Analysis of different Polygonal Cellular Structures under Impact Loading

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Abstract: ***Aluminum honeycomb structures have physical as well as mechanical properties includes high strength to weight ratio, high energy absorption capacity, low mass/volume ratio, for this purpose aluminium honeycombs are used in various industrial applications. Sandwich panels with polygonal cores are widely used in different structural applications such as aircraft floor panels, control surfaces, civil engineering structures and many more. The main use of these panels is to reduce weight and material usage. These panels undergo various static and dynamic loading along with thermal environment. This project is an investigative study of different polygonal structures under impact loading which will lead to better selection of the core.***

Keywords: Aluminium panel, Honeycomb structure, Ansys, Creo, Core height

1. Introduction

Aluminum honeycomb structures have physical as well as mechanical properties includes high strength to weight ratio, high energy absorption capacity, low mass/volume ratio, for this purpose aluminium honeycombs are used in various industrial applications. Thin walled tubes are good energy absorbent therefore they can be used as energy absorbers. These tubes are mostly available in square and circular shape. The main advantages of these tubes are they are inexpensive, efficient in use and versatile. Such energy absorption characteristics lead them to be used in car bumpers, train buffer and at the base of lift shafts. Mainly the bumper is used to absorb the shock in case of collision. To increase the shock absorbing capabilities the materials like glass, thermoplastics, steel, sheet molding compound are used in the honeycomb structure.

Bumper is an energy absorbing protective material. It absorbs the energy in front of collision and it also protects valuable parts such as radiator. From economical point of view as well as to decrease consumption of fuel manufacturing light weight vehicle is current situations need. Now a days in automobile sector , application of composite material has become a common thing. The typical honeycomb sandwich panel is as shown in fig.1

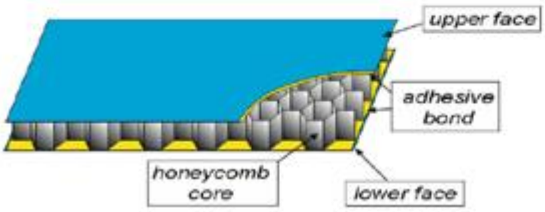

Figure 1: Honeycomb Panel [1]

2. Literature Survey

L.L. Hu (2014) investigated the two types of circular celled honeycombs with square packing and hexagonal packing subjected to impact loading. An analytical expression is concluded to forecast the crushing stress of honeycomb and to show the good agreements with numerical results. It was found that the rate of energy absorption per unit mass of hexagonal packing as well as square packing honeycomb is at least 13.3 % and 6.4 % , which is larger than cylindrical tubes. Due to denser package made of cells, HP honeycomb can soak up the 23 % energy per unit volume which is greater than SP.[2]
A.M.S. Hamouda (2007) investigated square tubes made up of metals and composite materials by varying length to width ratio. During the tube crushing, the three types of deformation modes were observed. They can of mixed , regular and irregular. Most of the metal, GRP 0/90, and 45 tubes crushing are ended to display the irregular modes and mixed modes. On the other side, the Kevlar tubes crushing are ended to display the regular modes. The energy absorbing capacity and maximum load carrying capacity are higher than other tubes. The specific energy of composite tubes is four times greater than that of specific energy of metal tubes.[3]
Ramôn Ruthes Auersvaldt (2014) investigated the thin walled square and hexagonal tube consisting of window subjected to axial dynamic impact. The size of the window affects the characteristic mode which was developed during the crushing. The symmetric and extensional mode depends upon the window dimensions. Hexagonal tubes decrease the energy absorption capacity during the impact. It is caused by volume which is extracted from the side walls to the lower stiffness in hexagonal cores in compare to square tube.[4]

C.C. Foo (2008) was investigated the aluminum sandwich panel subjected to low velocity impact. He Developed 3 D model of panel using ABAQUS. Parametric study had been conducted to decide effect of various geometric parameters like cell size as well as foil thickness, on the damage resistance of the core and impacted facesheet. It was found that cores which are denser exhibited greater peak loads as well as they experiences smaller damage profiles in the core. It was also found that cores having more thickness and high density is more damage tolerant core.[5]

M.A. Yahaya, et. al. 2015, investigated the Honeycombs sandwich panels having five different core configurations with 1 mm thick aluminium face sheets subjected to impact . It has been found that back-face deflection of the honeycomb sandwich panels was affected by the foil thickness as well as the cell size . if we increase the foil thickness as well as reduce the cell size it will result into decrease in the back-face deflection, but it will increase the overall honeycomb weight of sandwich panels.[6]

Dai-Heng Chen done the finite element analysis to investigate the crushing behaviour of hexagonal thin-walled tube. These thin walled tubes has partition wall and these are subjected to axial compression. It was found that in case of hexagonal tube with partition wall even when the middle of the outer walls becomes greatly folded the compression stress does not decrease in central part. Therefore to continue folding the lager compressive stress is required. [7]

