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Experimental investigation on empty aluminium honeycomb under quasi-static lateral compression

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ABSTRACT – In the span of last decades, honeycomb structures gained more attention in the field of energy absorption. The honeycomb structures especially made of aluminium has been investigated experimentally, analytically and through simulation in order to study their behavior. In this paper, the honeycomb had undergone a lateral compression. It is found that the honeycomb compressed in x_1 direction produced higher collapse load value, mean crushing value and energy absorption value compared to the honeycomb compressed in x_2 direction.

1. INTRODUCTION

Over the years, extensive research has been conducted on honeycomb structures. In the energy absorption structures, honeycomb cores are very popular as it offers good energy absorbing capability as well as lightweight yet high stiffness properties. Researchers [1-6] had investigated the behaviour of the honeycomb that undergone quasi-static loading. [5] found that during the compression, collapse mode of the honeycomb will be initiated at "top" and lastly forming a "V-shaped" type of deformation.

There are some differences in term of resulting graph of honeycomb compression. In axial loading, the energy absorption value is usually high. In addition, the existence of peak load can be observed. This peak load is one of the important characteristic of energy absorption. It is preferable if the peak load value is reduce the damage to the structure/device. Meanwhile, in the lateral loading, the energy absorption value produced is usually lower compared to the axial loading. However, the peak load does not exist in this situation.

2. METHODOLOGY

The presented result used aluminium honeycomb Al3003-H18 which is also known as Aluminium Commercial Grade (ACG) core with the size of 42 (6x7) cells. The other properties of the honeycomb core are tabulated in Table 1. The specimens were compressed in quasi-static condition with a speed of 5mm/min in two directions of "x_1" and "x_2" as illustrated in Figure 1.

Table 1 Properties of Al3003-H18 honeycomb.

Properties	Data
Young Modulus	69 GPa
Yield stress	115.8 MPa
Poisson's ratio	0.33
Ultimate stress	154.5 MPa
Cell size	12.7 mm
Cell thickness	0.007 mm

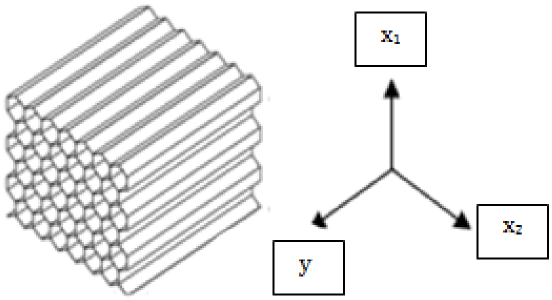

Figure 1 Direction of compression, x_1 and x_2.

3. RESULTS AND DISCUSSION

Based on the present result and previous research, it is found that the specimens undergone three important stages during the compression process. The first stage is known as linear elastic in which the specimen deformed until the critical stress is reached. Next, a plateau stage started in which the load is relatively constant up to certain value of displacement. Densification is the last stage of the compression where the load elevated steeply.

3.1 Lateral compression (x_1-directions)

According to Figure 2, it is observed that the collapse load of the specimen is 73.4 N at the displacement of 16.7 mm. The plateau stage follows afterwards and ended at the displacement of 69.3 mm in which the densification point is achieved. From the observation made, the deforming mode of the specimen started at the middle part (left side) of the specimen. The band then propagated to the opposite side. After the cells in the middle part were completely deformed, the band continued to propagate into the nearby cells.

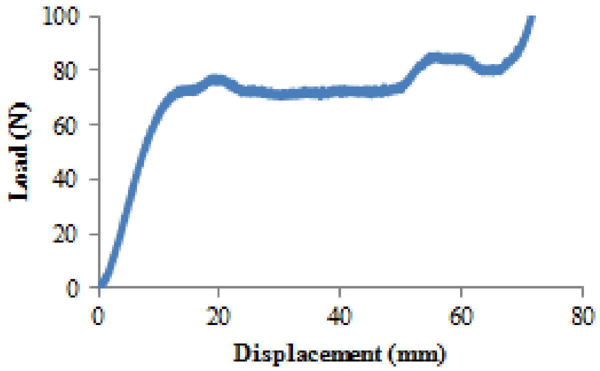

Figure 2 Load-displacement curve for x_1 direction.

3.2 *Lateral compression (x_2-direction)*

By referring to Figure 3, it is shown that the collapse load for the specimen compressed in this direction is 36.2 N at the displacement of 18.2 mm. The load then becomes steady until the densification stage started at 85.5 mm. The deforming mode of this specimen was started at the top-left side and the band propagated diagonally to the bottom-right side. Next, the band collapse spreads to the nearby cells in progressive way.

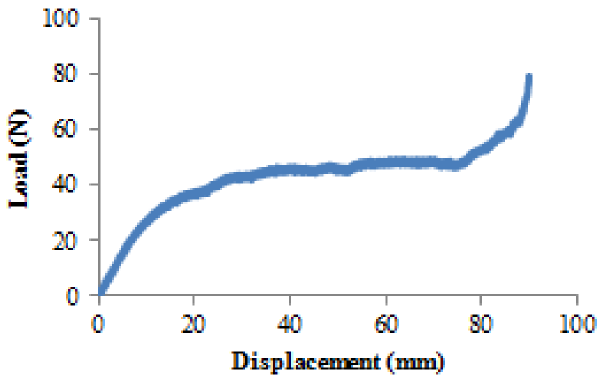

Figure 3 Load-displacement curve for x_2 direction.

Based on the attained result, the energy absorption value for all specimen were found by calculating the area under the graph. Other than that, the value of collapse load and mean crushing load were also calculated as shown in Table 2. Since the honeycomb compressed in x_1 direction has higher collapse load compared to the x_2 direction by a factor of 1.36, it contribute greatly for both mean crushing and energy absorption values. The factor that can contribute to this value is that the specimen in x_1 direction is stiffer than that in x_2 direction. Besides, the cell arrangement of honeycomb in x_2 direction make the cell to collapse easier compared to the cell arrangement in x_1 direction.

Table 2 Collapse load, energy absorption value and mean crushing load for both specimens.

Specimen	X_1 direction	X_2 direction
Collapse load (N)	72.4	42.2
Energy Absorption value (J)	5.2708	3.8815
Mean crushing load (N)	71.28	43.12

4. CONCLUSION

From the experiment, it is found that the cell of honeycomb compressed in x1 direction started to collapse from the left-middle part and propagate to the opposite side of the part (right-middle). Meanwhile, for the honeycomb compressed in x_2 direction, the collapse bands started at the top-left part and propagate diagonally to bottom-right part. In term of collapse load, energy absorption value and mean crushing load, honeycomb compressed in x_1 direction was superior to the honeycomb compressed in x_2 direction. This is largely due to the higher stiffness value and better cell arrangement of the honeycomb in x_1 direction.

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