Assessing the potential of adhesive bonding as an alternative to welding in vehicle body structures: An industrial case study

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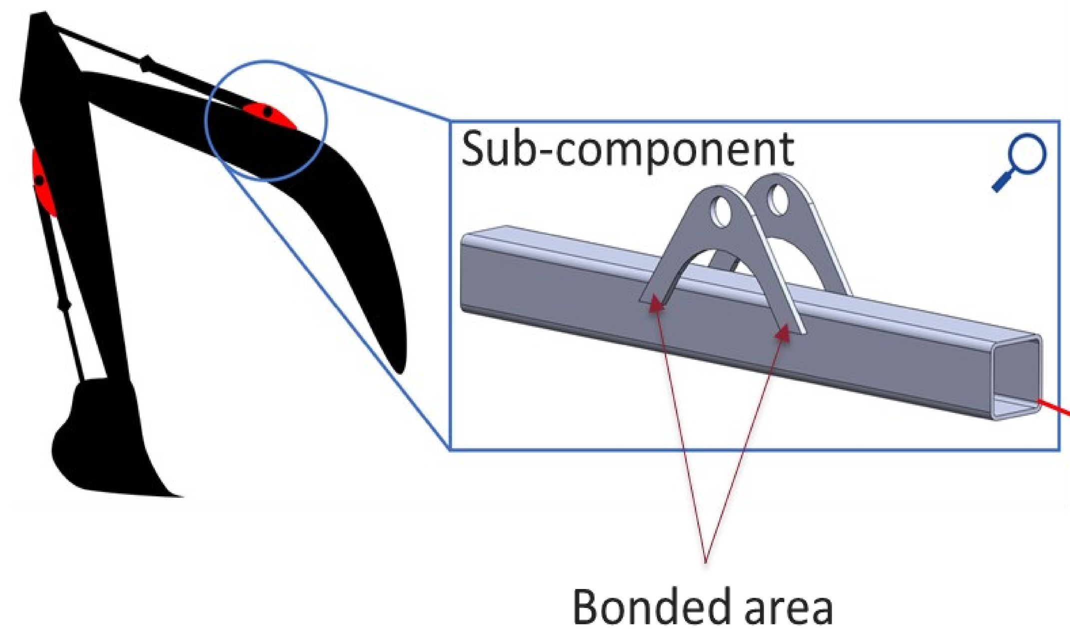
Advanced Joining Processes Unit

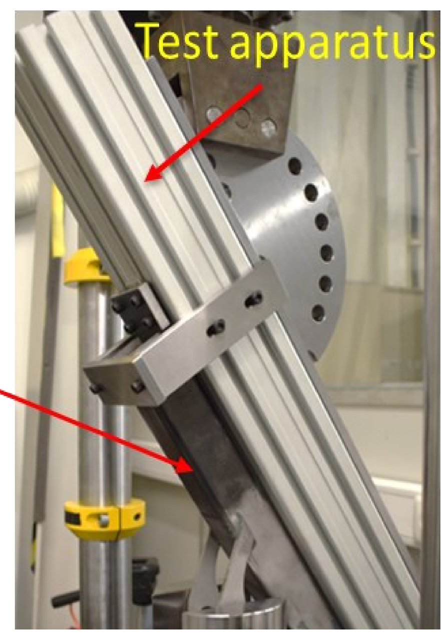
Introduction

The use of adhesive bonding has grown in many industrial sectors, as it allows for the construction of lightweight structures, devoid of heavy metallic fasteners, rivets and weld beads. The aim of this work is to study how well fatigue life predictions, based on Arcan tests results, apply to real joint with a complex geometry, used as a structural component in industrial vehicles. By utilizing the master curve, fatigue life predictions were made for the joints and compared with the welded assembly. Experimental fatigue tests were performed to verify the predictions.

