

Tensile fatigue life assessment of bonded joints subjected to cyclic ageing: Effects of ageing frequency and fatigue stress level

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Introduction

Moisture has a significant impact on the mechanical performance of bonded joints. In practice, adhesive joints are often exposed to cyclic environmental conditions. Accordingly, the effects of this phenomenon must be taken into account when designing the joint. On the other hand, the joints can also be exposed to cyclic mechanical loads. A combination of these two conditions can drastically reduce the lifetime of adhesively bonded structures [1,2]. The aim of the current study is to analyze the effects of cyclic ageing on the S-N behavior of bonded Arcan joints under pure tension loading conditions.

Experimental methodology

The Arcan substrate shown in Figure 1 was considered in this study. To investigate the fatigue strength under mode I loading condition, the Arcan joints were manufactured (Figure 2). The hygrothermal ageing was performed by immersing the Arcan joints in distilled water (Figure 3). The Arcan joints samples were then tested by using an Arcan testing device (Figure 4).

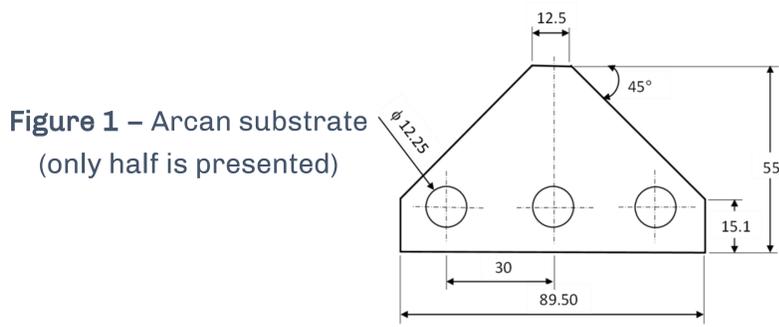


Figure 1 – Arcan substrate (only half is presented)

