Impact testing of CFRP adhesive joints for the automotive industry

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Introduction

The main objective of this study was to characterize the impact strength of carbon fibre reinforced plastics (CFRP) single lap joints using a epoxy adhesive. To achieve this, SLJs were tested in a drop weight impact machine, in order to simulate real situations. Quasi static-tests were also performed for obtaining the comparison between static and impact conditions. The numerical models of adhesively bonded joints using cohesive zone models were developed in ABAQUS® and the numerical results were validated with experimental results. The overall results of this study show that different overlap lengths affect considerably the impact response of the composite SLJs. From quasi-static to impact conditions an increase in the joint strength was perceptible. The results obtained by the use of analytical and numerical predictions are in a good agreement with the experiments.

Experimental details

Materials:
- Adhesive: SikaPower 472, two-component epoxy adhesive;
- CFRP: unidirectional 0° carbon-epoxy composite, HS 160 T700;

Cure process:
- Room temperature during 1 day.

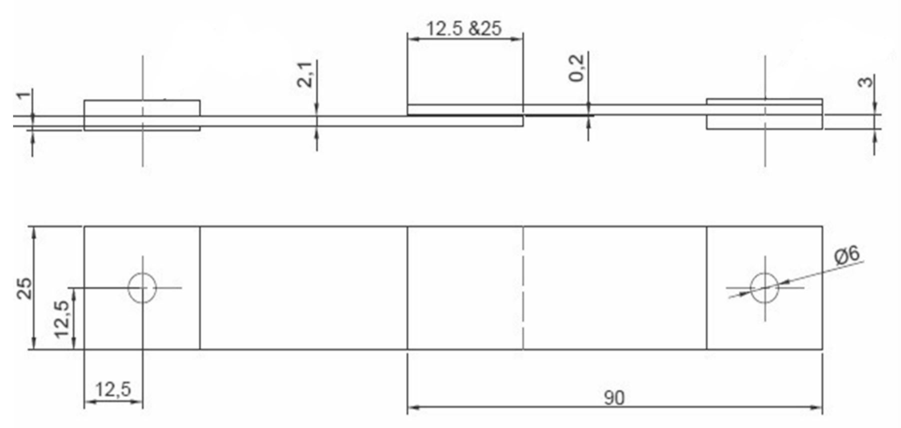

Figure 1 – SLJs geometry.

Characterization of the adhesive

The bulk tensile tests were performed in an INSTRON® model 3367 universal test machine with a capacity of 30 kN. The dogbone adhesive specimens [1] were tested at room temperature, under a constant displacement rate of 1mm/min and 100 min/min.

