On the mechanical behavior of L- and T-shaped wooden adhesive joints

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Introduction

Adhesive bonding has gained strong importance in the automotive industry due to its advantages, including the potential for weight savings. With increasing environmental concerns, efforts are being made to introduce eco-friendly materials into this sector. Developing design tools is crucial to facilitate their integration. In this work, Bigwood and Crocombe's model [1] is employed to investigate L- and T-shaped wooden bio-adhesive joints. The analytical results are compared with finite element predictions.

Methods

Analytical model

- Bigwood and Crocombe's [1] model (see Fig. 1) is a 2-D analytical mechanical model. It considers the overlap region of two adherends, bonded using an adhesive layer. The model is loaded at its both boundaries by axial forces, $\mathcal{N}_\mathrm{i}$, transverse shear forces, $\mathcal{Q}_\mathrm{i}$, and bending moments, $\mathcal{M}_\mathrm{i}$.
- The model is based on the first-order shear deformation theory. Both adherends and the adhesive are considered isotropic materials.
- The model can provide the peel and shear stress distributions along the overlap length.
- To analyze modular joints (see Fig. 2) using this model, a simple static analysis should be applied, so the internal force measures, $\mathcal{N}_\mathrm{i}$, $\mathcal{Q}_\mathrm{i}$, and $\mathcal{M}_\mathrm{i}$, in its both boundaries are determined from the applied loading.

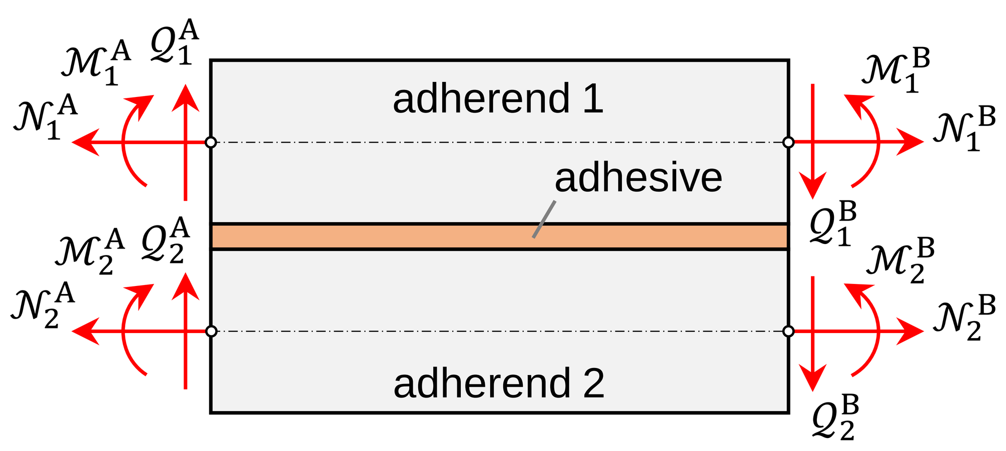

Figure 1 – Bigwood and Crocombe's [1] model.

