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MIXED-MODE FRACTURE OF BONDED JOINTS USING THE ASYMMETRIC TAPERED DOUBLE-CANTILEVER BEAM TEST

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ABSTRACT

In this work, the Asymmetric Tapered Double-Cantilever Beam (ATDCB) mixed-mode test is studied to estimate the fracture envelope of three adhesives with different ductility. The experimental load-displacement (P-δ) curves and R-curves were calculated and the fracture envelopes of each adhesive were built, which enabled calculating the most suitable propagation criterion in mixed-mode to be applied in numerical simulations. Mixed-mode cohesive zone model (CZM) laws were built based on the obtained data, and the respective numerical results were compared with the experiments, which enabled validating the CZM laws and the mixed-mode propagation criterion of each adhesive. A numerical sensitivity study of the CZM law parameters was also undertaken. With this work, the mixed-mode CZM laws and the respective mixed-mode propagation criterion of three adhesives were proposed and validated for strength prediction of adhesive joints.

Keywords: extended Finite Element Method, adhesive joint, structural adhesive.

INTRODUCTION

In order to enable the widespread use of adhesive joints in industry application, it is fundamental to be able to predict their strength. Advanced predictive techniques such as CZM require the estimation of both mechanical and fracture properties of adhesives (da Silva and Campilho 2012). Several fracture characterization tests were developed for pure and mixed-mode fracture. Under mixed-mode fracture conditions, which is the most common scenario in real applications, CZM require defining the most adequate propagation criterion of the adhesive to accurately predict the joints' behaviour. In this work, the ATDCB mixed-mode test is studied to estimate the fracture envelope of three adhesives with different ductility. The experimental P-δ curves and R-curves were calculated and the fracture envelopes of each adhesive were built, which enabled calculating the most suitable propagation criterion in mixed-mode to be applied in numerical simulations. Mixed-mode CZM laws were built based on the obtained data and the respective numerical results were compared with the experiments, which enabled validating the CZM laws and the mixed-mode propagation criterion of each adhesive. A numerical sensitivity study of the CZM law parameters was also undertaken.

RESULTS AND CONCLUSIONS

Figure 1 presents different theoretical fracture envelopes for the three adhesives considered in this work and the respective positioning of the experimental points from the ATDCB tests.

The theoretical fracture envelopes were built using the pure-mode data applied at the horizontal (shear data) and vertical axes (tensile data), and using four idealized curves resulting from the application of four exponents α in the energetic criterion: 1/2, 1, 3/2 and 2, aiming to define the most suited criterion for each of the three adhesives. A relatively low dispersion was found for the G_I/G_{II} data points of the Araldite® AV138, which allows to position all the specimens in a small area of the fracture envelope, quite close to the α=½ criterion and, thus, to easily identify the ½ criterion as the most suitable mixed mode criterion to describe the behavior of this adhesive. The obtained results for the specimens bonded with the Araldite® 2015 equally show a small dispersion of data points, which allows to easily locate the optimal propagation criterion for this adhesive (α=½). By analyzing the experimental fracture envelope of the SikaForce® 7752, some dispersion in the G_I and G_{II} values can be found. However, all points are clearly closer to the α=2 criterion, which the most adequate one for the simulation of bonded joints with this adhesive.

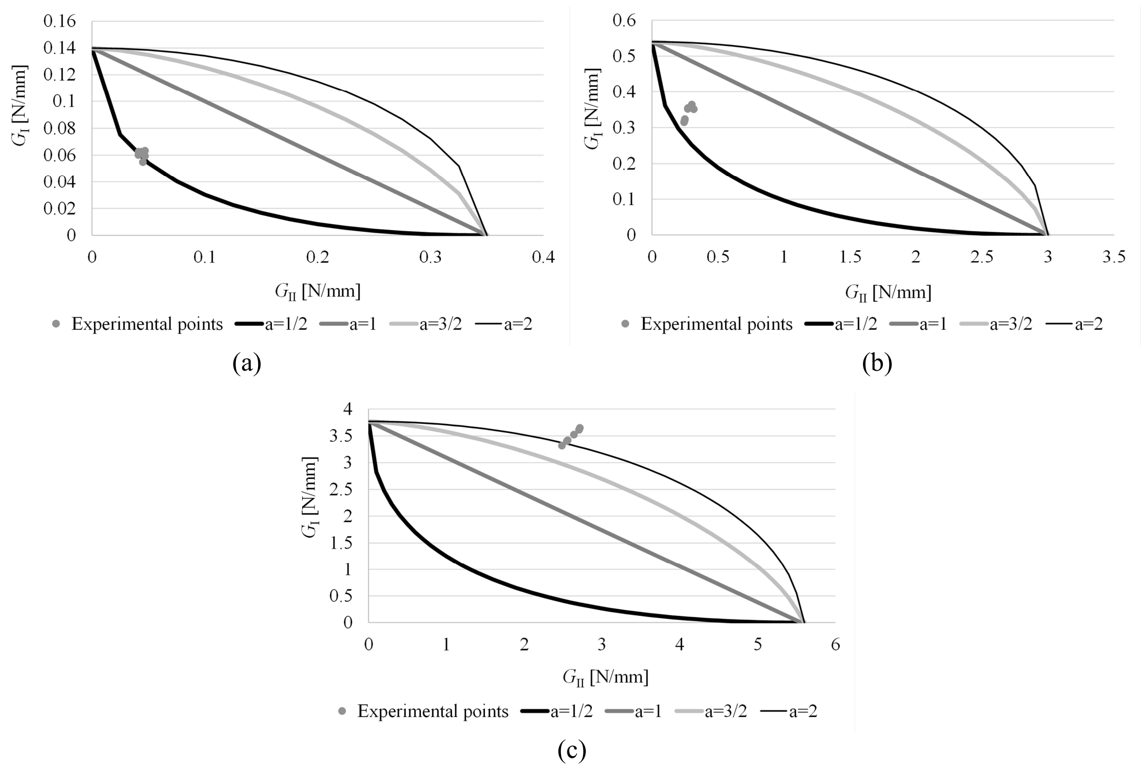

Fig. 1 - Idealised fracture envelopes and experimental G_I/G_{II} data points for each of the adhesives: (a) Araldite® AV138, (b) Araldite® 2015 and (c) Sikaforce® 7752.

REFERENCES

[1] da Silva, L.F.M. and Campilho, R.D.S.G. (2012). Advances in numerical modelling of adhesive joints. Heidelberg, Springer.