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advanced joining processes unit

Curved aluminum adherends for enhanced mechanical performance in bonded single lap joints

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INTRODUCTION

The single lap joint (SLJ) is widely adopted due to its simplicity, it suffers from stress concentrations at the overlap ends, particularly when using low-ductility adhesives. This study used curved SLJ design with non-uniform adhesive thickness to mitigate these stress concentrations. The performance of this joint configuration was investigated experimentally and numerically using two adhesives: Araldite® 2015-1 and AV138. Finite element models were developed using ABAQUS. This study demonstrates that the proposed curved SLJ effectively reduces stress concentrations, and its efficacy in enhancing joint strength is dependent on the adhesive's ductility.

EXPERIMENTAL DETAILS

- Adhesives and adherend

Two different structural adhesives were used, the Araldite 2015-1 and AV138., bi-component epoxy paste adhesive which cures at room temperature.

The adherend material used was an aluminum alloy AW6082 T6.

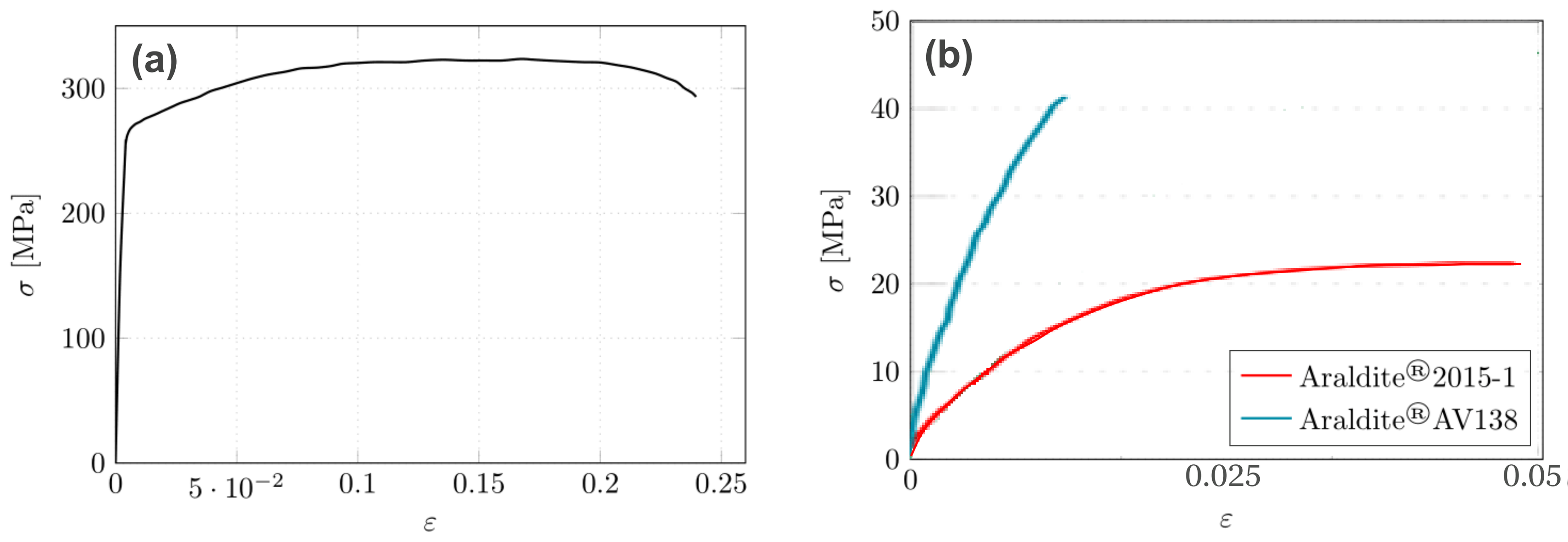

FIGURE 1. Stress-strain curves. (a) Aluminum. (b) Araldite® AV138 and Araldite® 2015.

- Joint geometry

Figure 2 illustrates the specimen geometry analyzed. The geometry parameters used: L_T = 240 mm, L_0 = 50 mm, t_s = 5 mm, $t_{a,min}$ = 0.2 mm, $t_{a,max}$ = 1.4 mm and h = 5 mm.

