Progressive Damage Assessment of CFRP Tapered Scarf Repaired Panel under Uniaxial Compressive Loading: Experimentally and Numerically

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ABSTRACT

The aim of this study is to investigate the damage behaviour of adhesively bonded tapered scarf repaired Carbon fibre reinforced polymer (CFRP) panel subjected to uniaxial compressive loading, both experimentally and numerically. Initially, to understand the complex damage mechanisms involved in the scarf repaired CFRP panel under compression, experiments are performed on tapered scarf jointed CFRP specimen subjected to compressive loading using digital image correlation (DIC) technique. The CFRP adherend of different stacking sequence, namely, unidirectional (UD) $[0^0]_{16}$ and quasi-isotropic (QI) $[+45/0/-45/90]_{2S}$ are fabricated and then co-bonded with Araldite 2015 as adhesive. The taper angle considered for the scarf joint is 6^o. Here, 2D DIC technique is used for capturing the whole field longitudinal, transverse and shear strain distribution over the adhesive bond line of the CFRP specimen. Also, localised DIC measurement with a microscopic tube lens is carried out to capture the complex strain field at micro length scales in the CFRP specimen. The progression of whole field strain distribution with increasing load is captured to study the damage mechanism of a tapered scarf joint CFRP specimen. Later, to investigate the damage behaviour of the scarf repaired CFRP panel under compression, both the panel and the patch are fabricated individually and co-bonded using Araldite 2015 adhesive. Both the panel as well as the patch is having quasi-isotropic (QI) $[+45/0/-45/90]_S$ layup sequence. Here, 3D DIC technique is used for capturing the whole field longitudinal, transverse and shear strain distribution over the CFRP panel to study the damage behaviour under compressive loading. Additionally, acoustic emission (AE) technique is also employed for the identification and characterization of various damage modes by analysing the parametric data obtained from AE testing. Further, a 3D finite element analysis (FEA) based progressive damage model (PDM) is developed to predict the damage behaviour of tapered scarf repaired CFRP specimen subjected to uniaxial compressive loading. Finally, to validate the developed PDM, initial stiffness, damage initiation load and ultimate load of the scarf repaired CFRP panel obtained from PDM are compared against the experimental values.

REFERENCES

[1] S. Matta and M. Ramji, "Prediction of mechanical behaviour of adhesively bonded CFRP scarf jointed specimen under tensile loading using localised DIC and CZM", *Int. J. of Adhesion & Adhesives*., Vol. 89, pp. 88 – 108, (2019).

[2] S. Kumar, S. Sivashanker, A. Bag and I. Sridhar, "Failure of aerospace composite scarf-joints subjected to uniaxial compression", *Mat. Sci. & Engg: A*, Vol. 412 (1-2), pp. 117 – 122, (2005).

[3] M. Kashfuddoja and M. Ramji, "An experimental and numerical investigation of progressive damage analysis in bonded patch repaired CFRP laminates", *J. of Comp. Mat.*, Vol. 49(4), pp. 439–456, (2015).

[4] C. Soutis, D.M. Duan and P. Goutas, "Compressive behaviour of CFRP laminates repaired with adhesively bonded external patches", *Comp. Strut.*, Vol. 45(4), pp. 289 – 301, (1999).