilities of this approach as they represent what is typically employed in mechanically-fastened joints in aeronautical applications.

Keywords:

Carbon fibre reinforced composites Mechanically-fastened joints Joint failure envelope