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Study on Simulation Analysis of DCB Aluminum Foam Adhesive Structures with Mode III-type

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Abstract. In this study, static analysis was carried out on DCB specimens manufactured with aluminum foam in order to investigate fracture characteristics at the adhesive joint of the structure bonded with adhesive. The result of the static analysis showed that maximum reaction force occurred when the forced displacement proceeds as much as 5mm. Maximum reaction forces became 0.25kN, 0.28kN, and 0.5kN with specimen thicknesses of 35mm, 45mm, and 55mm, respectively. By comparing the results of this study, the fracture characteristics of adhesive specimen models with aluminum foam were investigated. Based on this study data, it is thought that the data for variables other than the variables in this study can be acquired easily, and that the data would contribute to analyzing mechanical properties of DCB adhesive structures with mode III-type.

Keywords: Aluminum foam, Adhesive layer, Finite element analysis, Static analysis

1 Introduction

This study aims to study properties of the bonded structure with aluminum foam based on the aluminum foam for closed type. However, for the structures jointed only with adhesives, the data on fracture toughness on adhesive jointed part are mandatory to ensure the safe usage. The study on fracture toughness is especially important for the fracture properties of adhesive parts on aluminum foams, the porous materials, because these properties become different from those of nonporous materials. Therefore, by the basis of British standard (BS7991) and ISO international standard (ISO 11343), this study redesigned the aluminum foam for closed type bonded structure model by using single-lap bonding method as the specimen model of DCB mode III-type by thickness. For each specimen by thickness, the simulation analysis of static fracture was conducted by using the finite element analysis program of ANSYS. Based on results obtained from such method, the shear strength of DCB

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bonded structure constructed with porous aluminum foam can be predicted and evaluated through this study result [1].

2 Analysis Conditions

2.1 Analysis Model

The model with the configuration from British industrial standard 7991: 2001 was redesigned and 3D-modeled in the form of DCB bonded structure with single-lap bonding method, according to characteristics of this research. As shown in Fig. 1, the redesigned DCB bonded structure model was made with the thickness value of t as the variable. The width of its upper edge for the model is 80mm, the width of the lower edge is 130mm, and the length of lower edge is 190mm. The value of 50mm was determined by being based on form factor. Three models were designed with the thickness value(t) of 35mm, 45mm, and 55mm, each by the interval of 10mm [2].

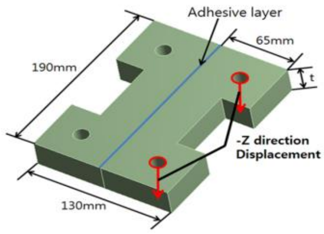

Fig. 1. Mode III-type specimen model

2.2 Analysis Conditions

The bottom face is fixed and the compressive force is applied downwards from the top. Therefore, the bottom face was under the fixed support condition while the compression acted downwards on the top face with the displacement applied on the –z direction. The connections were set as frictionless condition, allowing the slippage between elements. The analysis conditions are shown as Fig. 2.

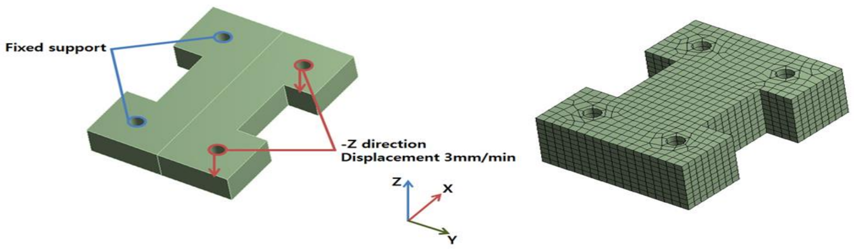

Fig. 2. Analysis condition of model

3 Analysis Results

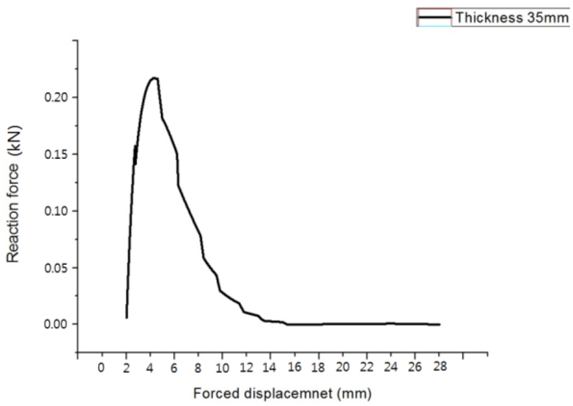

Fig. 3. Graph of reaction force due to forced displacement at static analysis*(Thickness of specimen is 35mm)*

Fig. 3 shows the analysis result of reaction data for DCB specimen model with the thickness(t) of 35mm, when pulling the specimen model with the direction of – Z axis by applying the forced displacement of 4mm/min. Maximum reaction force is shown when the forced displacement is approximately 5mm, and its value is approximately 0.25kN. After reaction force occurred, the adhesive strength on adhesive layer of specimen model decreased drastically. After the forced displacement passed approximately 12mm, the separation of adhesive layers of specimen was accomplished almost perfectly, with the reaction force on the forced displacement being almost 0. Fig. 4 is the analysis result of specimen with thickness (t) of 35mm, showing the stress distribution of specimen model along with the progress of forced displacement.

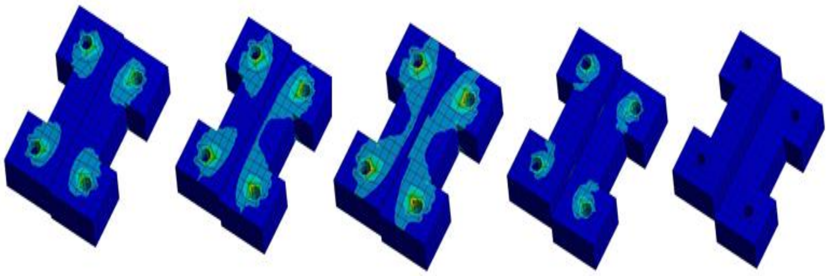

Fig. 4. Change of the equivalent stress according to the progress of forced displacement *(Thickness of specimen is 35mm)*

4 Future direction and practical application

Nowadays, the light weight of material and brevity of joint method are come to mind. So, the material with light weight and the joint method have been conducted. Aluminum foam becomes suitable for the light material and can be devoted at the light weight as it is possible to bond by using the adhesive. This study can secure the data about fracture characteristic of the practical structure bonded with aluminum foam and the result can be applied practically by verifying the safety. In future direction, it is thought that the data of the fracture characteristics at the more varied conditions can be obtained through the changes of the configuration, thickness and the bonded joint method at the structure bonded with aluminum foam.

5 Conclusion

This study aims to investigate static fracture properties on adhesive layers by conducting the static simulation analysis by thickness. Simulation analysis showed that maximum reaction forces of specimen models were approximately 0.25kN at the thickness(t) of 35mm, approximately 0.28kN at the thickness(t) of 45mm, and approximately 0.5kN at the thickness(t) of 55mm, respectively. As such, maximum reaction forces occurred at specimen models had the increasing tendency along with the increasing thickness. By comparing the obtained results, the fracture characteristics of adhesive specimen models with aluminum foam could be investigated. Based on this study data, it is thought that the data on variables other than the variables in this study can be acquired easily, and that the data would contribute to analyzing the mechanical properties of DCB adhesive structures with mode III-type.

Acknowledgments. The heading should be treated as a 3rd level heading and should not be assigned a number.

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