

A comparative study of thermoplastic and thermoset adhesives for CFRP joints under varying temperatures and strain rates

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INTRODUCTION

Adhesive bonding is increasingly preferred over conventional mechanical fastening for Carbon Fiber Reinforced Polymer (CFRP) structures due to superior strength-to-weight characteristics and improved load distribution. However, the structural integrity of bonded composites is often compromised by premature failure driven by low peel strength, stress concentrations at overlap ends, and delamination. This study investigates the potential of film-based thermoplastic adhesives as a high-performance alternative to traditional thermoset systems, specifically focusing on their ability to mitigate delamination risks through enhanced resistance to crack initiation and propagation.

The primary contribution of this work is the assessment of thermoplastic films—which offer the unique advantage of re-processing—under varying test conditions, including a range of temperatures and loading rates. Our research underscores the superior damage tolerance of thermoplastic adhesives relative to thermoset systems. By evaluating these materials across diverse operational environments, this study highlights their capacity to maintain structural integrity and provides a foundation for the implementation of thermoplastic bonding in advanced industrial applications.

EXPERIMENTAL DETAILS

Three different adhesives were compared (see Figure 1).

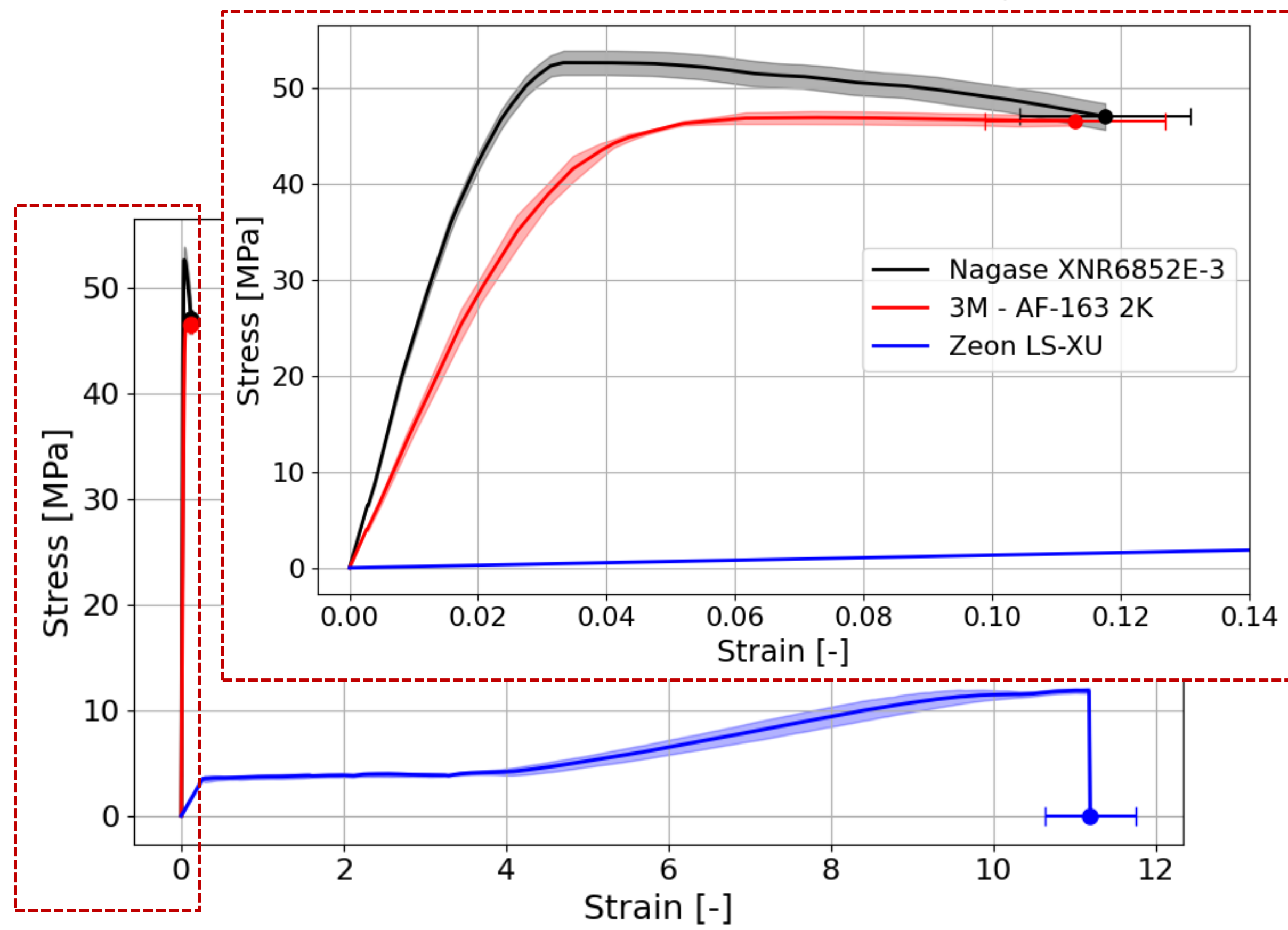


FIGURE 1. Stress-strain curve of three adhesives used.

The geometry of the single lap joint is illustrated in Figure 2.

