Delamination Behavior of Adhesive Joints in Epoxy Composites Reinforced with Glass and Carbon Fibers: Influence of Adhesive Type and Substrate Preparation Process

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Introduction and Objective

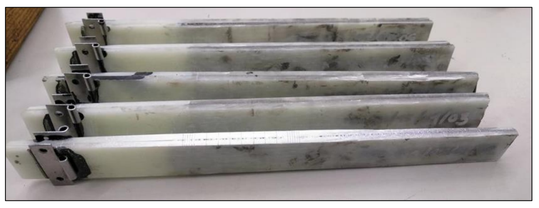
Composite joints can fail by delamination, which is a major concern in structural applications of fiber-reinforced polymers. Adhesive bonding is attractive because of its light weight, efficient load transfer and reduced manufacturing cost compared to mechanical fastening. However, the performance of the joint strongly depends on the surface preparation of the substrates.

The main objective of this work is to evaluate the influence of adhesive type and surface preparation on Mode I fracture toughness of carbon- and glass-fiber reinforced epoxy composites.

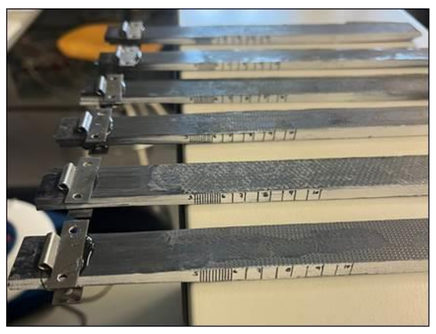
Materials and Methodology

Substrates

The substraes were epoxy laminates reinforced with either unidirectional carbon fibers (MTC510-UD300-HS) or stitched unidirectional glass fibers (MTC510-UD300-Eglass)



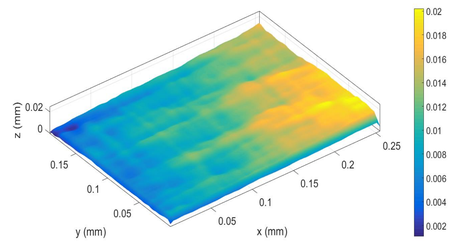
Glass-based laminates



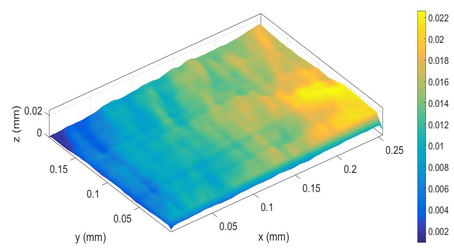
Carbon-based laminates

Surface preparation

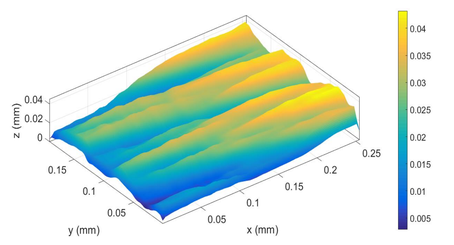
Surface preparation included sanding with P220 Al_2O_3, grit blasting (5s with corundum) and peel ply (PA80).



Al_2O_3 sanding



Al_2O_3 blasting



Peel Ply PA80

Adhesives

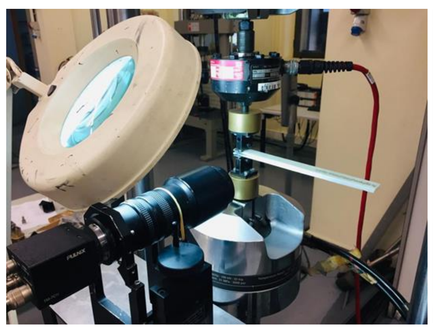
-Loctite EA 9461 (Epoxy)

-Araldite 2015 (Epoxy)

-3M DP8010NS (Acrylic)

Test: Mode I DCB (ASTMD5528)