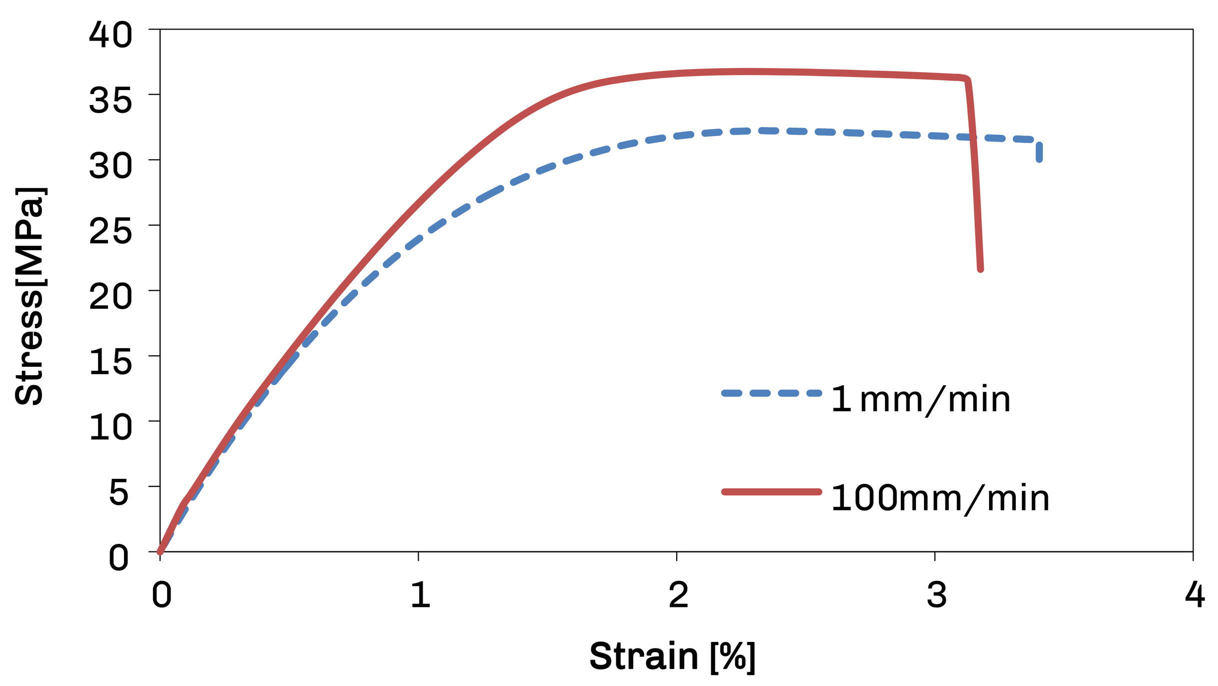

Figure 2 – SLJs geometry .

Numerical details

- 2D analysis in ABAQUS® software [2];
- Solid elements were used for elastic sections (CPE4R);
- Cohesive elements with traction separation laws (COH2D4).

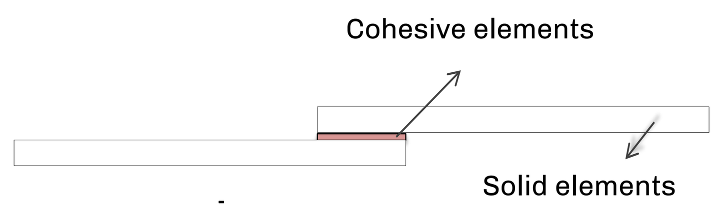

Figure 3 – Numerical model for the static analysis

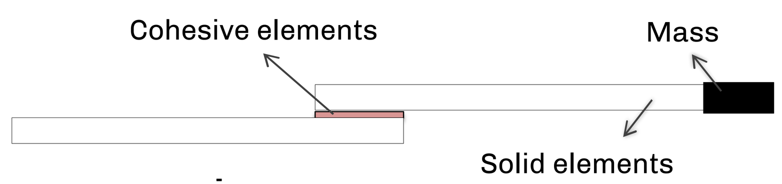

Figure 4 – Numerical model for the impact analysis

Experimental results

- Static tests were performed in the universal testing machine INSTRON® model 3367 with a capacity of 30 kN with a constant crosshead rate of 1mm/min.
- Impact loads were performed in the machine Rosand® Instrumented Falling weight impact tester, type 5 H.V., and with an impact energy of 50 J.

