Effects of strain rate on the mechanical response of bi-adhesive single lap joints

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Introduction

Using bi-adhesive joints leads to a reduction in shear and peel stress concentrations at overlap ends and also increases the stress level in the middle of the joint where the brittle adhesive is used. Several studies have been conducted to understand the behavior of bi-adhesive joints under static loads. However, a few studies have dealt with the effects of loading rate on the behavior of bi-adhesive joints. The purpose of this work is to analyze the loading rate effects on the strength of bi-adhesive single lap joints (SLJ). To achieve this, bi adhesive SLJs were manufactured tested under quasi-static, and dynamic loading conditions.

Joint geometries and tests conditions

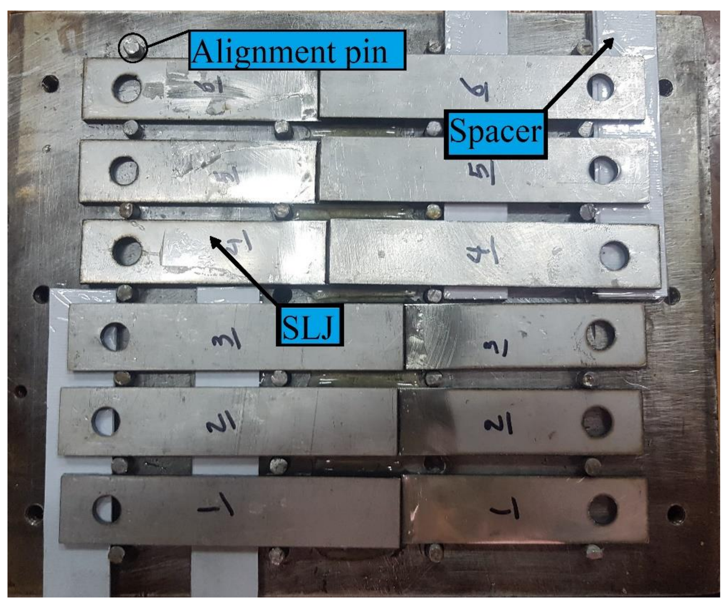

Figure 1 - Mold used for the manufacturing of SLJs

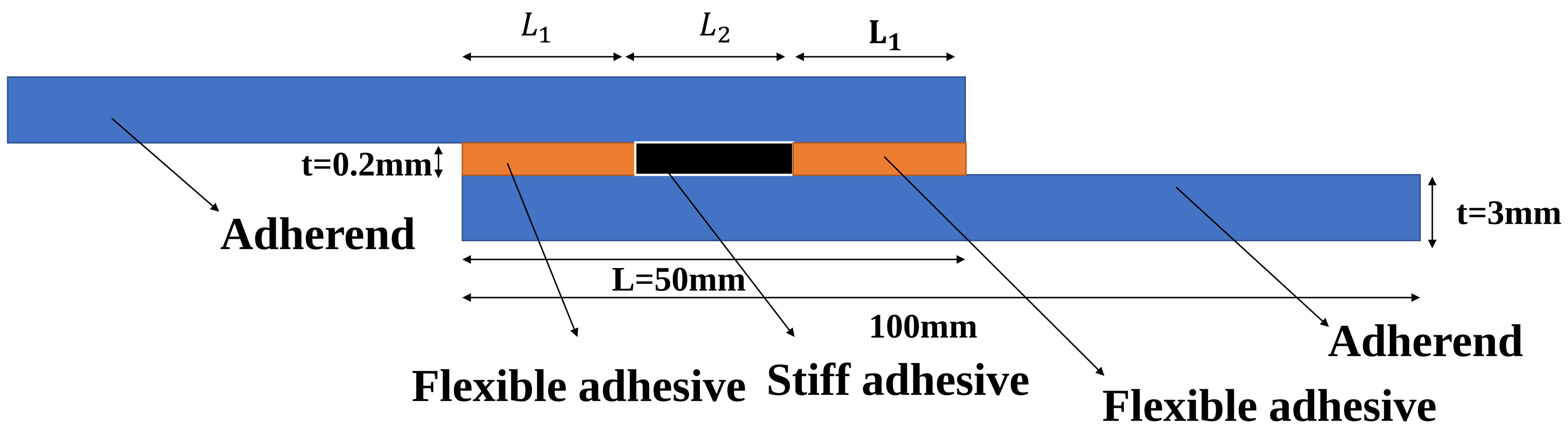

Figure 2 - SLJ specimen geometry (SLJ width= 20 mm)

