Extreme temperature effects on the dynamic response of highly flexible adhesive joints

B Hasumi (INEGI, Portugal) | A Akhavan-Safar | RJC Carbas | EAS Marques | S Wenig | LFM da Silva

INTRODUCTION

Adhesive bonding technology provides numerous benefits, including enhanced design flexibility, superior load distribution. However, the performance of adhesives can be significantly affected by variations in temperature and strain rates [1]. This study investigates the dynamic response of single lap joints composed of steel substrate and polyurethane adhesive under varied temperatures. The objective is to understand how these factors influence the mechanical behavior of the adhesive joints.

METHODS

The lap shear strength (LSS) for a two-component polyurethan flexible adhesive was obtained by single lap joint (SLJ) tests. Experimental tests were conducted at −30, 23, 60 Celsius degrees with a chamber completely surrounding an apparatus, enabling to elevate temperature inside to replicate real-world conditions. Loading rates such as 1, 200, 6000 mm/min were applied by Instron testing machine to investigate the corresponding strain rates.

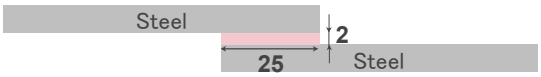

Figure 1 – Dimensions of SLJ joint.

RESULTS

	-30 °C	23 °C	60 °C
1 mm/min	14.7 (23.5)	8.3 (12.4)	4.2 (9.7)
200 mm/min	—	13.0 (18.7)	7.9 (10.2)
6000 mm/min	20.4 (20.7*) *Interfacial failure	16.7 (20.7)	10.4 (13.7)

Table 1 – LSS obtained in SLJ tests, adhesive thickness: 2.0 mm (values in parentheses indicate pure shear strength obtained in TAST, adhesive thickness: 0.6 mm).

Lap shear strength was smaller than pure shear strength because:

- Adhesive layer in SLJ was much thicker than that in TAST joint
- The edge of adhesive layer in SLJ was subject to opening load

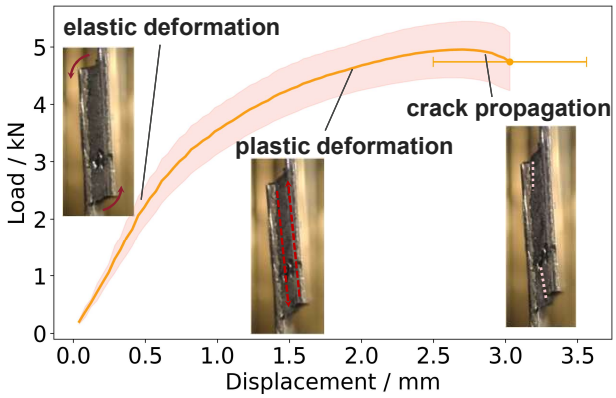

Figure 2 – Typical fracture mechanism of SLJ

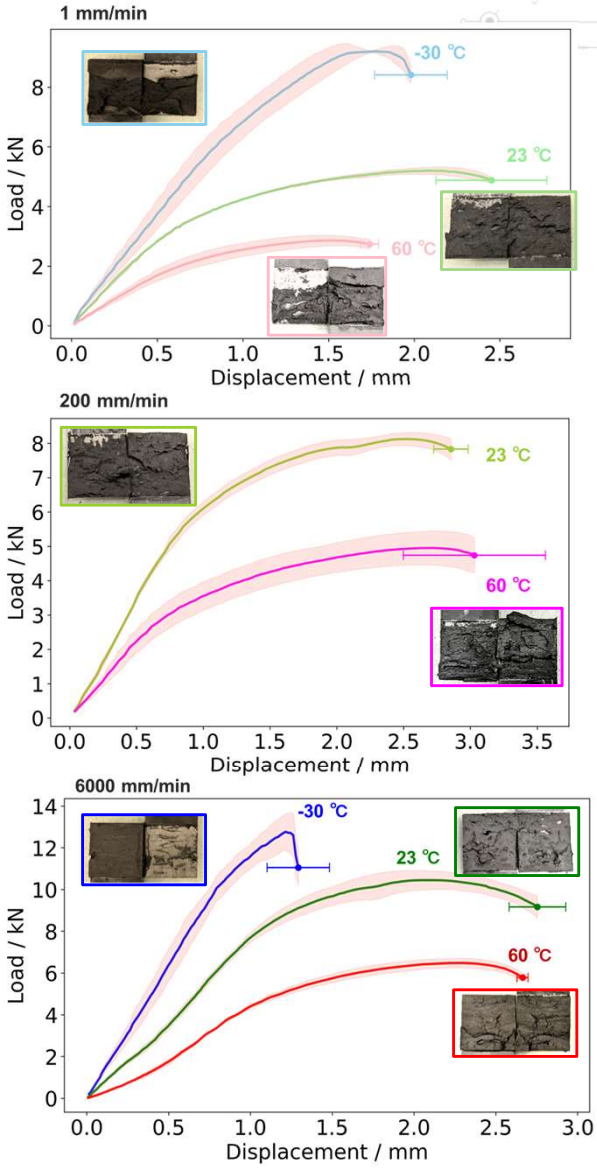

Figure 3 – Summary of load displacement curves.

CONCLUSIONS

- As the temperature decreased or the loading rate increased, both the joint stiffness and LSS tended to increase
- LSS was smaller than pure shear strength due to adhesive thickness and opening load at the edge of adhesive layer in SLJ

REFERENCES

[1] M. Ribas, A. Akhavan-Safar, P. Adam-Cottard, R.J.C. Carbas, E.A.S. Marques, S. Wenig, L.F.M. da Silva, Theoretical and Applied Fracture Mechanics, 130, 104274 (2024).

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