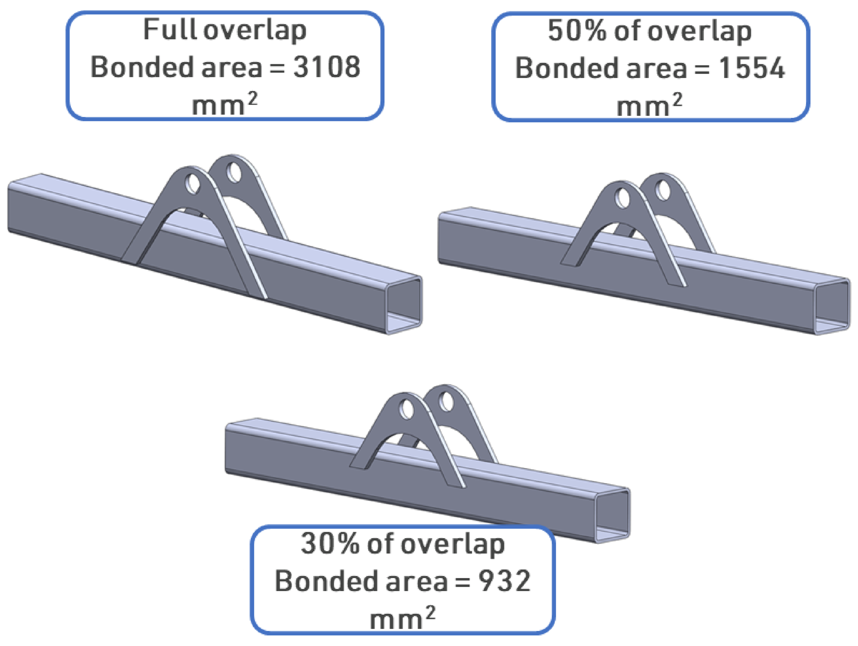
Experimental Procedure

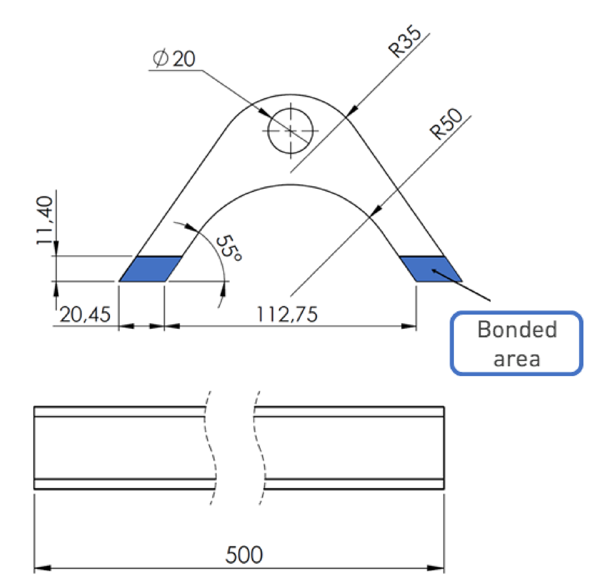


Example of a boom structure. The component analyzed in the current work is shown in the zoomed view.

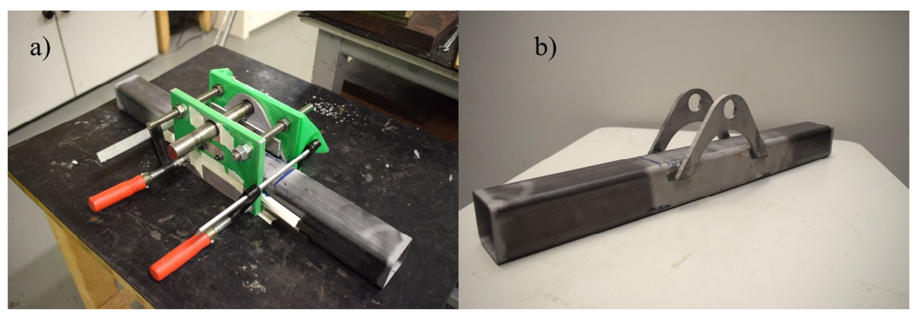


Apparatus mounted on testing machine at the 35◦ angle configuration.