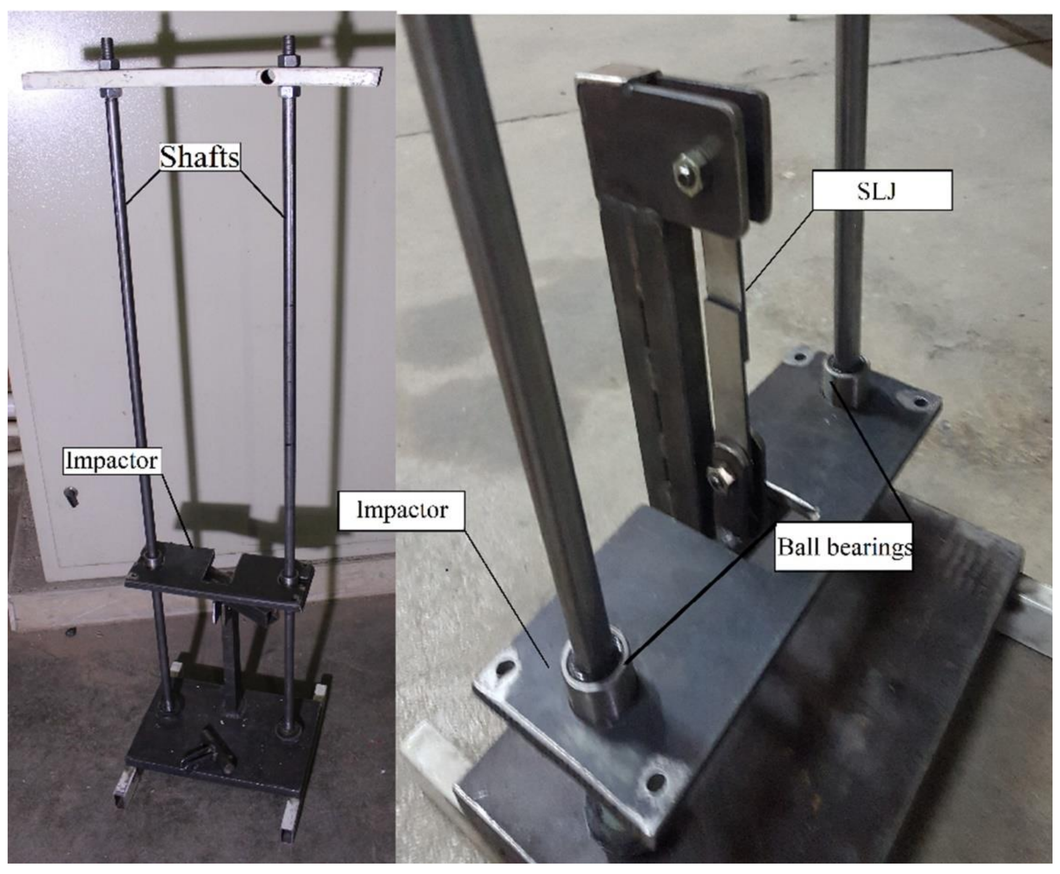

Figure 3 – Inhouse designed drop weight impact test machine

Experimental procedures

All the tested samples had the same geometrical dimensions but with different length ratios of the stiff to the flexible adhesives. The length ratio is defined as $\frac{L_1}{L}$. The crosshead loading rate for all quasi static conditions was set to 1 mm/min. The loading rate increased to 50 mm/min for dynamic tests and the linear speed at impact was 3 m/s. The samples were tested under tension uniaxial loading condition.

Since the viscosity of the two considered adhesives is very different, so there is no need to create a physical boundary such as silicon strips or rubbers between the two adhesives.

Discussion

The static strength of bi-adhesive joints increased about 100% for length ratio of 0.1, and the samples with the length ratio of 0.2 had 170% improvement in static strength. On the other hands the increase of loading rate caused a similar behavior of single adhesive and bi-adhesive joints. The final strength of bi-adhesive joints with length ratio of 0.1 increased about 20%. The failure load increased up to 90% for samples with the length ratio of 0.2.

The impact energy of the SLJs increased dramatically by increase of the length ratio as a results of ductile behavior and energy absorption properties of flexible adhesive.