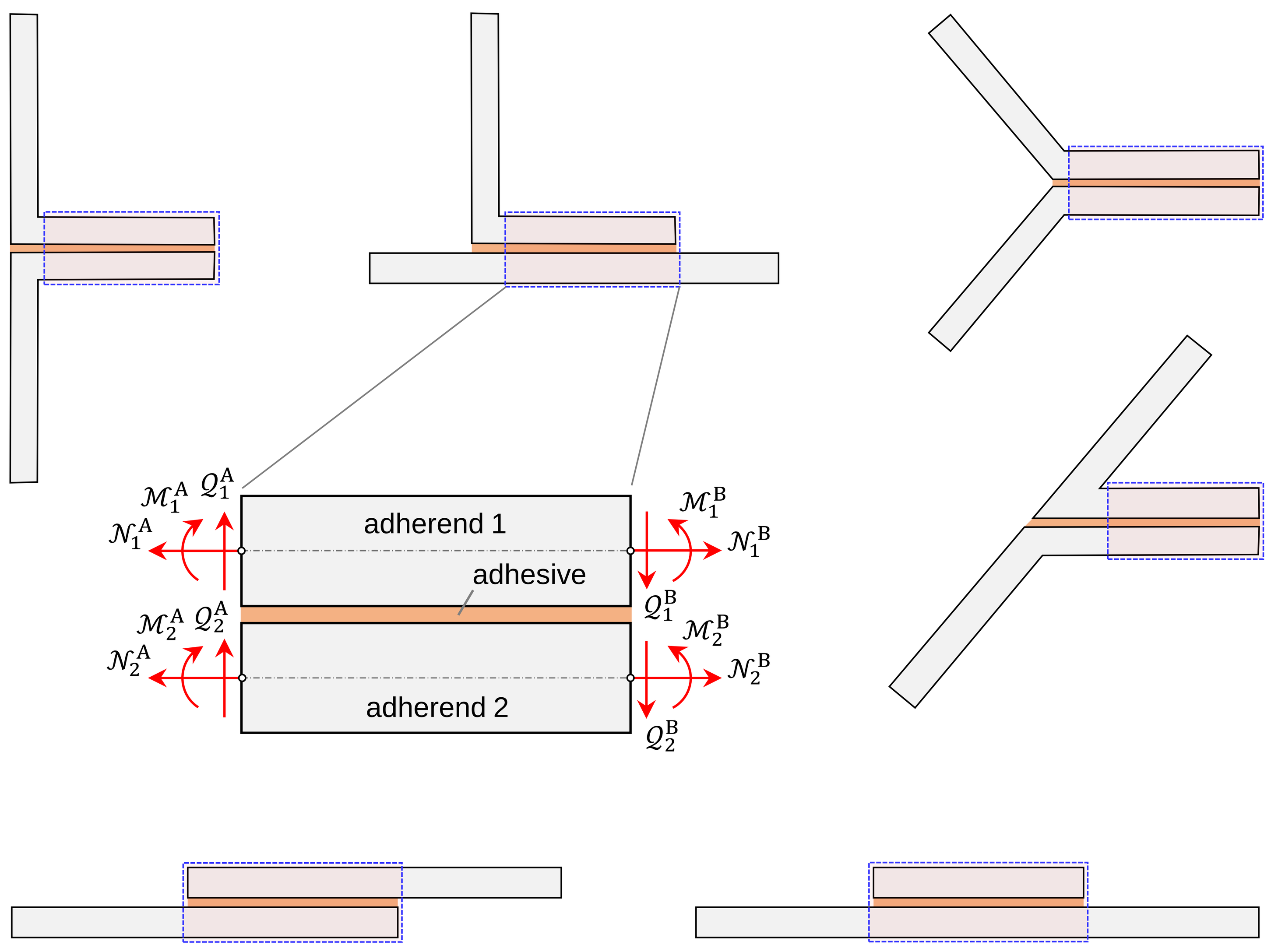

Figure 2 – Examples of modular adhesive joints that can be analyzed using Bigwood and Crocombe's model.

Finite element model

- In this study, the analytical model was compared with predictions from a finite element analysis (see Fig. 3).
- In the finite element model, the adhesive layer was modeled using cohesive elements and a triangular traction–separation law.

Materials

- Results for an L-joint with pine wood adherends and an almost-zero-thickness bio-adhesive are shown in this poster.

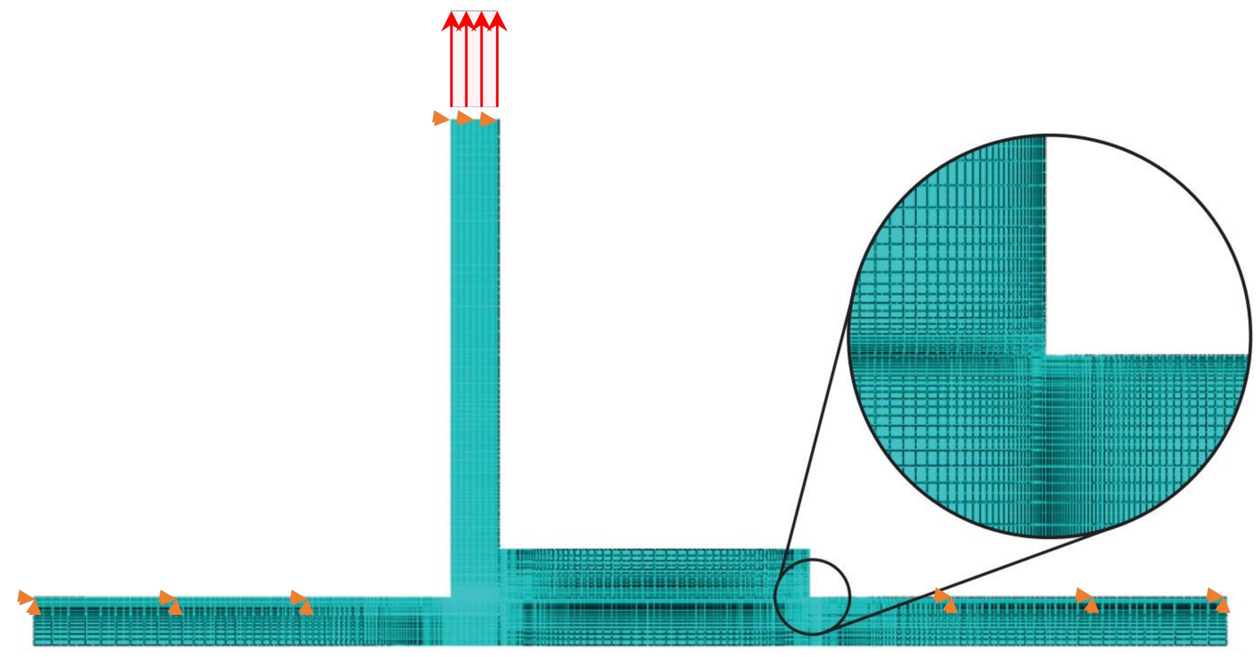

Figure 3 – Finite element model.

