Effect of cyclic aging on mode mixity in dissimilar DCB joints

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Introduction

Widespread application of CFRP and aluminum structures in different industries, generated considerable research interest in the fields of fractures of dissimilar adhesive joints [1]. In many structures such as shipbuilding [2] CFRP/aluminum adhesive joints are exposed to cyclic aging. This environmental conditions change the stiffness of the CFRP substrates and change the loading condition of adhesive joints. In this research the variation of mode mixity for DCB joints is studied.

Experimental methodology

The dissimilar DCB adhesive joints were fabricated by bonding of CFRP and aluminum 7075-T6 substrates. For bonding the structural epoxy adhesive Araldite 2011 was used (see Fig. 1).The thickness of the CFRP and Aluminum was calculated based on longitudinal strain criterion to achieve pure mode I loading [3]. The fabricated joints were exposed to cyclic aging condition (see Fig. 2).

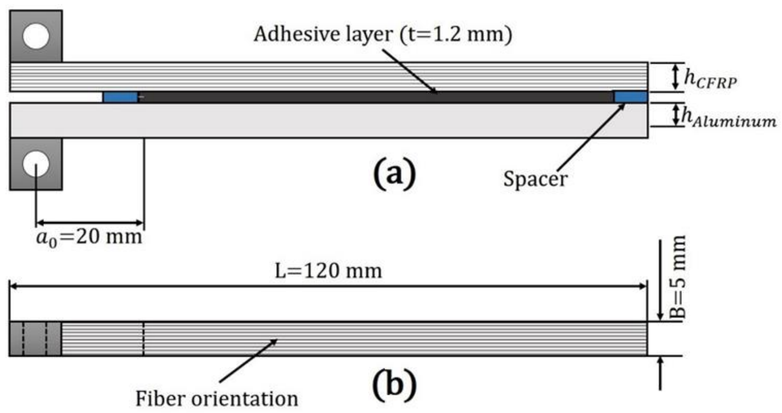

Fig. 1. Dissimilar DCB specimen.

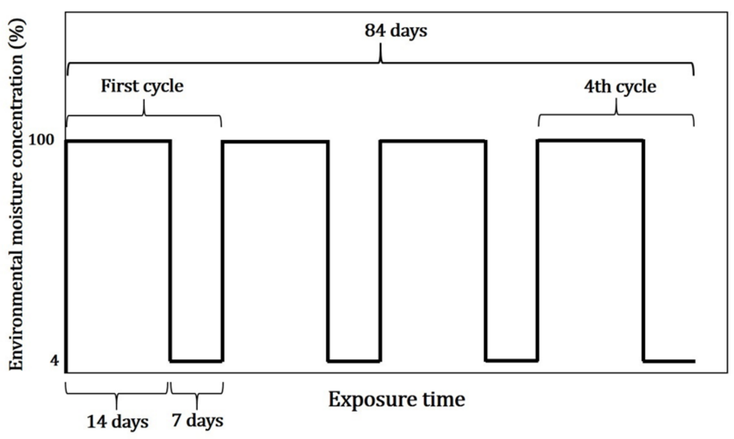

Fig. 2. Schematic of the cyclic aging process.

Discussion

Fig. 3 represents the displacement fields near the crack tip. The experimental results show that in the dissimilar DCB adhesive joints with CFRP/aluminium substrates the mode mixity increase with aging cycles. The variation of $\frac{K_{II}}{K_I}$ ratio which indicate mode mixity of DCB specimen is illustrated in Fig. 4. The mode I SIF deceases after cyclic. This decrease can be result of variation in mechanical properties of adhesive layer during the moisture uptake. The increasing of mode II SIF can be result of flexural stiffness drop and creation of residual stress in CFRP substrates.