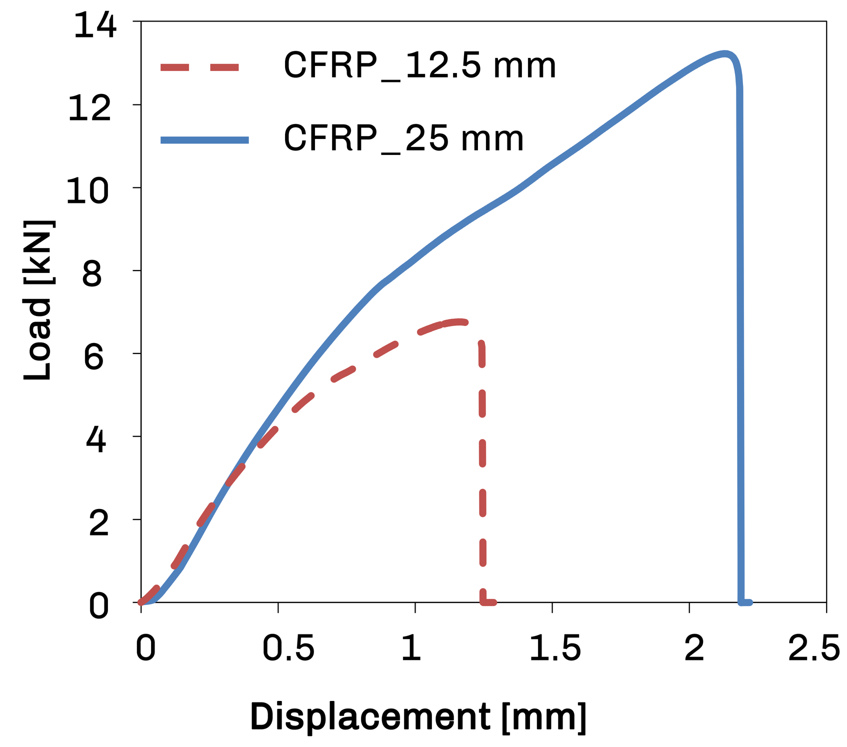

Figure 5 – Quasi-static response of SLJ's.

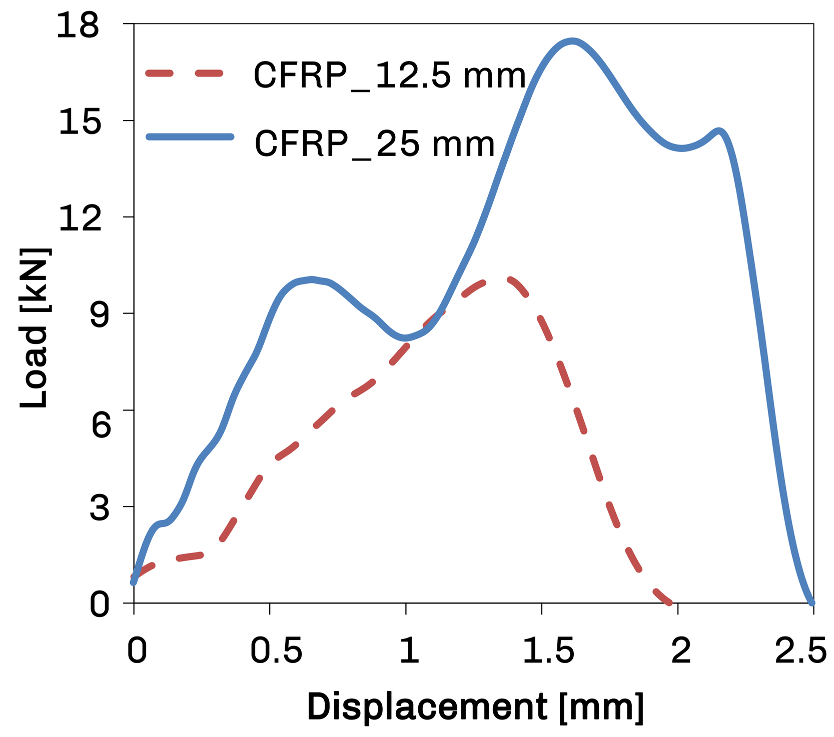

Figure 6 – Quasi-static response of SLJ's.

