11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

DELAMINATION CHARACTERISTICS OF SPLICES AND DOUBLERS IN GLARE LAMINATES DURING BUCKLING

A. Al-Azzawi, J. McCrory, L.F. Kawashita, C.A. Featherston, R. Pullin, K.M. Holford

Cardiff School of Engineering, The Parade, Cardiff, CF24 3AA, UK, FeatherstonCA@cardiff.ac.uk

Key Words: *Fibre Metal Laminates, Buckling, Cohesive Zone Model, DIC, AE*

Introduction A bi-linear cohesive zone model (CZM) has been developed to examine the behaviour of Glare™ Fibre Metal Laminate (FML) specimens containing manufacturing defects in typical features such as splices and doublers. In particular the effects of delamination at the metal-fibre interfaces on the buckling characteristics have been examined. A series of specimens with artificial delaminations have been tested under compression for validation. Tests have been monitored using Digital Image Correlation to determine delamination growth and strain energy release rates for use in the model. Acoustic Emission (AE) has enabled detection and location the onset and progression of damage. Preliminary results for Glare 4B specimens incorporating delaminations into both a splice and a doubler are presented. Good correlation is observed between test result and prediction.

Background FML's including Glare are manufactured from alternating metallic sheets and fibre reinforced composite layers. Glare offers a 10% reduction in specific weight compared with aluminium and has advantages over carbon fibre reinforced plastics (CFRP's) including improved impact, fire and corrosion resistance; and increased damage tolerance [1]. Its commercial use has increased progressively most recently being incorporated into the A380 fuselage. Despite its advantages however, there are additional challenges in terms of understanding damage mechanisms [2]. This paper examines potential damage arising from the manufacturing process, specifically from the need to fabricate large panels. For a typical metal sheet 0.3–0.4 mm thick the maximum width of material is normally 1.65 m, whilst a fuselage skin requires sheets of up to 2 m or wider. This is overcome by the introduction of splices and doublers .In order to obtain wider panels aluminium sheets are positioned side by side with a gap in between. The gaps are staggered through the thickness to prevent loss of strength with the fibre layers providing load transfer. This is known as splicing. Splices can be strengthened by adding additional layers (doublers) externally or internally to reduce stresses. Although solving size restrictions, this introduces a further manufacturing process and therefore the possibility of introducing manufacturing defects during processing.

Experimental work A series of specimens representative of features common to aircraft structures have been tested. Results are presented for an undisturbed doubler and longitudinal splice and equivalent specimens with artificial delaminations (Figure 1). Specimens measuring 140 mm × 80 mm were manufactured from Glare 4B and tested in a especially-designed test rig shown in (Figure 2).

Model The CZM method used combines the classical fracture mechanics concept of a critical strain energy release rate criterion for crack propagation with the damage mechanics

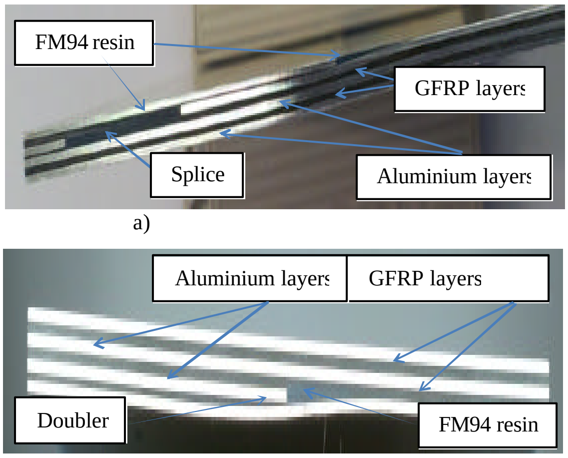

Figure 1 Glare specimens

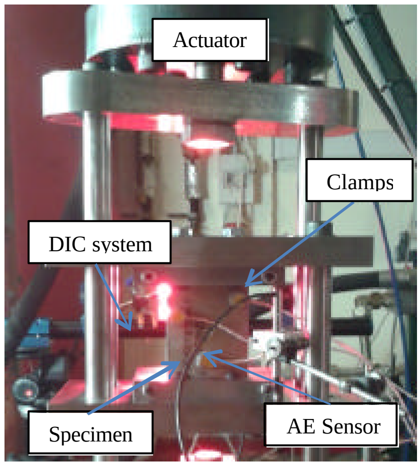

Figure 2 Experimental set-up

assumption of a zone ahead of the crack tip where a gradual, irreversible loss of material stiffness is observed [3]. This approach is very attractive for modelling fracture processes within the FE analysis framework because it avoids the treatment of singular and oscillatory stress fields which would be observed with the assumption of linear elasticity. In this study a user-defined cohesive element implemented in ABAQUS software is used to model the inter-laminar delamination at the metal-fibre interface under compressive loading. DIC data is used to identify the cohesive zone parameters that best describe the delamination initiation and growth processes in the Glare 4b material.

Results and Conclusions

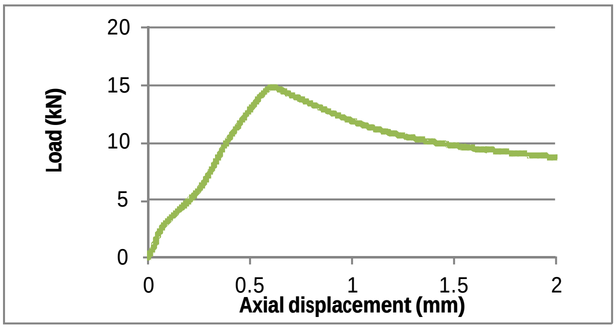

Figure 3 Load vs. displacement

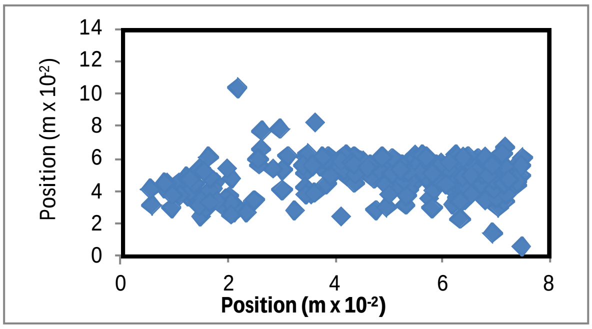

Figure 4 AE damage location

Preliminary results illustrate the onset of failure at the defective fibre metal interface (Figure 3), which is identified by the results of the AE monitoring (Figure 4). DIC enables the determination of delamination length advising the model which provides a good level of correlation.

References

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