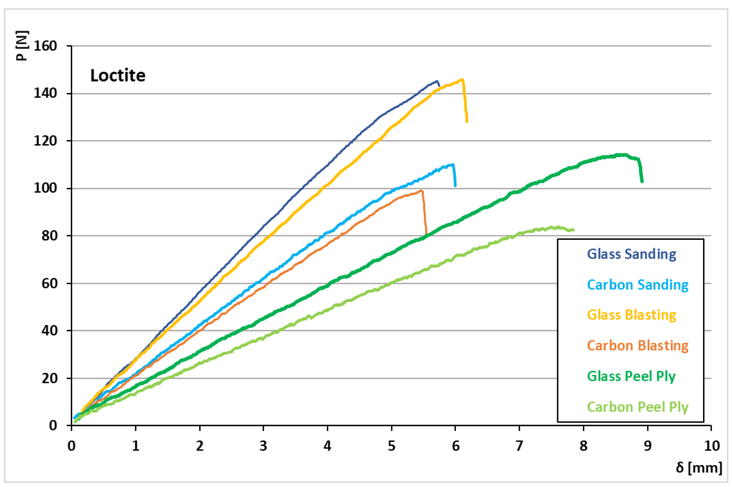
DCB tests were performed following ASTM D5528 under Mode I fracture. The crack propagation was monitored with a high-resolution camera. SEM was used to characterize the prepared surfaces.



Results

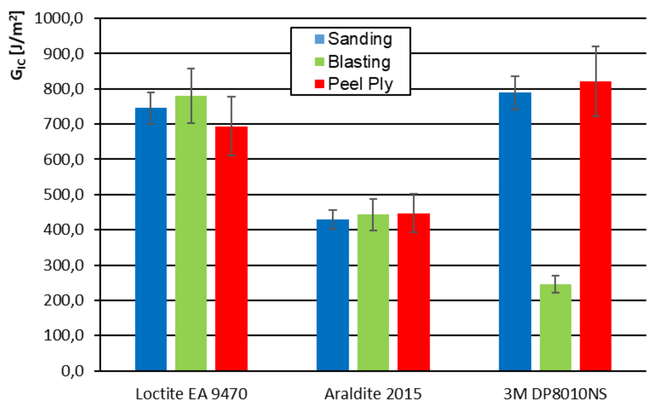
Curves Glass/Carbon using Loctite Adhesive

Load–displacement curves showed that sanding produced higher stiffness and delamination loads compared to grit blasting or peel ply.

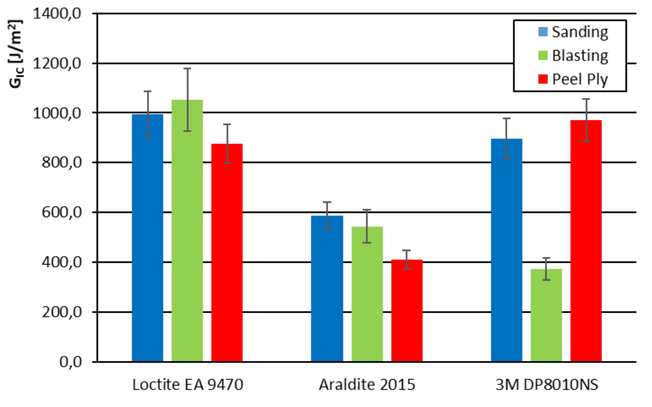


Energy (G_{IC})

The highest energy release rates (GIC) were obtained with Loctite®, while Araldite® gave the lowest performance. The acrylic adhesive 3M™ DP8010NS was highly sensitive to blasting, showing a marked reduction in toughness.



Carbon-based composite



Glass-based composite

Surface prep.

Sanding interlaminar	→	Failure modes / cohesive
Blasting	→	Adhesive failures
Peel ply bridging	→	Cohesive with fiber

Conclusions

- Surface preparation has a decisive effect on delamination resistance.
- Sanding is a robust method for all adhesives and substrates.
- Blasting should be avoided with acrylic adhesives.
- Peel ply can provide good cohesive fracture surfaces but requires integration during manufacture.
- The dominant fracture mode depends mainly on the substrate type.

Bibliography