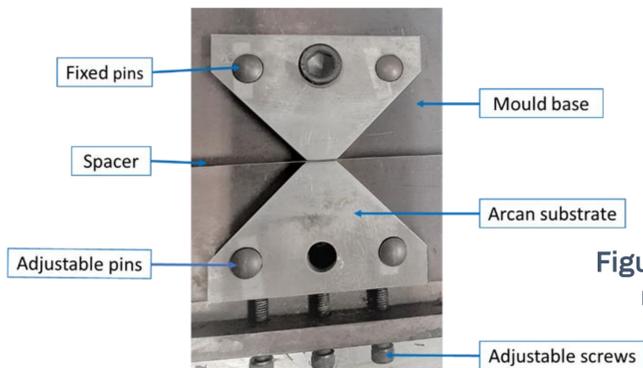


Figure 2 – Arcan joint manufacturing



Figure 3 – Arcan joint ageing

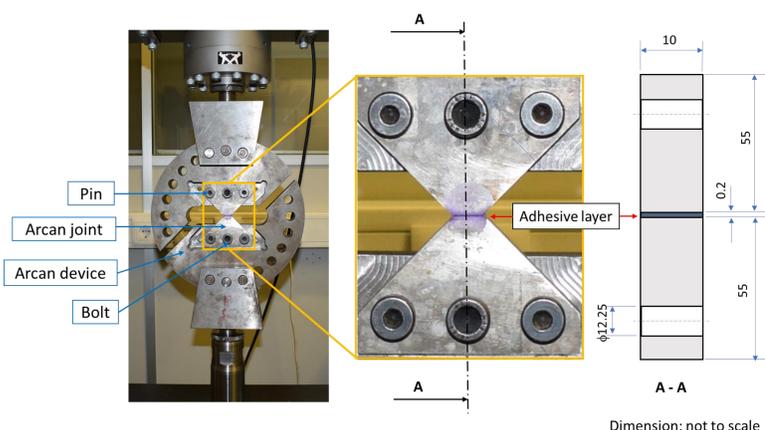


Figure 4 – Arcan testing device

Experimental results

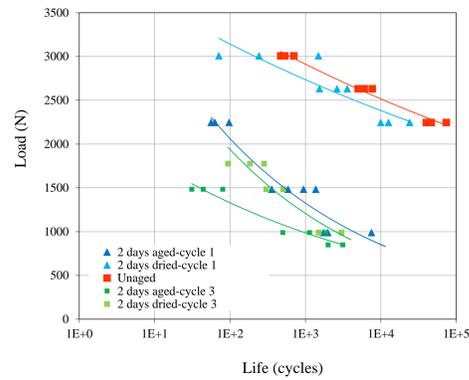


Figure 5 – The L-N curve for 2 days ageing frequency

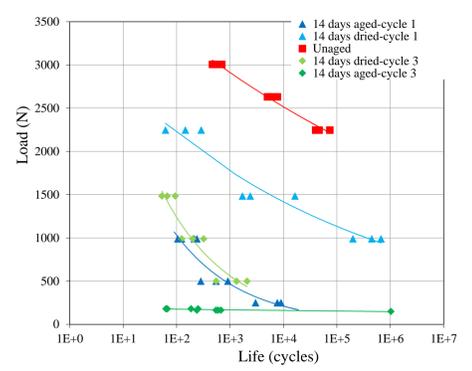


Figure 6 – The L-N curve for 14 days ageing frequency

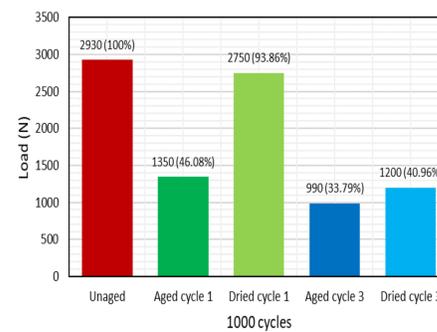


Figure 7 – Fatigue strength corresponding to 1000 loading cycles - 2 days ageing

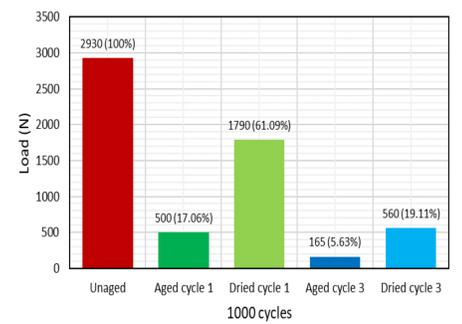


Figure 8 Fatigue strength corresponding to 1000 loading cycles - 14 days ageing

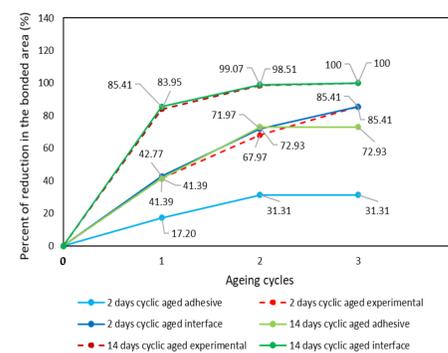


Figure 9 – Reduction in the bonded area for 2 and 14 days cyclic aged of Arcan joint

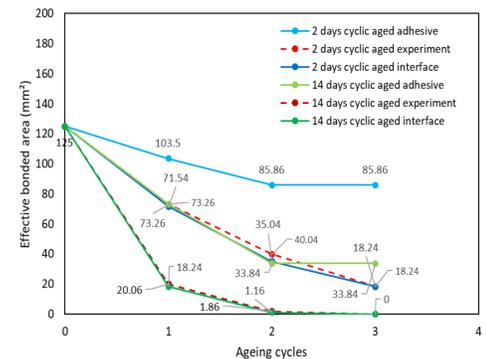


Figure 10 – Effective bonded area for 2 and 14 days ageing frequencies

Conclusions

Fatigue results showed that the joints are greatly affected by the moisture absorption and desorption phenomena. The tensile mechanical properties and the fatigue strength of the tested Arcan joints were significantly degraded by the increase of the ageing cycles. The fatigue strength reduction for the first and the third ageing cycles were found obtained as 46% and 34% for the ageing frequency of 2 days, and 17%, 6% for the 14-days ageing frequency. During the cyclic ageing mechanism, the interfacial ageing occurred, which affected the losses of the bonding strength where the bonded area tends to fail adhesively. The fatigue strength was recovered by the drying cycles; however, the properties were not returned to the initial stage as unaged condition. The cyclic ageing simulation of the adhesive joints, showed that the water diffusion through the interface becomes faster by increasing ageing cycles.

References

- [1] Viana G., Costa M., Banea M. D. and da Silva L.F.M. (2017). Behaviour of environmentally degraded epoxy adhesives as a function of temperature. The Journal of Adhesion, 93(1-2), 95-112.
- [2] da Costa J.A., Akhavan-Safar A., Marques E.A., Carbas R.J. and da Silva L.F.M. (2021). The influence of interfacial failure on the tensile S-N response of aged Arcan joints. Journal of Applied Polymer Science, 51991.