EFFECT OF THERMAL CYCLING ON STRESS - STRAIN BEHAVIOUR OF BONDED, RIVETED AND HYBRID JOINTS IN FAÇADE APPLICATIONS

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INTRODUCTION

The presented case study is focused on the verification of the effect of thermal cycling on the failure behaviour of bonded, riveted and hybrid joints in façade applications. Adhesive, as well as riveted joints, are already a common technique used in the area of façade implementation, however, hybrid joints are still a very rare solution.

A. To verify the impact of thermal cycling on the joint deformation behaviour is the main goal of the presented study.
B. To determine whether a hybrid joint can be a suitable solution for the purposed application area is the secondary aim.

The single lap joint (SLJ) designed according to EN 1465 was exposed to different 8 conditioning methods. These were:

1. cycles of sudden temperature changes (from +20 °C to +80 °C);
2. freeze-thaw cycles (from -20 °C to +20 °C);
3. combination of aforementioned methods, i.e. (from -20 °C to +20 °C and then from +20 °C to +80 °C);
4. immersion in rainwater at mild temperature ((45 ± 1) °C) for 21 days;
5. impact exposure and testing at high temperature above the service temperature limit (approx. 100 °C);
6. impact exposure and testing at low temperature ((-26 ± 2) °C);
7. exposure to UV radiation for 144 hours;
8. combination of eposure to humidity and low temperature ((-22 ± 2) °C) for 21 days;

A one-component modified polymer-based adhesive was selected. The adhesive used is a commercially available product intended for joining different materials and filing of gaps. The tested adhesive is flexible; with 25% elastic recovery and 500% elongation at break. Aluminium rivets ø 4.0/16 mm were used for both the riveted and hybrid joints. The SLJ was made of EN AW-6060 (AlMgSi) T66 aluminium alloy and aluminium composite panel called ALU-Bond (ACP). The shear strength of the SLJ under tension loading was tested.

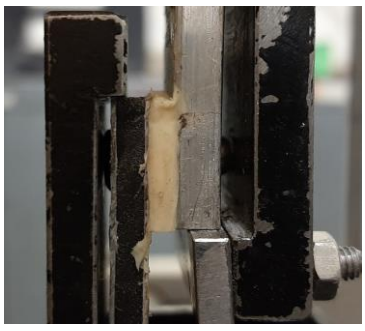
CONCLUSIONS

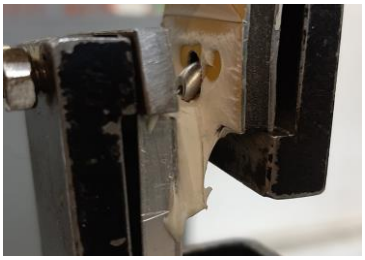
The experimental data show that the strengthening of the adhesively bonded joint with mechanical fastener has a positive effect on its strength and the total deformation behaviour. However, a higher normal stiffness was noted in conditioned hybrid joints. Due to the fastener, the joint was less ductile, and more brittle compared to the pure adhesive joint. On the contrary, a greater failure strain energy density was monitored in the hybrid joint.

The effect of artificial ageing was less severe for the adhesive joint and only cohesive joint failure was observed in this combination. On the contrary, in combination with rivet, i.e. in the hybrid joint design, combination of adhesive and cohesive failure was monitored. The adhesive failure in the interface between adhesive layer and ACP substrate in the area around the opening for the rivet was recorded.

<u>The main conclusions are:</u>

- Only a minor effect of different environmental conditions on adhesive joint strength in combination with selected substrates was observed;
- Similar deformation behaviour was monitored in all tested samples – the cohesive joint failure was almost 90%;
- The most critical for the main tested designs, i.e. bonded and hybrid joint, were methods no. 4 (immersion in rainwater at mild temperature ((45 ± 1) °C) for 21 days) and no. 5 (impact exposure and testing at high temperature above the service temperature limit (approx. 100 °C)), as can be seen in Figure 1. and Figure 2.;
- The less critical was the conditioning method no. 8 (combination of eposure to humidity and low temperature ((-22 ± 2) °C) for 21 days), as can be seen in Figure 1. and Figure 2.;





RESULTS

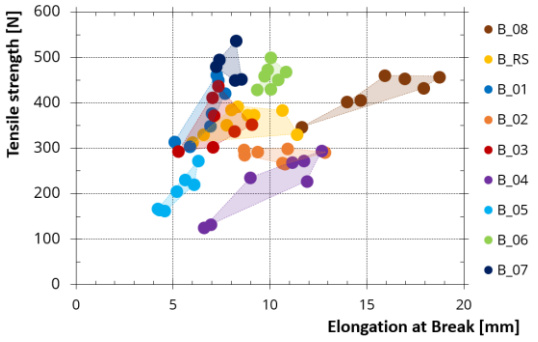


Figure 1. Strength/elongation comparison of bonded joints.

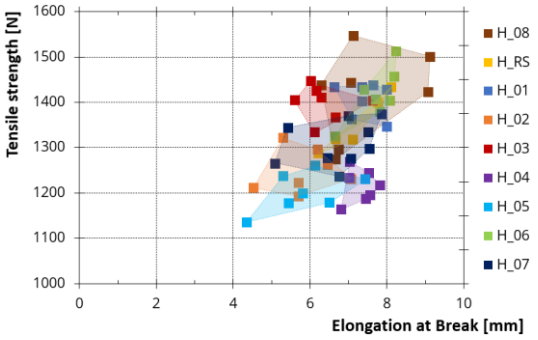


Figure 2. Strength/elongation comparison of hybrid joints.

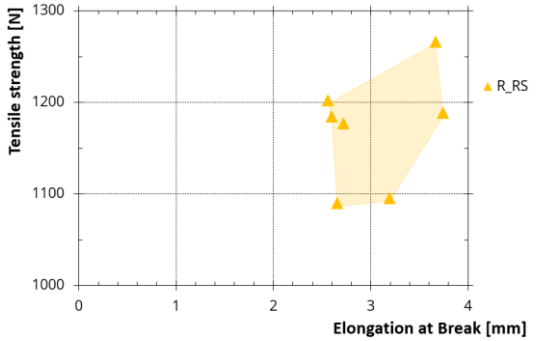


Figure 3. Strength/elongation relation of riveted joint.

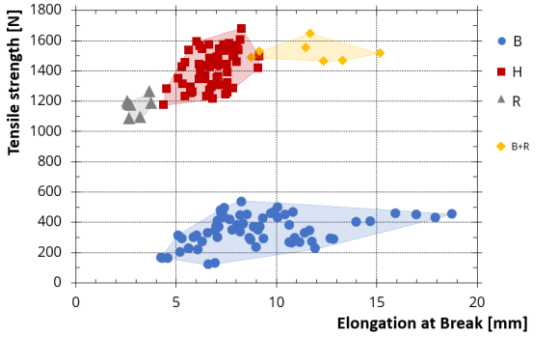


Figure 4. Comparison of tested joint designs.