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Axial Crushing of Aluminum Honey Comb under Dynamic Loading Condition

[1]Mr Srinivasa K, [2] Mr Sachin B, [3] Mr Rakshith N, [4] Mr Karthik Kumar M, [5] Mr Pavan Kumar K P

[1]Associate Professor, Department of Mechanical Engineering, ATMECE, Mysore
[2,3,4,5]Assistant Professor, Department of Mechanical Engineering, ATMECE, Mysore

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Abstract - *The study of worldwide association, has anticipated that honeycomb would develop at a Compound Annual Growth Rate (CAGR) of 8.5%. The assimilation capacities are about under half for industrially accessible honeycomb. Honeycomb has significant focal points in air ship, space transport and building industry. Numerous scientists are taking a shot at both trial and FE about for enhancing the vitality retention abilities hence, the principle plan to lead both test and FE investigation to contemplate normal for honeycomb under stacking conditions.*

To satisfy the objective, honeycomb structures of 75x75x35mm are readied. The readied examples are subjected to two tests in particular semi static and dynamic in the electronic UTM and drop weight machine separately. Limited component investigation is made utilizing LS Dyna, by taking component sorts of MAT24, MAT20 for honeycomb and impactor individually. The base hubs are obliged in all DOF and load is connected, to acquire the outcomes. These outcomes offer esteemed recommendations in the assembling of materials with high retention of vitality.

Key Words: *Honeycomb, semi static test, dynamic test, drop weight test*

1. INTRODUCTION

The collisions of the vehicles are the most common issue since 80% of the automobile vehicles are crashed on roads due to collisions, which the society is facing nowadays. These collisions of vehicles not only affect the occupants of vehicles but also it effects on other structures. Hence it is important to find the solutions for the collisions, which increase the protection without compromising the structural integrity. Therefore, there is urgent need for designing of light weight and high energy absorption cellular materials used in the applications for high velocity and low velocity loads.

Cellular materials are having consideration for design properties because of stiffness and less weight, also having good energy absorption quality. A cellular solid is prepared by network of interconnected solid struts or plates and also edges and faces are formed. The polygons of two dimensions can be used to fill area like the hexagonal cells of bee, due to this introduction of such two-dimensional cellular materials called honeycombs is evolved. The various mechanical properties of cellular solids are affected by imperfections such as variations in cell wall thickness, non-uniform cell shape etc. Honeycomb-like materials are utilized for light weight aviation segments. Cellular solids have great advantages in the field of impact engineering as they absorb more kinetic energy by undergoing plastic deformation. In recent trends in material processing and structural designs, honeycombs are exhibiting significant characteristics.

When honeycomb is loaded, work is done by the force applied to it, the area under stress strain curve shows the work done due to deformation strain ϵ of honeycomb. Due to the strain, small amount of energy is absorbed in linear elastic region. The plateau shows the crumble of cell by buckling, crushing and yielding in the stress strain curve. After plateau zone, the crushing takes place with the increasing load, the region that comes under this is densification zone. At the starting of this zone the structure seems like perforated plate, further compression reduces the thickness of the plate.

Ramesh S. Sharma et al[1]., The study is focused on cluster of cells, this means group or assembly of cells with solid edges tightly packed together so that it fills the space, such materials are called cellular solids. Tom Bitzer [2] has studied honeycomb materials, manufacturing, applications, testing on sandwich panels, material properties. He also studied the types of processes and honeycomb cores that are used. S T Hong et al [3]., studied that inclusion of shear stress on crush behavior of honeycomb under compression will dominate the combined loads. They prepared the specimens such that non uniform stresses at boundaries can be minimized and noted the microscopic and macroscopic behavior of honeycomb. The experiment results suggested the non normality of plastic flow and these results were used to develop microscopic models under plasticity.

Investigation shows that, cellular materials are stiffer and stronger, when the honeycomb core is sandwiched between the plates it increases strength, the bonding is strong between the cell walls and the structure becomes lighter. But, it cannot be used directly for applications, since the recent design makes moist air into cells of honeycomb which causes rusting and thus reducing strength and the plates increases the weight and energy absorption decreases. In this work, a effort is made to form honeycomb structures without face plates, the hexagonal cells which results in substantial reduction in weight without concession in strength, stiffness and increasing the energy absorption capacity.

