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Performance of adhesive single lap joints with curved aluminum adherends

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INTRODUCTION

This study used curved SLJ with a non-uniform adhesive thickness, aiming to mitigate these stress concentrations. The investigated the performance of this joint using both experimental and numerical methods with two adhesives: Araldite® 2015-1 and AV138. Finite element models were developed using ABAQUS software. Our findings indicate that cohesive failure within the adhesive layer was the dominant mode, consistent with numerical predictions. Strength improvements were linked to the adhesive's ductility. However, the curved configuration did not significantly enhance the strength of the ductile adhesive, which typically fails under global yielding. In contrast, the brittle adhesive AV138 showed a substantial 130% strength increase compared to the reference joint. In conclusion, this study demonstrates that the curved SLJ can reduce stress concentrations, and its effectiveness in improving joint performance depends on the ductility of the adhesive employed.

EXPERIMENTAL DETAILS

Two different structural adhesives were used, the Araldite® 2015-1 and AV138.

The geometry of the single lap joint (SLJ) is illustrated in Figure 1, with the adherend thickness t_s = 5 mm, the minimum adhesive thickness $t_{a,min}$ = 0.2 mm, the overlap length L_0 = 50 mm and the total distance between grips L_T = 240 mm. For the curved joint (h = 5 mm) with a varying adhesive thickness ranging from 0.2 mm at the middle of the overlap ($t_{a,min}$) to 1.4 mm at the edges of the overlap ($t_{a,max}$).

