The performance of adhesive joints with hybrid adherends

RJC Carbas (INEGI, Portugal), EAS Marques, LFM da Silva

ADVANCED JOINING PROCESSES UNIT

Introduction

Composite materials typically exhibit a low peel strength, which can contribute to premature failure when used in adhesive joints. In the literature different techniques to address this issue can be found, such as adhesive fillets, all aiming to enhance joint strength and prevent the delamination of composite materials. However, it is significant to strengthen the peel resistance of the adherend itself, through the incorporation of different laminates during the manufacturing process. Reinforcement of laminate materials with thin layers of materials can effectively increase the peel strength of the adherend, leading to improved peel resistance, delayed or prevented delamination, and enhanced joint strength [1].

This study evaluated the performance of various hybrid adherends in a single-lap joint (SLJ) configuration under different loading rates. Hybrid adherends composed of carbon fiber reinforced polymer (CFRP) were reinforced with distinct solid materials (e.g., metal and polymer) during the manufacturing process to bolster the peel strength of composite materials and augment the joint strength of adhesive joints. The ABAQUS software was employed for numerical analysis to better comprehend the influence of strain rate on the performance of hybrid adhesive joints.

Experimental methodology

Adhesive

The adhesive utilized was the Scotch Weld AF 163-2k, a film modified epoxy adhesive, provided by 3M Company.

Adherend

In all of the tested configurations, the unidirectional prepreg CFRP material used was Texipreg HS 160 T700, provided by Seal S.P.A..

Additionally, an aluminium alloy from the 2024-T3 Alclad series, supplied by AMI Metals and a titanium alloy from the Ti-6Al-4V alpha-beta (Grade 5) series, annealed, provided by Smiths Metal Centres Ltd, were used.

Joint geometry

Figure 1 illustrates the geometry of the specimens used.

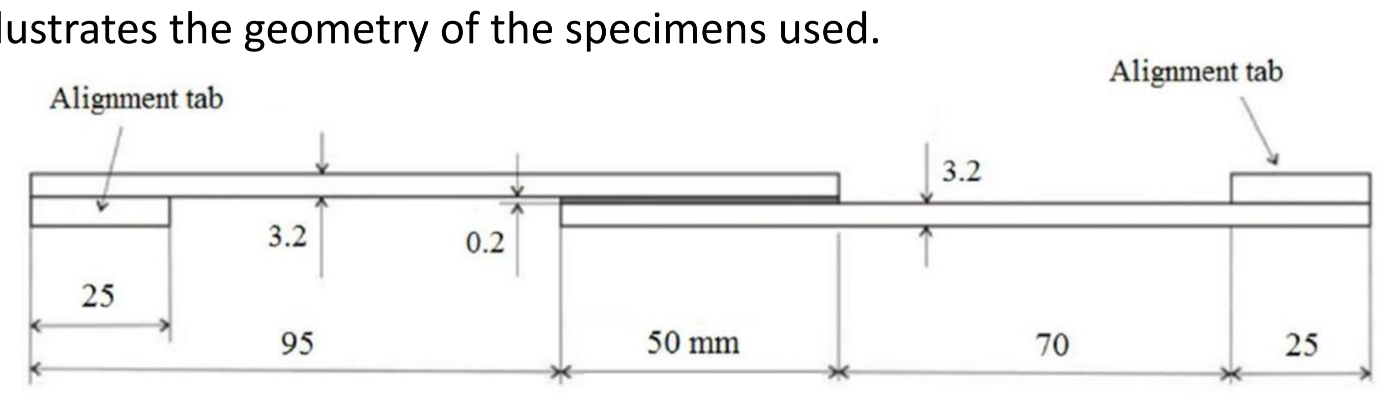

Figure 1 – SLJ specimen geometry.

Joint configuration

Different joint configurations were used, Figure 2.