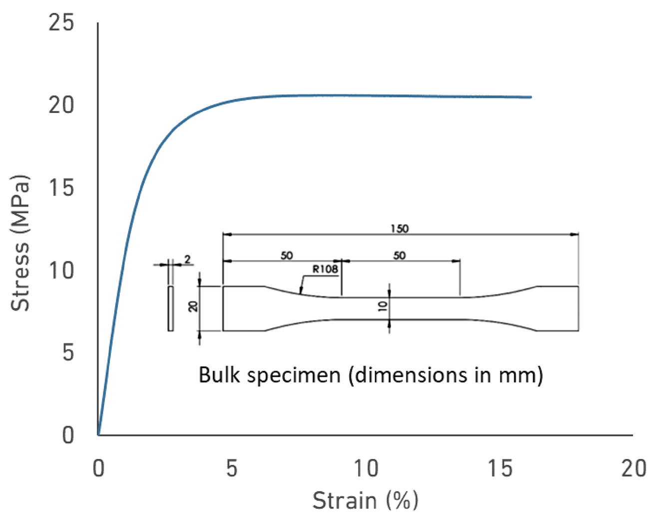


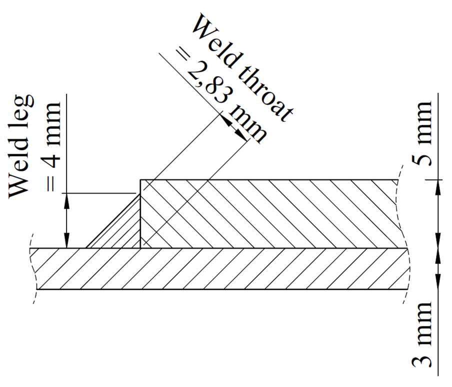


(Right): Different overlap sizes considered in adhesive bondline,
(Left): Dimensions of the tab and of the tubular profile

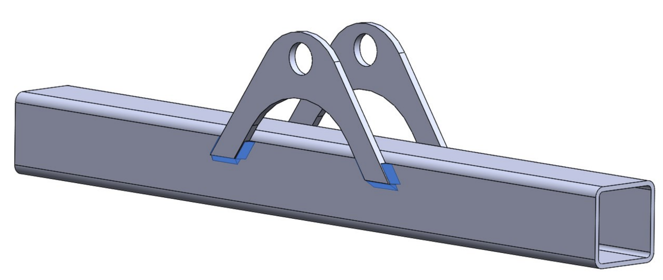


(a) Real joint during the manufacturing process.
(b) A manufactured joint before the testing procedure.