The aim is to develop honeycomb structures and study the behavior under dynamic conditions, other objectives is to determine the absorption capacity of kinetic energy of honeycomb cores under velocity impact dynamic conditions. Deformation behavior of honeycomb structures is also done, comparison of energy absorbed results under different loading. FEA simulation of honeycomb, using LS dyna and also comparison of these results with experimental under same conditions.

2. EXPERIMENTATION:

Table 1: Specimen details

Specimen details of honeycomb			
SL.NO	Specimen	Dimensions	Mass(gm)
1	EM-HC-01	75x75x35	13.5
2	EM-HC-02	75x75x35	13.8
3	EM-HC-03	75x75x35	14
4	EM-DY-01	75x75x35	13.9
5	EM-DY-02	75x75x35	13.6
6	EM-DY-03	75x75x35	13.8

2.1Equipment and testing method

Out of plane quasi static compression test are carried out as per ASTM standards C-365-03, on electronic universal testing machine of load capacity 400 kN at a constant rate of 5mm per minute The loading frame involves two cross heads which are parallel and a lower table as shown in Figure 4.5.The cross head which is at top is fixed and the cross head at centre can vary from up to down. The tension test is conducted among upper and central cross heads and compression tests are made between the central cross heads and the lower table. Experimentally attained load-displacement data are stored in the disk of computer.

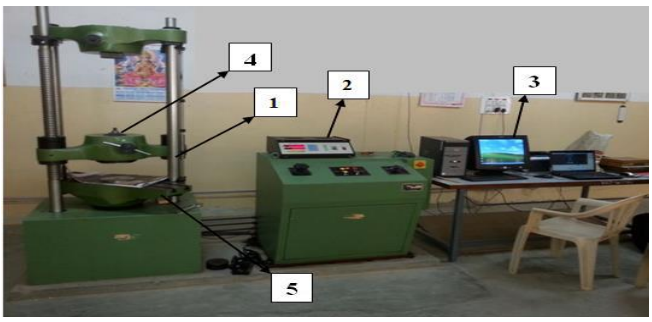
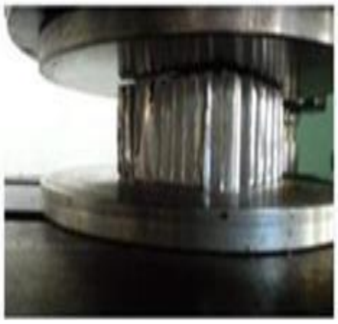


Fig-1: Electronic universal testing machine (1) Machine frame (2) Servo control unit (3) Computer control (4) Cross head (5) Lower Table

2.1.1 Crushing of Aluminum Honeycomb



a) No Load Condition

b) Initiation of minor bend (δ=2mm)

c) Crushing takes place (δ=15mm)

d) Before densification starts

e) Fully compressed specimen

Fig–2: Photographic views (a,b,c,d,e) of sequence of progressive deformation of aluminum honeycomb specimens

The specimen is positioned between central cross head and lower end of universal testing machine with the face vertical and crushed constantly. Three specimens are crushed repeatedly for best results. The progressive deformation of load characteristics of specimen and the results were recorded as show in fig 2 .the output of displacement load history is stored.

Dynamic compression test

The determination of energy absorbing capacity under dynamic compression is very important in recent world. The behavior of structures subjected to dynamic loading is quite different compared to quasi static loading. The loading conditions are different in dynamic test, the mass, impactor are functions of quasi static behavior of honeycomb . A series of specimens are used to get the best results and to predict the crush rate and behavior of structure.

This segment gives the data of experiment results of aluminum honeycomb structures tested for Dynamic compressive loading. The study is focused on Load-Displacement response and energy absorbed during test in out -of -plane conditions. In dynamic response a rapid deformation occurs as the load is applied suddenly with some velocity. The sudden deformation results are studied and reported.

Testing method and Equipment for Dynamic test

Drop weight testing machine are used for out-of-plane dynamic compression test for honeycomb structures [1] ,Figure 3 shows the detailed view of drop weight testing machine which involves two frames which is C shaped having six meter height which is initiated from ground with good concrete foundation. The steel guide is in touch with C-frames which will guide the drop mass. Drop mass is placed between the two flat plates and is bolted tightly with four bolts. The drop mass can be increased or decreased according to requirement of height and velocity. The height of the mass can be changed using a motor system, which consists of electric motor, rope, gear and rope drum. The drop mass can be lifted up using wire rope with the help of pulley and rope drum assembly. A ratchet mechanism is used to hold mass of impactor at required height to attain the predetermined impact velocity. Release mechanism of impactor is used to drop the mass at less period of time. The mass required is dropped on specimen to be tested which is placed on load cell.