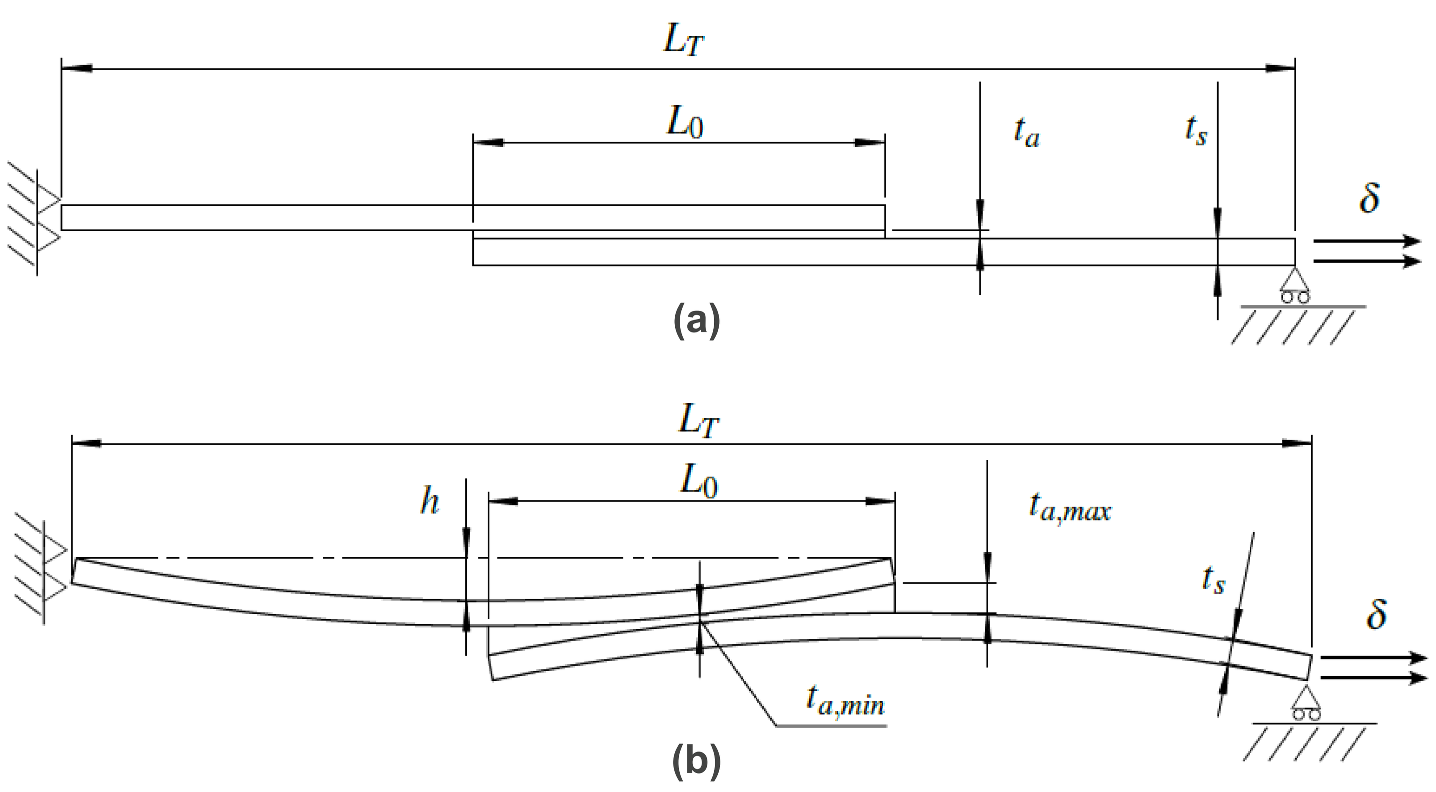

FIGURE 2. SLJ specimen geometry. (a) Planar SLJ. (b) Curved SLJ.

