



# The effect of temperature and strain rate on CFRP single-lap joints using different film adhesives

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## INTRODUCTION

Delamination is still a major problem when composites are used for structures, especially in joints held together with adhesive. In order to evaluate a different means of delaying delamination, for this Joint, an alternative method was evaluated by using a non-structural thermoplastic adhesive for the work in the project. The non-structural thermoplastic adhesive provides its own means of delaying delamination without mechanical reinforcement due to the energy absorbing properties of the thermoplastic adhesive which will absorb energy and thus resist crack propagation. To evaluate the energy absorbing characteristics of the SLJs, they were tested at quasi-static (1 mm/min) and impact (3m/s) loading conditions to determine how rate sensitive SLJs are for these two conditions and the temperature at which these conditions took place: sub-zero (-30 °C), ambient and elevated (80 °C). The results of the tests indicate that the presence of the thermoplastic layer to the joint does not only directly delay the onset of delamination, but will also increase the energy absorbing capacity of the joint, especially when the joint is in impact loading and low temperature conditions. Therefore, the results of the project indicate that the use of non-structural thermoplastic adhesives will be an effective means of mitigating delamination for composite joints exposed to varying service conditions.

## EXPERIMENTAL DETAILS

Three different adhesives were compared. Table 1 shows the main characteristics.

TABLE 1. Adhesives used in this analysis.

	Zeon LS-XU	AF 163-2k	Nagase Denatite XNR 6852 E3
<b>Cure conditions</b>	150°C, 1 hour	150°C, 1 hour	150°C, 3 hour
<b>Family</b>	Hot-melt thermoplastic	Thermosetting modified epoxy	One-component epoxy
<b>Form</b>	Film	Film	Paste
<b>T<sub>g</sub> (°C)</b>	85	108	100

The composite material used was a unidirectional prepreg CFRP (carbon-fiber reinforced plastic), specifically the Texipreg HS 160 T700, featuring a ply thickness of 0.15 mm.

The geometry of the single lap joint is illustrated in Figure 1.

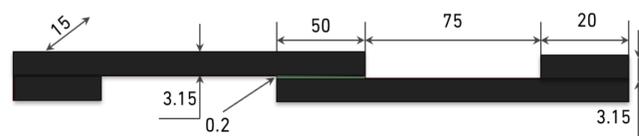


FIGURE 1. SLJ specimen geometry.

For the quasi-static tests, were evaluated using an Instron 3360 universal testing machine and conducted at a constant displacement rate of 1 mm/min.

Impact testing was performed on a custom-built drop-weight machine, a 10 kg mass was dropped at 3 m/s.

## ACKNOWLEDGEMENTS

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## RESULTS

The joints were manufactured and subjected to quasi-static (1 mm/min) and impact (3 m/s) test conditions, as well as different test temperatures (-30, 23 and 80 °C). Figure 2 shows the failure load and surface for the different conditions tested.

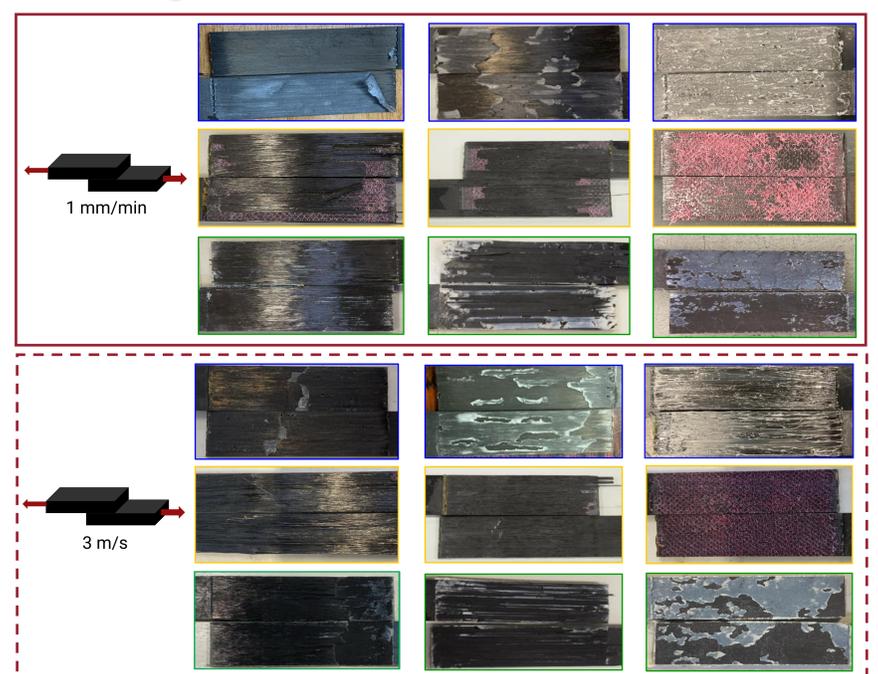
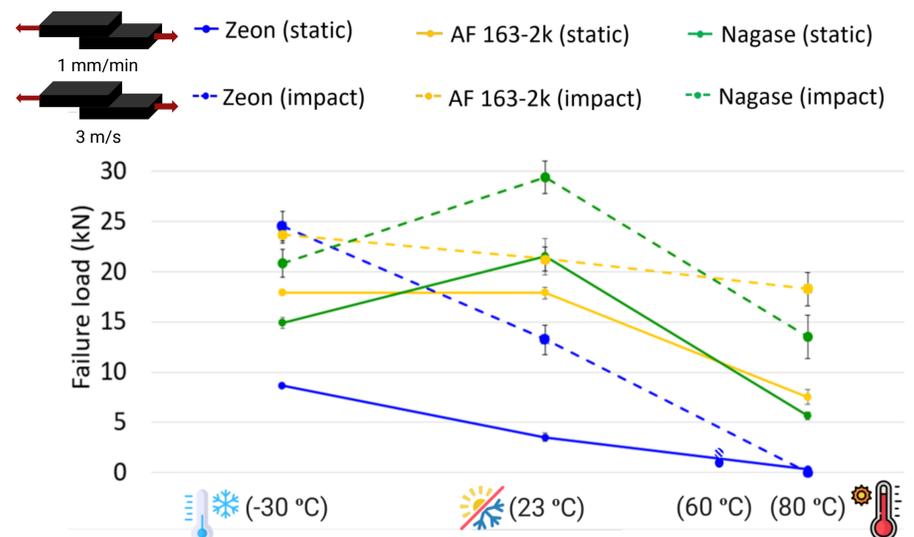


FIGURE 2. Failure loads and surfaces of three adhesives under varying temperatures and testing rates.

## CONCLUSION

- Performance of the LS-XU improved under impact, showing a very high strain-rate sensitivity;
- The LS-XU is excellent at low temperatures, acceptable at RT but totally unsuitable at 80 °C due to low T<sub>g</sub> (85 °C);
- Energy absorption increased in both CFRP and wood joints, especially under dynamic loading;
- Overall, this adhesive is lightweight, recyclable and can be a viable repairable bonding strategy.
- Cyclic olefin-based thermoplastic adhesive offer a recyclable, and repairable alternative applications.