The load cell is fixed on to the base as shown in the fig 4, the load cell is designed in such a fashion that it should measure the forces when the dynamic test is conducted. When the test is conducted the specimen undergoes deformation and dissipates the kinetic energy of mass. The deformation of the specimen and the force that is transmitted to the base have to be measured.

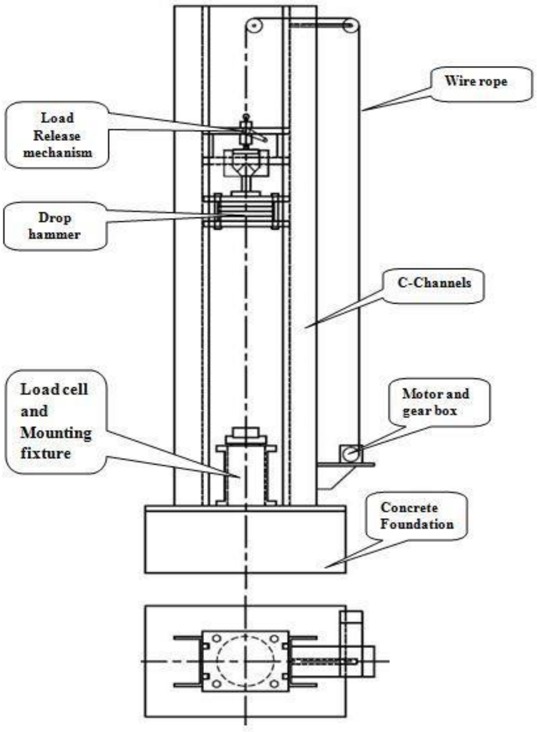


Fig 3 : Detailed view of drop weight testing machine

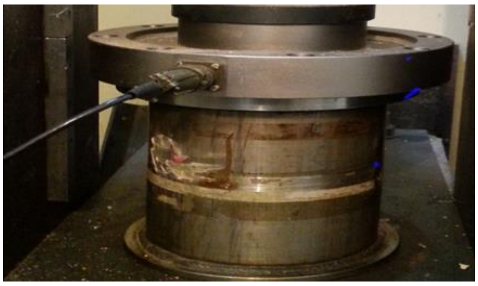


Fig 4: Load cell with strain gauges

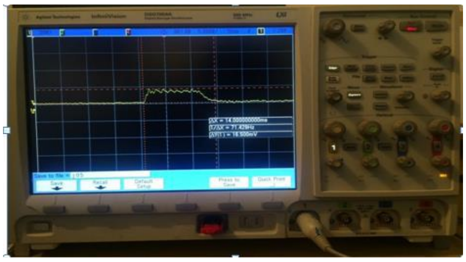


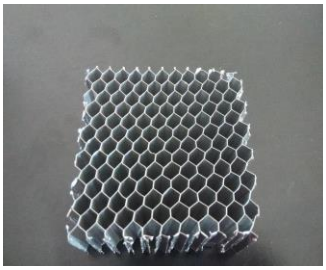
Fig 5: Data acquisition, using digital storage oscilloscope.

The load cell with strain gauge sensors was placed between the top and bottom loading of drop weight testing machine and mass at certain height is applied, the amplifier converts the charge signal to a voltage signal which is sent by load cell. The voltage signal is then passed to data acquisition system. The above Figure 4.9 shows the data acquisition using digital storage oscilloscope. This converts and displays the output of this acquired data and is stored in ASCII format.

The dynamic compression test is conducted for the three identical specimens (as conducted in quasi static loading). The specimens are placed on load cell in such a way that cell faces are parallel to frame of machine. A known mass of 60Kg was moved above to a height of 750mm (0.75m) using motor and gear box which drives the rope of pulley, the data acquisition set up and software is checked. The loads are taken off by the release mechanism, due to the kinetic energy transfer from drop mass to honeycomb specimens, the specimens are crushed. The signal which is coming from the load cell is transferred to the amplifier, where the signal is amplified to the required rate and is converted into voltage signal and finally transferred to Data Acquisition system. Load along y axis and time is along x axis is plotted and test is repeated for other specimens. The dimensions of honeycomb specimens and corresponding mass and heights are shown in Table 2. Figure 4 shows the specimen before and after Impact test.