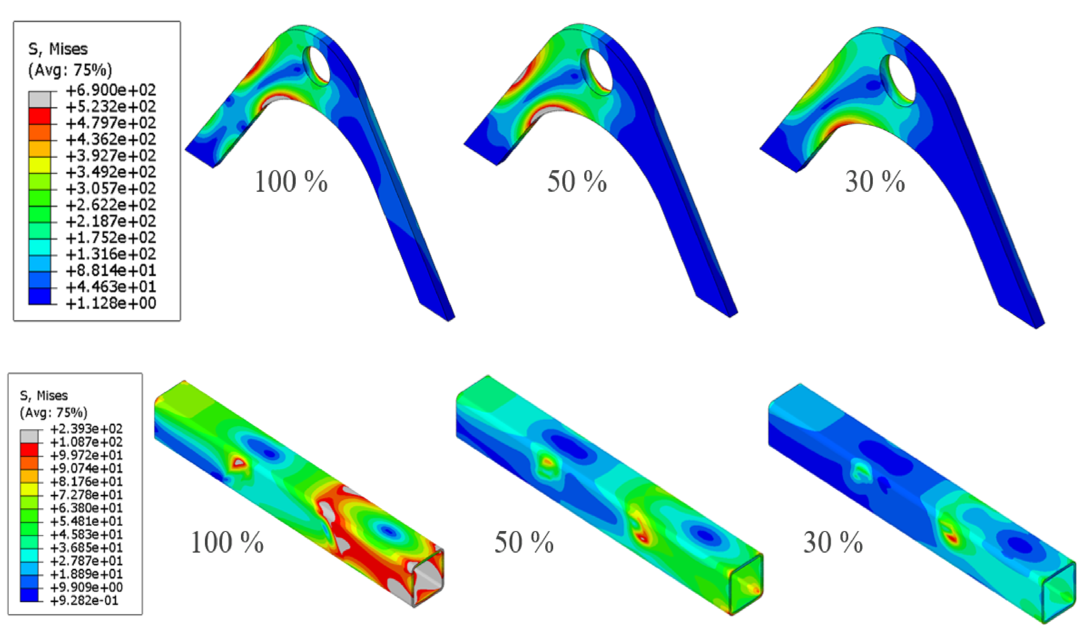


Geometry and dimensions of the weld beads

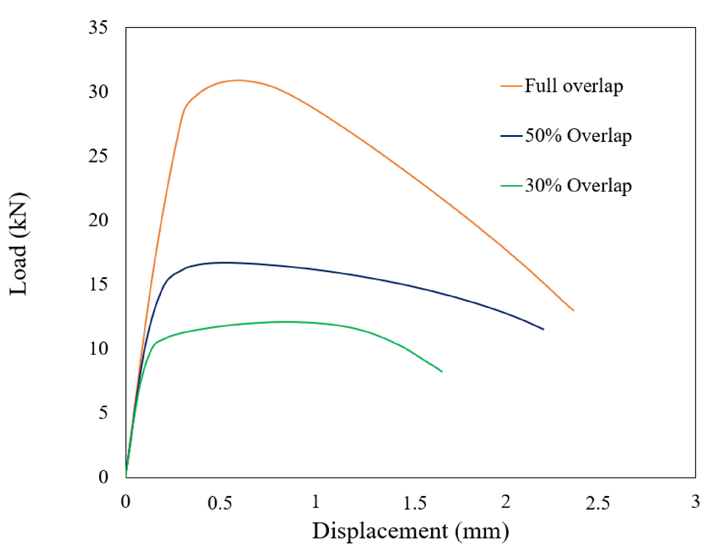


Welded joint with weld beads shown in blue

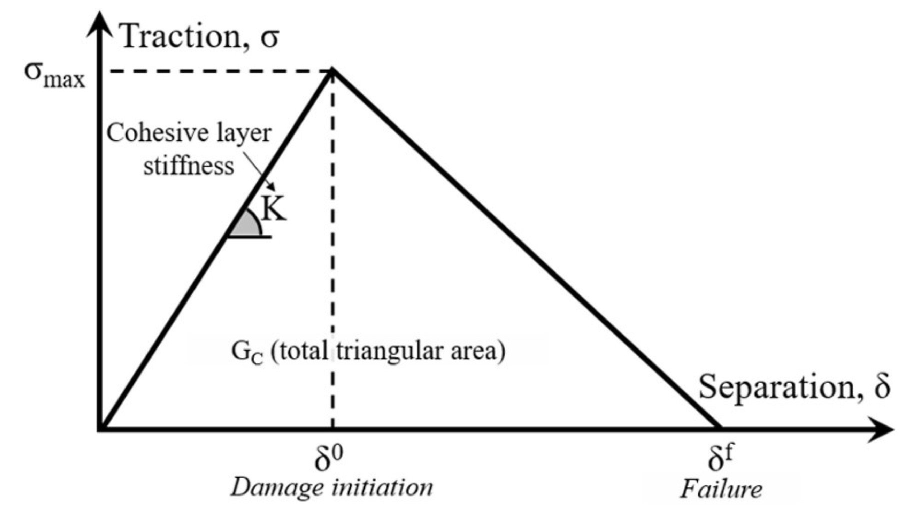
Results and Discussion



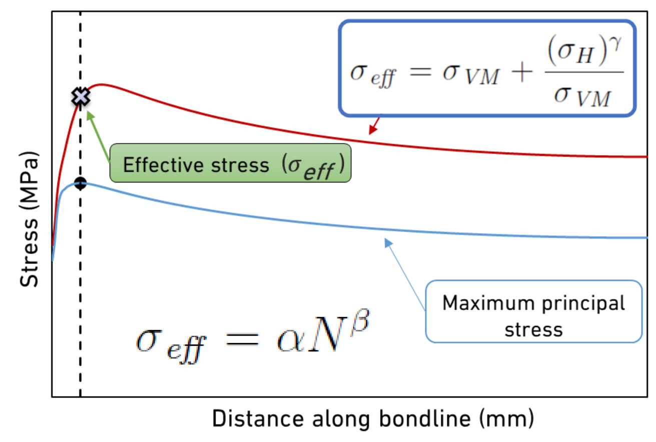