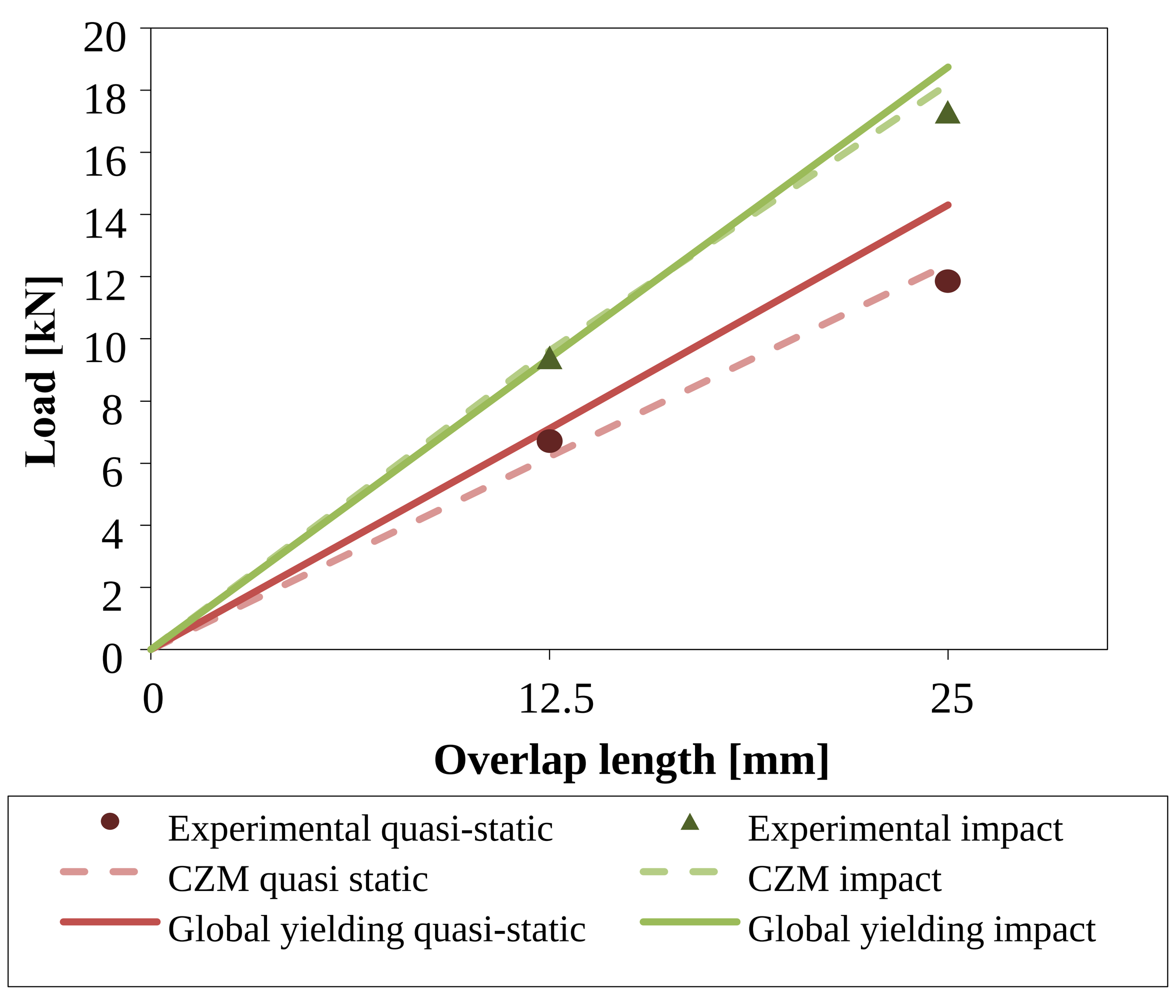

Figure 7 – Comparison between experimental, analytical and numerical resuts

Conclusions

- The strength properties of epoxy adhesive for different rates were evaluated and was notice a rate dependence.
- Static and impact SLJ tests were performed with the same adherends and was observed that the high strain rate considerably affects the responses of the SLJs when compared to static conditions.
- The SLJ's showed highest joint strength when are tested under impact loads.
- The numerical analysis using ABAQUS® software and the analytical analysis using Global Yielding criteria was compared with experimental results obtained and showed a good agreement for both rates of test and for both overlap length.

References

[1] L.F.M. da Silva, A. Öchsner, and R.D. Adams. Handbook of Adhesion Technology, 2nd Edition (Springer-Verlag, Berlin, 2018).
[2] L.F.M. da Silva, Modelling of adhesively bonded joints (Springer. Berlin, 2008).

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