Table 2: Specimen and drop height details

Specimen	Size (mm)	Drop height (m)	Drop mass (kg)
EM-DY-01	75x75x35	0.75	60
EM-DY-02	75x75x35	0.75	60
EM-DY-03	75x75x35	0.75	60



Specimen Before impact test position

Specimen under impact

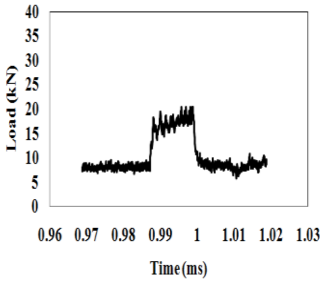
Specimen after impact test

Fig 4: specimen before and after Impact test

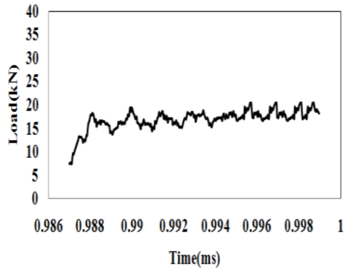
RESULTS AND DISCUSSIONS

Dynamic characteristics of honeycomb

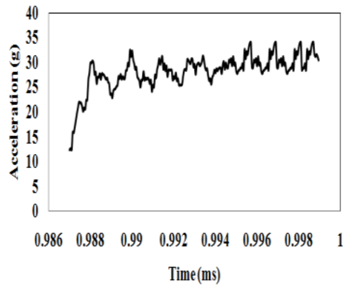
Honeycomb specimens are crushed under dynamic loading using drop weight testing machine. The Load vs time plots are obtained DAQ system and is processed and converted to displacement vs time plot, velocity vs time plot, acceleration vs time plot, and load-displacement plots for specimens of honeycomb tested at a velocity of 0.75m/sec are drawn. The fig 5 shows the load vs time plot of honeycomb specimen before the mass is dropped and until the specimen is fully crushed. The required par of plot, is then suitably enlarged as shown in Figure 6. The main objective is to determine the area under the curve to determine energy absorption.



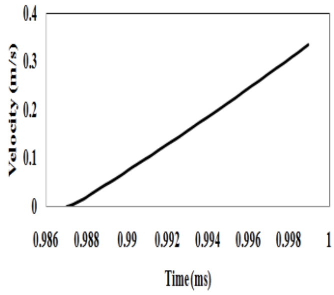
a) Load vs time plot



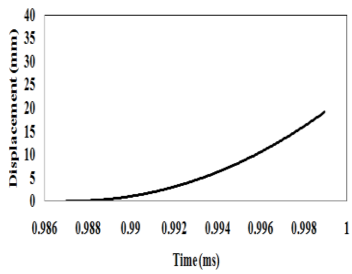
b) Load vs time plot (resized view)



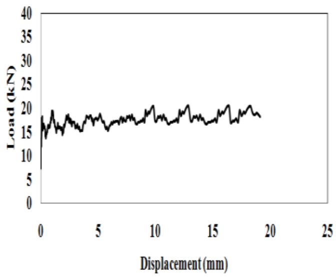
c) Acceleration vs time plot



d) Velocity vs time plot



e) Displacement vs time plot



f) Load vs displacement plot

Fig 5 : Plots of acquired process data for honeycomb

Figure 6 load vs displacement traces for three honeycomb specimens, the peak load and energy absorption in KJ is noted for honeycomb under dynamic conditions.

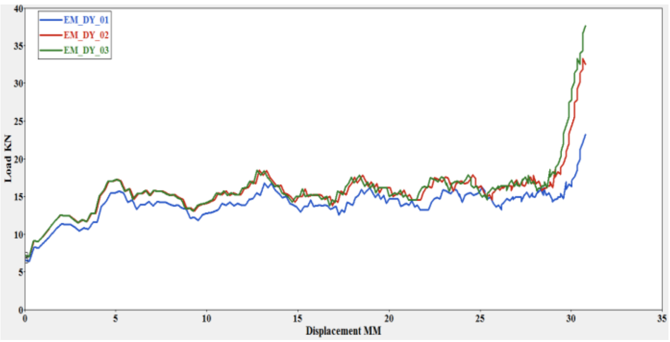


Fig 6: Load-displacement traces for three honeycomb specimens for dynamic loading

Dynamic energy absorption graphs and results

The energy absorption for honeycomb specimens under impact loading or dynamic conditions are determined using LS dyna software. The figure 7, 8, 9 shows the energy absorption of EM DY 01, EM DY 02 and EM DY 03 respectively.

