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Analytical work of honeycomb based on single ring hexagonal ring subjected to quasi-static lateral loading

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ABSTRACT – Over the years, there are many experimental works done in order to investigate the effect of lateral loading on honeycomb. The works however were only validated by using software such as Finite Element Analysis (FEA) and ABAQUS. This paper attempted to validate the result of the experiment by using the single theory on a single hexagonal ring compressed across face which was developed by previous researcher. It is found that the difference between theoretical and experimental value for the compression across faces is 22.46%.

1. INTRODUCTION

Structures that are deformable such as honeycombs as in Figure 1 are often used as an energy absorber. Honeycomb, in particular, is widely used as it has a relatively strong and stiff properties, as well as its good energy absorption characteristics and cost-effective. Previous researcher has found that the energy absorption of tubular structures can be increased by the addition of filler such as foam and wood [1,2,3,4,5,6]. These findings were found in both axial (out-of-plane) and lateral (in-plane) crushing mode. For lateral loading on a single hexagonal ring, it has been found that the collapse load in ring compressed across face is higher than that compressed across corner by a factor of 1.8 [7]. The objective of this paper is to find the energy absorbed by multi-cells honeycomb (hexagonal-shaped) and compare it with the single hexagonal ring theory.

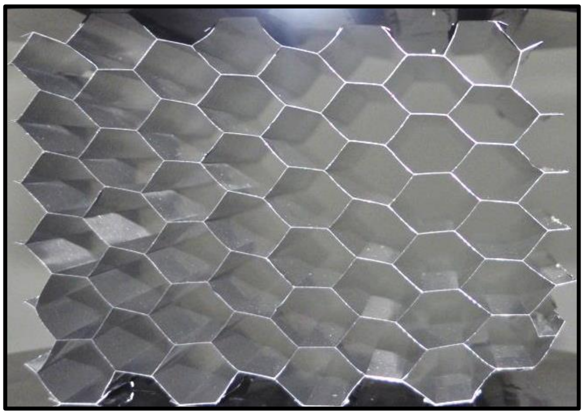

Figure 1 Multi-cell honeycomb

2. METHODOLOGY

Results that presented later used aluminum honeycomb 3003-H18 with the data in Table 1. The basic collapse mechanisms of the hexagonal ring were introduced in [7]. As shown in Figure 2, there are two methods to compress the specimen laterally namely corner and face. By assuming the model to be rigid perfectly plastic, some formulas were derived. The formulas derived by considering the mode of deformation stages. During the compression across faces, the first mode of deformation is known as Mode 1 Phase 1 (M1P1). In the second phase, there are two modes of deformation, namely Mode 2 Phase 1 (M2P1) and Mode 2 Phase 2 (M2P2) is observed and formulated.

Table 1 Data for aluminium honeycomb 3003-H18

Properties	**Data**
Dimensions	100mm x 100mm x 100mm
Poisson ratio	0.33
Yield Strength	115.8 MPa

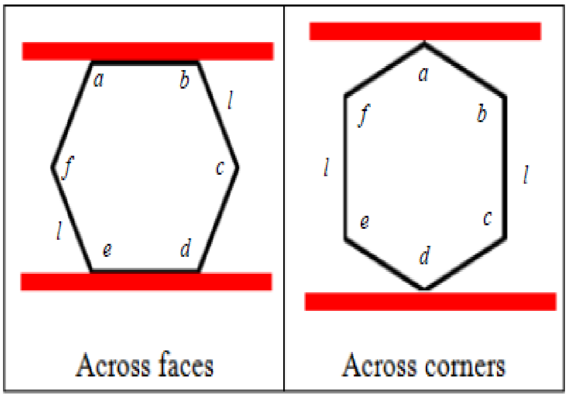

Figure 2 Compression method under lateral loading

Figure 3 shows the basic collapse mode of honeycomb under lateral loading. During compression, all shows a linear-elastic behaviour at the first regime. It is then followed by the second regime in which a plateau of roughly constant stress is observed. In the final regime, a steeply rising stress is detected [7].

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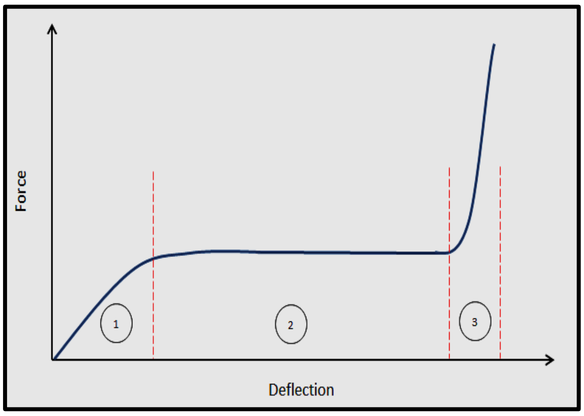

Figure 3 Basic collapse mode of honeycomb under lateral loading, where region 1, region 2, and region 3 is Linear-elastic, Plateau and Densification respectively

3. RESULTS AND DISCUSSION

From the experiment conducted, it is found that the collapse behavior of the specimen agrees with the theoretical collapse mode for metal. In addition, there are some distinctive differences between the theoretical and experimental graph for both cases. The specimen are assumed to be in perfect condition (perfect hexagonal shape) either in theory and experiment. Based on this assumption, there are slight differences between the theoretical and experimental graphs for both cases. By referring to Figure 4, the energy absorbed by the specimens is obtained by calculating the area under graph for both theoretical and experimental. The energy absorption value for the theory is 2.73 Nmm whereas 2.23 Nmm for the experiment. These values were differed by 22.46%. In addition, by using a simple empirical formula, it is found that the theoretical graph agrees with the experimental graph by a factor of 3 cells.

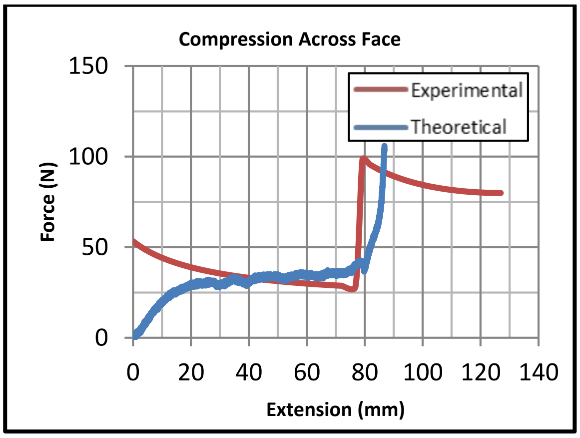

Figure 4 The load against displacement curve for compression across faces

4. CONCLUSIONS

As a conclusion, the results of analytical work agree significantly with the theory of the single ring developed in terms of deformation. For the energy absorbing capacity for the theoretical and experimental work, it is found to be a difference of 22.46%. It is also found that the experimental graph is higher compared to the theoretical graph by a factor of 3 cells.

5. REFERENCES

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