Impact of extreme temperatures on the performance of highly ductile adhesive joints

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INTRODUCTION

Adhesive bonding is recognized as an advanced joining technology, offering design flexibility and efficient load transfer over conventional fastening. Its performance, however, is highly sensitive to temperature and strain-rate variations [1]. This study explores the dynamic response of steel-polyurethane single lap joints under controlled thermal conditions to inform the reliable design of next-generation lightweight structures.

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.

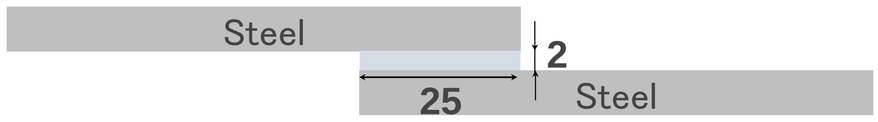

Figure 1 – Dimensions of SLJ joint.

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

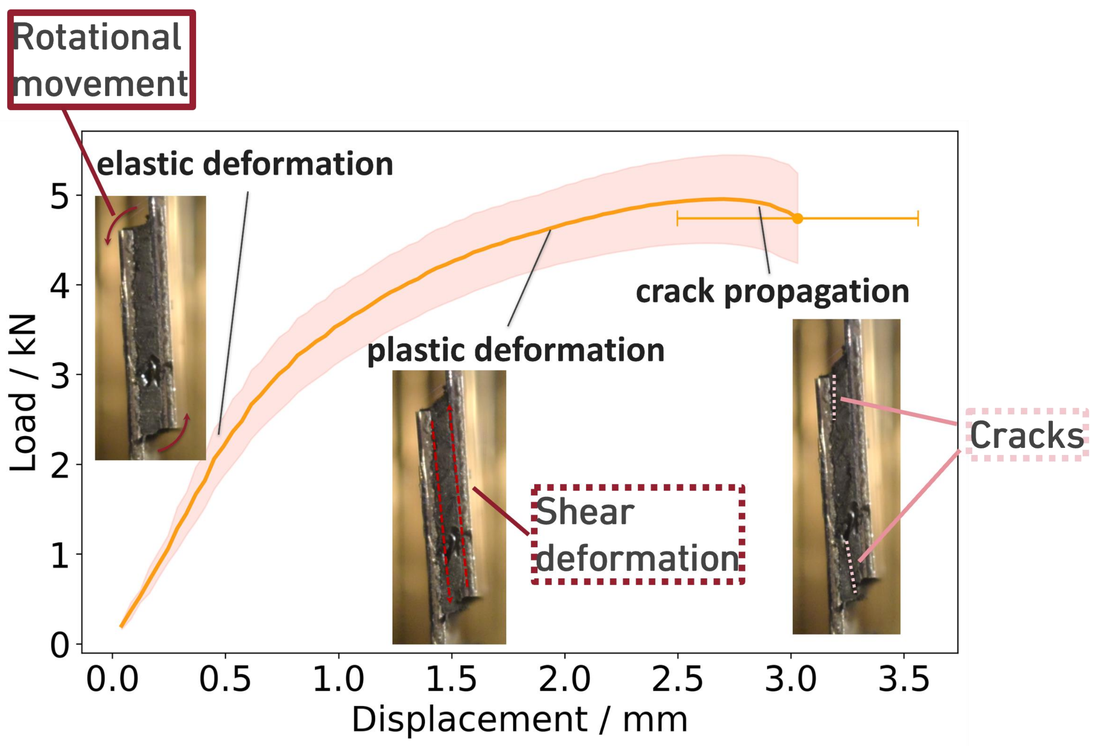

Figure 2 – Typical fracture mechanism of SLJ

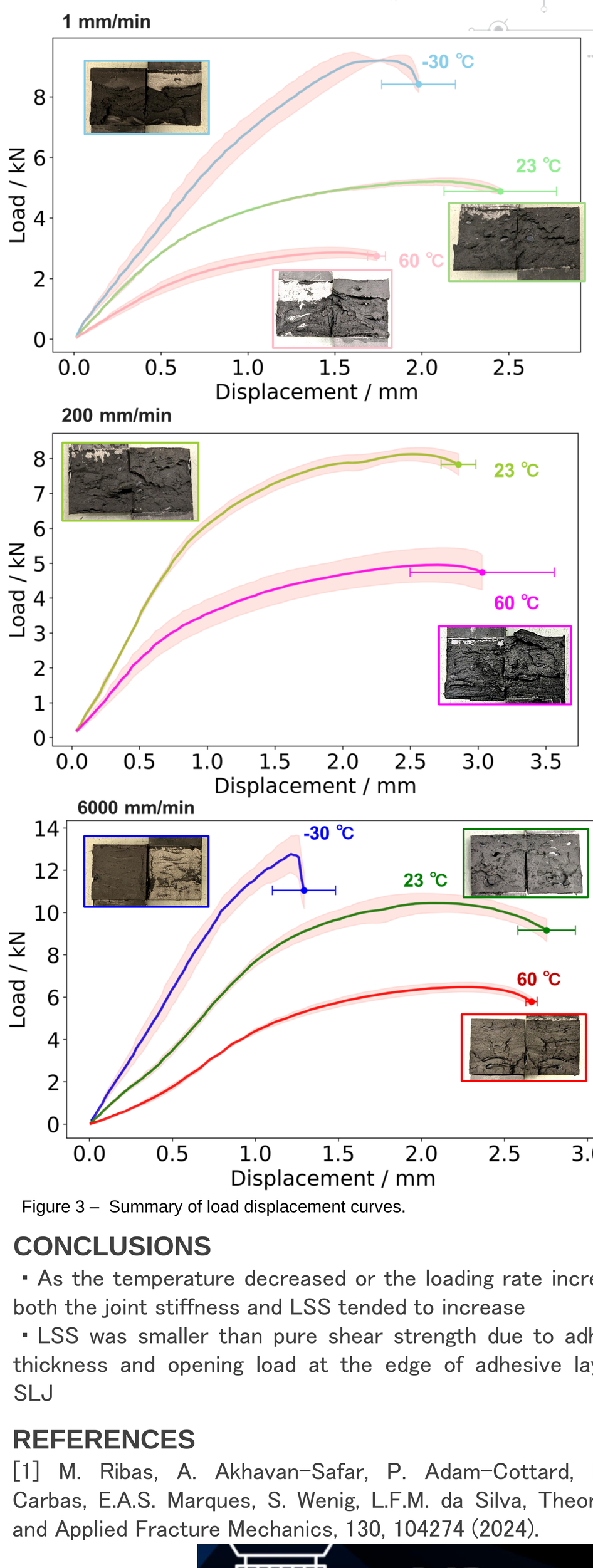

Figure 3 – Summary of load displacement curves.

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).