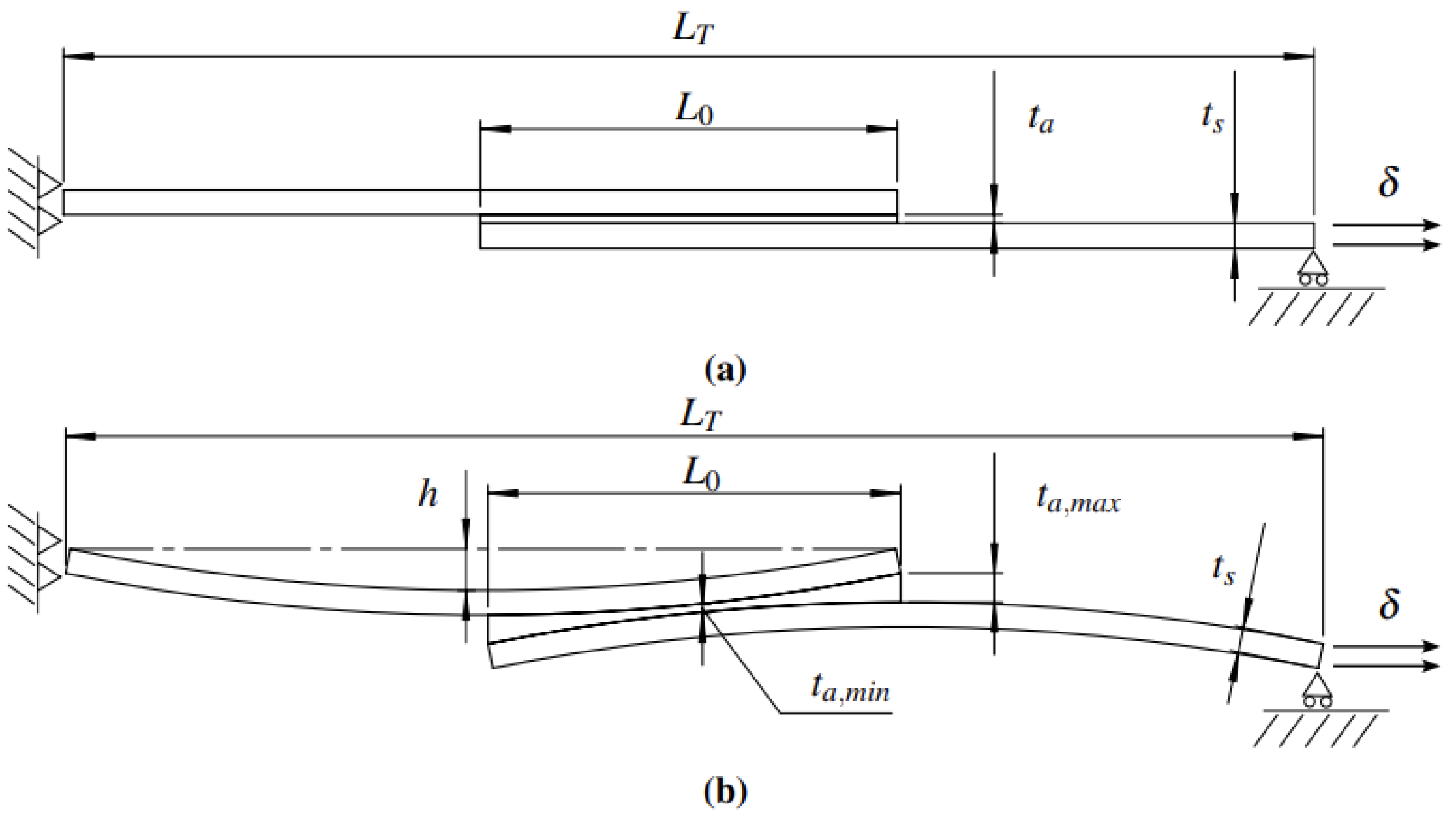

FIGURE 1. SLJ specimen geometry. (a) Planar SLJ. (b) Curved SLJ.

NUMERICAL DETAILS

Each configuration was simulated using the ABAQUS CAE software, employing a design space within the program. The models were developed using an appropriate computational mesh and used solid sections using four-node plane strain (CPE4) elements, while the cohesive layers were modelled using cohesive (COH2D4) elements, to simulate the behaviour of the joint and predict its failure, as can be seen in Figure 2.

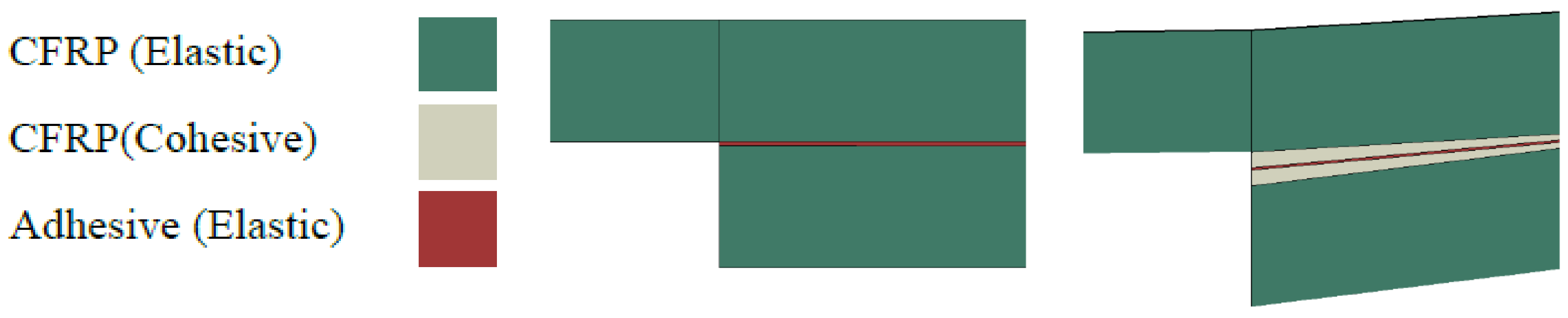

FIGURE 2. Section assignment of the numerical models used.

RESULTS

Both reference and curved joints were manufactured and subjected to quasi-static tests, enabling an examination of their failure load and critical displacement. Figure 3 depicts the P−δ curve acquired for both adhesives and configurations, presenting experimental and numerical results obtained using CZM.