Adherend curvature was obtained through rolling and deformed plastically (see Figure 3).

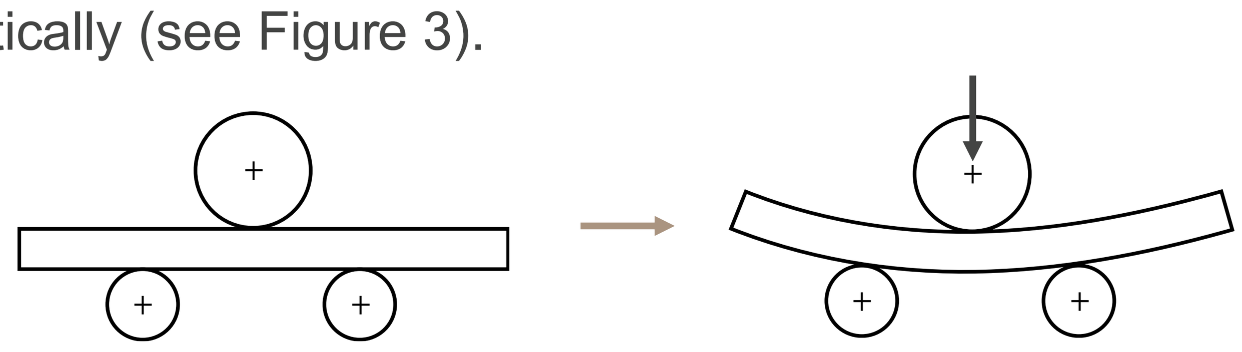

FIGURE 3. Adherend curvature procedure.

NUMERICAL DETAILS

Numerical models were developed to predict the failure load and failure mode of the joints under quasi-static conditions using cohesive zone modelling (CZM).

Figure 4 shows the elements used were four-node plane strain (CPE4) elements for the solid sections and cohesive (COH2D4) elements for the adhesive cohesive layer.

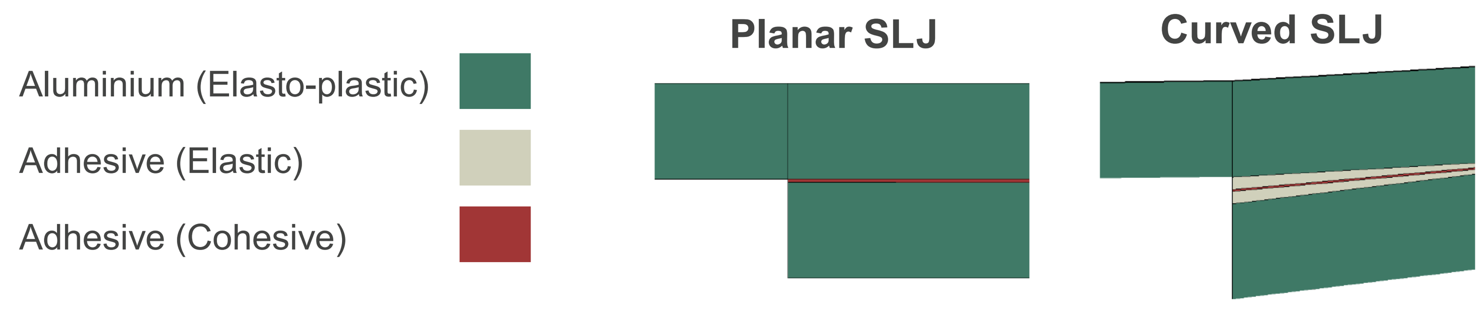

FIGURE 4. Section assignment of the numerical models.

RESULTS

Figure 5 shows the failure surfaces and the load-displacement curves acquired for both adhesives and configurations, presenting experimental and numerical results obtained using CZM.

