# Testing method to determine the strength and fracture toughness of adhesives in a single continuous test

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## Introduction

Different approaches can be used to tackle simultaneously the crack initiation and propagation in adhesive joints, however, what these approaches have in common is that they can be based on a stress and an energy criterion. Therefore, to predict and model the crack propagation along an adhesive bondline, it is necessary and sufficient to know the strength and the fracture toughness of the adhesive. These two properties are independent and, therefore, the two must be determined.

This work aims to validate a testing method [1], which combines the determination of strength and fracture toughness of the adhesive, enabling the direct application of the different methods explored above. This method aims to combine the advantages of pull-off and peel tests, enabling the evaluation of the joint properties in-situ, in a production line, in a single loading step.

## Experimental details

The testing method used in this work consisted of three pull-off tests followed by one peel test, Figure 1a. These four tests were performed in a single loading step, Figure 1b. A steel strip was used to combine the tests, as the flexible substrate of the peel test, and to ensure that the loading of the pull-off tests is purely tensile.

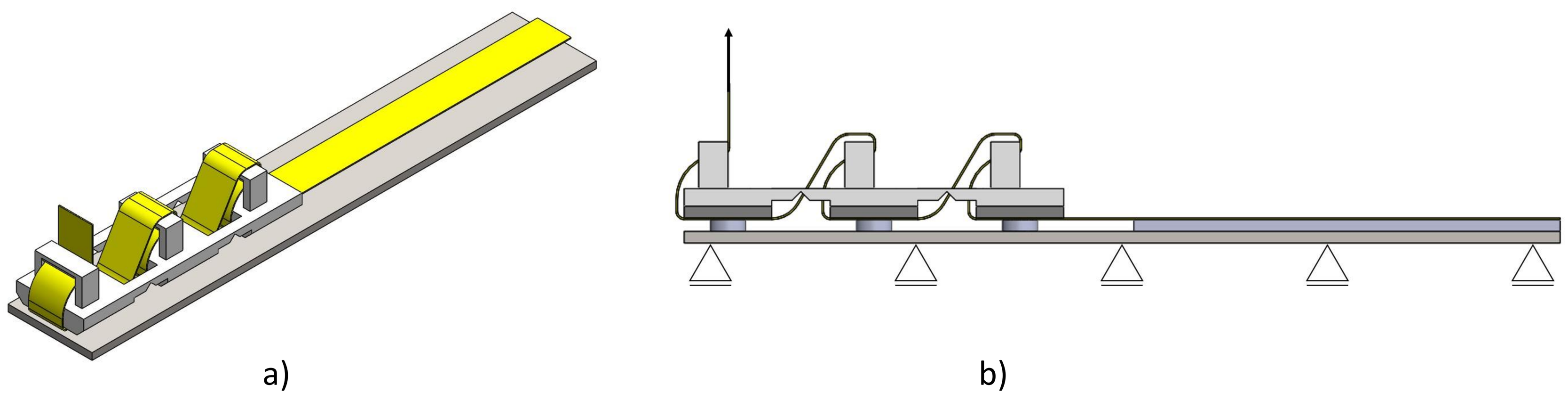


Figure 1 – Schematic representation of the joint tested a) and of the testing method b).

The pull-off test adhesive overlaps are circular, with a diameter of 6 mm. The width of the peel substrate is also 6 mm. The testing specimen used was composed of several materials, Figure 2. The part (1), correspondent to the pull-off tests was manufactured from polycarbonate (PC). The strip identified with the number (2) was 0.03 mm thick carbon steel 1.1274. The adhesive overlaps identified by (3) were manufactured from a two-part silicone adhesive, commercially available, characterized by Borges et al. [2].