Effect of overlap length on the stress level in bonded joints



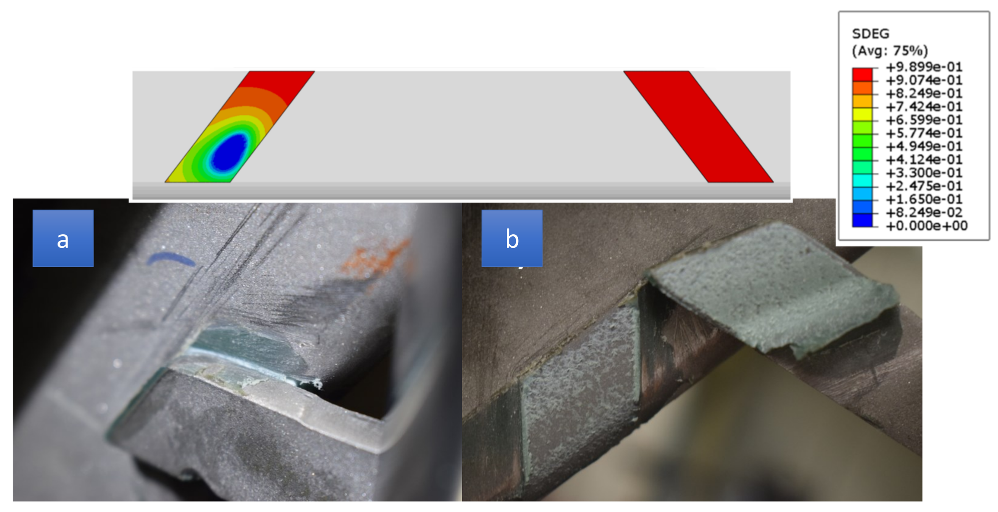
Overlap length	Strength
Full	30.9 kN
50%	16.7 kN
30%	12.1 kN



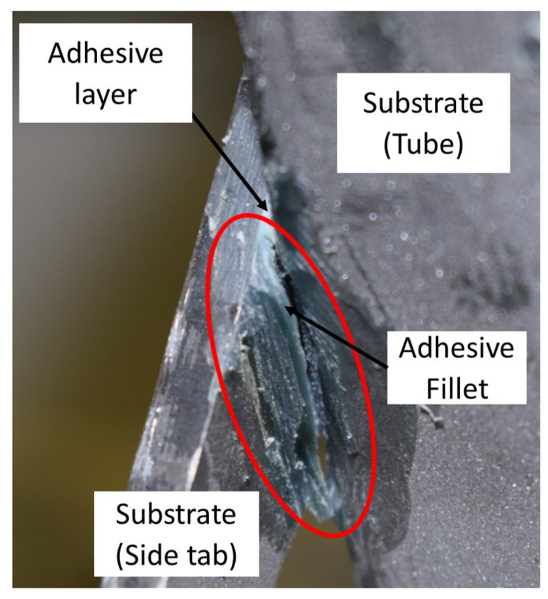
A typical triangular CZM shape used in numerical analysis of the adhesive.

