

Extreme Temperature Effects on the Dynamic Response of Highly Flexible Adhesive Joints for Automotive Applications

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

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 polyurethane 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*) | 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

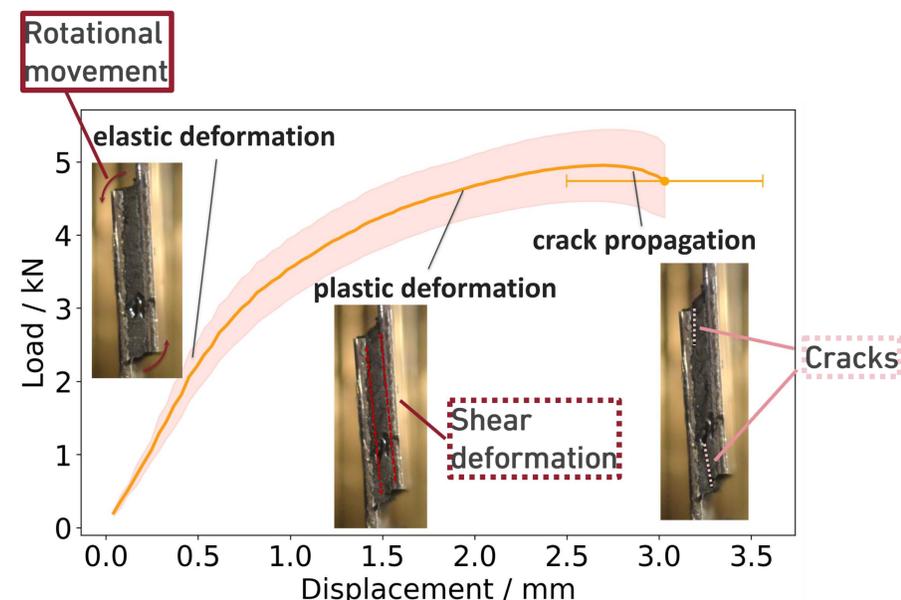


Figure 2 – Typical fracture mechanism of SLJ

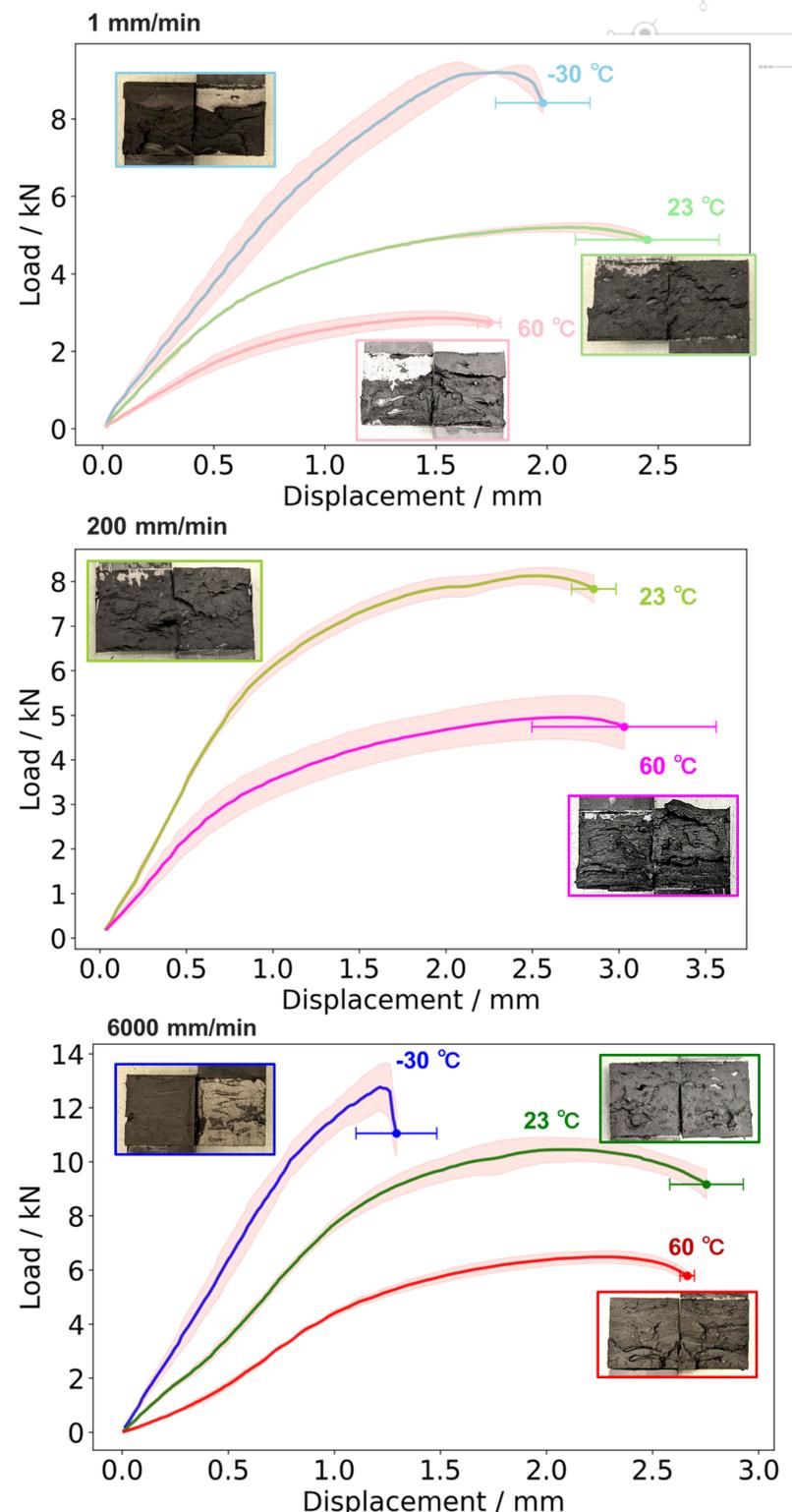


Figure 3 – Summary of load displacement curves.

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).