Effect of joint geometry on mixed-mode fracture energy of adhesives

A. Akhavan-Safar (INEGI, Portugal), A. Ajdani, M.R. Ayatollahi, L.F.M. da Silva

ADVANCED JOINING PROCESSES UNIT

Introduction

Semi-circular bend (SCB) specimen has been recently introduced for pure mode and mixed-mode fracture energy measurement of adhesively bonded joints [1]. It has been successfully used for ductile and brittle adhesives [2]. In this work, the effect of substrates and adhesive bondline thickness on the obtained fracture energy of brittle adhesive joints from SCB specimen is studied.

Experimental methodology

A schematic view of modified SCB specimen for adhesive joints and its main geometrical parameters are presented in Fig.1. Table 1 provides the test matrix used to study the effect of substrates and adhesive bond line thicknesses on the fracture energy. Each configuration shown in this table represents 4 joints with 0,36,60 and 90 degrees mixed-mode phase angle ratios. Experiments were conducted using a universal test machine with standard three-point-bend fixture and 0.2 mm/min cross head speed. Obtained fracture loads were used in a 2-D finite element analysis to calculate fracture energy of the joints

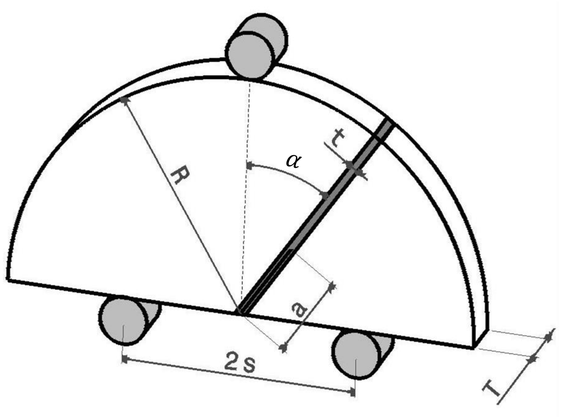

Figure 1 – SCB specimen.

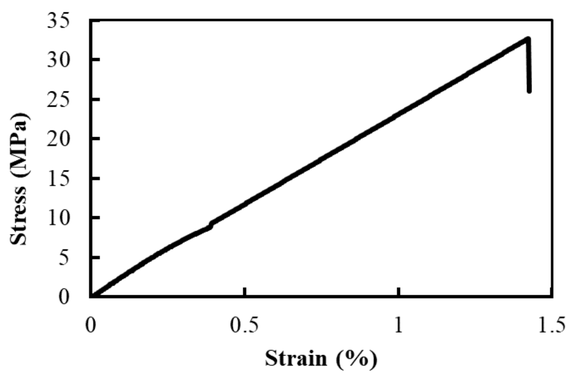

Figure 2 – Stress-strain curve of the used adhesive

Table 1– Test matrix

Joint name	Bond line thickness[mm]	Substrate thickness[mm]
J1	0.4	10
J2		20
J3	1	10

Discussion

Increase in substrate thickness, reduces the fracture energy of the adhesives (see Fig.4). Results showed that an increase in mixed-mode ratio causes an increases in the influence of the substrate thickness on the fracture energy of the tested adhesive. On the other hand, based on the results increasing the bond line thickness increases the fracture energy (see Fig.5). It was also found that the adhesive layer thickness has a small effect on pure mode I conditions. But the effect of bond line thickness increases with the mixed-mode ratio. Therefore, adhesive joint strength in pure mode II loading case is rather sensitive to the bondline thickness.

