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ADHESIVELY BONDED JOINT SHEAR TEST CHARACTERIZATION USING A MODIFIED ARCAN FIXTURE

David J. Brearley[1], M'hamed Lakrimi[2], Janice M. Dulieu-Barton[1], Ole T. Thomsen[1]

[1]Bristol Composites Institute
Faculty of Engineering, University of Bristol, Bristol, UK,
Email: david.brearley@bristol.ac.uk

[2]Siemens Healthineers MR Magnet Technology, Oxford, UK

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ABSTRACT

Adhesively bonded joints are frequently used for many composite engineering applications in eg. the aerospace, energy, civil, automotive [1] and medical sectors. This is because bonded joints display several advantages relative to other joints including improved stiffness and strength, reduced mass, ability to form continuous surfaces and ability to join dissimilar materials. However, depending on the joint geometry, bonded joints may not be as strong as joints made using other techniques, especially if a butt joint is required. In magnetic resonance imaging (MRI) machine magnets, butt joints are used between glass-fibre reinforced plastic (GFRP) rings and epoxy infused coils of superconducting wire. Because such joints are subjected to large electromagnetic biaxial forces induced by the magnetic fields they produce, it is important to understand the strength of such joints. Thus, a mechanical test method needs to be devised that can produce representative biaxial and uniaxial loads, and able to produce accurate failure envelopes that can be related to the complex stress states experienced by such adhesive joints.

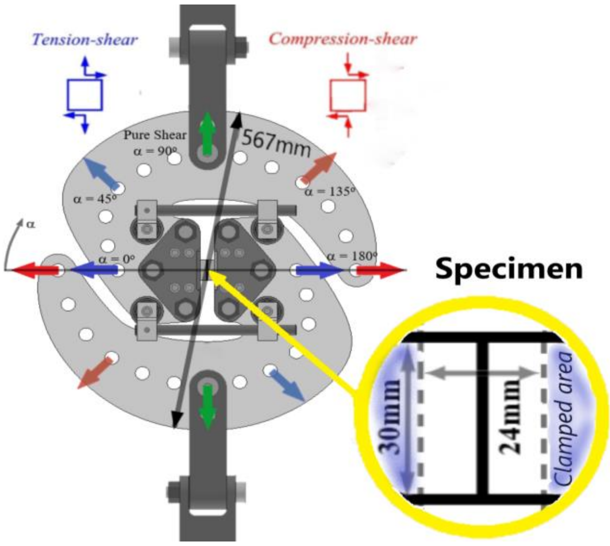

Figure 1: Modified Arcan Fixture (MAF)

A Modified Arcan Fixture (MAF) [1] was used capable of inducing combinations of tension-shear and compression-shear load states. Figure 1 shows how different load/stress states can be applied to the specimen, containing a butterfly joint, by changing the loading hole pair [2]. For this investigation, the MAF was used to induce pure shear loading. Importantly, there is no need to machine test specimens to complex shapes like e.g. the Iosipescu shear test specimens. Instead, specimens can be rectangular. To examine the test method's suitability for investigating the shear failure of an adhesive joint, the specimens tested consisted of two 30x65x10mm steel blocks, joined end to end with a two-part epoxy adhesive used in the composite magnet assembly. This is then compared to two composites joined together in the same configuration with the same epoxy resin.

The distance between the clamps of the MAF are shown in Figure 1 is 24 mm, which dictated the maximum possible width of the field of view (FOV), as seen in Figure 2, for Digital Image Correlation (DIC). Load was applied quasi-statically to the specimens in displacement control, with stereo DIC being used to obtain the displacement and strain fields. The DIC system used for data acquisition and post processing was MatchID®. The strain components normal (ε_x) to the bond line and the engineering shear strain (γ_{xy}) were calculated from the subset displacements between the test images and the reference image.

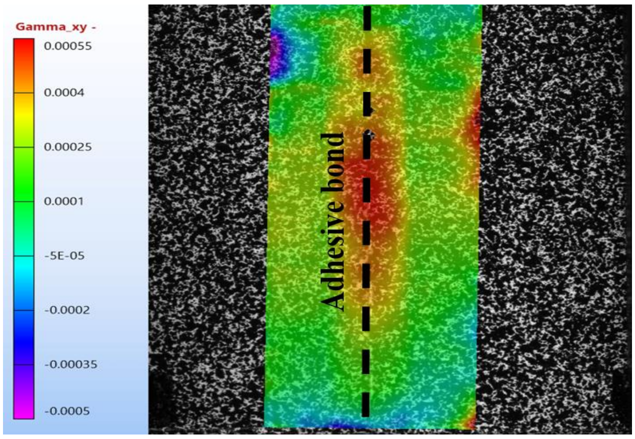

Figure 2: Shear strain (γ_{xy}) map just before failure

To establish if the failure was predominately mode II (shear), ε_x was compared with γ_{xy} just before failure, as shown in Figure 2. As expected, it was observed that ε_x was very small indicating that there is little peel and that the load is transferred mainly in shear. Furthermore, the transverse stress made little contribution to the initiation of failure The average bond line shear stress (averaged over bonded area) at failure extracted from the experiments was 11MPa.

In the presentation, the experimental data will be benchmarked and compared against finite element (FE) model predictions. The part geometry used in the FE model, developed in Abaqus, is the same as the FOV from the experimental setup, with two same sized 2D plates separated by an adhesive. Instead of cohesive zone modelling (CZM), which is usually used in composite interfacial models, a linear elastic brittle interface model (LEBIM) [3] approach was adopted. To emulate the MAF specimen loading conditions as realistically as possible, the FE boundary conditions were imposed as multi-point constraints (MPCs) fixed at the points where the loading pins of the MAF would be located and connected to the side of the part opposite the bond. This ensures that the shear load is applied across and parallel to the bond, with one MPC being fixed and the opposite imposing a displacement in the y-direction.

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