Experimental results

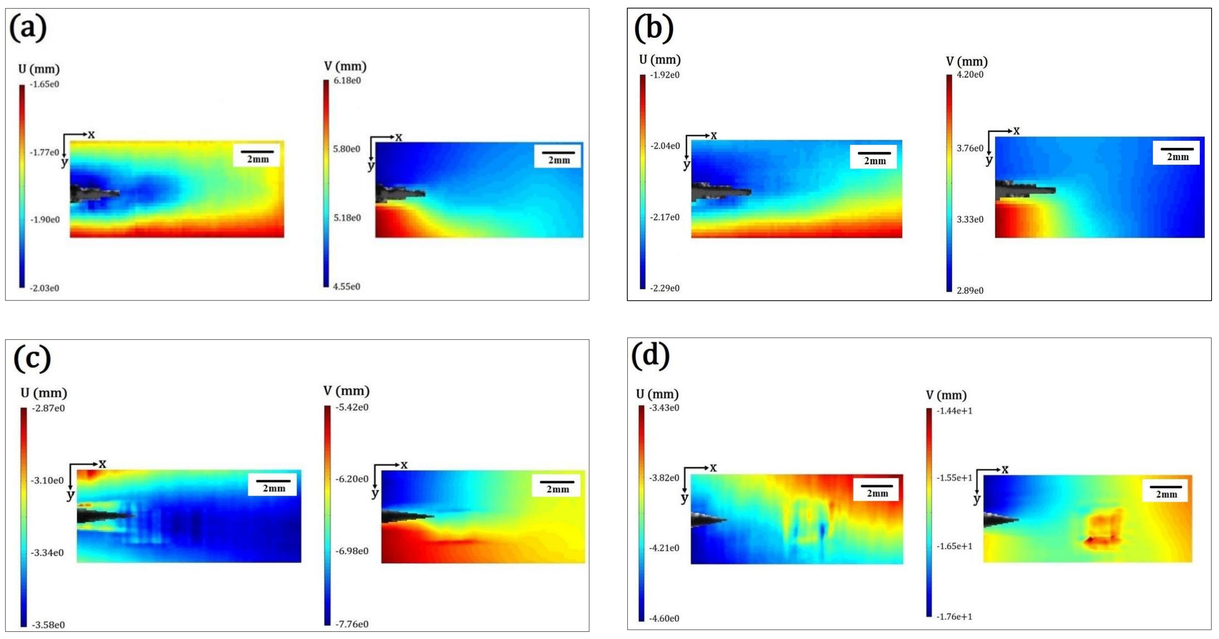

Fig. 3. Horizontal (U) and vertical (V) displacement fields in front of the crack tip for un-aged (a) and cyclically aged DCB specimen after one cycle (b), two cycles (c), and four cycles (d) aging.

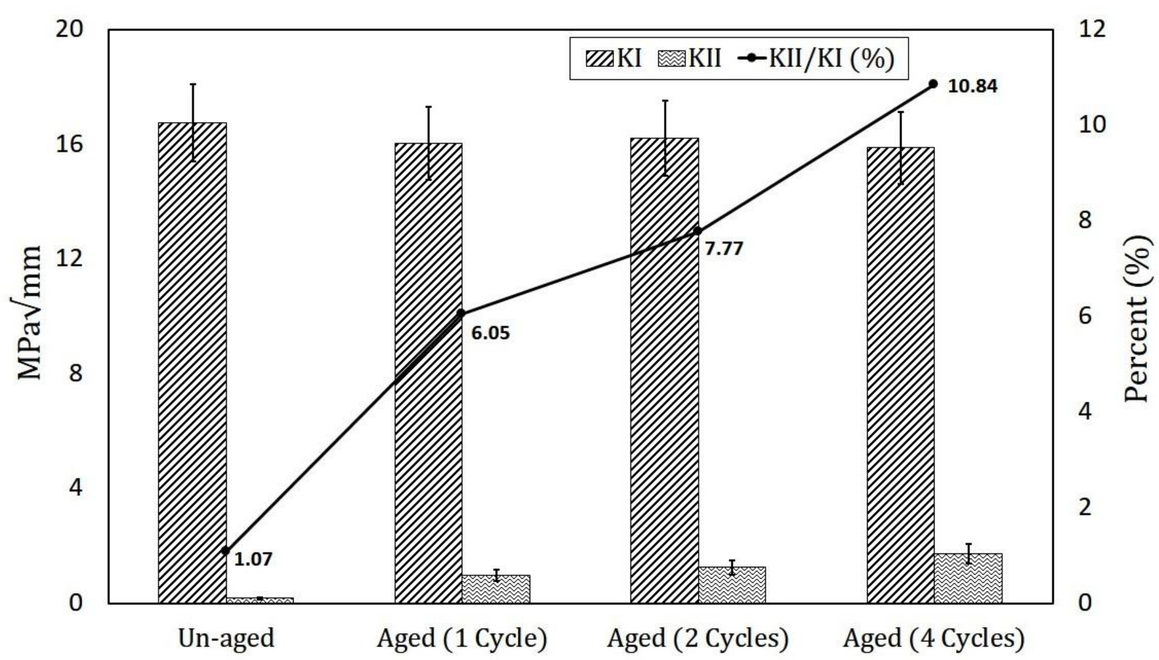

Fig. 4. Mode I and mode II SIFs obtained for un-aged and aged DCB specimens.

Conclusions

In the dissimilar DCB adhesive joints with CFRP/aluminium substrate the mode mixity increase with increasing aging cycles. The $\frac{K_{II}}{K_I}$ ratio which indicates mode mixity in dissimilar DCB specimen increase from 1.07 % in un-aged specimen to 10.84 % in the aged specimen after 4 cycles aging.

References

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[3] Wang W, Fernandes RL, De Freitas ST, Zarouchas D, Benedictus R. How pure mode I can be obtained in bi-material bonded DCB joints: A longitudinal strain-based criterion. Composites Part B: Engineering. 2018;153:137-48.