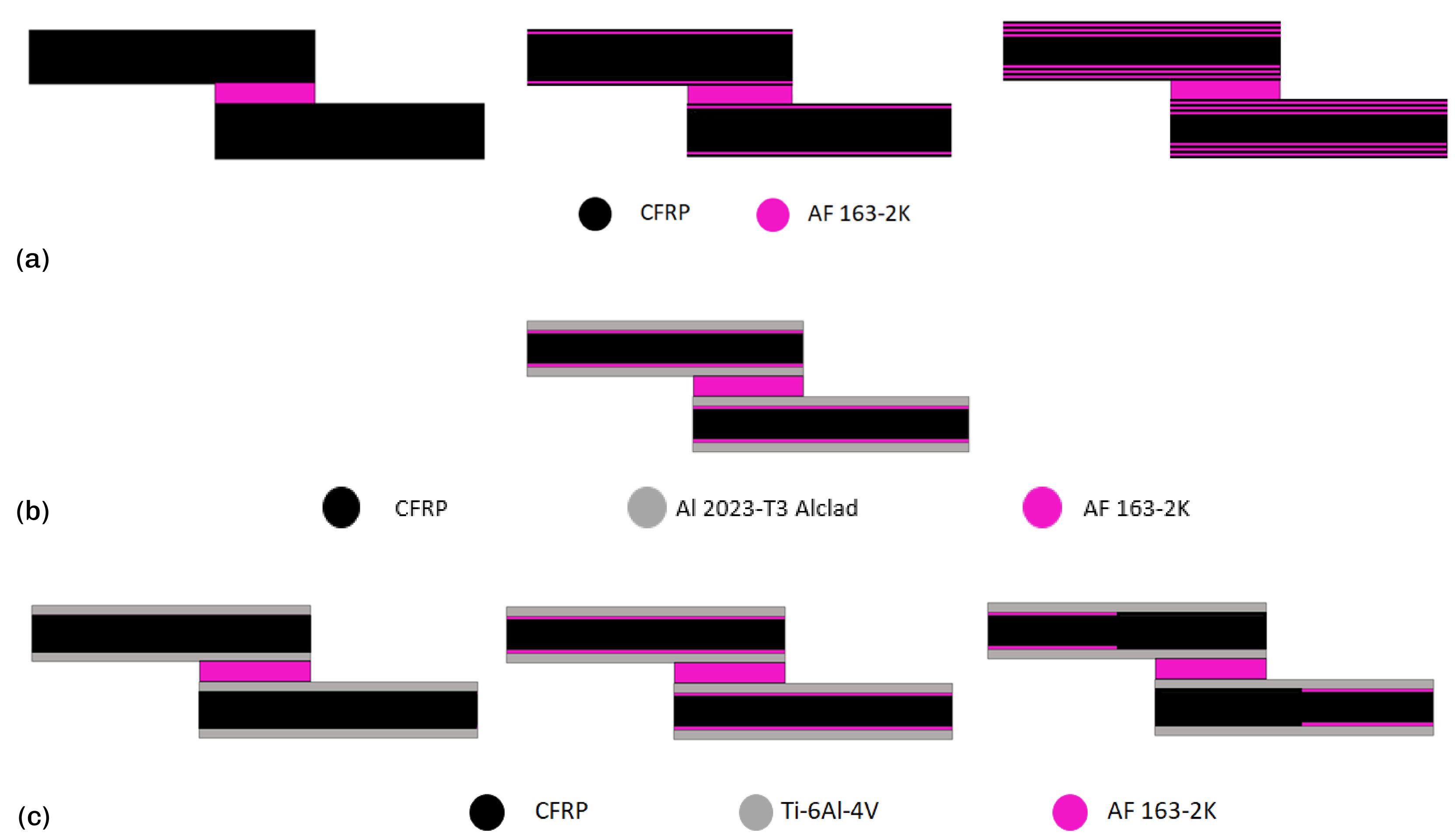

Figure 2 – Joints studied: a) adhesive, b) aluminium and c) titanium lay-up configurations.

Results

All configurations were simulated using ABAQUS CAE software. The failure mode and failure load were predicted using cohesive zone modelling (CZM) and thermal residual stresses were incorporated into the models using a thermal step [2].

The experimental and numerical failure loads can be seen in Figure 3.