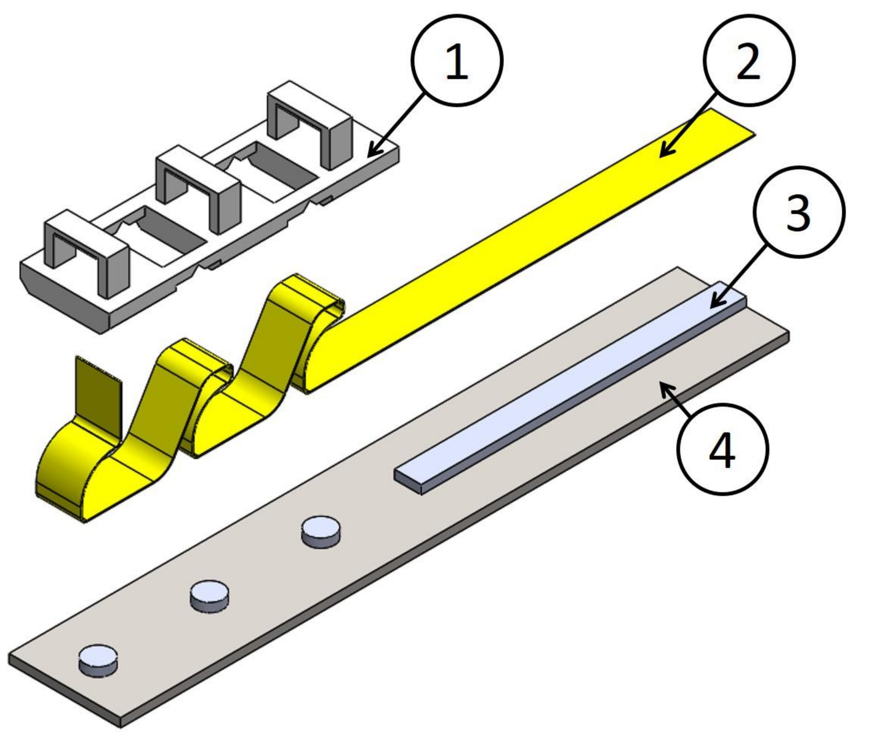


Figure 2 – Schematic representation of the different parts of the joint used for the test.

## Experimental results

The tests performed in this work correspond to three pull-off tests, which allow the determination of the strength of the adhesive, and one peel test, which allows the determination of the fracture toughness of the adhesive. For both tests the fracture surface of the joints was analyzed, exhibiting cohesive failure both in the pull-off and peel tests.

The curves obtained from these tests are represented in Figure 3.

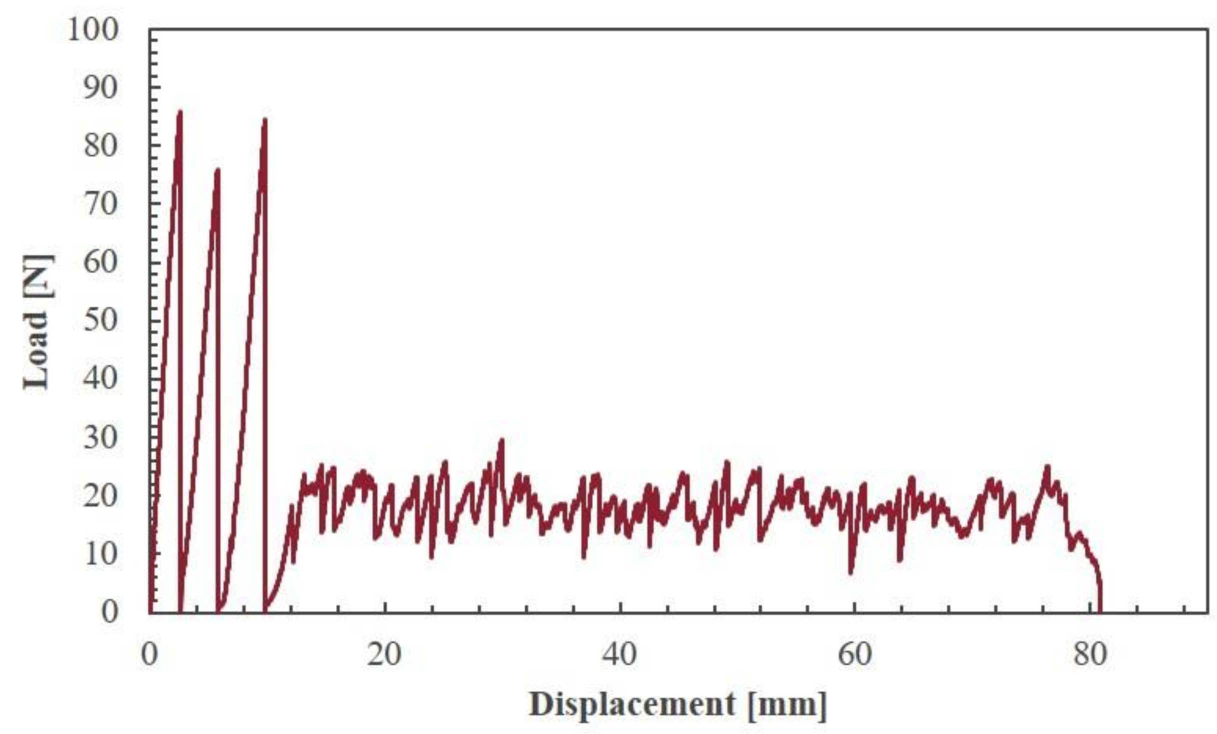


Figure 3 – Representative curve of the experimental results for one test.

