Strain and Stress Field Measurement in Functionally Graded Adhesive Joints Bonded by Honeymoon Adhesion Using Two Types of Second Generation Acrylic Adhesives

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Abstract: In this study, the strain field of the adhesive layer in a functionally graded adhesive joint (FGAJ) was measured using the digital image correlation (DIC) method. The DIC results are compared to analytical results obtained by the finite element method (FEM). As a result, analytical shear strain using the FEM exhebits the same tendency of DIC results.
Keywords: Functionally graded adhesive joints / Digital image correlation method / Honeymoon adhesion / Second generation acrylic adhesives

1. Introduction

An adhesively bonded joint has stress concentration points at the both ends of the adhesive layer. As a method to make the stress distribution uniform, functionally graded adhesive joints (FGAJs) have been proposed by a few researchers. In this study, functionally graded adhesive joints was realized by honeymoon adhesion using second generation acrylic adhesives. Some authors have researched the joints to obtain the strain field using the finite element analysis method (FEM)[(1,2)], but experimental approach is still rare. In this study, the strain field of a FGAJ was measured using the digital image correlation (DIC) method. The DIC method is an optical experimental technique for measuring displacement and strain fields. The measured strain field was compared to analytical results calculated by the FEM.

2. Experimental

2.1 Specimens

For this study, two types of SGA, one was brittle and the other was flexible, were used. These adhesives were both two-component type, thus, the total number of components was four. So-called honeymoon adhesion, in which each component of an adhesive is applied to different adherends and the adhesive is cured when these components come into contact with each other, is used for the proposed method as shown in Figure 1. Single lap shear joint (SLJ) specimens were made with aluminum alloy adherends . The mixing ratio of the SGAs was varied to control the mechanical properties of the adhesive layer. The configuration and dimensions of the SLJ specimens for the research are shown in Figure 2.

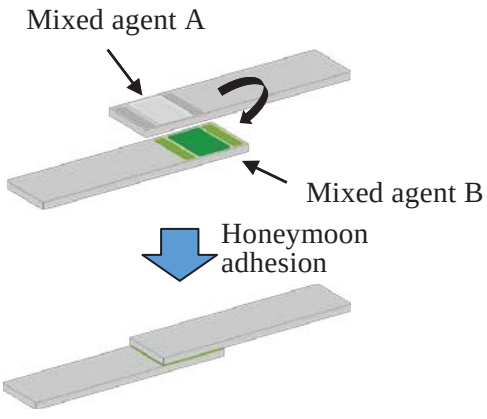


Figure 1. Schematic manufacturing method of FGAJs bonded by honeymoon adhesion

2.2 The experimental setup

Tensile tests of SLJs were performed using a servo-hydraulic cycle test machine (Instron 8802, Illinois Tool Works Inc., USA) that had a capacity of 100 kN. The experimental setup was shown in Figure 3. As shown in Figure 4 (a), an area captured by digital camera (LRA500PC-2S, Shodensha, Inc., Japan) is the upper half of adhesive layer in SLJs. An enlarged view of the random pattern is shown in Figure 4 (b).

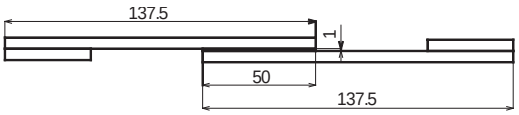


Figure 2. Schematic representation of a single lap shear joint (Dimensions in mm)

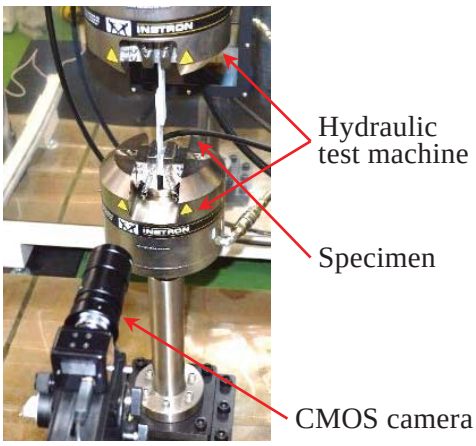


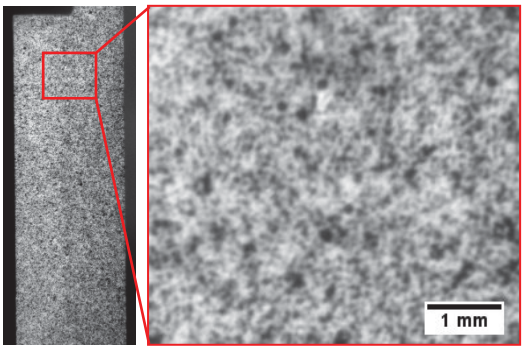
Figure 3. The experimental setup

3. Results and Discussion

From the comparison of DIC results with FEM results, the shear strains were underestimated by FEM compared to DIC. However, analytical shear strain exhibited the same tendency to the measurement results. And the stress field of adhesive layer is calculated based on the strain distribution. From the result of the stress field, FGAJ could reduce stress concentration at the ends of overlap in comparison with brittle adhesive alone.

4. Conclusions

- Strain and stress field of adhesive layer in the FGAJ could be measured using DIC technique.
- Analytical shear strain using the FEM denotes the same tendency of DIC results.
- FGAJ could reduce stress concentration at the ends of overlap.



(a) **(b)**

Figure 4. (a) The upper half of the SLJs and (b) Enlarged view of random pattern.

Acknowledgments

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ABSTRACTS

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