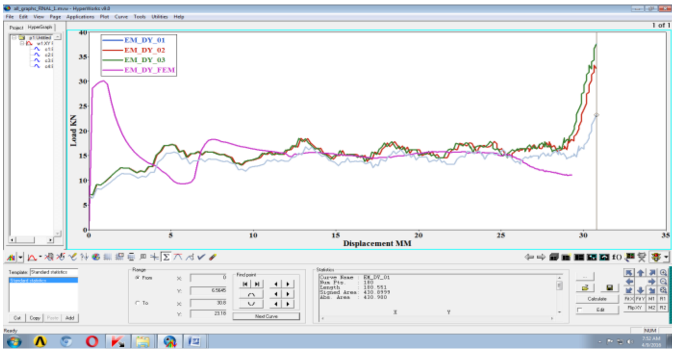


Fig 7: Energy absorption results using LS dyna for first Specimen EM DY 01

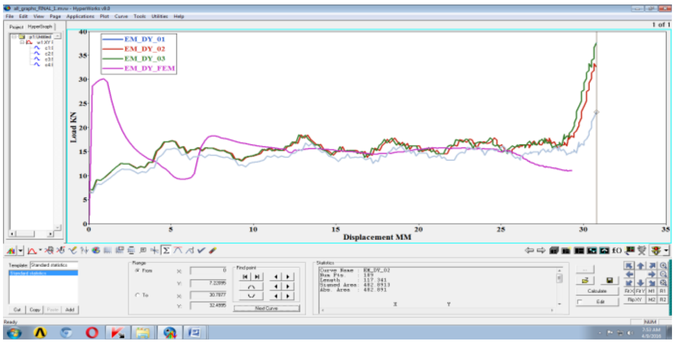


Fig 8: Energy absorption results using LS dyna for second Specimen EM DY 02

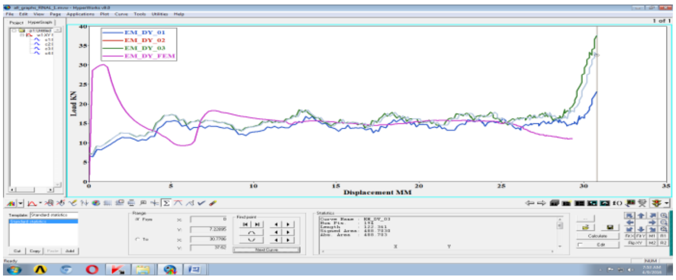


Fig 9: Energy absorption results using LS dyna for third Specimen EM DY 03

Dynamic results tabulation and discussions

Energy absorption, mass, load are tabulated for honeycomb dynamic loading specimens as shown in Table 3

Table 3: Results of dynamic tests on honeycomb specimens

Specimen	Mass (gm)	Density (kg/m3)	Initial Crush Load (kN)	Energy Absorbed EA (J)
EM-DY-01	13.9	74.12	16.75	430.9
EM-DY-02	13.6	77.11	17.3	482.89
EM-DY-03	13.8	75.82	16.4	488.7
Average	13.76	75.82	16.81	467.49

Load vs displacement plot for honeycomb specimens under impact loading is as shown in figure 6.6.The following aspects were seen in results.

- Upto linear elastic region the energy absorption is less.
- The initial crush load is 16.81KN absorbed in honeycomb specimens.
- A constant load is attained near plateau region and more energy absorption takes place.
- The load increases suddenly at the densification zone and the specimens are fully crushed.

REFERENCES

[1] Ramesh S. Sharma, V P Raghjupathy,Priyamvada G M, Abishek A. and Abhiraj M, “Investigation of Low Velocity Impact Response of Aluminium Honeycomb Sandwich Panels”ARPN Journal of Engineering and Applied Sciences.M. Vol 6, November 2011, ISSN1819-6608

[2] Haydn N. G. Wadley, Kumar P. Dharmasena, Doug T. Queheillalt, Yungchia Chen, “Dynamic Compression of Square Honeycomb structures during underwater impulsive Loading", Journal of Mechanics Of materials and structures Vol 2, No10,2007.

[3] C.Fremgen, L. Mkrtchyan, U. Huber, M. Maier., Modelling and testing of energy absorbing lightweight materials and structures for automotive applications,” Science and Technology of Advanced Materials 6 (2005) 883–888