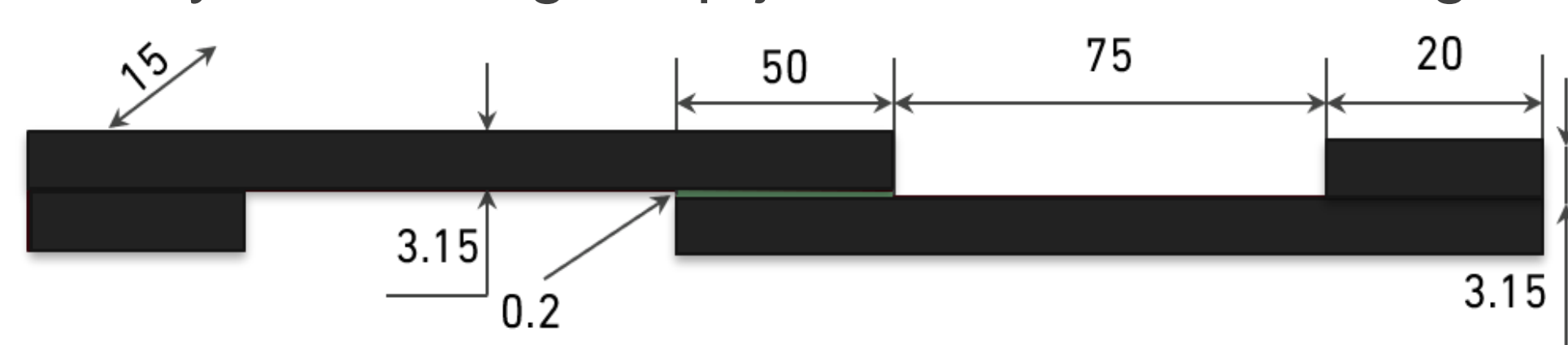


FIGURE 2. SLJ specimen geometry.

Quasi-static and impact tests, were evaluated using an Instron 3360 universal testing machine and a custom-built drop-weight machine.

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 3 shows the load-displacement curves for the different conditions tested.

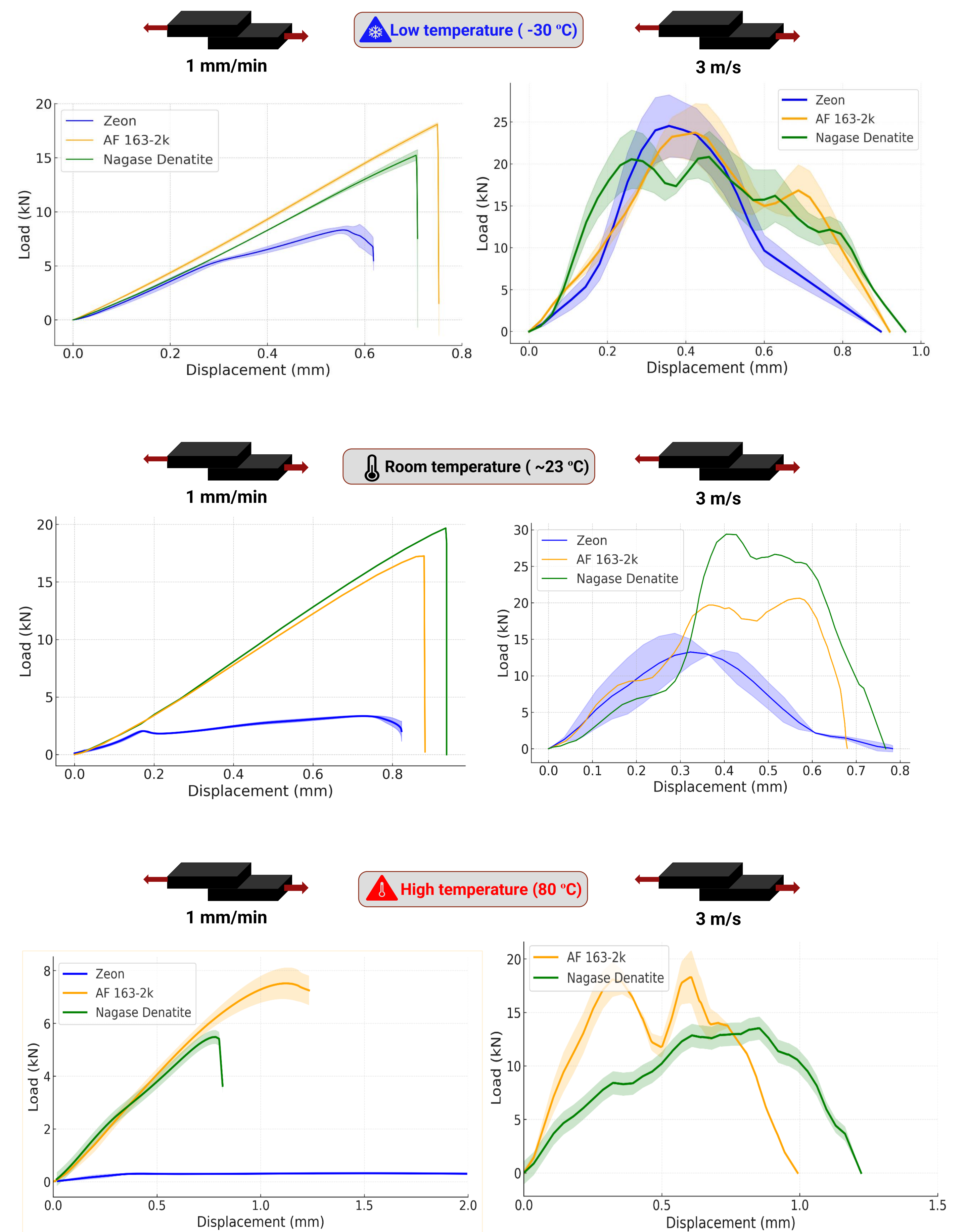


FIGURE 3. Load-displacement curves of three adhesives under varying temperatures and testing rates.

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_g (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.