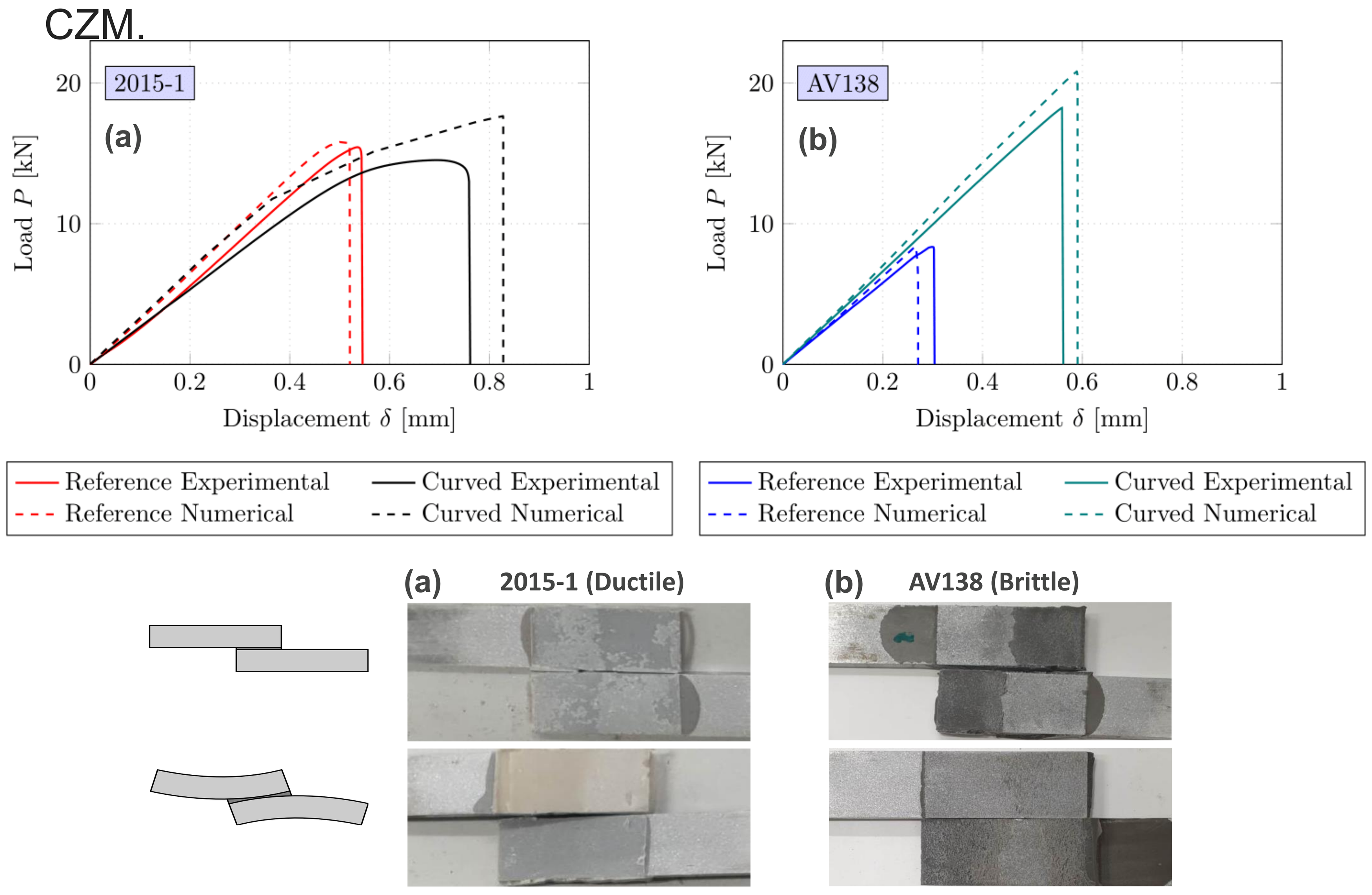

FIGURE 5. $P-\delta$ curves and failure surfaces for both adhesives. (a) 2015-1 (b) AV138.

CONCLUSION

- The use of the curved geometry significantly decrease the peak stresses in the overlap edges.
- Curved SLJs showed increased energy absorption and an improved failure load when using with a brittle adhesive.
- The curved substrate SLJs, offering superior failure modes and performance.

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