Experimental results

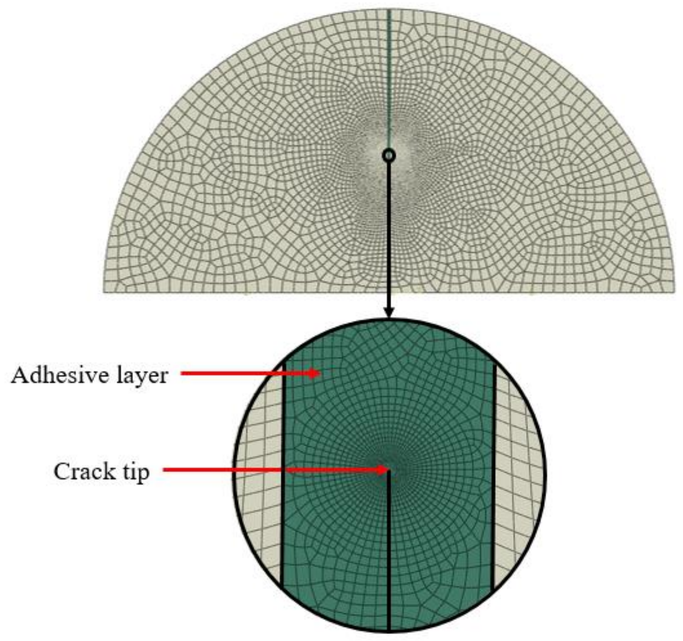

Figure 3 – Mesh used in FE analysis

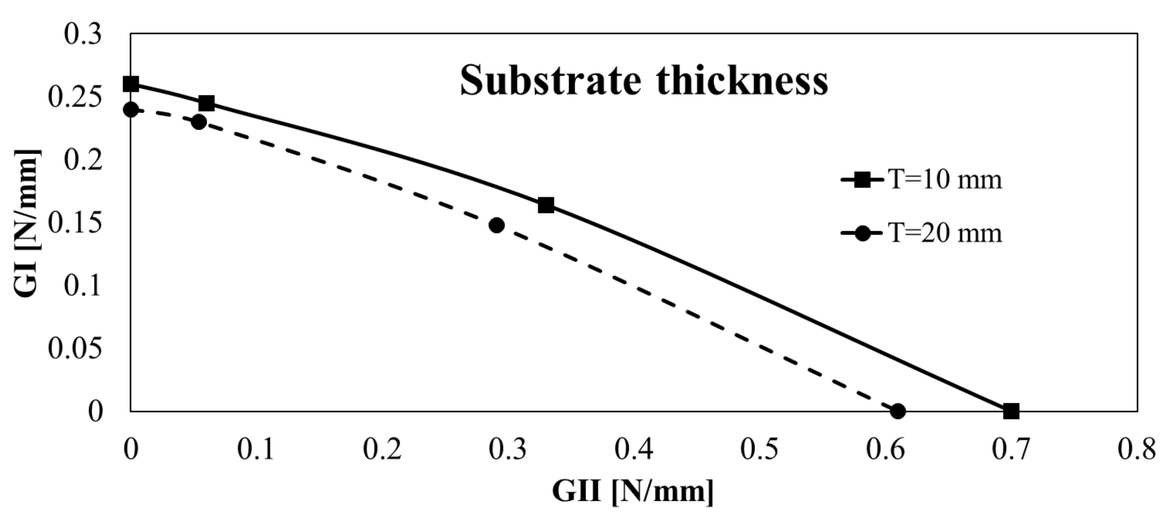

Figure 4 – Effect of substrate thickness on fracture energy

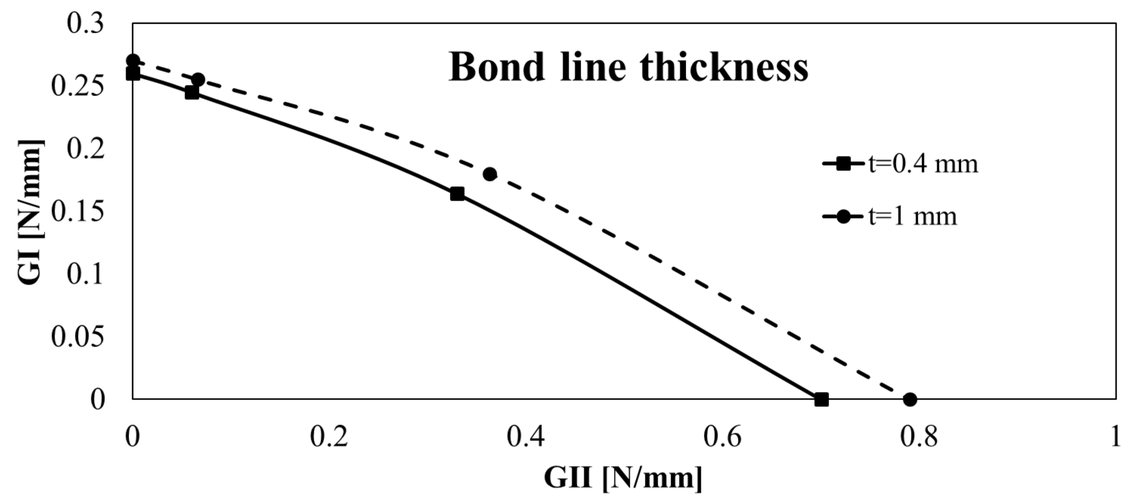

Figure 5 – Effect of bondline thickness on fracture energy

Conclusions

In this research, effects of bondline and substrate thicknesses were studied experimentally and numerically. Increment in substrate thickness decreases fracture energy but increment in bond line thickness increases the fracture energy. Fracture energy in mode II loading condition is more sensitive to both adhesive layer and substrate thickness.

References

[1] Ajdani, A, Ayatollahi, MR, Akhavan-safar, A, da Silva, LFM, International Journal of Adhesion and Adhesives, 101 (2020): 102629.

[2] Ajdani, A, Ayatollahi, MR, da Silva, LFM, Theoretical and Applied Fracture Mechanics, 112 (2021):102927.