From the results obtained it was possible to determine that the strength of the adhesive is 2.7±0.2 MPa.

In the peel test results, a Savitzky-Golay Filter was applied to get a smoother curve, by adjusting the window length and the order of the polynomial used, Figure 4.

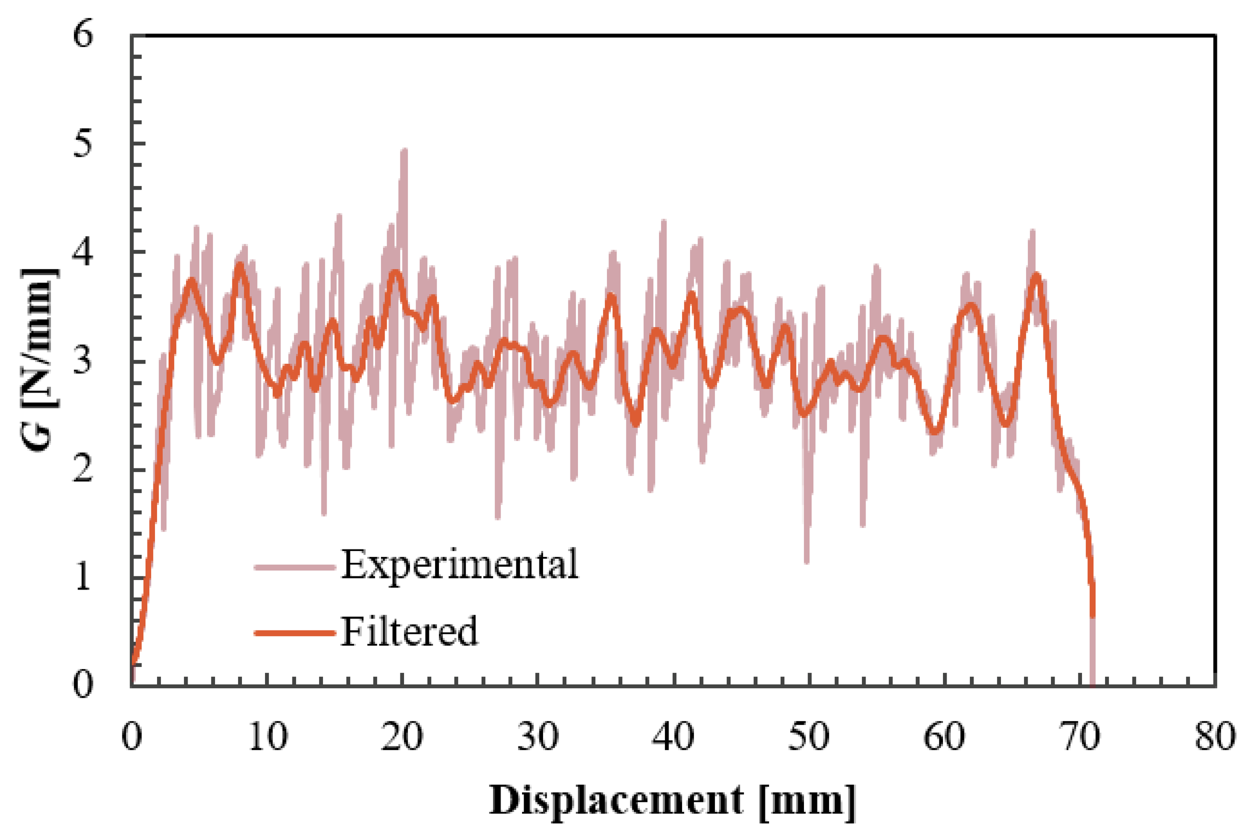


Figure 4 – Representative curve of the results for the peel tests.

Performing the same data treatment to the different tests performed, the energy release rate obtained was 3.0±0.1 N/mm.

## Conclusions

In this study, a method was successfully used to assess the strength and fracture toughness of an adhesive material. The determined strength of the adhesive was found to be lower than that obtained through bulk tensile tests. This difference can be attributed to the joint testing approach, where substrate constraints led to a lower determined strength for brittle adhesives. The critical energy release rate obtained from the peel test was similar to the standard DCB joint test. Additionally, the peel test showed that the loading was purely tensile, and there was no plastic deformation of the substrates during the test.

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## References

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[2] C.S.P. Borges, R. Brandão, A. Akhavan-Safar, E.A.S. Marques, R.J.C. Carbas, C. Ueffing, P. Weißgraeber, F. Schmid, and L.F.M. da Silva. Influence of water and surfactant contamination on the mechanical and chemical properties of a sili cone adhesive before and after curing. *The Journal of Adhesion*, 99:1–28, 2022.