A new geometry to evaluate the strain rate sensitivity of Mode II Interfacial Shear Strength in CFRPs

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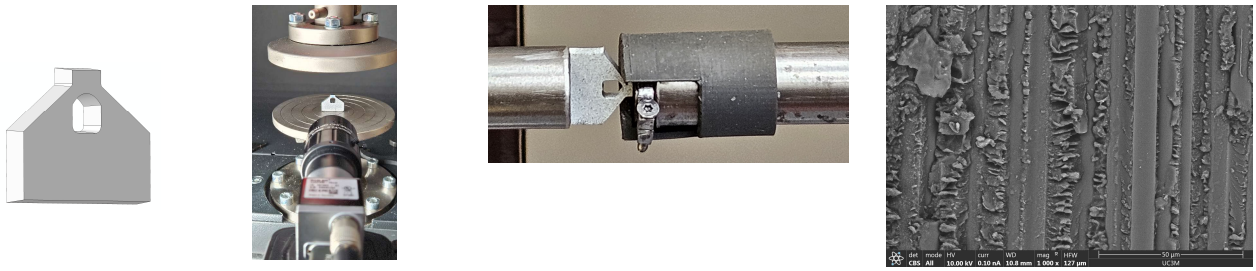
EXTENDED ABSTRACT

The influence of strain rate on Mode II interfacial shear strength (IFSS) in CFRPs is a critical area of study, particularly for applications subjected to dynamic loading conditions. The energy absorption in composite materials under such conditions occurs through a combination of mechanisms spanning different length scales. At the microscale, mechanisms such as fiber breakage, fiber-matrix debonding and frictional sliding dominate, playing a crucial role in determining the energy dissipation characteristics. A strong correlation has been observed between the interfacial properties and the mechanical performance of composite materials at the macroscale, being the bonding at the interface essential for good shear and off-axis strength [1,2]. Several techniques have been developed to evaluate interfacial shear strength and failure mechanisms, including the microbond test [3], single fiber fragmentation test, fiber push out, and push in [4] and pull-out tests [5]. Despite advancements in testing methods, the interfacial strength values obtained from different tests often vary significantly and even results from the same type of test can exhibit considerable scatter [6]. Furthermore, studies at higher strain rates remain limited. Tamrakar et al. [1], Greenfield et al. [7] or Tanoglu et al. [8] developed new test methods like microdroplet test specimen or dynamic micro-indentation to conduct a single fiber fragmentation test at a high displacement rate. However, tests that utilize specimens with a single fiber embedded in the matrix may not accurately reflect the complexity conditions present in real composites.

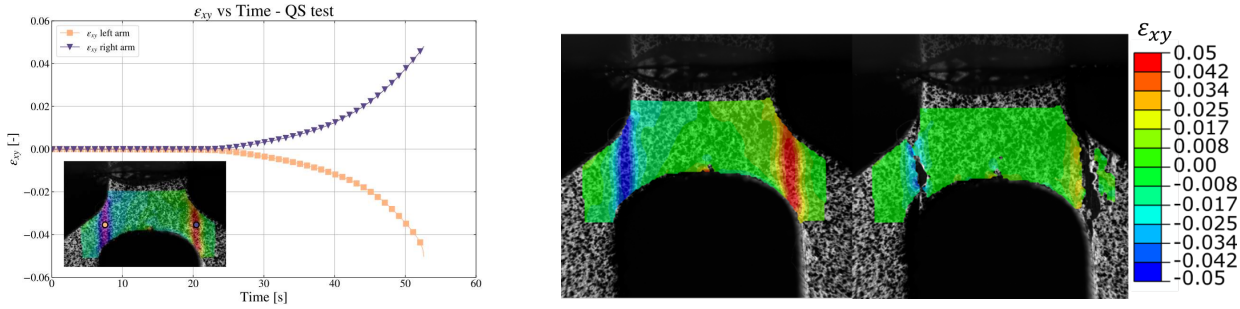
In this work, a novel geometry has been developed to experimentally evaluate Mode II interface shear strength between fibers and the matrix in CFRPs. The macroscale design is optimized to concentrate the shear stresses in two narrow regions while loading the sample in compression while minimizing tensile and mixed-mode effects. The experimental samples were obtained through water jet cutting, followed by machining and grinding, from a 3mm thick AS4/8552 composite material plate with a unidirectional stacking sequence. The fiber direction is aligned with the compression direction of the specimen, with particular attention given to the parallelism and flatness of the faces in contact with the surfaces during the test. Two loading regimes are considered here to capture the strain sensitivity of the IFSS using the same sample geometry, both in compression loading configuration: (a) quasi-static, carried out in an electromechanical universal testing machine, and (b) dynamic, performed in a Split Hopkinson Pressure bar. A complete analysis about the stress state in the sample during test is done using the information obtained by DIC and a finite element model implemented in ABAQUS/Explicit. The fracture response of the sample is consistent with the results shown in

the literature. Meanwhile in the dynamic tests non-symmetrical loading seems to be less relevant due to inertial forces acting on the sample. All in all, the geometry proposed reveals itself as a viable way to study the behavior of fiber/matrix interface, especially under dynamic conditions. Research was funded by the Spanish Ministry of Science, Innovation and Universities under the State Program to Promote Scientific-Technical Research (State Subprogram for Knowledge Generation), project H-FROST, reference number PID2022-142937OB-I00.



(a) Geometry (b) QS experimental setup (c) Dynamic experimental setup (d) Post-mortem SEM

Figure 1.



(a) Shear strains at the sample's arms (b) Shear strain fields at the sample during test

Figure 2.

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