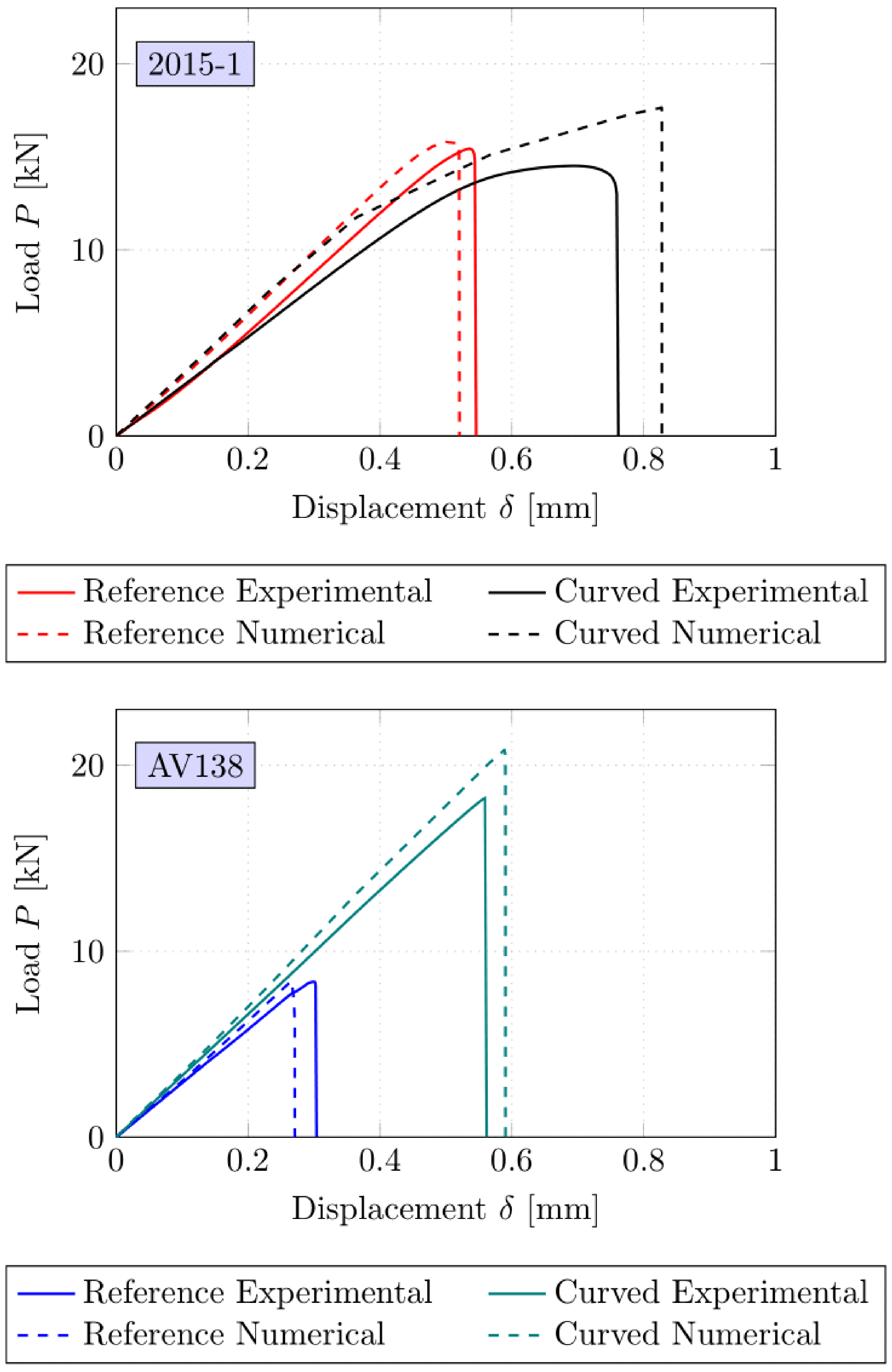

FIGURE 3. Load - displacement curves obtained experimentally and numerical for both configurations and adhesives.

CONCLUSION

- This study showed that the use of the curved geometry significantly decrease the peak stresses in the overlap edges;
- Curved metal SLJs showed increased energy absorption with a ductile adhesive and significantly improved failure load when using with a brittle adhesive.
- The decrease of peak stresses, namely peel stresses on the overlap edges prevented delamination, allowing for a cohesive failure modes and improve performance on the composite SLJs.

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