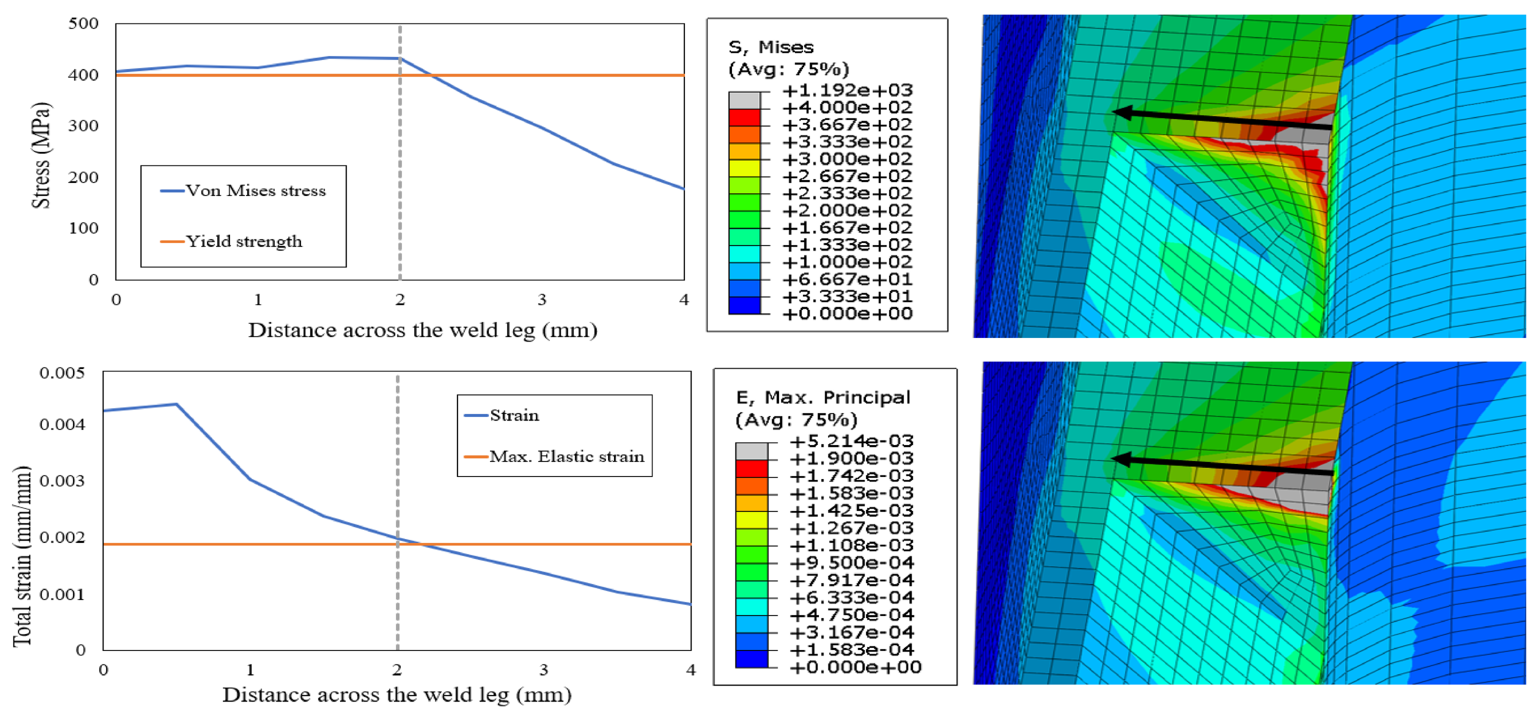


The effective stress is measured at the point where the maximum principal stress is maximum