Results

- Fig. 4 shows the distributions of peel and shear stresses along the overlap length for the L-joint of Figs. 2 and 3.
- Regarding the peel stress, the calculation from the analytical model deviates from the FEA prediction, mainly due to the almost-zero adhesive thickness; the analytical model is not accurate in this case.
- Regarding the shear stress, a quite close agreement between the analytical model and the FEA prediction is achieved.
- The stress values calculated from the analytical model are always higher than the numerical ones, so the analytical model can be used for a safe design of L-joints or other modular joints.

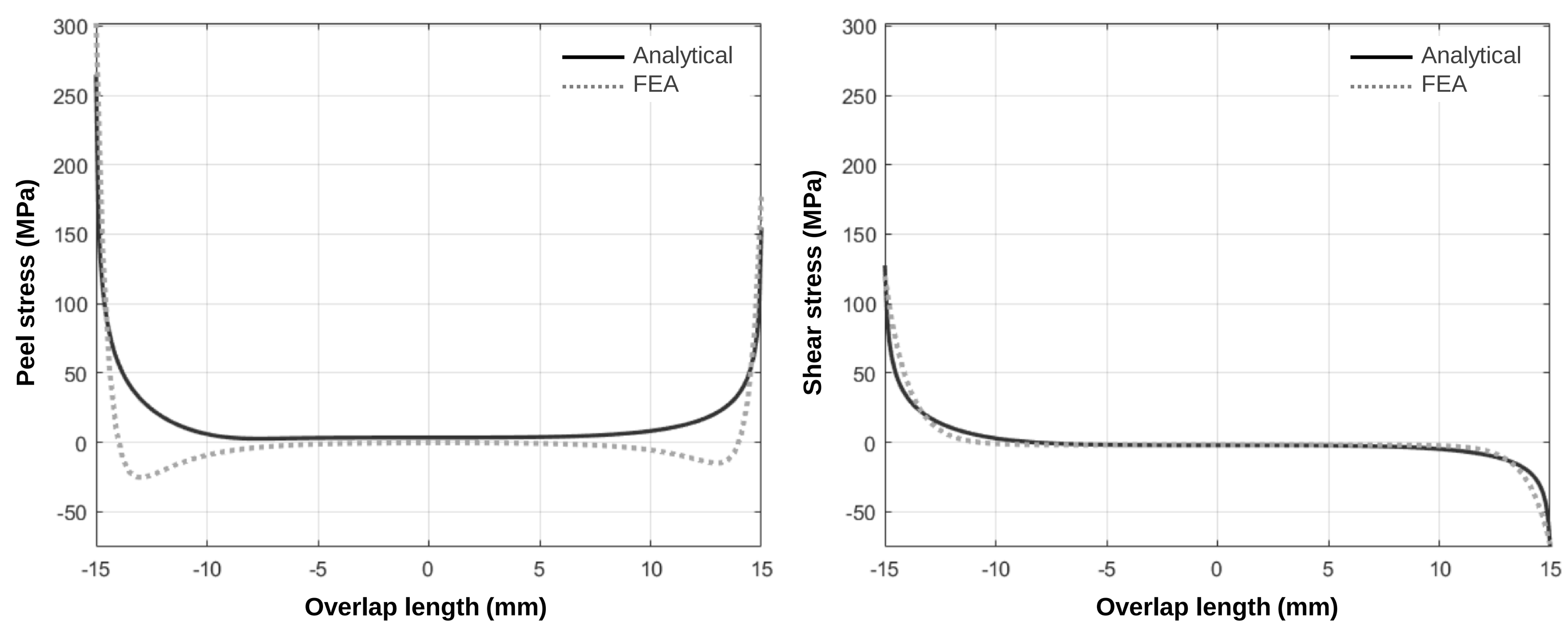

Figure 4 – Stress distributions in the overlap region of the L-joint.

Conclusions

- The stress distributions obtained from the analytical model are not accurate enough along the entire overlap length. Nevertheless, the model is capable of accurately calculating the critical stress values.
- Considering its simplicity and efficiency, the analytical model can be employed for preliminary design purposes.
- For a more comprehensive understanding of joint behavior, experimental testing or more advanced numerical modeling is necessary.
- Bigwood and Crocombe's nonlinear mechanical model [2] can be employed to improve the accuracy of the calculations and broaden the range of applications to joints with a nonlinear material or geometric behavior.

References

[1] Bigwood, DA, Crocombe, AD. Int J Adh Adh 9(4) (1989): 229–242.
[2] Bigwood, DA, Crocombe, AD. Int J Adh Adh 10(1) (1990): 31–41.

Acknowledgments

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