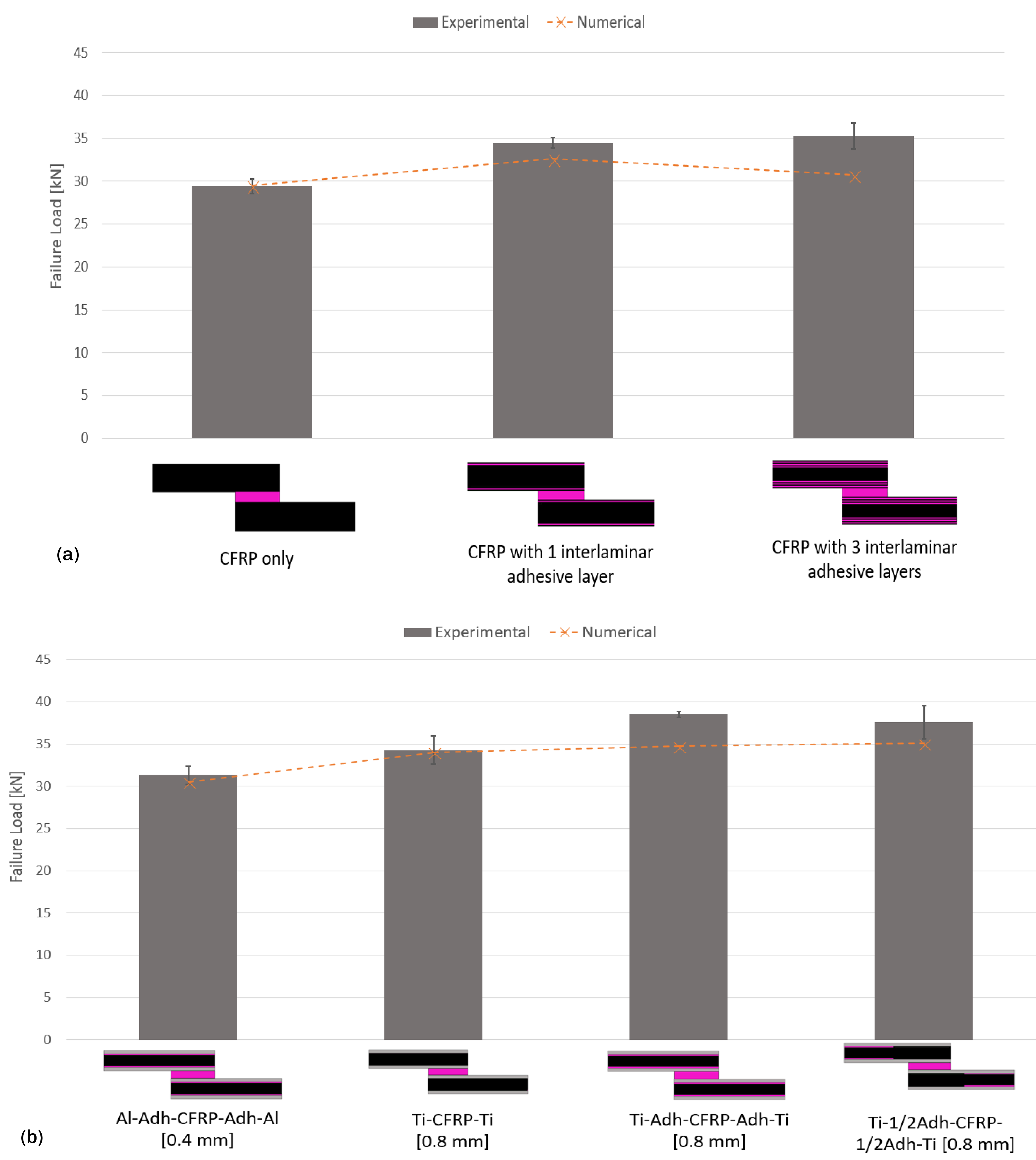

Figure 4 – Numerical and experimental results obtained for SLJ configurations with additional: a) adhesive layers and b) metal laminates as the reinforcement.

Conclusions

- CFRP joints reinforced with additional adhesive layers and titanium laminates the average failure load had a good improvement and the failure was cohesive in the adhesive layer.
- The joints reinforced with additional adhesive layers showed a poor agreement between the experimental and numerical failure loads due to the use of several cohesive layers.

References

[1] da Silva, L. F. M., Öchsner, A., & Adams, R. D. (2018). Handbook of Adhesion Technology (2nd ed.). Springer Berlin Heidelberg.

[2] Morgado, M. A., Carbas, R. J. C., dos Santos, D. G. & da Silva L. F. M. (2020). Strength of CFRP joints reinforced with adhesive layers. Int. J. Adhes. Adhes., 97, 102475.

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