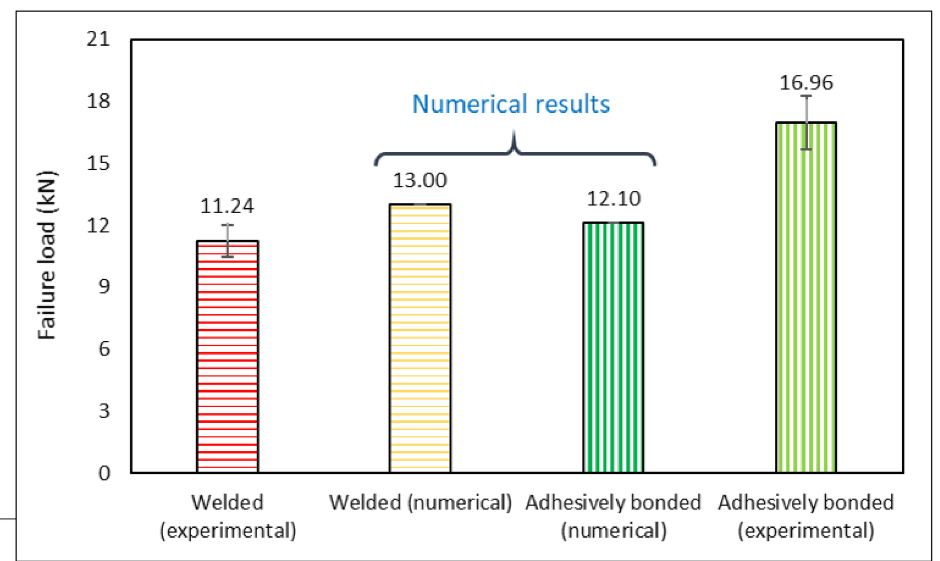
a) Plastic deformation visible as a white line on the non-failed bonded overlap. Fracture surface of the failed bonded area, under static conditions.

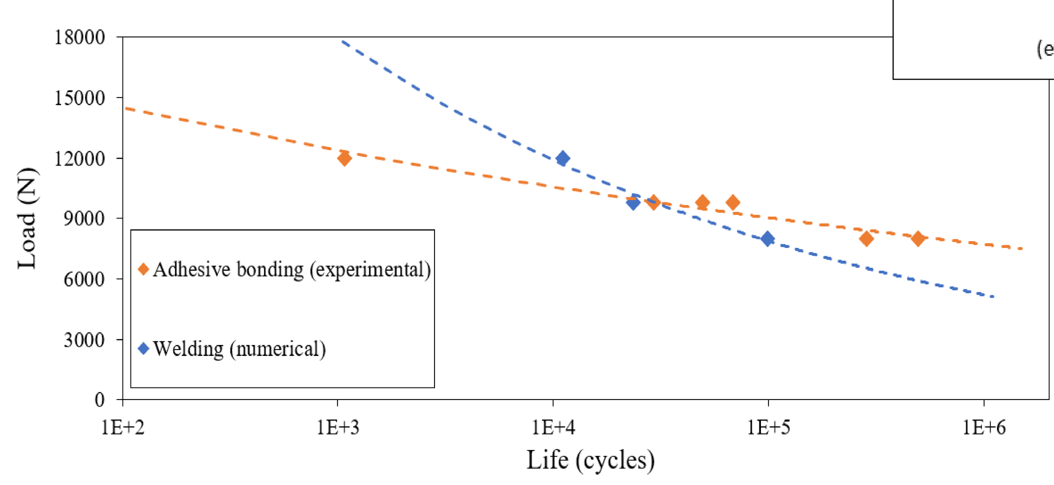




von Mises stress distribution along the weld leg, on top, total strain distribution along the weld leg, on the bottom. The applied load is 13 kN at 35◦ angle

Static strength: Adhesive bonding with 70% reduced overlap vs. welding. Error bars show the standard deviations.





Blue. Welded joint numerical fatigue life against bonded joint experimental fatigue life.

Conclusions

- Replacing welding by adhesive bonding in a load bearing component of agricultural and construction vehicles was investigated.
- Adhesive bonding can significantly increase the fatigue life of the tested real joints at high cycle fatigue regime.
- Adhesive bonding is a suitable replacement for welding in structural applications.
- Increasing the bonded area leads to improvement of the strength, while the same does not happen for welding.
- Using the maximum principal stress approach can present accurate results in the measurement of the effective stress.
- The new proposed fatigue life prediction model is able to accurately predict the total fatigue life.

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