Test results

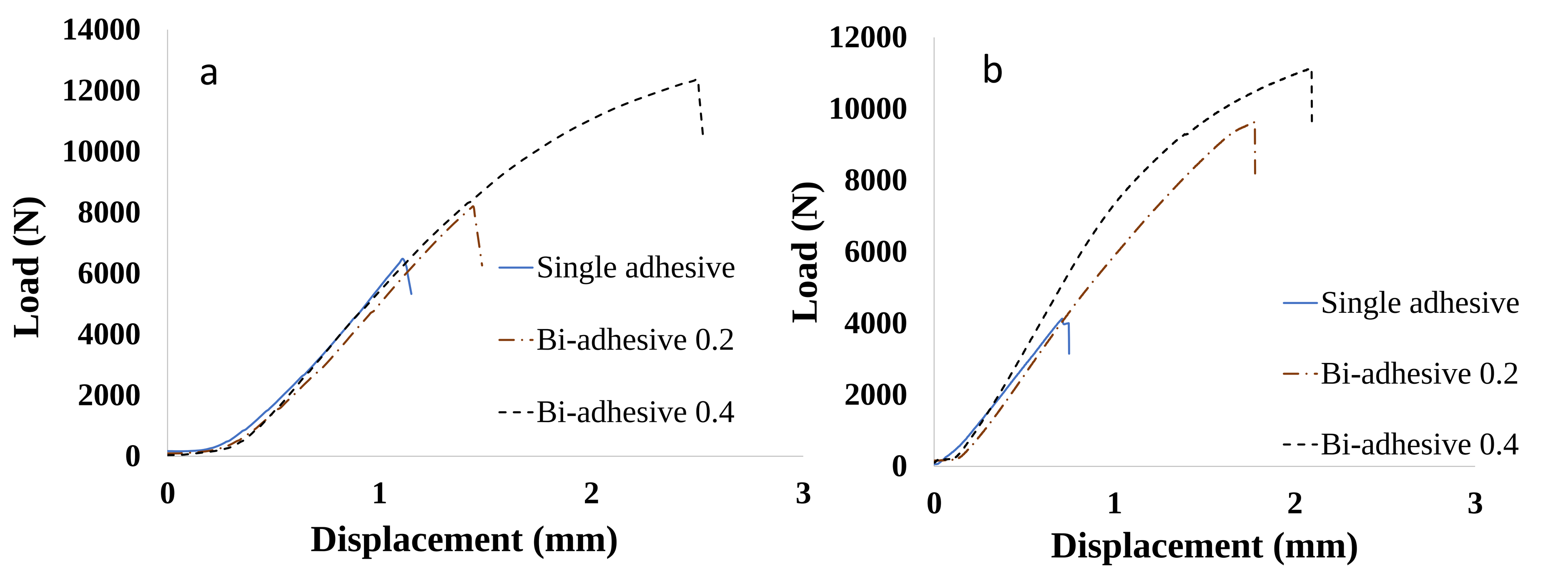

Figure 4 – (a) Typical load displacement behavior of specimens in static conditions; (b) Typical load-displacement behavior of specimens in dynamic conditions

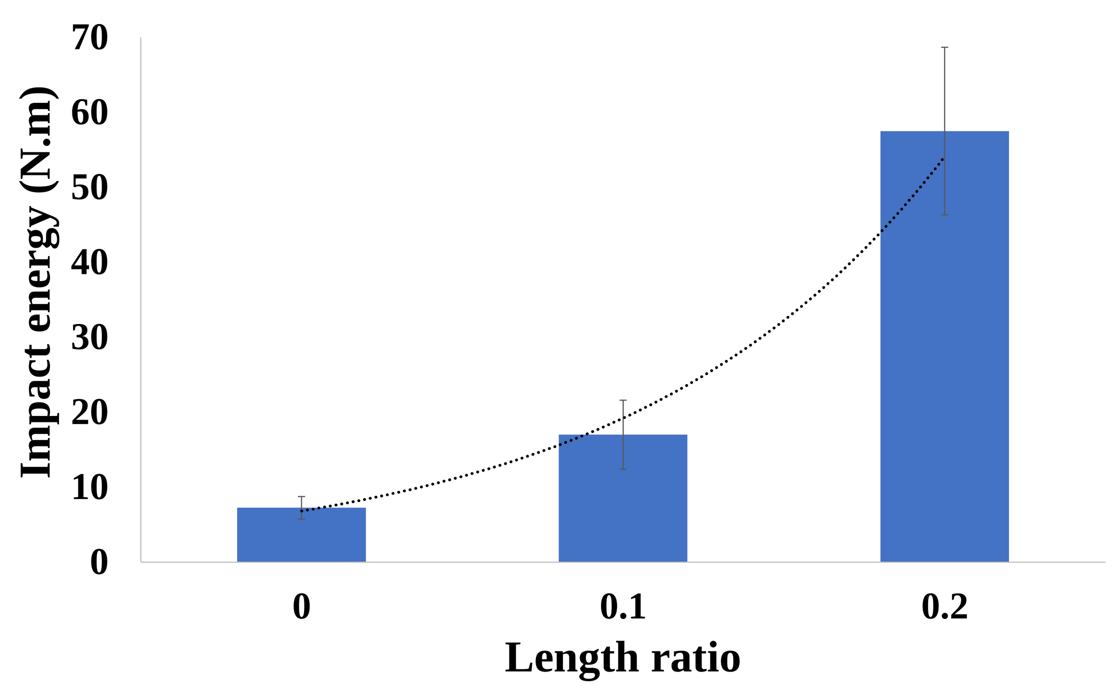

Figure 5 – Fracture energy of the adhesive at impact

Conclusions

One of the main reasons for catastrophic failure in bonded joint is the impact load which structures usually experience in service. Experiments proved that bi-adhesive bonding has high potential for impact absorption and a considerable strength improvement at high strain rates.

References

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[3] W. Huang, Investigations on low-energy impact and post-impact fatigue of adhesively bonded single-lap joints using composites substrates, J. Adhes.

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