B. Hou conducted the quasi – static and impact test on seven different types of with varying relative density from 1.78 % to 4.72 % . In single Y – shape cell , stress and strain both profiles are being analysed during successive folding. The strain under impact loading is larger than quasi – static loading. The 3003 alloy has a greater ratio between increased stress and yield stress than 5052 alloy.Crushing pressure enhacement of 3003 honeycomb is larger than 5052 honeycombs. [8]

Mathematical calculation :

Velocity at different height

When h = 300 mm

$$v = \sqrt{2gh} = \sqrt{2 \times 9810 \times 300} = 2426 \text{ mm/s}$$

when h = 500 mm

$$v = \sqrt{2gh} = \sqrt{2 \times 9810 \times 500} = 3132.09 \text{ mm/s}$$

when h = 1000 mm

$$v = \sqrt{2gh} = \sqrt{2 \times 9810 \times 1000} = 4429.44 \text{ mm/s}$$

3. Analysis

This study uses facesheet of aluminum and aluminium core of hexagonal and square shape. The dimension of panel for all structures is 100 mm × 100 mm. Cell size is 8 mm. Thickness of facesheet is 1 mm and height of the core is 8 mm thickness of the core is 0.07mm. The modeling of structures is done in Creo. The finite element analysis software ANSYS 14.5 was used to study impact behavior of hexagonal and square structure. The area of sheet considered for all structures is same. Rigid body is impacted on panel from different heights. The material used for this structures are aluminum 3003.

Table 1: Properies of Aluminium 3003

Sr. no.	Property	Value
1.	Modulus of elasticity	70 GPa
2.	Yield Strength	190 MPa
3.	Shear modulus	25GPa
4.	Density	2700 kg/m^3

The geometry of hexagonal and square shape is as shown in Fig. 3 and Fig 4 below.

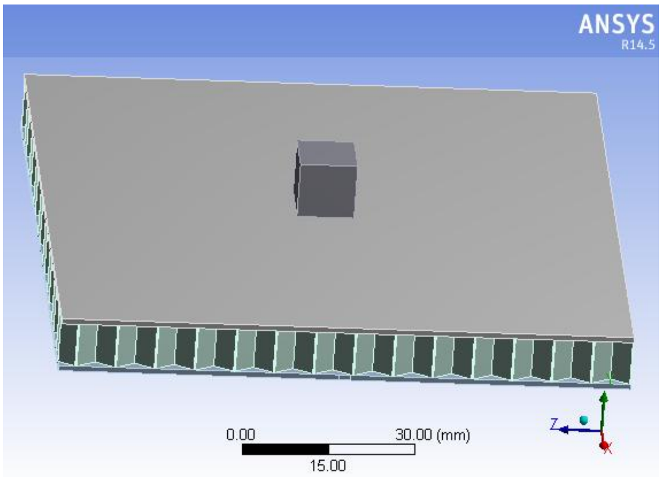

Figure 2: Geometric model of hexagonal

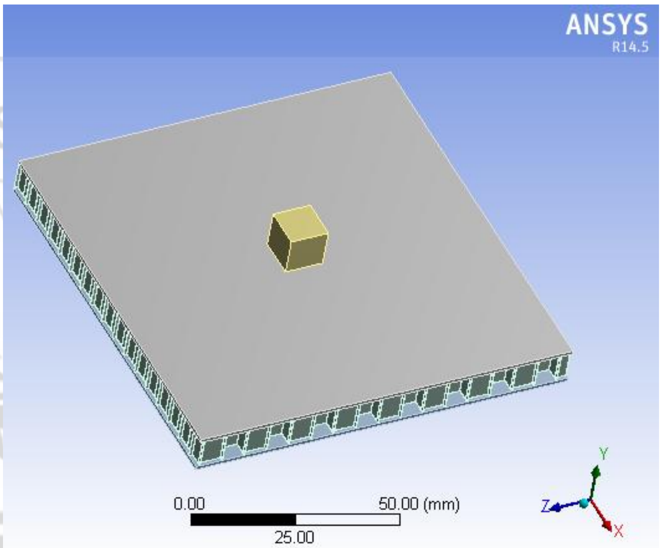

Figure 3: Geometric model of Square

For hexagonal structure when rigid body is impacted from height 1000 mm then we get maximum equivalent stress is 27792 MPa as shown in Fig. 4

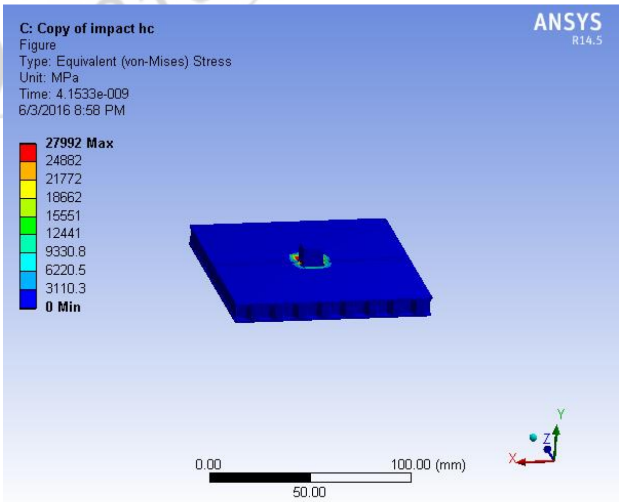

Figure 4: Stress in hexagonal

For square structure when rigid body is impacted from height 1000 mm then we get maximum equivalent stress is 1.5695e5 MPa as shown in Fig. 5

