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Impact damage behavior of sandwich composite with aluminum foam core

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Abstract: Impact property of the sandwich composite with aluminum foam core was investigated by experiment and simulation analysis. Impact energies of 50, 70 and 100 J were applied to the specimens in impact tests. The results show that the striker penetrates the upper face sheet, causing the core to be damaged at 50 J test but the lower face sheet remains intact with no damage. At 70 J test, the striker penetrates the upper face sheet and the core，and causes the lower face sheet to be damaged. Finally at 100 J test, the striker penetrates both the upper face sheet and the core, and even the lower face sheet. The experimental and simulation results agree with each other. By the confirmation with the experimental results, all these simulation results can be applied on structure study of real sandwich composite with aluminum foam core effectively.
Key words: sandwich composite; aluminum foam core; impact energy; maximum load

1 Introduction

As the composite material has superior mechanical properties as well as specific rigidity and strength, the need for the composite material in automobile and aviation industry continuously grows [1,2]. The multi-pore material including metal foam material, refers to the material in which pores are distributed regularly or irregularly [3]. Such multi-pore material has the advantages of lightweight, impact-proof, and noise-prevention properties. The composites addressed in this study are multi-pore aluminum foam whose specific gravity is 1/10 that of solid aluminum metal and has excellent impact energy-absorption capability [4]. Impact tests for sandwich composite with aluminum foam core were carried out to examine its mechanical properties [5,6]. The specimens in this study were sandwich composite with aluminum foam core where various impact energies such as 50 J, 70 J, and 100 J were applied for impact tests. The mechanical properties of sandwich composite with aluminum foam core by impact experiment were studied and compared with those of simulation analysis [7−10]. Through the experiments, the displacement configuration of the specimens was investigated. The relations of load to time and energy to time were analyzed. Through analysis, the data on impact property of specimens were secured and the design method of 3-dimensional model was suggested [10−14]. Through the finite element model, the mechanical properties of the material that is the same as the experimental material in impact tests were studied. Load, energy and deformation of the analysis result similar to the experimental data were verified in this study [15,16].

2 Experimental

As seen in Fig. 1, the thickness of the face sheet is 1 mm, its total height is 20 mm, and its length and width are both 100 mm.

As the characteristics of sandwich composite with aluminum foam core, the face sheet is Al-3003 and the core is Al-foam. And the mass of a specimen is 128 g, and the density of the core is 0.4 g/cm³. The impact energies of 50 J, 70 J and 100 J are applied to the impact tests, respectively. As the working principle of experimental

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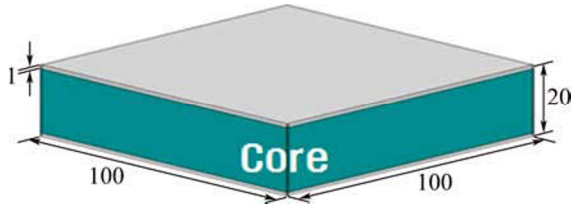

Fig. 1 Dimensions of test specimen (Unit: mm)

apparatus, the impact energy is increased by increasing the impact velocity of penetrator.

The experimental apparatus used in this experiment is Intron's Dynatup 9250 HV. The diameter of the striker is 12.5 mm. The impact energy of the striker is 50 , 70 J and 100 J. After the impact test, the computer data are produced. The experimental apparatus is shown in Fig. 2.

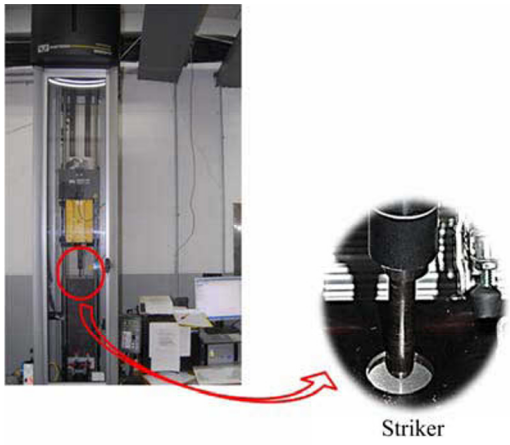

Fig. 2 Experimental apparatus used in experiment

3 Finite element modeling

Figure 3 shows the finite element model of which the material is the same as the experimental specimen. The finite element model is divided as tetrahedral element. The numbers of nodes and elements are 9832 and 6264, respectively. The material properties are shown in Table 1. The striker is assumed as rigid body. And the materials of the face sheet and core sheet are Al-3003 and Al-SAF40, respectively.

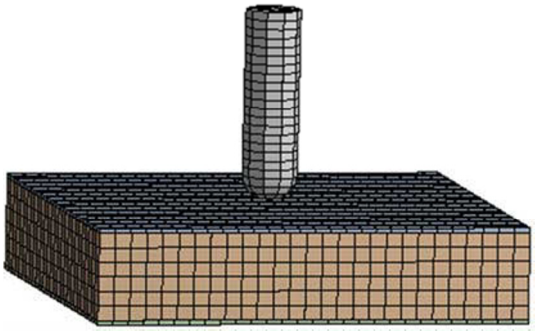

Fig. 3 Finite element model

Table 1 Material properties of analysis model

Material	Density/ ($kg \cdot m^{-3}$)	Elastic modulus/ GPa	Poisson ratio	Yield strength/ MPa	Shear modulus/ GPa
Al-SAF40	400	2.374	0.29	1.8	0.92
Al-3003	2730	66.5	0.33	186	25

Figure 4 shows the constraint condition of simulation analysis. The striker is applied with impact speed as shown in Fig. 4. The contact between core sheet and face sheet is bonding. The contact between the striker and the specimen is frictionless. The end face of core sheet is set as fixed support. The impact velocity conditions on impact energy applied on striker are shown in Table 2.

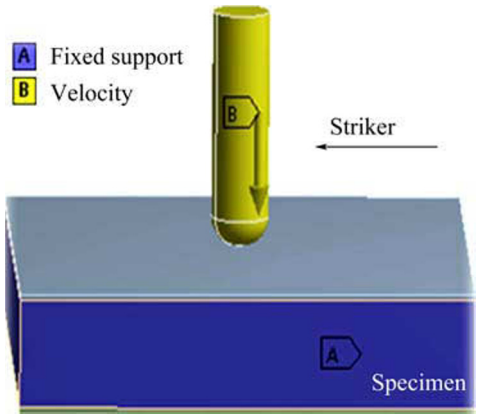

Fig. 4 Constraint condition of simulation analysis

Table 2 Impact velocity according to impact energy

Impact energy/J	Impact velocity/($m \cdot s^{-1}$)
50	2.3
70	2.7
100	3.3

4 Experimental and analysis results

4.1 Results after applying impact energy of 50 J

Figure 5 shows the cutting face of specimen after applying impact energy of 50 J in experiment and analysis. The striker penetrates 8 mm in specimen, showing that the striker generally causes damage to the middle of the core, penetrating the upper face sheet, but not damaging the lower face sheet. In experimental and analysis results, the striker pierces the specimen to the depth of 8 and 9 mm, respectively. The simulation result is not different from the experiment result.

Figure 6 shows the result in load graph over the time after applying impact energy of 50 J in experiment and analysis. In the experimental and analysis results, the maximum loads appear at 4 and 3.4 ms. And the