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Standard and Impact Fatigue of Bonded Joints: modelling transient strains and progressive damage

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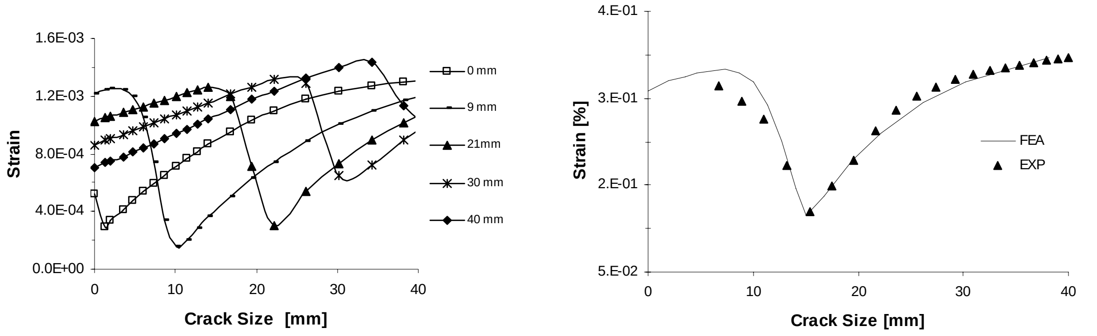
ABSTRACT

Carbon fibre reinforced polymers are now well established in many high performance applications and look set to see increased usage in the future, especially if lower cost manufacturing and solutions to certain technical issues, such as poor out of plane strength, can be achieved. A significant question when manufacturing with CFRP is the best joining method to use, with adhesive bonding and mechanical fastening currently the two most popular methods. It is a common view that mechanical fastening is preferred for thicker sections and adhesive bonding for thinner sections, however, advances in the technology and better understanding of how to design joints has lead to increasing consideration of adhesive bonding for traditionally mechanically fastened joints. In high performance applications fatigue loading is likely and in some cases cyclic low energy impacts, or impact fatigue, can appear in the load spectrum. This paper looks at mixed mode crack growth in adhesively bonded joints in standard and impact fatigue and in particular the application of computational modelling methods in this investigation.

Back face strain technique can be used to monitor cracking in lap strap joints and piezo strain gauges can be used to measure the strain response of impacted samples. Finite element analysis has been used to relate the backface strain signal with damage in the

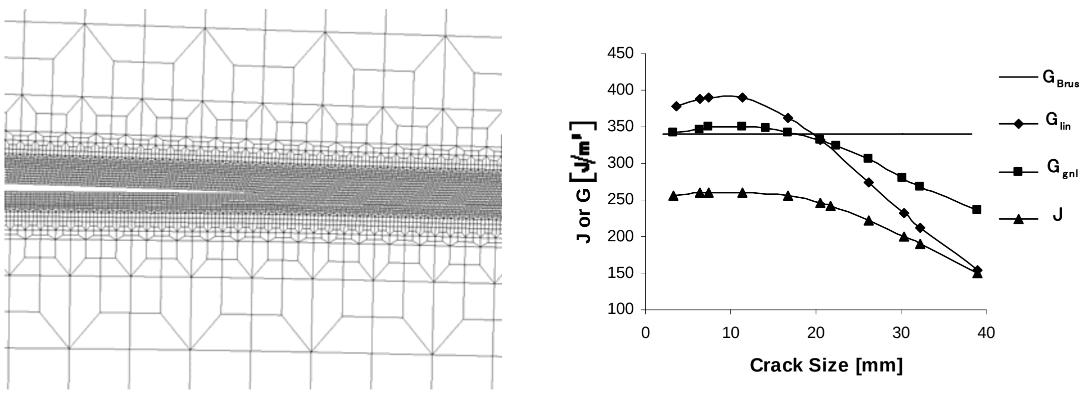
sample and a good agreement is seen between experimental and predicted results, as shown in fig. 1. Dynamic models have also been created and compared with the dynamic strain response in the impacts.



(a) (b)

Fig. 1. Backface strain (a) FEA (b) comparison of experimental and predicted

Progressive damage is characterised through the use of fracture mechanics parameters such as J and G and these have been computed for various failure scenarios, such as in the adhesive, in the adherend or in an interfacial region between the two. The mesh and results for cracking in the adhesive layer are shown in Fig. 2. These parameters have been related to crack growth in standard and impact fatigue to enable empirical crack growth laws to be formulated that can be used in progressive damage modelling.



(a) (b)

Fig. 2 Fracture in adhesive layer (a) mesh, (b) fracture parameters as a function of crack length.