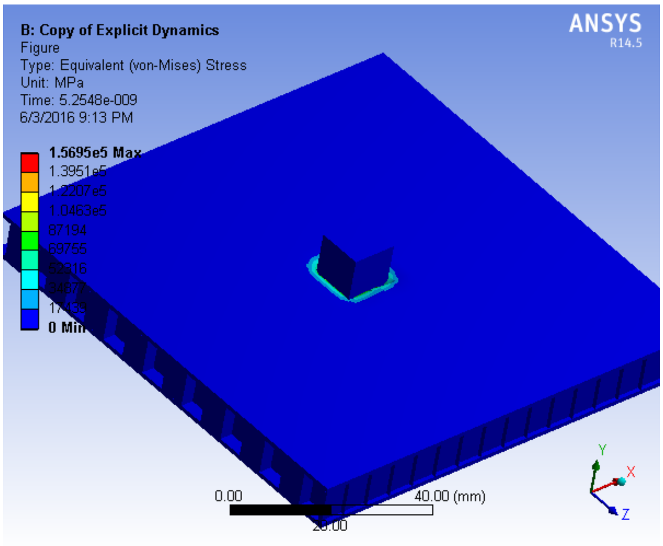

Figure 5: Stress in Square

For hexagonal structure when rigid body is impacted from height 1000 mm then we get total deformation is 2.2445 mm as shown in Fig. 6

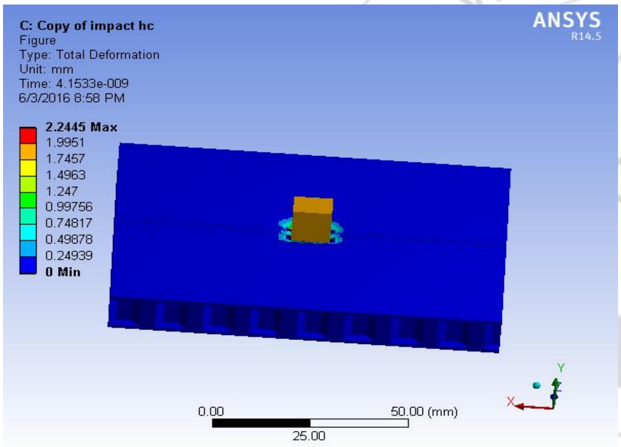

Figure 6: Total deformation in hexagonal

For square structure when rigid body is impacted from height 1000 mm then we get total deformation 2.0156 mm as shown in Fig. 7

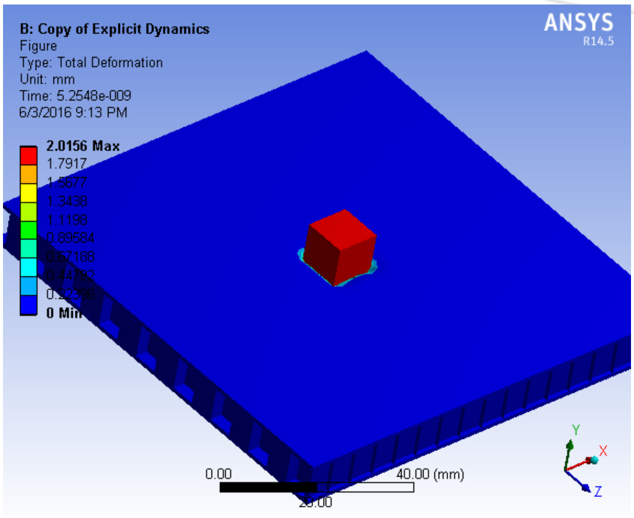

Figure 7: Total deformation in Square

4. Results and Discussion

Table 2: Deformation Vs velocity results for hexagonal structure

Height (mm)	Velocity(mm/s)	Deformation(mm)
300	2426	0.10398
500	3132.09	0.20046
1000	4429.44	0.41196

Table 3: Deformation Vs velocity results for square structure

Height (mm)	Velocity(mm/s)	Deformation(mm)
300	2426	0.0.45889
500	3132.09	0.6048
1000	4429.44	0.68595

5. Conclusion

The effect of hexagonal and square cellular structure and impact loading is analysed using ANSYS FEA software package. The deformation of cellular panala is studied by droping a rigid body from different height and results. It is formed that hexagonal structure having less deformation than square panel under impact loading.Also when height of drop is increasing the panel is getting more deformed as expected

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