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Computer modeling of adhesively bonded joints

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Properly used adhesively bonded joints have a lot of advantages comparing to conventional joints such as rivets, pins, bolts or welds. They are light, they have relatively high shear strength, they don't corrode and they are easily produceable. When applied on fibre reinforced composites they don't break the fibres. This work is focused on the finite element (FE) analysis of adhesively bonded joints using cohesive elements and on the identification of needed material constants of Araldite 2021 and Spabond 345 adhesives.

Behavior of cohesive elements is described by *cohesive energy* (G) that is an area bellow driving curve and by *critical displacement* (v_c). Every single element is driven by dependence of force or stress (*Traction, t*) on opening (*Displacement, v*) of a crack tip that together also define an elastic linear stiffness of an element. Dependence can be approximated by different functions (fig. 1). An element can transfer the loading until traction forces reach critical value during critical displacement v_c. Then traction decreases according to chosen model.

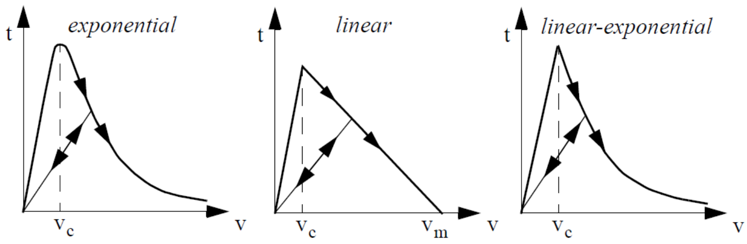

Figure 1: Types of cohesive models.

When reaches zero traction (or very close to zero in case of the exponential model), element breaks and crack is spreading further. The crack spreading is possible in two different modes (normal and shear) or in it's combination. Material costants have different values for different modes and there are different methods for their identification.

Four material constants for every combination adhesive-adherend are neccessary: G_{Ic} – the cohesive energy during first break in mode I, G_{IIc} (in mode II) and appropriate critical displacements v_{Ic} a v_{IIc}. *DCB* (double cantilever beam – for mode I) and *ENF* (end notched flexure – for mode II) experiments were used for identification of these constants (fig. 2).

Analytical formulas related to the beam theory [Ducept (2000), Zemčík,Laš (2007)] were used for G_{Ic} and G_{IIc} calculation whereas v_{Ic} and v_{IIc} were determined by optimization of models (fig.3) to give the best fit with experimental values. An example of the comparison of the experimental results, the optimized FE models for an experimental sample and FE models with average constants corresponding to all experiments is on fig.4.

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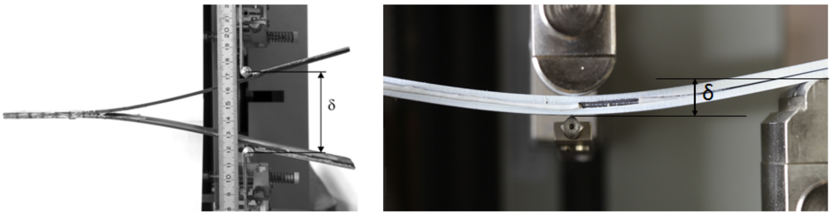

Figure 2: DCB (left) a ENF experiment.

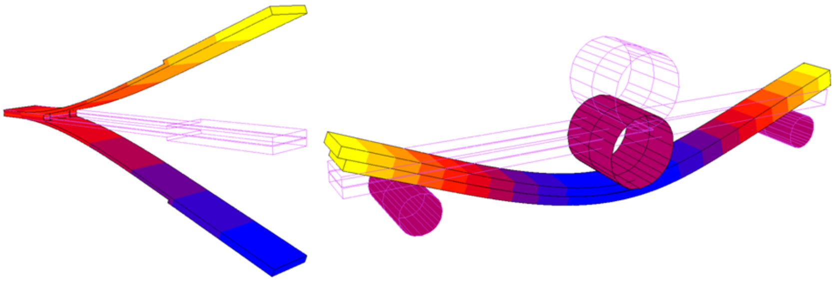

Figure 3: Model of DCB (left) and ENF experiment.

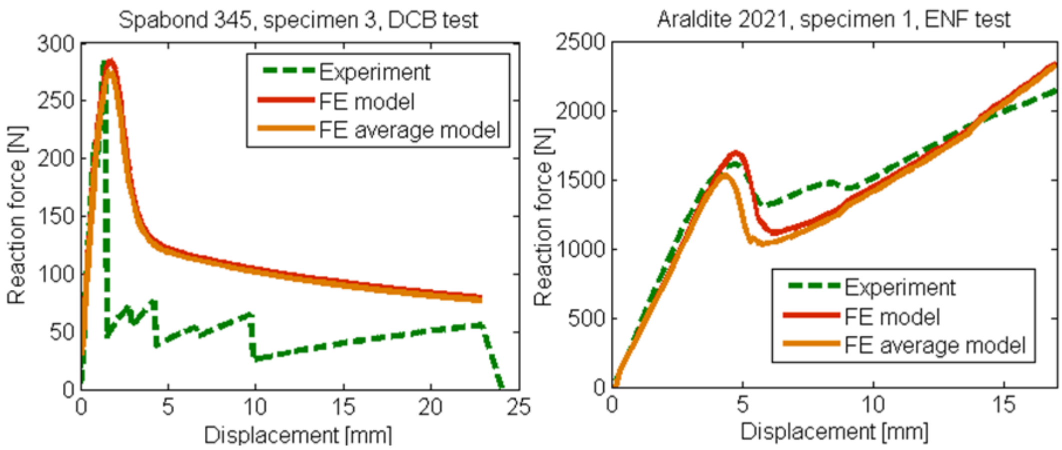

Figure 4: Comparison of experiment, optimized FE model and average FE model.

The failure of Araldite 2021 adhesive was cohesive therefore curves of experimental and FE values were in good agreement. Since the failure of Spabond 345 was not mostly cohesive better agreement could not be achieved.

Acknowledgement

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References

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F. Ducept, P. Davies, D. Gamby, 2000, Mixed Mode Failure Criteria For a Glass/Epoxy Composite And An Adhesively Bonded Composite/Composite joint